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USING DIATOMS IN BIOLOGICAL ASSESSMENT OF THE WATER QUALITY ON THE EXAMPLE OF SMALL KARSTIC RIVER IN BOSNIA AND HERZEGOVINA

Korištenje dijatomeja u biološkoj procjeni kvalitete vode na primjeru male krške rijeke u Bosni i Hercegovini

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Abstract

Research into the benthic diatoms in the Bunica River was performed during the period from 5th May 2013 to 9th January 2014 on three different sites, from the headwaters to the mouth. The Bunica River is located in the south-eastern part of the Mostar valley, in the south of Bosnia and Herzegovina. The aim of this research was to test the use of benthic diatoms as indicators and the use of diatom indices as a tool for estimating water quality in an example of a small karstic river. For that purpose, diatom indices were calculated using OMNIDIA GB 5.3 software. This was the first testing of diatom indices for a small karstic river. Diatom indices showed different results and huge variations between sites on the Bunica River. According to the results, the indices in the OMNIDIA software are not applicable for karstic rivers in Bosnia and Herzegovina and they must be modified for this purpose. This paper can be the first step towards calibration indices for karstic region. Also, it can be useful for the development of biomonitoring tool for karstic rivers in Bosnia and Herzegovina.

Keywords: diatoms, diatom indices, water quality, Bosnia and Herzegovina, OMNIDIA

INTRODUCTION - *Uvod*

Diatoms are a good environmental indicator and are often the main component of phytobenthos and phytoplankton in surface water bodies, representing an important element in aquatic ecosystems and one of the most important groups of algae for monitoring activities (KELLY et al., 1998). Diatom based assessment of environmental conditions in rivers and streams has a long history and different approaches such as pollution levels on the one hand and biodiversity on the other. According to this, diatoms are being used to assess ecological conditions in streams and rivers around the world (KELLY et al., 1998; WU 1999., LOBO et al., 2004, PORTER et al., 2008). Diatoms are widespread and can be found in almost any type of running water. A combination of

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short generation time and ability to clearly designate nutrient status of their habitat, makes them a great indicator of water quality. Therefore, benthic diatoms are often used for assessing nutrient enrichment (KELLY, PENNY & WHITTON, 1995; ROTT et al., 1997, 1999; CORING, 1999), salinity (ZIEMANN, 1999) and acidity (CORING, 1993; BATTARBEE et al., 1997; VAN DAM, 1997). Consequently, several studies have addressed the tolerances and preferences of diatoms along with a number of environmental gradients; salinity, pH, trophy, saprobity (DENYS, 1991; VAN DAM, MERTEN & SINKELDAM, 1994; ROTT et al., 1997). The European Water Framework Directive (WFD; The European Parliament & European Council, 2000) establishes a framework for the protection of water resources. According to the Water Framework Directive, European Union member states and candidate states are required to achieve a good ecological status for all rivers. The European Water Framework Directive (WFD; The European Parliament & European Council, 2000) considers benthic diatoms as one of the key groups of organisms for assessing the ecological quality of rivers. Some studies show that diatom metrics detect eutrophication effects better than metrics calculated using fish, macroinvertebrates and macrophytes and they respond most strongly to land-use gradients (HERING et al., 2006). Many indices have also been developed to illustrate general water quality, mostly reflecting organic load or/and nutrient concentration level (WATANABE et al., 1986; LECLERCQ & MAGUET 1987; COSTE & AYPHASSORHO 1991; DESCY & COSTE 1991; SCHIEFELE & SCHREINER 1991; KELLY & WHITTON 1995; PRYGIEL et al. 1996; PRYGIEL, 2002). In most European countries those have been adopted as the routine monitoring method of biological quality elements for ecological status assessment in rivers.

In this study we used multimeric diatom indices calculated by OMNIDIA software as a tool for estimating the river water quality and ecological status. It presents the relationship between measured water quality variables in the Bunica River and diatom indices scores. Diatom indices scores were calculated and correlated to concurrent physical and chemical water quality data.

The aim of this study is to test diatom indices in ecological status assessment on an example of a small karstic river, Bunica, in the south of Bosnia and Herzegovina.

Study area

The Bunica River is a short, only 5.8 km long, karstic river. It flows in the south of Bosnia and Herzegovina and belongs to the Neretva river basin. Bunica River is a tributary of the Buna River. The spring of the Bunica River is of the siphon character and it is the underground extension of the Zalomka River flow. The spring depth is 73 m and it is one of the largest sources of the Dinaric karst (MILANOVIĆ, 2006). This study was conducted at three sampling stations named Bunica 1 (spring area: N: 43°13'11.81" E: 17°53' 29.95"), Bunica 2 (middle part of longitudinal flow: N: 43°14' 95" E: 17°51' 42.92") and Bunica 3 (mouth of Bunica to Buna river: N: 43°14' 39,53" E: 17°51.8' 26") (Figure 1).

Figure 1. Research area site
Slika 1: Područje istraživanja

MATERIALS AND METHODS - *Materijal i Metode*

Samples were collected from the three sites in different seasons (spring, summer, autumn and winter) in the small karstic Bunica River. Diatoms were collected using the standard procedure of scraping materials from the surface of rocks (EN 13946, 2003). The upper surface of each rock was scratched with a scalpel and carefully brushed with a toothbrush. The samples were preserved in 4% formaldehyde and stored in appropriately labelled bottles. According to standard procedure samples were cleaned of organic matter with concentrated sulphuric acid, potassium-permanganate and oxalic acid (KRAMMER & LANGE-BERTALOT, 1986). The obtained material was used for permanent diatom microscope slide preparation. The composition and relative abundance of diatoms were estimated at 1000X magnification, using a light microscope Carl Zeiss Jena. At least 400 valves were counted. Identification and nomenclature were based on relevant scientific literature and keys; KRAMMER & LANGE - BERTALOT (1986 - 1991), LANGE-BERTALOT & KRAMMER (1989), LANGE-BERTALOT & METZELTIN (1996) LANGE – BERTALOT (1993, 2001), KRAMMER (2000 - 2003), KRAMMER & LANGE – BERTALOT (1997a, 1997b, 2004) and LEVKOV (2009). The nomenclature of taxa was determined by the nomenclature set out in algae base (GUIRY and GUIRY, 2019). Simultaneously with benthic samples, physical and chemical parameters (pH, electric conductivity, dissolved oxygen, oxygen saturation and temperature of water) were measured using a field measuring probe Hach Sension probes 156. Also, samples for nutrients analyses were taken and were processed in the standard spectrophotometric method in an accredited laboratory to valid norms, in the Laboratory of Public Health Mostar. The following chemical parameters were analyzed: chemical oxygen demand, nitrate, nitrite, total nitrogen, total phosphorus, orthophosphate and silica. The correlation between parameters and diatom indeces score was estimated with the Pearson Correlation Coefficient. Indices were calculated using OMNIDIA GB 5.3 software (LECOINTE et al., 1993). The diatom taxa counts were entered into the diatom database and indices calculation tool. Indices taken into account for the assessment of water quality are those with the highest proportion of species accounted for in the calculation. The following indices were used: EPI-D (DELL'UOMO A., 1996), IBD (LENOIR & COSTA, 1996), SHE (SCHIEFELE & SCHREINER, 1988-91), SID (ROTT et al., 1997), TID (ROTT et al., 1999), IPS (CEMAGREF, 1982), SLA (SLÁDEČEK, 1986), IDSE (LECLERCQ & MAQUET, 1987), IDG (CEMAGREF, 1982-90), CEE (DESCY et al., 1988) and TDI (KELLY & WHITTON, 1995). Indices can be divided into three different categories; indices which show global warming; saprobity and trophy indices. All values of indices in OMNIDIA software are ranged from 1 to 20 and show five different ecological statuses (Tab. 1). The software shows ecological characteristics of species: life form, pH values, salinity, dissolved nitrogen, necessary for oxygen, saprobity, trophicity and other indicators. Except for the above mentioned, it calculates diversity and distribution of species.

Table. 1. Ranges of the diatom indices and ecological status (ELORANTA & SOININEN, 2002).
Tabela 1. Raspon dijatomnih indeksa i ekološki status (ELORANTA & SOININEN, 2002)

Status	Values	Colour
High	> 17	Blue
Good	15-17	Green
Moderate	12-15	Yellow
Poor	9-12	Orange
Bad	< 9	Red

RESULTS - *Rezultati*

Physico-chemical and chemical variables

The main abiotic variables measured in the Bunica River are shown in Table 2. Data of physical and chemical variables show low concentrations of nutrients, good aeration, pH typical for carbonate bed/origin and generally oligotrophic conditions. According to the measured parameters water quality in the Bunica River has a high ecological status, corresponding to a natural status without anthropogenic influence (Official Gazette FBiH, No. 70/06). Physico-chemical and chemical conditions in water were statistically insignificant and low correlated with values of the used indeces. In contrast, the values of indices are significantly correlated with each other ($p < 0.05$) (Tab. 5). Indices showed variations in results from high to low ecological status (I-V class), completely deviating from the state of water gained on the basis of the physico-chemical parameters (I class).

Table 2. The main abiotic variables in the Bunica River (12 samples).
Tabela 2. Glavne abiotičke varijable u rijeci Bunici (12 uzoraka).

SITES	Season	Chemical oxygen demand (mg/L)	Ammonium (mg/L)	Nitrate (mg/L)	Total nitrogen (mg/L)	Silica (mg/L)	Total phosphorus (mg/L)	Orthophosphate (mg/L)	Temperature (C°)	pH	Conductivity (µs/cm)	Dissolved Oxygen (mg/L)	Oxygen saturation (%)
BUNICA 1	spring	1.15	0	0.184	0.305	2.685	0.006	0.003	13.7	7.9	313	11.98	116
	summer	1.28	0	0.34	0.42	3.0	0.011	0.004	14.2	8	390	12.25	119.3
	autumn	0.77	0	0.453	0.615	4.8	0.009	0.005	12	7.79	384	9.65	90.1
	winter	0.89	0	0.447	0.54	4.048	0.006	0.002	11.3	7.6	403	11.25	102.4
BUNICA 2	spring	1.00	0	0.180	0.3	3.1	0.005	0.003	14.1	7.8	314	12.8	120
	summer	1.28	0	0.292	0.374	3.109	0.01	0.002	15.5	7.9	384	12.77	127.9
	autumn	2.43	0.003	0.372	0.489	4.711	0.006	0.003	13.8	7.76	382	12.02	90.1
	winter	3.58	0	0.492	0.555	4.364	0.004	0.002	11.4	7.8	406	11.48	104.1
BUNICA 3	spring	1.10	0	0.182	0.31	3.15	0.005	0.003	14.7	7.86	312	13.28	132
	summer	1.28	0	0.279	0.375	3.148	0.008	0	15.3	7.9	384	12.59	125.6
	autumn	1.28	0.003	0.351	0.464	4.099	0.006	0	17	7.84	375	11.71	122.3
	winter	0.89	0	0.439	0.526	4.207	0.006	0.005	11.4	7.8	406	11.43	103.4

General taxonomic analysis

During the research period 147 diatom taxa were identified in the Bunica River. The most numerous genera were: *Gomphonema* (with 23 taxa) and *Navicula* (18 taxa). *Meridion circulare* (Greville) C. Agardh and *Ulnaria ulna* (Nitzsch) P. Comparé were recorded in all samples. All sampling stations had similar species richness in all seasons. Number of taxa at Bunica 1 ranged from 30 (in winter and summer) to 43 (in autumn), for Bunica 2 from 33 (spring) to 53 (autumn) and for Bunica 3 from 40 (summer) to 49 (autumn). The most abundant taxa at the Bunica 1 site were: *Encyonema ventricosum* (C.Agardh) Grunow, *Encyonema silesiacum* (Bleisch) D.G.Mann and *Planothidium lanceolatum* (Brébisson ex Kützing) Lange-Bertalot; at Bunica 2 *Halamphora veneta* (Kützing) Levkov, *Cocconeis euglypta* (Ehrenberg) Grunow and *Cocconeis placentula* Ehrenberg and at Bunica 3 *Gomphonema olivaceum* (Hornemann) Brébisson, *Achnanthes* sp. and *Cocconeis placentula* var. *klinoraphis* Geitler.

Diatom indices

In our study eleven (11) OMNIDIA indices were selected: EPI-D (DELL'UOMO A., 1996), IBD (LENOIR & COSTE, 1996), SHE (SCHIEFELE & SCHREINER, 1988-91), SID (ROTT et al.,1997), TID (ROTT et al.,1999), IPS (CEMAGREF, 1982), SLA (SLÁDEČEK, 1986), IDSE (LECLERCQ & MAQUET, 1987), IDG (CEMAGREF, 1982-90), CEE (DESCY et al., 1988) and TDI (KELLY & WHITTON, 1995). The values of applied indices are shown in Table 3 (Tab. 3) and the water quality classes in Table 4 (Tab. 4). The highest percentage of involved taxa was IDG (100%) and IPS (95-100%), while others had ranges between 60 and 95%.

Table 3. Values of diatom indeces for the Bunica River.
Tabela 3. Vrijednosti dijatomnih indeksa za rijeku Bunicu.

Station/Season	Index	EPI-D	IBD	SHE	SID	TID	IPS	SLA	IDSE	IDG	CEE	TDI
BUNICA 1	spring	15.6	18.6	17.6	14.5	7.1	16.2	13.1	3.9	17.9	15.8	11.5
	summer	15.2	19	14.8	13.5	7.1	17.4	12.5	4.2	16.7	17	9.4
	autumn	14.3	19.3	16.1	14.4	8.3	18.2	12.9	4.15	18.4	17	10.4
	winter	17.1	14.8	13.9	13	5.1	16.6	14.4	3.8	16.4	14.5	8.2
BUNICA 2	spring	9.6	10.5	10.5	8.3	4.9	8.9	8.5	3.01	11.7	12.4	4.6
	summer	15	16.7	15.4	13.6	7.8	16.2	12	3.65	14.5	14.5	7.5
	autumn	16.2	17.1	18.2	16.6	12.6	17.7	13.1	4.19	13.4	18.7	9.9
	winter	15.8	16.5	14.3	13.7	7.5	16.5	12.5	3.98	16.2	16.6	12.3
BUNICA 3	spring	14.5	18	13.9	12.7	6.6	17.7	11.1	3.93	15.7	15.8	6.2
	summer	15.3	13.2	14.6	18.8	11	15.1	11.3	3.03	14.2	14.5	9.1
	autumn	14.4	15.1	16.1	15.7	9.3	17.1	12	3.79	13.6	16.4	9.6
	winter	15.6	18.5	14.2	13.2	6.9	18.5	10.9	3.75	16.2	15.8	5.2

Table 4. Water quality classes according to OMNIDIA interpretation indeces.
Tabela 4. Razredi kvalitete vode prema interpretaciji OMNIDIA indeksa.

Station	Index / Season	**EPI-D**	**IBD**	**SHE**	**SID**	**TID**	**IPS**	**SLA**	**IDSE**	**IDG**	**CEE**	**TDI**
BUNICA 1	spring	II	I	I	III	V	II	III	II	I	II	IV
	summer	II	I	III	III	V	I	III	II	II	I	IV
	autumn	III	I	II	III	V	I	III	II	I	I	IV
	winter	I	III	III	III	V	II	III	II	1	III	V
BUNICA 2	spring	IV	IV	IV	V	V	IV	V	III	IV	III	V
	summer	II	II	II	III	V	II	III	II	III	III	V
	autumn	II	I	I	II	III	I	III	II	III	I	IV
	winter	II	II	III	III	V	II	III	II	II	II	III
BUNICA 3	spring	III	I	III	III	V	I	IV	II	II	II	V
	summer	II	III	III	I	IV	II	IV	III	III	III	IV
	autumn	III	II	II	II	IV	I	III	II	III	II	IV
	winter	II	I	III	III	V	I	IV	II	II	II	V

A significant positive correlation ($p<0.05$) was established between several indices (Tab. 5). The most significant correlation with nine indices was shown by SHE, IPS (with seven), IBD, CEE and SLA (with five). The highest correlation was established between the IBD and IDSE index, IBD and IPS, IDG, CEE, and IDSE and CEE indices.

Table 5. Pearsons correlation ($p < 0.05$) between diatom indices. (* correlation is significant)
Tabela 5. Pearson-ova korelacija ($p < 0,05$) između dijatomnih indeksa (značajna korelacija)*

	EPI-D									
IBD		IBD								
SHE	0.626*	0.612*	SHE							
SID	0.629*		0.709*	SID						
TID			0.673*	0.846*	TID					
IPS	0.800*	0.841*	0.667*			IPS				
SLA	0.843*		0.683*			0.666*	SLA			
IDSE		0.847*	0.618*			0.772*	0.678*	IDSE		
IDG		0.780*				0.624*	0.603*	0.604*	IDG	
CEE		0.719*	0.766*		0.593*	0.770*		0.854*		CEE
TDI			0.669*				0.689*			0.592*

Omnidia interpretation of Shanon-Weaver diversity index *H* were ranged between 2.42 and 3.46 for Bunica 1; 2.81-3.82 for Bunica 2; and 2.72-3.15 for Bunica 3.

Bunica 1:

According to the OMNIDIA results the Bunica 1 site showed a low degradation and antrophogenic eutrophication, and non-existent organic pollution. Values of indices were shown in the differences in results. According to IPS, IDSE and IDG indices the water quality at the Bunica 1 site is I-II class (high to good ecological status) (Tab. 3, 4). Saprobic indices showed III class (moderate ecological status), while trophic indices TDI and TID showed IV-V class water quality (poor to bad ecological status) (Tab. 3, 4). The percentage of species tolerant to pollution (% PT) is very low, in the spring was 0.3 %, and in the summer 1.8 %, while in autumn and winter presence of % PT is not recorded. Almost all taxa are neutrophile in view of pH values. One expectation was in winter when there were more alaliphilic taxa. In the summer period there were determined alpha meso-saprobic taxa with more abundant taxa sensitive on pollution (LANGE-BERTALOT, 1979, OMNIDIA). Saprobic indices values showed more alpha mesosaprobic taxa with the exception of the spring period. In the spring period there were more oligo-betamesosaprobic and betamesosaprobic taxa. According to the trophic indices values more taxa were tolerant and oligo-betamesosaprobic (HOFFMAN, 1994, OMNIDIA) or eutrophic in the winter period (VAN DAM, 1994, OMNIDIA).

Bunica 2:

According to OMNIDIA indicator values, Bunica 2 showed low degradation, organic pollution which is non-existent and antrophogenic eutrophication which is moderate in summer and low in winter time. At the station Bunica 2, depending on the season, quite a large variation was observed in water quality. The spring sample is the most different from all the other samples. According to the indices of global pollution, the spring period was moderate to poor (III-IV class) in ecological status, with communities under significant anthropogenic influence (Tab. 3, 4). The trophic state was bad according to the TID and TDI indices, while according to the SHE it was poor (Tab. 3, 4). The values of saprobic indices also present a bad ecological status, which highlights the existence of strong organic pollution. According to the percentage of pollution tolerant taxa (% PT) in that period which was 39.7%. Generally, in other seasons most indices showed good ecological status (class II) (Tab. 4). Saprobic indices present a moderate status (class III), while trophic (TID and TDI) present a poor to bad ecological status (IV-V class) (Tab. 3, 4). In the summer and winter samples % pollution tolerant taxa were 0.3 %, while in the autumn sample it was not present. Almost all taxa were alkaliphile in regard to pH values. According to saprobic and trophic indices values in spring taxa were alpha-meso-saprobic and polysaprobic (HOFFMAN, 1994, OMNIDIA) or eutrophic and saprothropic taxa (VAN DAM, 1994, HOFMANN, 1994, OMNIDIA). In other seasons at Bunica 2 there were beta-alpha-mesosaprobic taxa present (summer and winter) and oligo-beta-mesosaprobic (autumn) (VAN DAM, 1994, HOFFMAN 1994, OMNIDIA). According to LANGE-BERTALOT (1979, OMNIDIA) there were more sensible taxa recorded for pollution. Trophic indices showed oligo-alpha-mesothrophic and alpha-mesotrophic taxa (HOFFMAN, 1994) or eutrophic taxa (VAN DAM, 1994, OMNIDIA).

Bunica 3

According to OMNIDIA indicator values Bunica 3 showed low degradation (moderate only in summer); organic pollution which was non-existent (moderate only in summer) and antrophogenic eutrophication (moderate in spring and winter). According to most indices (IPS, IPD, IDSE, IDG, CEE) the water quality at Bunica 3 is II-III class and the ecological status is good to moderate (Tab. 3, 4). Saprobic indices SID and SLA indicate water quality class III - IV (moderate to poor ecological status) and the TID and TDI indicate V class (bad ecological status) (Tab. 3, 4). In spring, summer and autumn % of PT was not recorded, while in the winter it was 0.3 %. At Bunica 3 neutrophile were recorded (in spring and summer), alcaliphile (in autumn) and alcalibionte (in winter) taxa in regard of pH values. The most commonly represented were beta-mesosaprobic and eutrophic taxa (VAN DAM, 1994, OMNIDIA). The most abundant were more sensible for pollution taxa (LANGE-BERTALOT, 1979, OMNIDIA). According to saprobic and trophic indices values Bunica 3 showed beta-alpha mesosaprobic and oligosaprobic taxa present (only in autumn) (HOFFMAN, 1994, OMNIDIA) or tolerant (spring and autumn), oligo-betamesotrophic (summer) and alpha-mesoeutrophic taxas (HOFFMAN, 1994, OMNIDIA).

DISCUSSION-Rasprava

In this paper the assessment of water quality in the Bunica River was based on diatom indices where the highest percentage of the diatom taxa were selected and incorporated into the OMNIDIA database. The results showed differences in values and indicated more variations between sites on the Bunica River. This variation has also been observed by, among others, KITNER & POULÍCKOVÁ (2003), POULÍCKOVÁ, (2004), STENGER-KOVÁCS et al. (2007), KALYONCU & ŞERBETCI (2013), BELTRAMI et al. (2012), SZCZEPOCKA & SZULC (2009). Diatom indices showed good correlations with each other, but they are not showing the real situation in the Bunica River. The variation in indicator indices has caused confusion among researchers' quality assessments. It is unclear whether there are significant differences between the results of the indices, and if so, what these differences are and what causes this variation. Probably, the cosmopolitan nature of diatoms displays a constant trophic preference. According to studies from North America (POTAPOVA & CHARLES, 2007) it has been shown that European indicator indices may need to be calibrated to regional conditions. Also, other researchers (KELLY et al*.*, 1998; PIPP, 2002; ROTT et al., 2003) have argued that indices developed in certain regions of Europe are not effective in others. European indices are designed according to a wide range of characteristics, but not according to the ecoregion and reference conditions. According to research conducted by RIMET et al. (2007) and KELLY et al. (1998, 2001) factors of each ecoregion such as geology, soil type, climate and vegetation type can cause an adjustment in water quality. Measured environmental preferences of each species can be geographically specific. Results of research conducted by SOININEN & NIEMELA (2002) showed that the reaction of species which have a wide geographic distribution area and similar ecology is still conditioned by nutrients and the conditions of the ecoregion. Therefore, the use of trophic indices that were not originally intended for a particular ecoregion can cause unmatched results. For Bosnia and Herzegovina CSANYI et al*.* (2008) calculated OMNIDIA indices and found that according to the IPS, EPI-D and CEE indices the Neretva River (Herzegovina area) and the Fojnica River (Bosnia area) had a high ecological status. They stopped just on the calculation indices. On the other hand, the results of this research disagreed and showed inapplicable values of indices and ecological status for a small karstic river. In our study any indices demonstrated expected results for all sites. Recent studies show that climate, geology, vegetation, and soil, can modify species responses to water quality characteristics (KELLY et al., 1998; RIMET et al., 2007). SOININEN & NIEMELÄ (2002) reported that although diatoms might have a wide geographical distribution and a globally similar ecology, their response to nutrient conditions may still be different between ecoregions. According to BESSE-LOTOTSKAYA et al*.* (2011) each trophic index is originally intended to be applied in the region for which it was developed and using these indices in another region may cause uncertainty in assessment results, as happened in our study. BESSE-LOTOTSKAYA et al. (2011) considered that when assessing the trophic condition in regions for which no specific indices have been developed, it is advisable to apply several trophic indices and analyse carefully the variation in results. Some indices correlate better, whereas others appear to be completely different, and that is not always easy to explain (STENGER-KOVÁCS et al., 2007). In our study the best correlation with up to 9 indices was shown by SHE, followed by IPS (with 7), IBD, CEE and SLA (5) and EPI-D. This was expected in respect of the aims of the indices. The study of rivers in southern Poland KWANDRANS et al. (1998) concluded that the IPS has the best correlation with the IDSE and SHE index, IDSE with SHE index, and IDG also showed good results. SZCZEPOCKA & SZULC (2009) established that it is suitable for lowland rivers. Also, IPS and IDG have shown approximately good results in our study. They might serve as good indicators for planning in future research. According to all these and the results of our research, the indices in the OMNIDIA program results are not applicable without a calibration process for karstic rivers in Bosnia and Herzegovina. However, due to the fact that geographic characteristics are different, saprobity and trophy values of organisms must be modified for karstic and Bosnian-Herzegovinian conditions. This study was the first test in using diatom indices on an example of a small karstic river and can be the first starting point towards a calibration process in this karstic region.

CONCLUSION - *Zaključak*

Diatoms have been regularly used as bioindicators to assess water quality of surface waters. However, diatom-based indices developed for a specific geographic region may not be appropriate elsewhere. Benthic diatom assemblages in the Bunica River were sampled in different seasons to evaluate the applicability of 17 diatom-based indices used worldwide for water quality assessment. According to the physical and chemical conditions the water in the Bunica River showed high oxygen saturation and water transparency, as well as low nutrient concentrations and indicated the oligotrophic character of the river. Diatom indices showed different results and indicated more variations among sites on the Bunica River. According to the results, the indices in the OMNIDIA program, the same are not applicable for karstic rivers in Bosnia and Herzegovina. Saprobity (SID and SLA) and trophy (TID and TDI) indices showed the greatest deviations. The better result was given by EPI-D, IBD, SHE, IPS, IDG, IDSE and CEE. It is important to carry out more detailed research to determine whether they are suitable for assessing the quality of water in karstic rivers in Bosnia and Herzegovina, i.e. whether the indicator values are of a type adequate for this area. However, due to the fact that geographic characteristics are different, saprobity and trophy values of organisms must be modified for karstic and Bosnian-Herzegovinian conditions.

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SAŽETAK

Istraživanje bentoskih dijatomeja u rijeci Bunici provedeno je u razdoblju od 5. svibnja 2013. do 9. siječnja 2014. na tri različite postaje, od izvora do ušća. Rijeka Bunica je krška tekućica kratkog toka (oko 6 km), ulijeva se u rijeku Bunu, a nalazi se u jugoistočnom dijelu mostarske doline, na jugu Bosne i Hercegovine. Cilj ovog istraživanja bio je testirati korištenje bentoskih dijatomeja u svrhu praćenja kvalitete vode budući da se dijatomeje redovito koriste kao bioindikatori za ocjenu kvalitete površinskih voda. Uz bentoske dijatomeje testirano je i korištenje dijatomnih indeksa kao alata za procjenu kvalitete vode. Ukupno 17 indeksa je izračunato korištenjem softvera OMNIDIA GB 5.3. Korišteni indeksi su pokazali različite rezultate kao i varijacije između istraživanih postaja. Prema vrijednostima indeksa kvaliteta vode u rijeci je u lošijoj kategoriji (II, III, IV razred) u odnosu na kvalitetu vode prema fizikalno kemijskim čimbenicima (I razred). Prema tome indeksi u programu OMNIDIA nisu primjenjivi za krške rijeke u Bosni i Hercegovini i trebali bi se modificirati u tu svrhu. Važno bi bilo provesti detaljnija istraživanja koja bi uključivala veći broj sličnih postaja kako bi se utvrdilo koji indeks je najprimjenjiviji postajama te kako bi se napravila modifikacija indeksa koji bi odgovarao specifičnim krškim i bosanskohercegovačkim uvjetima.

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