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OBSERVATION OF THE QUALITY OF DANUBE WATER IN THE BELGRADE REGION BASED ON BENTHIC ANIMALS DURING PERIODS OF HIGH AND LOW WATER CONDITIONS IN 2002

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Abstract - The present paper states conclusions about the quality of Danube water in the Belgrade Region based on analyses of the invertebrate community. The investigation was performed during periods of high (May, 2002) and low (October, 2002) water conditions. Meio- and macrozoobenthos were observed. Qualitative, quantitative, and saprobiological analyses were performed. The sampling area covered five stations along 66 km of the river. The community was represented by 26 species. Aquatic worms were the principal component of the benthos with respect to both species richness (six species) and abundance (58.39-99.47 % of the total community). Gastropods were also diverse (six species). Snails were found to be subdominant as far as participation in the total community density is concerned. Structure of the benthic community and the saprobity index (S= 2.78-3.43) indicated the presence of organic pollution. No notable differences of estimated environmental quality were observed between a station upstream from Belgrade and one situated below the exit from the broader territory of Belgrade. Since Belgrade is recognized as one of the main contaminants in regard to biodegradable pollutants in the Middle Danube, this finding points to an impressive self-purifying ability of this huge river.

Key words: Danube River, Serbia, macrozoobenthos, community structure, saprobiological analysis

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INTRODUCTION

The present paper states conclusion about the quality of Danube water in the Belgrade Region in May (high water condition) and October (low water level) of 2002 based on analyses of the invertebrate community. Meio- and macrozoobenthos were observed. Results of qualitative and quantitative investigation as well as saprobiological analyses were included in the study.

Aquatic invertebrates were the target group, since they offer numerous advantages in biomonitoring, which explains why they are the most commonly used group in assessing water quality. They are the group most often recommended for use in aquatic ecosystem surveys because: 1) They are a generally well-known group; 2) aquatic invertebrates are basically sedentary organisms; 3) there is an array of widely distributed species among the group; 4) it is a diverse component of the aquatic environment, one which offers a spectrum of responses to stress; and 5) sampling can be done easily, using simple and inexpensive equipment (Rosenberg and Resh, 1993).

The investigated sector is situated in the middle part of the Danube basin - the largest segment of the river's watercourse from Bratislava to the Iron Gate dams (Serbia/Romania). It is an interesting area for hydrobiological investigations for the following reasons: 1) With its main tributaries, the Danube represents the most significant Serbian water resource, one which has been extensively used for the water supply, irrigation and land melioration, ship traffic, and hydroelectric energy production; 2) In this part the Danube flows through a densely populated area, and a permanent risk of pollution is present (Martinović-Vitanović *et al.* 1999); 3) A surface drinking water intake is situated in the sector near the settlement of Vinča, and this that necessitates regular biomonitoring; and 4) Due to constructions of the Iron Gate dam (943 km) on the Danube near Sip, hydrological changes were observed up to Slankamen (1215 km), and they too affected the ben-

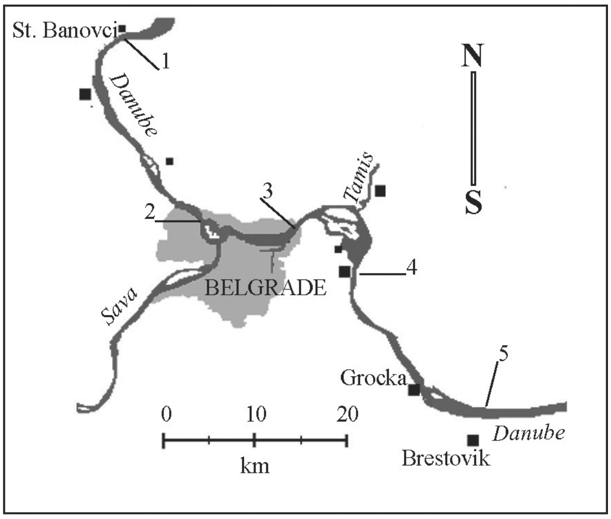

Fig. 1. Sampling stations - the Danube, Belgrade Region, 2002 (sampling stations correspond to the explanation in the text)

thic fauna in the Belgrade Region (M a r t i n o v i ć and V i t a n o v i ć *et al.* 1999). Those alterations affected both water quality and the biota (N e d e l j k o v i ć , 1979; J a n k o v i ć and J o v i č i ć , 1994; S i m i ć *et al.* 1997).

DESCRIPTION OF THE SAMPLING STATIONS AND THE METHODS USED

The investigation was performed during periods of high (May, 2002) and low (October, 2002) water conditions. The sampling area covered five stations along 66 km of the river (Fig. 1):

Station No. 1 - the village of Stari Banovci, downstream from the Tisa's confluence, upstream from the boundary of the Belgrade Region;

Station No. 2 - Zemun, inside the narrow city area;

Station No. 3 - Višnjica, on the periphery of Belgrade, situated below the downtown and downstream from the Sava River's inflow. Ten municipal sewage outlets are located on the right bank upstream from the site. Effluents from the nearby port and shipyard as well as from several upstream industrial facilities also affect the river at this station.

Station No. 4 - the vicinity of a surface drinking water intake near the village of Vinča, downstream from the mouth of the River Tamiš (a left-hand tributary).

Station No. 5 – the village of Orešac, at the exit from the broader territory of Belgrade, downstream from the town of Grocka, where the river enters a region characterized by more intensive agricultural activities.

Benthic samples were collected from soft substrates using a Van Veen dredge with a grab area of 270 cm^2 in the shore region. Animals were separated from sediment with a 200-μm sieve. The samples were preserved with 4% formaldehyde. Sorting and identification were carried out using a binocular magnifier (5-50 x) and a stereomicroscope (10 x 10 and 10 x 40).

The study included qualitative and quantitative analysis of the benthic community. The number of observed taxa and community density (number of individuals per square meter - ind m^{-2}) are presented in order to describe the distribution of invertebrates along the sector. Correspondence (reciprocal averaging) analysis or CA

Tab. 1. Qualitative and quantitative (ind/m^{-2}) composition of macroinvertebrate fauna along examined stretch of the Danube River

taxa station	1	2	3	4	5	1	2	3	4	5
preiod	May					October				
Oligochaeta	**18907**	**34521**	**4625**	**30229**	**3145**	**14503**	**29600**	**3460**	**6180**	**1665**
Eisenniella tetraedra, (Sav.)	74									
Tubificidae*	**18833**	**34521**	**4625**	**30229**	**3145**	**14503**	**29600**	**3460**	**6180**	**1665**
Branchiura sowerbyi, Bedd.	555					875				37
Tubifex tubifex, (Müll)	4218	3811	370	8510		8127	9990	299	644	407
Limnodrilus hoffmeisteri, Clap.	592	17945	259	17020		875	2960	599	1287	481
L. claparedianus, Retz.	9657	2405					740	1231	1030	74
Limnidrilus (fr. and juv.)	3626	10360	3996	4699		4626	15910	1331	3219	666
Potamotrix hammoniensis, (Mich)	185									

Tab. 1. Continued

taxa station	1	2	3	4	5	1	2	3	4	5
preiod	May					October				
Hirudinea						**259**				
Erpobdella octoculata						259				
Chironomidae	**1221**	**37**	**1258**	**111**				**56**		
Gastropoda	**703**	**148**	**185**	**74**	**666**	**703**	**9620**			**740**
Viviparus viviparus, L.			111		37					
Litoglyphus naticoides, C.Pf.	703	148	74	74	629	592	9250			296
Bythinia tentaculata							370			
Acroloxus lacustris										333
Theodoxus danubialis										37
Theodoxus fluviatilis, L.					37	111				74

Tab. 1. Continued

taxa station	1	2	3	4	5	1	2	3	4	5
preiod	May					October				
Hydrozoa						**37**				
Hydra sp.						37				
Bivalvia	**111**					**370**	**9250**		**37**	**37**
Sphaerium rivicola, Lam.	111					333	9250			
Unio crassus										37
Dreissena polymorpha						37			37	
Amphipoda	**111**			**37**		**1491**				**111**
Dikerogammarus villossus, Sow.	111					185				37

Tab. 1. Continued

taxa station	1	2	3	4	5	1	2	3	4	5
preiod	May					October				
Potamogammarus obessus										74
Corophyum curvispinum						1406				
Isopoda										**111**
Asellus aquaticus										74
Isopoda										37
Nematoda	**185**		**222**				**2220**			
Hydracarina			**37**							
Coleoptera										**37**
Hydrophylidae										37
Total	**21238**	**34706**	**6327**	**30451**	**3848**	**17463**	**50690**	**3516**	**6217**	**2701**

(P i e l o u , 1984) was carried out on an input table consisting of 26 rows (taxa) x 5 columns (mean abundance of taxa per station). This statistical technique resulted in an ordination diagram, which made it possible to analyze the relations between stations and fauna. Saprobiological analysis was performed using combined lists of bioindicators (S l a d e č e k , 1973; U z u n o v , 1979; U z u n o v *et al.* 1988; M o o g , 1995). The saprobic level was estimated applying the P a n t l e and B u c k (1955) saprobic index S. Water quality was evaluated according to national standards (YUFROW, 1985).

RESULTS

During the investigation, the occurrence of 26 taxa belonging to the following groups was recorded (Tab. 1): Oligochaeta (six species), Gastropoda (six), Bivalvia (three), Amphipoda (three), Isopoda (two), Hirudinea (one), Hydrozoa (one), Coleoptera (one) and the groups Nematoda, Hydracarina, and Chironomidae, which were not identified to the species level. The number of recorded taxa per station fluctuated between four (stations 3 and 4, October) and 14 (station 5, October).

During the period of a high water level, 15 taxa were recorded, while the number of taxa observed during the period of a low water level period was 22 (Tab. 1).

Total abundance of benthic organisms varied between 2,701 (station 5, October) and 50,690 ind m^{-2} (station 2, October).

Aquatic worms (Oligochaeta), which were represented by species belonging to the Tubificidae family, were the principal component of the community with respect to species richness and abundance. The participation of aquatic worms in the benthic community varied between 58.39 % (station 2, October) and 99.47 % (station 2, May).

Snails (Mollusca: Gastropoda) and non-biting midges (Diptera: Chironomidae) also made up a significant part of the benthic community. Dense populations of snails were observed at stations 5 in May (17.31 %) and 5 and 2 in October (27.40 % and 18.98 %, respectively). Chironomids were abundant in May at stations 3 (19.88 % of the total community) and 1 (5.75 %). Mussels and clams (Bivalvia) were represented with 18.25 % of the total community density at station 2 in October. At the other stations, representatives of Bivalvia were observed with considerably lower densities of up to 2.12 % (loc. 1, May and October; loc. 4 and 5, October) or they were not

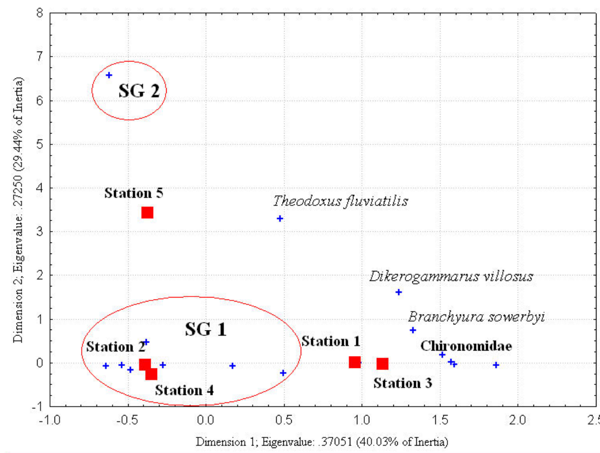

Fig. 2. Ordination diagram based on correspondence (reciprocal averaging) Analysis or CA (P i e l o u , 1984) - input table 26 rows (taxa) x 5 columns (mean abundance of taxa per station); Sampling stations correspond to Fig. 1 and explanation in the text.

Tab. 2. Saprobity index [S] (Pantle and Buck, 1955) and category of the watercourse evaluated according to Yugoslav standards (YUFROW, 1985) – the Danube, Belgrade Region, 2002.

Location		1	2	3	4	5
Saprobity index S	May	2,96	3,32	2,91	3,43	2,82
	October	2.90	2.89	3.26	3.22	2.78
Category	May	III	III-IV	III	III-IV	III
	October	III	III	III-IV	III	III

detected.

Within the principal benthic group (Oligochaeta), the following species, adapted to a high organic load, were observed: *Tubifex tubifex, Limnodrilus hoffmeisteri, Limnodrilus claparedeanus,* and *Branchyura sowerbyi* (Tab. 1). Among snails, *Litoglyphus naticoides* was the most abundant (up to 96.15 % of the gastropods and up to 18.25 % of the total invertebrate community at loc. 2, October; up to 40.00 % of the gastropods and up to 10.96 % of the total invertebrate community at loc. 5 in October). Among other species of gastropods, worth mentioning in connection with population density is *Acroloxus lacustris*, which was found to represent 12.33 % of the total community at station 5 in October.

The CA ordination diagram (Fig. 2) shows the relationships between invertebrates (mean abundance of taxa per station) and sampling stations. The position of stations 2, 4, and 1 on the ordination diagram is determined mainly by the presence of species that are common to the majority of sampling stations - SG 1 (Fig. 2). Moreover, station 2 (in both periods) and station 4 (in May) were characterized by higher total community density in relation to the other stations. Station 1 was characterized by the presence of *Branchiura sowerbyi* (Oligochaeta). This aquatic worm was also observed at station 5, but it was less abundant. At the other stations, *B. sowerbyi* was not recorded. Also, a high population density of *Dikerogammarus vilosus* was observed, at the station 1, which is in keeping with the station position on the ordination diagram in regard to dimension 1 (Fig. 2). The position of stations 1 and 3 is affected as well by high density of Diptera larvae belonging to the family Chironomidae. Station 5 was distinguished from the others by the presence of the snails *Theodoxus danubialis* and *Acroloxus lacustris,* along with the species *Pontogammarus obesus* (Amphipoda) and *Asellus aquaticus* (Isopoda) (Fig. 2, species group "SG" 2). The total density pattern and presence of the mentioned animals most strongly affected the position of station 5 on ordination diagram in relation to the others (Fig. 2).

The results of saprobiological analysis (Tab. 2) indicated that water quality varied within the limits of category III according to national standards (YUFROW, 1985). The Saprobic index (Pantle and Buck, 1955) varied between S=2.78 (station 5, October) and S=3.43 (station 4, May).

DISCUSSION

During the investigation, 26 benthic taxa were recorded. Dominance of four species - [*Tubifex tubifex, Limnodrilus hoffmeisteri,* and *Limnodrilus claparedeanus* (Tubificidae: Oligochaeta) and *Litoglyphus naticoides* (Gastropoda)] was observed. The sampling stations were distinguished by variation in total density and principal components of the community, as well as by the presence and distribution of taxa with minor participation in the total invertebrate association, present affected the CA ordination diagram (Fig 2).

Relations between the community present and saprobic conditions have been extensively discussed in the literature (Kovačev and Uzunov, 1986; Rosenberg and Resh, 1993). Thus, a small number of taxa recorded, together with dominance of one a or few species, indicates the presence of stress (Chapman, 1996). Mass development of oligochaetes, accompanied by reduction of other benthic species, points to the occurrence of organic matter in both water and the substratum (Slepukhina, 1984; Timm, 1987).

The dense populations of aquatic worms of the family Tubificidae (adapted to high organic loads) which were observed during the investigation indicate the presence of organic pollution. The number of animals indicating lower saprobity levels was considerably smaller.

Comparable results of investigating the zoobenthos community along the Serbian reach of the Danube River were reported previously. A high density of aquatic worms was observed along the Serbian part of the river (Djukić *et al.* 1987, 1994; Simić *et al.*1997; Martinović-Vitanović *et al.* 1999). A tendency toward increase in the density of eutrophic species of oligochaetes after damming of the Danube was also emphasized (Nedeljković 1979; Djukić *et al.* 1987, 1994). The results presented here corroborate earlier drawn similar conclusions concerning zoobenthos and water quality of the Danube in the Belgrade Region (Jakovčev, 1987, 1988; Martinović and Vitanović *et al.* 1999) - all studies reported the same community structure (dominance of aquatic worms and mollusks) and confirmed that water quality was within limits of the third category according to national standards (YUFROW, 1985). This means that the Danube is exposed to the constant inflow of a high organic load. On the other hand, in spite of the high pollution level, the significant self-purifying ability of this huge river was confirmed. Our investigations, as well as previous studies (Jakovčev, 1987; 1988; Janković and Jovičić, 1994; Martinović-Vitanović *et al.* 1999), showed that there is no considerable difference of water quality between stations upstream and downstream from the narrow city area.

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АНАЛИЗА КВАЛИТЕТА ВОДЕ ДУНАВА У РЕГИОНУ БЕОГРАДА, ЗАСНОВАНА НА БЕНТОСНИМ ЖИВОТИЊАМА – ПЕРИОД ВИСОКИХ И НИСКИХ ВОДА ТОКОМ 2002. ГОДИНЕ

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Рад представља студију квалитета воде Дунава у региону Београда која је обављена у време периода високог (мај 2002) и ниског водостаја (октобар 2002) и која је базирана на анализи заједнице бескичмењака. Разматран је меио- и макрозообентос. Приказују се резултати квалитативних и квантитативних сапробиолошких истраживања. Подручје узорковања обухватило је пет локалитета дуж 66 km реке. У оквиру заједнице констатовано је 26 врста. Oligochaeta су биле најзначајнија компонента бентоса у односу на разноврсност (шест врста) и абунданцу (58,39-99,47 % укупне заједнице). Пужеви (Gastropoda) су заступљени са шест врста и они су субдоминантна група у односу на учешће у укупној густини заједнице. Структура бентосне заједнице, као и вредности индекса сапробности (S = 2,78-3,43) указује на органско загађење реке. Битне разлике у процењеном стању окружења на локалитетима узводно и низводно од ужег подручја Београда нису уочене. Како је Београд препознатљив као један од главних загађивача биодеградабилним материјама у средњем току Дунава, овај налаз истиче импресивну способност самопречишћавања ове моћне реке.