Indicative Ecological Status Assessment of the Zapadna Morava River Based on Aquatic Macroinvertebrate Community

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Abstract

The aim of this study is to provide an indicative ecological status assessment of the Zapadna Morava River, based on the analysis of aquatic macroinvertebrate communities. Investigations were carried out during the summer period in 2011 and 2012 and covered four sampling sites: Gugaljski Most, Kraljevo, Jasika and Maskare. A total of 71 aquatic invertebrate taxa were recorded. Eight metrics were used for indicative ecological status assessment: total number of taxa, Zelinka and Marvan Saprobic Index, Biological Monitoring Working Party (BMWP) Score, ASPT (Average Score per Taxon), percentage participation of Oligochaeta/Tubificidae in the total macroinvertebrate community, Shannon-Weaver's Diversity Index, number of sensitive taxa (Austria) and number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa. Based on analyses of all selected metrics, the indicative ecological status of the Zapadna Morava River could be assessed as moderate (Class III).

Keywords: aquatic macroinvertebrates, Zapadna Morava River, biological metrics, ecological status assessment

Introduction

In the present work the results of the ecological status assessment of the Zapadna Morava River was introduced based on aquatic macroinvertebrates as the most commonly used biological quality element.

The Zapadna Morava is a river in central Serbia, with a 308 km-long longer headstream of the Velika Morava which it forms with the Južna Morava River. It originates in the Tašti field, east of the town of Požega, from the Golijska Moravica and Đetinja headstreams. It receives the Skrapež from the left of its main tributary in the field Đetinja, less than a kilometer after the confluence, it meets the Golijska Moravica from the south, forming the Zapadna Morava River. Owing to the proximity of the confluences of the Đetinja, Skrapež and Golijska Moravica, some sources consider all three rivers to be direct headstreams of the Zapadna Morava.

The Zapadna Morava River Valley is called Zapadno Pomoravlje. With the valley of the Ibar River, the Zapadna Morava has a considerable potential in electricity production (the Ovčar Banja and Međuvršje). Water is also used for the irrigation and the artificial lake Parmenac was created on the river for that purpose, thus helping the already fertile region (grains, orchards). Also, out of all three Morava rivers, the Zapadna Morava's Valley is the most forested one.

Altogether, the Zapadna Morava River receives 85 tributaries. The most important left ones are: Čemernica, Kamenica and Dičina and the right ones are: Ibar, Rasina and Ribnica. The river used to be longer (319 km), but due to the regulation of the flow, it is shorter now.

The river has an average discharge of 120 m³/s, but it is characterized by extreme fluctuations, which results in severe floods. The Zapadna Morava River drains an area of 15,849 km² (42,3 % of the entire Velika Morava River watershed) and it is not navigable.

The catchment of the Zapadna Morava River covers four water bodies (Official Gazette of the Republic of Serbia 96/2010), and three of them are situated within the investigated stretch: ZMOR_1, JMOR_2, ZMOR_4.

According to the national typology of surface waters, the Zapadna Morava River belongs to Type 2 (large rivers with medium grain-size mineral substrates, except for the Pannonian plain rivers) (Official

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Gazette of the Republic of Serbia 74/2011). With regard to ecoregion delineation for the territory of Serbia, the Južna Morava River is included in Ecoregion 5 (ER5) (Paunović et al, 2012).

Material and Methods

Sampling was performed during periods of high and low water level at four sampling sites (Figure 1; Table 1 and 2) in 2011 and 2012, according to AQEM protocol (AQEM, 2002). The semi-quantitative sampling was performed using a hand net (25x25 cm, 500 µm mesh size). The multi-habitat sampling procedure (Herring et al, 2004) was applied. Samples were preserved using 70% ethanol solution and further processed in the laboratory.

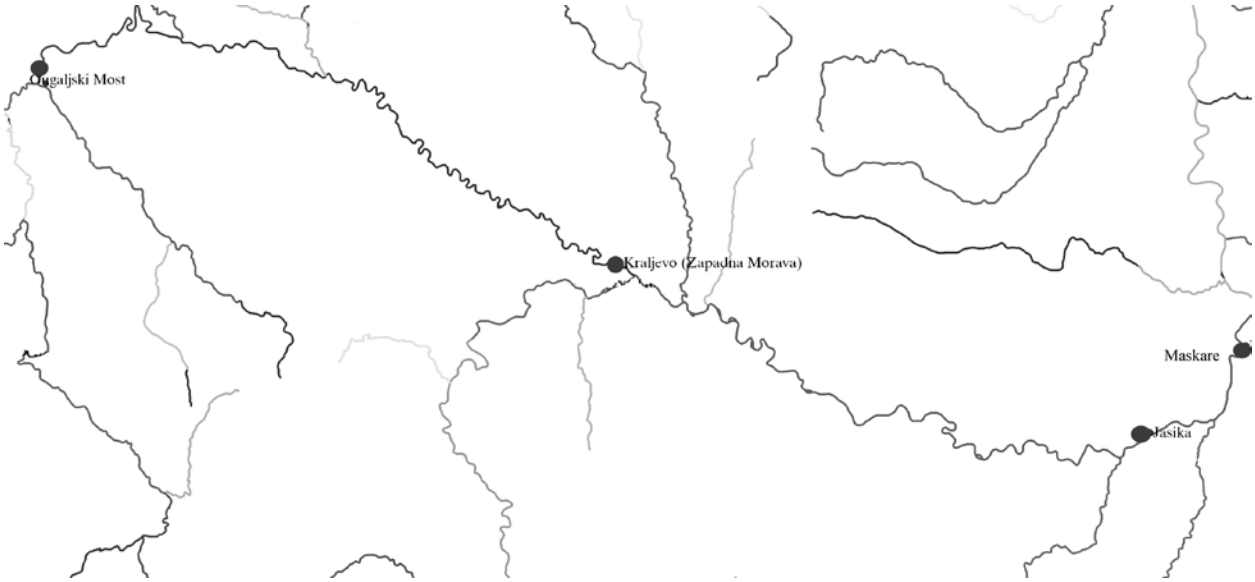

Figure 1: Map of sampling sites

Table 1: Sampling sites in the Zapadna Morava River

	Gugaljski Most	Kraljevo	Jasika	Maskare
Latitude, N	43° 52' 19''	43 ° 44' 02''	43 ° 36' 29''	43 ° 40' 19''
Longitude, E	20 ° 07'27''	20 ° 44' 35''	21 ° 18'02''	21 ° 24' 07''
Altitude (m)	240	209	142	138
Water Body	ZMOR_4	ZMOR_2	ZMOR_1	ZMOR_1

Table 2: Short codes for sampling sites

Sampling site	Short code	Sampling date
Gugaljski Most 1	GM1	17 Sep 2011
Gugaljski Most 2	GM2	20 Jun 2012
Kraljevo 1	KR1	13 Jun 2011
Kraljevo 2	KR2	13 Sep 2011
Kraljevo 3	KR3	18 Jun 2012
Jasika 1	JS1	21 Jun 2011
Jasika 2	JS2	06 Sep 2011
Jasika 3	JS3	24 Jul 2012
Maskare 1	MS1	20 Jun 2011
Maskare 2	MS2	05 Sep 2011

A scale used for taxa relative abundance estimation is shown in Table 3.

Table 3: Taxa relative abundance scale

Relative abundance	Description	Number of individuals per sample
1	single present	1
2	low abundance	2-5
3	moderate abundance	6-30
5	high abundance	31-60
7	very high abundance	61-100
9	mass present	>100

The following metrics were selected to be used for indicative assessment of ecological status: total number of taxa, Zelinka and Marvan Saprobic Index, Biological Monitoring Working Party (BMWP) Score, ASPT-Average Score per Taxon (Armitage et al, 1983), percentage participation of Oligochaeta/Tubificidae in the total macroinvertebrate community, Shannon-Weaver's Diversity Index (Shannon, 1948), number of sensitive taxa (Austria) and number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa.

Ecological status assessment of the Zapadna Morava River was performed by using macroinvertebrates as bioindicators and taking into consideration community structure and composition. For saprobiological analyses, a list of bioindicator organisms according to Moog was applied (Moog, 1995). Some taxa were not identified to the species level due to low level of confidence and the complex identification process. The metrics calculation was performed using ASTERICS software (AQEM, 2002). Indicative status assessment was carried out according to the national legislation (Official Gazette of the Republic of Serbia 74/2011), based on the class boundaries for rivers Type 2 (large rivers with medium grain-size mineral substrates, except the Pannonian plain rivers), as presented in Table 4. The colour code for each status class is shown in Table 5. The recommendations provided by the EU Water Framework Directive were applied (WFD, 2000).

Table 4: Ecological status class boundaries of selected metrics

METRIC STATUS	high/good	good/moderate	moderate/poor	poor/bad
Total no. of taxa	17	10	9	5
Zelinka & Marvan SI	2.00	2.50	3.00	3.20
BMWP Score	60.00	45.00	30.00	10.00
ASPT Score	6.00	5.00	4.00	3.00
(%) Oligochaeta / Tubificidae	10.00	25.00	40.00	70.00
Shannon-Weaver	2.20	1.50	1.20	0.50
No. of sensitive taxa		4		
EPT taxa	7	5	2	1

Table 5: Colour codes for ecological status classes

Ecological status	Colour code
high	
good	
moderate	
poor	
bad	

Results and Discussion

A total of 71 aquatic invertebrate taxa were recorded (Table 6). Insecta was found to be the most dominant component of the community with 38 taxa, followed by Mollusca (13 taxa) and Oligochaeta (8 taxa). The most diverse insect groups were Ephemeroptera and Plecoptera, both with 13 taxa. Diversity of other groups was significantly lower. Snails were represented with 10 taxa and bivalves with 3 species: *Sinanodonta woodiana, Unio crassus* and *U.tumidus.* Keeping in mind that taxa within some groups were not identified to the species level due to the complex identification process and low level of confidence, the taxa richness is certainly higher.

Table 6: Taxa recorded at the Zapadna Morava River and relative abundances

TAXON / SITE	GM1	GM2	KR1	KR2	KR3	JS1	JS2	JS3	MS1	MS2
Gordius aquaticus			2	1						
Nematoda sp.	1						1			
Dendrocoelum lacteum	1									1
Dugesia lugubris				2			2			
Dugesia polychroa	2	2		2					2	2
Dero spp.	2	5	3	3						
Enchytraeidae sp.									2	
Limnodrilus spp.	3	3			3	3		5		
Nais spp.						3				
Stylaria lacustris	2									
Stylodrilus heringianus			2							
Tubifex tubifex		3			2		2	3		
Tubificidae sp.			2							
Erpobdella octoculata		2	2	2	2		2	2	1	3
Erpobdella testacea				2	2					2
Erpobdella sp.							1			
Dina lineata				3				3	2	2
Glosspihonia complanata								1		
Bithynia tentaculata			2	5		5	7	7	5	5
Borysthenia naticina										2
Holandriana holandrii				2	1					
Lithoglyphus naticoides					1					
Radix auricularia							1	5	1	1
Radix labiata				2			2			2
Radix balthica				1					2	
Myxas glutinosa							1			
Physella acuta									2	5
Valvata piscinalis										2
Sinanodonta woodiana			2							1
Unio crassus					1					1
Unio tumidus			2		1					
Asellus aquaticus								2	2	
Gammaridae spp.	3	5	7	2	5	5	2	7		2
Baetis fuscatus		3								
Baetis lutheri		3		1						
Baetis sp.	2	1								
Caenis macrura				2						
Caenis robusta			2			2				
Cloeon dipterum			2							
Ecdyonurus dispar		2	2							
Heptagenia sp.		1								
Oligoneuriella rhenana		5								
Serratella ignita		3		1	3					
Ephemerella sp.			1		2	2				
Torleya major		5								
Potamanthus luteus			5		2	2			3	
Calopteryx splendens									2	2
Calopteryx virgo							3	1		1
Ophiogomphus cecilia			1							
Cyrnus trimaculatus			3							1
Ecnomus tenellus					2					
Ceraclea sp.		1								
Leptoceridae sp.					1		2			
Limnephilidae sp.							2			
Orthotrichia costalis					1					

TAXON / SITE	GM1	GM2	KR1	KR2	KR3	JS1	JS2	JS3	MS1	MS2
Anabolia nervosa				2						
Halesus sp.		1								
Hydropsyche contubernalis			2		5		2		2	1
Hydropsyche dissimulata	3			2						
Hydropsyche incognita	5	2		3	7				3	
Hydropsyche sp.	1									
Chironomidae spp.									2	
Dicranota sp.			2							
Empidiidae sp.			2							
Tipulidae sp.			3							
Simuliidae sp.	2									
Pomatinus sp.	5									
Pomatinus substriatus				1						
Potamophilus acuminatus	2									
Gerris sp.			5			2	1		5	
Hydrometra stagnorum						2			2	

With respect to the relative abundance/percentage participation in the community, Gastropoda (18.06%), Trichoptera (14.14%) and Gammaridae species (9.95%) were found to be principal components of the community. The most abundant taxa were: Gammaridae species, *Bithynia tentaculata* (Gastropoda) and *Hydropsyche incognita* (Trichoptera).

The total number of taxa per sample ranged from 21 (KR1) to only 9 (JS1). The average number of total taxa found points to good water status (Class II).

Values obtained for the Zelinka & Marvan Saprobic Index varied from 2.20 (β-mesosaprobity; JS1) to 2.67 (α-β-mesosaprobity; JS3), which indicate variable presence of organic pollution. Overall status estimation in accordance to Zelinka & Marvan SI correspond to Class III (moderate status), because most of the values are near the Class III boundary. Some taxa were not identified to the species level due to low level of confidence. Also some taxa in different taxonomic ranks are not included in the used list of indicator taxa (Moog, 1995). Thus calculated values of SI index were lower than expected.

Calculated values of BMWP Score ranged from 90 (KR1) to only 30 (JS3). Average values of BMWP Score indicate good status of the river (Class II).

The highest ASPT value was 6.18 (KR3) and the lowest was 3.75 (JS3). An overall status evaluation considering ASPT values reflects moderate quality of water (Class III).

Taxa within class Oligochaeta and family Tubificidae were the most frequent at GM2 (23.40 %) and JS1 (23.08 %). Average values of percentage participation of Oligochaeta/Tubificidae in the total macroinvertebrate community indicate good water quality (Class II).

Relation between macroinvertebrate community structure/composition and water status is important for the final assessment. High diversity within some groups indicate high (Class I) or good (Class II) status respectively. Average values of Shannon-Weaver Diversity Index reflect high water status (Class I).

Number of sensitive taxa (Austria) varied from 4 (GM2; KR3) to 0 (KR2). An overall status considering this parameter points to moderate water quality (Class III). Generally a large number of sensitive taxa indicate better water quality. Because there is no national list of sensitive taxa, this data should be treated with a low level of confidence.

Number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa varied from 11 (GM2) to 0 (JS3). Average values of EPT taxa correspond to Class III (moderate status).

Values obtained of each metric are given in Table 7.

Table 7: Values of examined metrics

Metric/Site	GM1	GM2	KR1	KR2	KR3	JS1	JS2	JS3	MS1	MS2
Total no. of taxa	14	17	21	19	17	9	15	10	16	18
Zelinka & Marvan SI	2.45	2.27	2.38	2.29	2.50	2.20	2.44	2.67	2.46	2.39
BMWP Score	41	61	90	59	68	47	56	30	56	57
ASPT	4.56	6.10	6.00	4.92	6.18	5.88	5.09	3.75	4.31	4.75
Oligochaeta/Tubificidae [%]	20.59	23.40	12.96	7.69	12.20	23.08	6.45	22.22	5.26	0
Shannon-Weaver	2.52	2.70	2.92	2.85	2.63	2.12	2.53	2.12	2.68	2.74
No. of sensitive taxa	1	4	5	0	4	2	1	1	2	2
EPT taxa	4	11	7	6	8	3	3	0	3	2

An overall ecological status assessment of the Zapadna Morava River with regard to examined metrics is shown in Table 8.

Table 8: Overall ecological status assessment of the Zapadna Morava River with regard to examined metrics

	GM1	GM2	KR1	KR2	KR3	JS1	JS2	JS3	MS1	MS2	Overall Status
Total no. of taxa											
Zelinka & Marvan SI											
BMWP Score											
ASPT											
Oligocha-eta/Tubifi cidae [%]											
Shannon -Weaver											
No. of sensitive taxa											
EPT taxa											

According to the results of this study, it is concluded that the Zapadna Morava River is primarily under the influence of moderate organic pollution as well as various types of hydromorphological pressures. Therefore an overall status of the river could be assessed as moderate (Class III).

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