Indicative status assessment of the Danube River (Iron Gate sector 849 - 1,077 rkm) based on the aquatic macroinvertebrates

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Abstract

The aim of this paper is to present the results of the ecological status assessment of the Danube River in the Iron Gate Region (rkm 849 to 1077), based on the analysis of the macrozoobenthos community. The investigation was performed in September 2011. The following metrics were used: Saprobic Index (Zelinka & Marvan), BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) indices, participation of Tubificidae (% Tubificidae), total number of taxa, number of gastropods and bivalves taxa and Shannon's Diversity Index. Based on the value of the selected metrics, the status of the Danube in the Iron Gate stretch was assessed as moderate (class III). A total of 61 macroinvertebrate taxa were recorded. With regard to the taxa richness, the dominant components of the community were found to be Insecta, Oligochaeta and Mollusca. With respect to the percentage participation/relative abundance, Molusca and Crustacea were found to be the principal components.

Keywords: Danube River, Iron Gate, macrozoobenthos community, water quality

Introduction

The Serbian part of the Danube is 588 km long and covers the middle stretch and a part of the lower stretch. The major part of the Serbian sector of the Danube (358 km) belongs to the Pannonian plain. In this section the Danube is a typical lowland river with a slope of 0.05–0.04 ‰ (Paunović et al., 2005). The Iron Gate sector is transitional (between the middle (Panonian) and the lower part of the Danube), and in many aspects (geomorphology, hydromorphology, etc.) is specific. Due to the dam construction at 943 rkm (Djerdap I; 1970), a large, 100 km long, reservoir was formed. After the damming of the Danube, the flow rate was slowed down upstream to Slankamen (1,215 rkm). In 1984, another dam (Iron Gate II, 863 rkm) was built.

Besides hydromorphological pressures, the Iron Gate sector is influenced by the urban waste waters from numerous settlements within the stretch, as well as by the Kostolac Power Plant. The Iron Gate Reservoir therefore acts as a depository of sediment and adsorbed pollutants. Through water-sediment interaction, water quality may also be affected, although its extent is yet to be studied (Paunović et al., 2005).

The Serbian reach of the Danube has been extensively examined since the early sixties (for details see Paunović et al., 2007). The results of studies referring primarily to water pollution problems (Jankovic & Jovicic, 1994) showed that water quality in the Serbian reach of the Danube had deteriorated in comparison to the 1960–1970 period. The long-term damaging impacts resulted mostly from the increase of untreated industrial and communal effluents, originating from rapidly growing cities along the river banks, from leaching and erosion of extensively fertilized agricultural soils, as well as from changes in the hydrological regime induced by the damming of the Danube and the creation of the hydropower reservoirs Djerdap (Iron Gate) I and II.

The aim of this work is to provide results on the ecological status assessment of the Iron Gate (Djerdap) stretch of the Danube, based on the national legislation (Službeni Glasnik RS, 74/2011). According to the national water body delineation, the Serbian stretch of the Danube River covers nine water bodies (Službeni Glasnik RS, 96/2010) and four of them are situated within the investigated stretch - D_1, D_2, D_3 and D_4.

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Material and Methods

Samples were collected in September 2011 at seven sampling sites (Figure 1, Table 1). The semi-quantitative sampling was performed using a hand net (25x25 cm, 500 μm mesh size). The multi-habitat sampling procedure (Hering, 2004) was applied. The samples were preserved using 4% formaldehyde solution and further processed in the laboratory. The identification was carried out in accordance with the recommendation on the required taxonomic level (Schmidt-Kloiber & Nijboer, 2004).

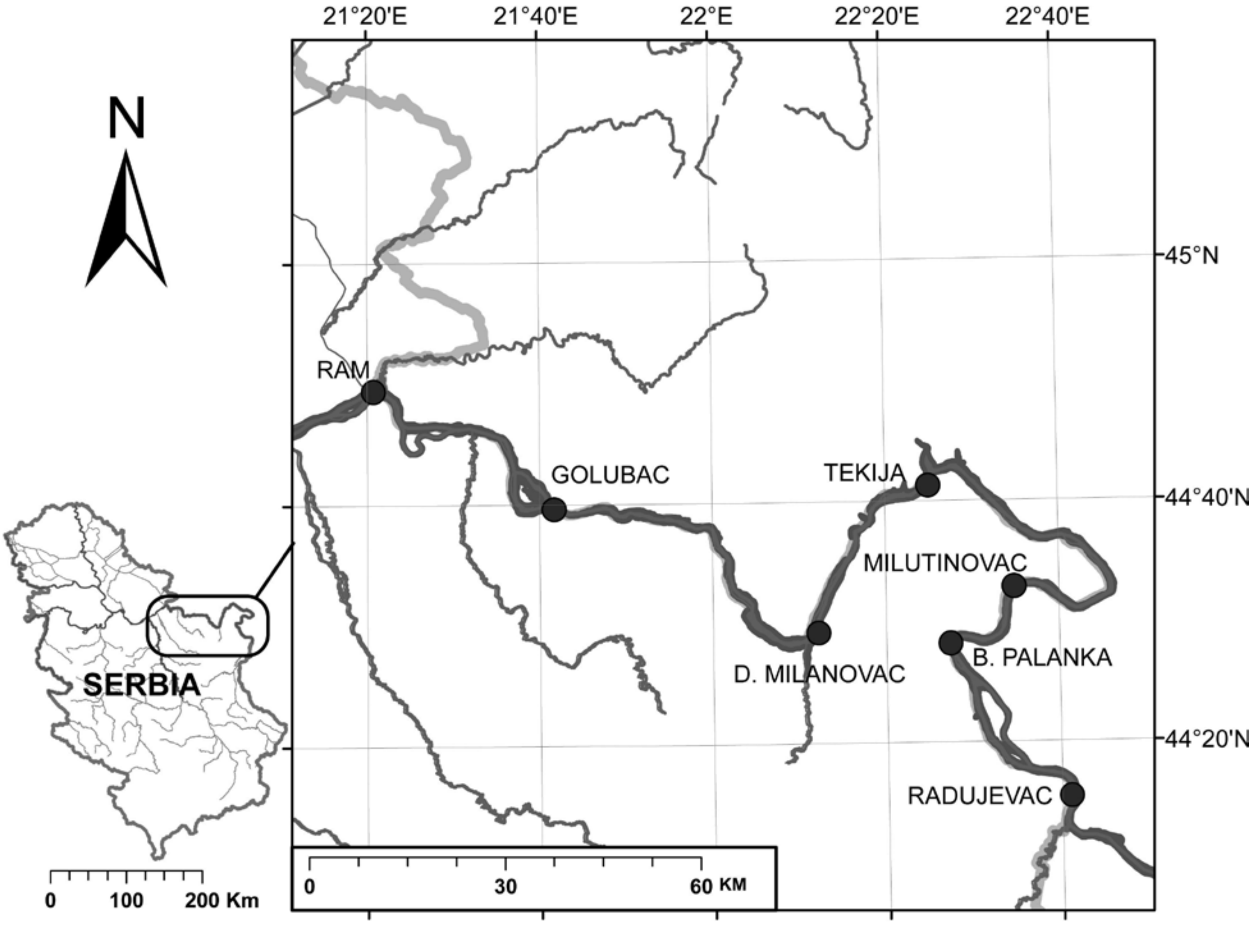

Figure 1: Map of the sampling sites

Table 1: Sampling sites

	Ram	Golubac	D. Milanovac	Tekija	B. Palanka	Milutinovac	Radujevac
Latitude	44° 48.905’	44° 39.634’	44 ° 28,518’	44 ° 41.167’	44 ° 27.908’	44 ° 33.066’	44 ° 14.813’
Longitude	21° 19.858’	21° 40.331’	22 ° 11.277’	22 ° 24.600’	22 ° 27.09’7	22 ° 34.368’	22 ° 40.733’
Altitude	68	66	63	56	/	/	32
River Km	1077	1040	991	954	/	/	849
Sector	6	7	7	7	7	7	8
Water Body	D_4	D_3	D_3	D_3	D_2	D_2	D_1

The following metrics were used to evaluate the ecological status: Zelinka and Marvan Saprobic Index (SI, Zelinka & Marvan, 1961), BMWP and ASPT scores (Armitage, 1983), Shannon’s Diversity Index (Shannon, 1948) and percentage participation of Tubificidae in the total macroinvertebrate community (% Tubificidae). The taxa richness parameters (total number of species, number of species of bivalves and number of species of gastropods) were also considered as the metrics for the ecological status assessment. The saprobiological analysis was performed using a list of bioindicator organisms according to Moog (Moog, 1995). The metrics calculation was done using AQEM software (AQEM, 2002).

The indicative status assessment was performed according to relevant national regulations (Službeni Glasnik RS, 74/2011).

Results and Discussion

A total of 61 macroinvertebrate taxa were recorded (Table 2). The overall recorded taxa richness is slightly lower than in some of the previous (more recent) investigations of the Danube River in Serbia (84 - Paunović et al., 2005; 74 - Paunović et al., 2007), as well as in some other similar watercourses in Serbia (e.g. V. Morava River – 84 taxa; Marković et al., 2011). On the other hand, it is significantly higher than in some other investigations (26 - Jakovčev et al., 2005). Having in mind that only the Iron Gate sector was taken into consideration during our investigation, as well as having in mind that the investigated sector is under considerable pressure caused by nutrient and organic pollution, as well as hydromorphological modification, the recorded taxa richness could be characterized as high. Similar community composition was recorded in the Serbian stretch of the Sava River, with a total of 62 macroinvertebrate taxa (Paunović et al., 2008).

Table 2: Taxa recorded within the investigated stretch

TAXON NAME	
Nematoda	
Oligochaeta	
Aulophorus furcatus (Oken, 1815)	
Nais sp.	
Nais bretscheri (Michaelsen, 1899)	
Nais elinguis (Müller, 1773)	
Ophidonais serpentina (Müller, 1773)	
Stylaria lacustris (Linnaeus, 1767)	
Branchiura sowerbyi (Beddard, 1892)	
Limnodrilus claparedeanus (Ratzel, 1868)	
Limnodrilus hoffmeisteri (Claparede, 1862)	
Limnodrilus udekemianus (Claparède, 1862)	
Tubifex tubifex (Müller, 1774)	
Potamothrix hammoniensis (Michaelsen, 1901)	
Psammoryctides barbatus (Grube, 1861)	
Enchytraeidae	
Lumbricidae	
Stylodrilus heringianus (Claparede, 1862)	
Hirudinea	
Glossiphonia sp.	
Piscicola geometra (Linnaeus, 1761)	
Mollusca	
Gastropoda	
Bythinia tentaculata (Linnaeus, 1758)	
Holandriana holandrii (Pfeiffer, 1828)	
Lithoglyphus naticoides (Pfeiffer, 1828)	
Lymnea auricularia (Linnaeus, 1758)	
Lymnaea stagnalis (Linnaeus, 1758)	
Lymnaea sp.	
Viviparus acerosus (Bourguignat, 1862)	
Viviparus sp.	
Theodoxus danubialis (C. Pfeiffer, 1828)	
Theodoxus sp.	
Theodoxus fluviatilis (Linnaeus, 1758)	
Esperiana acicularis (Ferussac, 1823)	
Esperiana esperi (Ferussac, 1823)	
Physa acuta (Draparnaud, 1805)	
Bivalvia	
Corbicula fluminea (Müller, 1774)	
Dreissena polymorpha (Pallas, 1771)	
Crustacea	
Mysida	
Paramysis lacustris (Czerniavsky, 1882)	
Amphipoda	
Corophium curvispinum (Sars, 1895)	
Dikerogammarus villosus (Sowinsky, 1894)	
Dikerogammarus haemobaphes (Eichwald, 1841)	
Dikerogammarus sp.	
Gammarus sp.	
Chaetogammarus ischnus (Stebbing, 1899)	
Obesogammarus obesus (Sars, 1894)	
Insecta	
Odonata	
Aeschna mixta (Latreille, 1805)	
Ischnura elegans (Vander Linden, 1820)	
Ischnura pumilio (Charpentier, 1825)	
Ischnura sp.	
Pyrrhosoma nymphula (Sulzer, 1776)	
Sympetrum fonscolombei (Selys, 1840)	
Ephemeroptera	
Baetis lutheri (Müller-Liebenau, 1967)	
Baetis sp.	
Caenis horaria (Linnaeus, 1758)	
Caenis luctuosa (Burmeister, 1838)	
Trichoptera	
Hydropsyche sp.	
Diptera	
Ceratopogonidae	
Pericoma sp.	
Chironomidae	
Chaoboridae	
Limoniidae	
Heteroptera	
Mesoveliidae	
Bryozoa	
Plumatellidae	
No. of Taxa	61

The dominant components of the community (with respect to taxa richness) were found to be Insecta (with 17 taxa), Oligochaeta and Mollusca (16 species). The diversity of other taxa groups was significantly lower: Crustacea 8, Hirudinea 2, while groups Nematoda and Bryozoa were represented with only one species each. Among Insecta, the dominant groups were found to be Odonata (6 species), Diptera (5 species), and Ephemeroptera (4 species). Among aquatic worms (Oligochaeta), Tubificidae and Naididae were found to be the most diverse families (with 12 taxa). Bearing in mind that one of the most abundant taxa Chironomidae (Insecta: Diptera) were not identified at the species level, due to the complex identification process and a possibility to identify only fourth instars larvae with a high level of confidence, the taxa richness of the investigated stretch is certainly higher.

With regard to the percentage participation/relative abundance, Mollusca and Crustacea were found to be the principal component of the community with 34.6 and 32.9 %, respectively. The most abundant taxa were found to be *Dikerogammarus villosus* (17.6%), Chironomidae (14.2%), *Theodoxus fluviatilis* (12.3%) and *Paramyysis lacustris* (11.3%). The Killer Shrimp (*D.villosus*) was found to be present in all samples and was particularly abundant at the Donji Milanovac sampling site (67.8%). The second most abundant taxa (Chironomidae) were the most abundant at the Ram site (32.2%).

The values of used parameters and estimated ecological status classes are given in tables 3 (for sampling sites) and 4 (for water bodies, as well as assessment for the investigated stretch, based on each selected parameter).

Table 3: The values of examined parameters at sampling sites

SAMPLING SITE	Ram	Golubac	Donji Milanovac	Tekija	Bačka Palanka	Milutinovac	Radujevac
Parameter values							
No. of TAXA	30	18	16	7	14	24	23
No. of Gastropoda Taxa	5	3	0	0	5	5	9
No. of Bivalvia Taxa	2	1	1	1	1	0	1
Shannon's Diversity Index	2.36	1.61	1.32	1.33	2.28	1.88	1.91
SI (Zelinka & Marvan)	2.38	1.99	2.10	1.98	1.97	2.67	2.01
BMWP Score	47	24	19	20	48	67	26
ASPT Score	4.7	4	3.8	5	4.8	4.79	3.71
% Tubificidae	0.36	0.25	0.08	0.02	0	0	0.08
Status assessment							
No. of TAXA	1	1	2	4	2	1	1
No. of Gastropoda Taxa	S	S	F	F	S	S	S
No. of Bivalvia Taxa	F	F	F	F	F	F	F
Shannon's Diversity Index	1	2	3	3	1	2	2
SI (Zelinka & Marvan)	2	1	1	1	1	3	1
BMWP Score	2	4	4	4	2	1	4
ASPT Score	2	3	3	2	2	2	3
% Tubificidae	3	3	1	1	1	1	1
Overall status	3	3	3	3	3	3	3

Legend: 1 - very good ecological status; 2 - good ecological status; 3 - moderate ecological status; 4 - poor ecological status; S - satisfy to meet criteria for good ecological status; F - fail to meet criteria for good ecological status.

Table 4: The values of examined parameters with regard to water bodies covered by the investigation

Water Body	D4	D3	D2	D1	Mean value for stretch
Parameter values					
No. of TAXA	30	14	19	23	21.6
No. of Gastropoda Taxa	5	1	5	9	5
No. of Bivalvia Taxa	2	1	0.5	1	1.12
Shannon's Diversity Index	2.36	1.42	2.08	1.91	1.94
SI (Zelinka & Marvan)	2.38	2.02	2.32	2.01	2.18
BMWP Score	47	21	57.5	26	37.9
ASPT Score	4.7	4.27	4.79	3.71	4.37
% Tubificidae	0.36	0.12	0	0.08	0.14
Status assessment					
Water Body	D1	D2	D3	D4	Overall stretch assessment
No. of TAXA	1	2	1	1	1
No. of Gastropoda Taxa	S	F	S	S	S
No. of Bivalvia Taxa	F	F	F	F	F
Shannon's Diversity Index	1	3	2	2	2
SI (Zelinka & Marvan)	2	1	2	1	2
BMWP Score	2	4	1	4	3
ASPT Score	2	2	2	3	2
% Tubificidae	3	2	1	1	2

Legend: 1 - very good ecological status; 2 - good ecological status; 3 - moderate ecological status; 4 - poor ecological status; S - satisfy to meet criteria for good ecological status; F - fail to meet criteria for good ecological status.

Based on the analyses of all parameters, the ecological status of the selected part of the Danube River could be assessed as moderate (class III).

Although some of the tested parameters indicated good ecological status and above in the majority of cases (e.g. number of taxa, except for Tekija, and Saprobic index, except for Milutinovac), other parameters indicated the presence of stress (Tables 3 and 4), which influenced the overall status assessment for the investigated stretch. This illustrates the necessity for using several parameters to effectively evaluate the ecological status of water bodies (Marković et al., 2011).

There is a need for further improvement of the national status assessment system (Službeni Glasnik RS, 74/2011), in particular finding a way to combine the metrics in one value, which would involve the pondering of each parameter, based on its significance for the specific water type assessment as well as its indicator value for a particular group of pressures.

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