Saprobiological analysis of water of the southern Morava River (a second-order tributary of the Danube in Serbia) on the basis of Macrozoobenthos as a bioindicator

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Abstract

Saprobiological analysis of water of the Southern Morava River (a second-order tributary of the Danube) was performed using macrozoobenthos as a bioindicator. Samples were collected seasonally during the period of 2001-2003. At all investigated localities along the course of the Southern Morava, absolute dominance was achieved by bioindicators of β-mesosaprobity, whose presence characterizes water of quality class II. Greater values of the saprobity index were recorded at localities SM3 (2.43), SM4 (2.27), and SM6 (2.27). Downstream from the sixth locality, the saprobity index varied within a narrow range of values (from 1.92 at locality SM7 to 2.01 at locality SM12) all the way to profiles SM14 and SM15, where increased values of the index were recorded (2.22 and 2.18, respectively). The Southern Morava is characterized by a significant capacity for self-purification, which is most evident in the upper course of the river (at localities SM3 and SM5).

Introduction

Communal and industrial waste waters entering aquatic ecosystems alter the recipient's quality and cause communities characteristic of clean water to be replaced by ones found in polluted water. Being unable to adapt to negative changes, more sensitive aquatic organisms disappear, which causes a decrease in diversity of the community, while more tolerant ones fill the emptied ecological niches. In shallow streams, such changes are most evident in communities of macrozoobenthic organisms, which due to their confinement to the bottom, long life cycles, and limited possibilities of movement are reliable indicators of changes in quality of the water in highland brooks and rivers in response to organic pollution and altered content of dissolved oxygen caused by it (HYNES, 1964; WIHLM, 1975; HELLAWEL, 1986). This fact enabled us to monitor water quality in the drainage area of the Southern Morava on the basis of the presence or absence of certain bioindicatory species characteristic of clean or polluted water.

In selection of sites on the Southern Morava, special attention was paid to definition of the localities at which water quality was monitored so as to get a better picture of the influence of major tributaries and influxes of industrial and communal waste waters contributed by larger urban and rural settlements along the river's course.

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Materials and Methods

The Southern Morava River arises from the confluence of the Binačka Morava and Preševska Moravica Rivers, which merge south of the town of Bujanovac at an elevation of 392 m above sea level. The Southern Morava merges with the Western Morava before Stalac to form the Morava (Velika Morava in Serbian) River at an elevation of 129 m avove sea level. After flowing for a length of 185 km, the Morava empties into the Danube near the village of Dubravica at an elevation of 66 m above sea level.

Total length of the Southern Morava from Bujanovac to Stalać is 232.6 km, and the river has a total fall of 263 m or average fall of 1.07% per km. If the Binacka Morava is taken to be the source branch of the river, then the Southern Morava has a total length of 320.56 km. The watershed of the Southern Morava has an area of 15,655 km^2.

During the period from 2001 to 2003, specimens of macrozoobenthos were taken in 336 quantitative and 22 qualitative samples at 16 localities along 232.6 km of the course of the Southern Morava River. Macrozoobenthic organisms were collected with a Surber net having a catchment area of 300 cm^2 and mesh size of 250 µm (for quantitative analysis). Organisms were removed with tweezers from the lower surface of rocks and other objects submerged in the water (for qualitative analysis).

Saprobity was expressed in terms of the S saprobity index according to the Pantle-Buck method (PANTLE-BUCK, 1955). The list of bioindicators given by Ortendorfer and Hofrat (ORTENDORFER & HOFRAT, 1983) was used for saprobiological analysis.

Results

To get an idea of the quality of water in the Southern Morava River, saprobiological analysis was performed using macrozoobenthos as a bioindicator. Of 141 species of macrozoobenthos found in the Southern Morava (ŽIVIĆ, 2005), 108 have characteristics of bioindicators. At all investigated localities during the entire period (2001-2003), the dominant forms of macrozoobenthos were bioindicators of β-mesosaprobic water, whose presence means that the water belongs to quality class II.

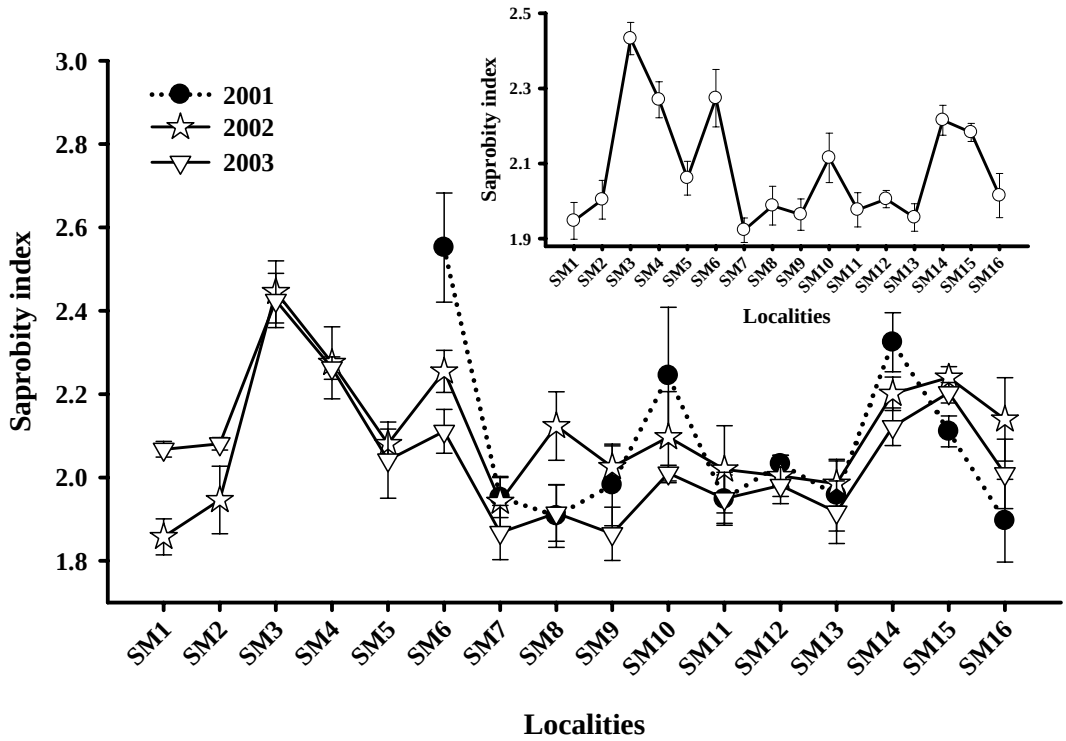
During the first year of investigation (Graph 1), average values of the saprobity index fluctuated from 1.90±010 or 1.91±0.08 (at localities SM16 and SM8, respectively) to maximal value of 2.55±0.13 at locality SM6 (which is the highest value of the index for all three years of investigation and indicates class III water quality), where the α-mesosaprobes *Erprobdella octoculata* and *Asellus aquaticus* were found, together with the β-α-mesosaprobic indicators *Erprobdella testacea* and *Helobdella stagnalis*.

The maximal saprobity index in 2002 (Graph 1) of 2.45±0.07 was recorded at locality SM-3. At this locality only β-α-mesosaprobic indicators (*Erprobdella testacea*, *Helobdella stagnalis*, *Hydropsyche contubernalis*, and *Hydropsyche modesta*) were found, while the presence of β-mesosaprobic indicators was recorded at the other localities. At locality SM6 during 2002 (in contrast to the previous year), only indicators of β-mesosaprobic water quality were dominant. The absence of α-bioindicators at profile SM6 (in 2002), which points to an improvement of water quality, caused a decrease in average value of the saprobity index at the given locality from 2.55±0.13 (2001) to 2.25±0.05 (2002). This decrease continued to average value of 2.11±0.05 in 2003 (which was a consequence of work stoppage at factories in the town of Vladičin Han, whose waste waters were the greatest polluters of the Southern Morava in this part of its course).

Graph 1. Average values of the saprobity index in the Southern Morava River during 2001, 2002. and 2003. Insert: average values of the saprobity index throughout our investigation of the Southern Morava River.

During the third year of study (Graph 1), an improvement of water quality occurred at the majority of localities along the middle course of the river (from SM6 to SM12), whereas average values of the saprobity index rose at ones along its lower course (1.92±0.07, 2.12±0.05, and 2.20±0.02 at localities SM13, SM14, and SM15, respectively). During 2003, the highest average value was recorded at profile SM3 (2.42±0.07) and the lowest value at locality SM7 (1.87±0.06).

Analysis of data on average values of the saprobity index for the entire period of study (Graph 1) indicates that the presence of bioindicators of β-mesosaprobic water quality was recorded at all localities along the course of the Southern Morava, which means that the water belonged to quality class II. It should be noted that higher values of the index were recorded at locality SM3 (2.43±0.04, Graph 1), which is a consequence of the influx of industrial and communal waste waters from the city of Vranje, and at locality SM6 (2.27±0.08, Graph 1), which is situated downstream from Vladičin Han, where the river receives pollutants from the "Fopa" factory, together with waste waters from the town's sewar system. Downstream from locality SM6, the saprobity index varied within a narrow range, from 1.92±0.03 at locality SM7 to 2.01±0.02 at locality SM12 (Graph 1). The exception is locality SM 10 where saprobity index significantly increases to 2.12±0.07 due to inflow of waste waters from the city of Leskovac. There was another major increase in saprobity index at profiles SM14 and SM15 to 2.22±0.04 and 2.18±0.02, respectively (Graph 1). Deterioration of water quality occurs due to the influx of communal and industrial waste waters from the city of Nis (locality SM14 is situated by the mouth of the Nišava River) and town of Aleksinac (locality SM15 lies 200 m from the mouth of the Sokobanjska Moravica River). After Aleksinac, the Southern Morava to its junction with the Western Morava (locality SM16) flows through no larger towns or settlements and does not receive any larger tributary, so that partial self-purification of the water and decline of the saprobity index to a value of 2.01±0.06 occurred (Graph 1).



Graph 1. Average values of the saprobity index in the Southern Morava River during 2001, 2002. and 2003. Insert: average values of the saprobity index throughout our investigation of the Southern Morava River.

Discussion

In our investigation of the Southern Morava River, the strongest influence on quality of the river's water was found to be exerted by waste waters from urban settlements in the drainage area. To be specific, the index of saprobity increased very significantly at localities downstream from urban settlements, and they represent the points where the river is most strongly polluted. Thus, in comparison with the first locality upstream from the indicated urban settlements, the average value of the saprobity index throughout the entire study period increased from 2.00±0.05 to 2.43±0.04 at locality SM3 near Vranje, from 2.06±0.04 to 2.27±0.08 at locality SM6 near Vladičin Han, and from 1.96±0.03 to 2.22±0.04 at locality SM14 beyond the mouth of the Nišava River. It should be noted that the influence of urban regions on aquatic ecosystems (above all running waters) is very complex and not solely confined to chemical characteristics of the water, but rather extends to its physical properties (like temperature) as well (LEBLANC et al., 1997). In addition to affecting water temperature, urban settlements exert significant influence in the guise of sedimentation caused by construction of bridges and dams, channelization of the watercourse, and increased erosion of the river banks (WATERS, 1995; WOOD and ARMITAGE, 1997, 1999).

The Southern Morava River is characterized by a significant capacity for self-purification, which is most evident in the upper course of the river (at localities SM3 and SM5). The Vranjska River empties into the Southern Morava upstream from locality SM3, and the pollution it carries causes drastic deterioration of water quality (2.43±0.04) and changes in composition of the benthofauna. To be specific, the tolerant groups Oligochaeta, Chironomidae, Hirudinea, and

Isopoda assume total dominance, while the sensitive groups Plecoptera, Ephemeroptera, Trichoptera, and Coleoptera disappear almost completely (ŽIVIĆ, 2005).

Partial purification of the Southern Morava (indicated by a statistically significant decrease in the saprobity index to 2.27±0.05) occurs already 10 km downstream from locality SM3 at locality SM4, where Trichoptera larvae, primarily species from the family Hydropsychidae (present with only 0.43% of the benthofauna at SM3), assume a dominant role with participation of 35.62% at profile SM4 (ŽIVIĆ, 2005). In contrast to Oligochaeta and Chironomidae, whose participation in total abundance (at locality SM4) declines drastically in relation to SM3, the representation of Hirudinea declines only insignificantly, while that of Isopoda even increases, with the result that this group assumes a subdominant role with 15.41%, which indicates that the level of organic pollution (in which these organisms achieve their greatest abundance) (HILSENHOFF, 1988; MCNEIL et al., 2002) is still high. However, 10 km downstream from SM4, the situation at locality SM5 in regard to both the saprobity index (2.06±0.04) and composition of the bottom fauna returns completely to the picture observed before entry of the Vranjska River (ŽIVIĆ, 2005). In this way, after a succession of several bottom communities caused by anthropogenic disturbance and processes of self-purification, a stable community with pronounced dominance of species from the family Hydropsychidae was once again formed, and this community remained characteristic of the benthozoocenosis all the way to locality SM14. Since the Southern Morava between localities SM3 and SM5 receives only relatively small watercourses (the Banjska Vranjska and Korbačevska Rivers), the river's large capacity would appear to be primarily responsible for the process of its self-purification.

In the course of the investigation, changes of water quality, i.e., its improvement, were noticed at the same locality in different study periods. This process was most clearly expressed at locality SM6, which is situated near the town of Vladičin Han. To be specific, water at this locality in 2001 was assignable to the α-mesosaprobic quality category on the basis of value of the saprobity index (2.55±0.13). One of the greatest sources of pollution (apart from the town's sewar system) was the "Fopa" Cellulose Processing Plant, which is situated about 1 km upstream from locality SM6. When the factory closed down at the beginning of 2002, water quality gradually improved, with the result that the saprobity index dropped to 2.11±0.05 in 2003.

The recorded process of water quality improvement and succession of the leading groups of macroinvertebrates in benthocenoses took place parallel with the breakdown of industry that occurred on the territory of Serbia during the 1990's. Since this breakdown was widespread, it can be assumed that similar improvement of water quality also occurred then at a number of other localities in the watershed of the Southern Morava.

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