RIVER INTEGRITY ASSESSMENT BASED ON HABITAT QUALITY AND THE MACROINVERTEBRATE COMMUNITY

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Abstract
High anthropogenic impact on the aquatic ecosystem of the Zapadna Morava River (Serbia) gave rise not only to a deterioration of water quality, but also to the abundance of the allochthonous fauna representatives. A brief field survey using the Index of Habitat Integrity methodology (IHI) was conducted along three river sections in order to identify the level of habitat modification and degradation. How established river fauna reacts to present changes? This study showed that habitat conditions along the investigated sector of the Zapadna Morava River were moderately modified without significant impact on aquatic macroinvertebrates diversity and functionality.
Keywords*: habitat modification, impact, aquatic macroinvertebrate, large river*
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1. Introduction

The Zapadna Morava River is the left tributary of the Velika Morava River. It arises at the confluence of Golijska Moravica and Đetinja rivers near Požega. The river bed in its upper and middle course is rocky and pebbly, while muddy substrate dominates in the reservoirs and downstream course (Markovic & Simovic 1994). The catchment area of the Zapadna Morava river basin is 15,754 km^2 with river length of 308 km. Hydroelectric power plants "Ovčar Banja" and "Međuvršje" were constructed on the river, whose reservoirs are almost completely covered with fine sediment. The ecological quality of the Zapadna Morava River is assessed as moderate (III class) (Novaković 2013).

Zapadna Morava belongs to Type 2 watercourses, according to the valid regulation (Official Gazette of RS 74/2011), large rivers with medium grain-size mineral substrates.

The Zapadna Morava River basin is exposed to pollution of different origin: organic (biodegradable waste waters) and inorganic (suspended sediment, tailings leaching, and chemicals), and very often there is a combination of organic and inorganic waste with industrial or communal pollution (Marković *et al.* 2000). Illegal landfills and communal wastewaters are also becoming more common. By releasing water from agricultural land polluted with fertilizers and pesticides, as well as by discharging organic waste from livestock farms, the process of eutrophication (algal bloom) of aquatic ecosystems is intensified. Also, the exploitation of gravel in the coastal part of the Zapadna Morava is a major problem, affecting the degradation of the ecosystem. Hydro-morphological changes, such as regulations of the watercourse, have made this sector suitable for bio-invasions (Djikanović *et al.* 2013).

The Index of Habitat Integrity methodology, described by Kleynhans (1996), was undertaken to verify the habitat classification of the Zapadna Morava River. The IHI methodology rates the riverine habitat by assessing the change of instream and riparian habitat from natural conditions.

The aim of this work was, using the Index of Habitat Integrity methodology, to examine how river habitat modification influenced the biological quality elements, i.e. river fauna composition.

2. Material and methods

A brief field survey of the Zapadna Morava River using the Index of Habitat Integrity methodology (IHI) (Kleynhans 1996) was conducted in October 2020 (Error! Not a valid bookmark self-reference.). The IHI methodology was applied along three river sections (Figure 1) in order to investigate the level of habitat modification and degradation. The IHI provides a tool for assessing instream (9 instream channel criteria) and riparian habitat (8 riparian zone criteria) by scoring impacts on the river system under present conditions. The severity of impact of the modifications is based on six categories which comprise of ratings ranging from 0 to 25: where 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact).

A total of 19 sites were investigated. Five sites were sited in Section 1 (Pojate - Kruševac), seven sites in Section 2 (Kruševac -Adrani), and seven sites in Section 3 (Adrani – Preljina) **(**Figure 1**)**. For each sampling site GPS co-ordinates (latitude and longitude) were measured and photographs have been collected.

Figure 1. Map of sampling sites in three investigated sections of the Zapadna Morava River

The samples of benthic macroinvertebrates were collected with standard hand net (mesh size 500 μm) using semi-quantitative Kick and Sweep technique in bank regions (up to a depth of 1.5 m). Samples were collected from all available habitats according to EN 27828 standard, at the same time with brief habitat survey. Specimens were observed in laboratory using the Carl Zeiss, Stemi 2000-C binocular magnifier. The collected individuals were identified using the appropriate identification keys.

The main ecological features of the recorded community (the characterization of the species with regard to saprobic preference, current preference and substrate type) were taken from ASTERICS software Version 4.0.4 (AQEM 2002) and used to estimate the functional groups within the community. 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) using several biotic parameters calculated from AQEM (2002) (saprobic index, BMWP and ASPT score, Diversity index Shannon-Weaner, Total number of taxa, Tubificide and EPT indices).

3. Results and discussion

The field survey results of IHI of the Zapadna Morava River pointed that the three investigated sections were moderately modified habitats belonging to a Category C. Section 3 (Adrani – Preljina) showed the highest integrity (76%) due to the functionality and state of the river, but still remained in a Category C and moderately modified state. The reasons for the better status in this part, compared to sections 2 and 1, were the widening of the riverbed, the quality of the gravel substratum and the meandering nature of the Zapadna Morava River. The riverbanks also retained pockets of dense vegetation, which buffered the run-off from agriculture lands (Table 1).

Riverbanks of the Zapadna Morava were heavily modified by agriculture which likely led to increased sedimentation and deposition of the river bed. In addition, gravel mining was also noted instream along the course with a great impact to the river bed.

Macroinvertebrate community sampled in the Section 3 of the Zapadna Morava River stood out by number of identified bottom fauna taxa (47) and by high diversity of Oligochaeta, while in the other two sections the fauna diversity was lower, 27 (Section 2) and 22 (Section 1) (Table 2). Percentage participation of identified macroinvertebrate taxa groups per investigated riverine sections is presented in Figure 2.

Table 1. IHI evaluated habitats along investigated riverine sections

River Section	Ecological category for river section based on field results (IHI- Kleynhans, 1996)
Section-1: Pojate - Kruševac	C category (68% integrity). The river in this section was moderately modified according to the IHI, based on riverbank land use, rubbish dumping and encroachment of towns and agricultural activities on banks. Instream sand mining was noted. A few allochthonous and invasive macroinvertebrate species were founded in this section. The water level inundation was increased. The riparian habitat was more impacted than the instream habitat which retained in a relatively natural sequence capable of supporting some element of the natural freshwater biotic community.
Section-2: Kruševac -Adrani	C category (69% integrity). The river in this section was moderately modified and in a similar state to river section 1. Industrial activities were noted on the banks in this catchment (associated with a decreased water quality) and some instream activities such as gravel excavation. A large portion of the riparian and wetland areas along the riverbanks have been cleared for agriculture and urban use. The water inundation level was increased. The instream habitat sequence remained largely intact and capable of supporting a natural freshwater biotic community.
Section-3: Adrani-Preljina	C category (76% integrity). The river in this section was moderately modified tending to be predominantly natural, with high self-purification functionality, as consequence of widening of the riverbed, gravel substratum and slowing of the river flow. Along the riverbanks was a zone of dense vegetation, buffering the run-off from agriculture lands. In a few localities instream sand mining activities were noted. Overall, the instream habitat sequence remained largely intact and capable of supporting a largely natural freshwater biotic community.

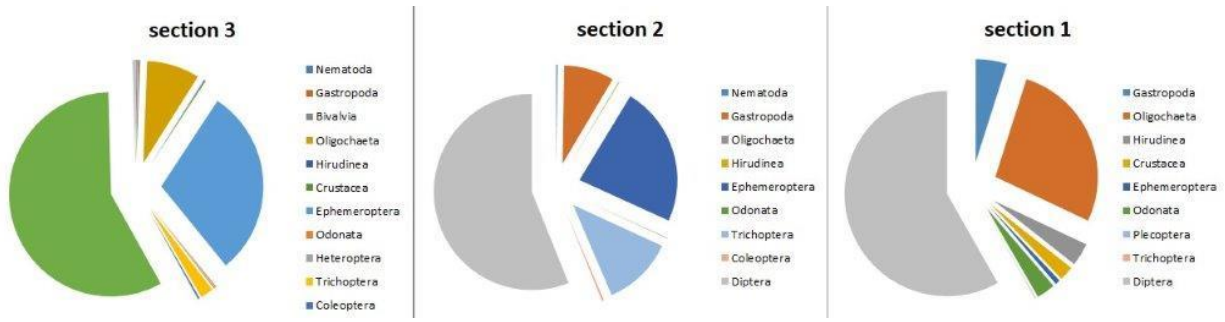

Figure 2. Share of different taxa group in three sections

According to the ecological classification of the taxa (AQEM 2002), with regard to saprobic conditions (saprobic valence of the species) and taking into consideration all recorded taxa within the investigated Sections, the majority could be considered as tolerant to moderate organic load (in total of 71.58% alpha- and beta-mesosaprobic species in Section 3, 70.07% in Section 2 and 61.97% in Section 1). The larger number of species adapted to high organic load (poly-saprobic) were found in Section 1 (16%), while the highest number of taxa sensitive to organic pollution (xeno-saprobic and oligo-saprobic taxa) were observed in Section 2 (24.72%) (Table 2).

In regard to current preference, species characterized as limnophilous (together LB, LP and LR type of species, preferring standing waters) had the smallest participation in the macroinvertebrate communities in all three Sections (from 0.42% - Section 2 to 4.78% - Section 1). The recorded communities were characterized by a domination of rheophilous taxa (together RL, RP and RB type of species) from 31.28% - section 3 to 25.42% - Section 2). This type of species prefers fast-flowing streams and lotic zones (Table 2).

Table 2. AQEM parameters using macroinvertebrate community as biological parameter along riverine sectors

Metrics	section 3	section 2	section 1
Number of Taxa	47	27	22
Saprobic Index (Zelinka & Marvan)	2.082	1.972	2.498
Saprobic Valence [%]			
- xenosaprobic species	0.253	0.527	0.026
- oligosaprobic species	21.51	24.197	18.605
- beta-mesosaprobic species	50.727	49.038	37.557
- alpha-mesosaprobic species	20.849	21.028	24.414
- polysaprobicspecies	2.699	0.025	15.992
- no data available	3.962	5.184	3.405
BMWP Score	132	109	89
Average score per Taxon	5.739	5.737	5.235
Diversity (Shannon-Wiever-Index)	1.877	1.861	1.415
Current preference [%]			
- limnobionts (LB)	0.06	0.084	0
- limnophilous (LP)	0	0	0.065
- limnorheophilous (LR)	2.681	0.334	4.715
- rheolimnophilous (RL)	5.958	4.515	26.13
- Type rheophilous (RP)	22.639	14.716	1.506
- rheobionts (RB)	2.681	6.187	0.262
- Type indifferent (IN)	4.26	11.371	6.483
- no data available	61.722	62.793	60.838
Microhabitat preference [%]			
- pellophilous	5.946	2.726	16.536
- Argyllophilous	0.867	0.602	0.013
- Type Psammophilous	5.034	2.074	10.327
- Type Akalophilous	3.664	3.06	0.635
- Type Litophilous	11.558	16.798	3.268
- Type Phytophilous	7.846	8.445	4.669
- Type Pom detritophilous	3.622	3.135	3.477
- Type Other	0.217	0.033	0.236
- No data available	61.245	63.127	60.838
EPT-Taxa [%]	31.933	34.783	0.917
Tubificidae %	1.39	0.08	27.11

The majority of the identified species was adapted to bottom substrate types typical of large lowland rivers (substrate types pelal, psammal and argylal) (Table 2).

Based on macroinvertebrate community composition, the ecological quality of sectors 2 and 3 of the Zapadna Morava was assessed as good (II class of Water quality) according to all indices analyzed (saprobic index Zelinka & Marvan, BMWP and ASPT score, Diversity index Shannon-Weaner, Total number of taxa, Tubificide and EPT indices). Section 1 stood out by moderate ecological quality (III water quality class) according to Shannon-Weaner and Tubificid indices and by bad ecological quality (V water quality class) according to presence of EPT taxa (Table 2).

Based on river bank land use and encroachment of towns, agricultural practices and industry a decrease in quality from run off (increased salts, nutrients and pesticides and potentially decreased oxygen concentration) is possible.

Hydro-morphological changes have also caused greater presence of a non-native fish species in the studied area (Djikanovic *et al.* 2013). In particular this had been attributed to deteriorated water quality, regulated

river bed, negligence in river bottom exploitation, non-periodical work of the Međuvršje HE plant and turbulent water flow release (Markovic &Veljovic 2005; Markovic & Simic 1994).

Aquatic habitats are, due to their unique features, among the most vulnerable ecosystems. This study showed that habitat conditions along the investigated sector of the Zapadna Morava River were moderately modified without significant impact on aquatic macroinvertebrate community, i.e. diversity and functionality. Hydro-morphological modification caused changes in habitat characteristics and can potentially form suitable habitat for non-native species. Considering that river regulation and habitat modification in the investigated sector of Zapadna Morava River may become more intensive, the impacts may become more severe. All that activities may also cause a disappearance of habitats suitable for some protected aquatic species, like *Astacus astacus* and *Unio crassus.*

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