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COMPARISON OF TWO BIOLOGICAL METHODS FOR ASSESSMENT OF RIVER WATER QUALITY BASED ON MACROZOOBENTHOS

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Summary

In the present paper, the results of two macrozoobenthos analysis based indices (Saprobic Index and Extended Biotic Index) are used as biological indicators in the assessment of river water quality. The objective of the paper is to establish the extent to which the results of these methods are comparable. The results indicate that both indices are suitable for assessing the quality of river water in the Croatian hydrographic network. Major deviations were only detected in xenosaprobic waters, i.e. at the springs of the Krka River and Crna rijeka, where the values of the Extended Biotic Index indicated poorer water quality.

Key words: macrozoobenthos, Saprobic Index, Extended Biotic Index, Croatia

INTRODUCTION

In addition to being an important food source for fish, benthic invertebrates have become an important factor in assessing water quality.

As a candidate state, Croatia is currently aligning its legislation with that of the European Union. In the water sector, the most important piece of legislation is the Water Framework Directive (WFD EU) (Directive 2000/60/ES). The classification of the ecological state of river and lakes is conducted using biological, hydromorphological, chemical and physicochemical elements. According to the WFD, biological quality elements to be monitored are: macrozoobenthos, fish, phytobenthos and saprophytes. The Water Framework Directive does not explicitly request that the Saprobic Index be used for the determination of river water quality, but does require the use of benthic invertebrates.

Water Classification Act (Uredba o klasifikaciji voda) (Narodne novine, 77/98) lists two biological indicators in the assessment of water quality: the

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Saprobity Index (Pantle and Buck, 1955) and the Biotic Index (Woodiwiss, 1964). However, in the Regulation on amendments to the Water Classification Act (Uredba o izmjenama i dopunama Uredbe o klasifikaciji voda, Narodne novine, 37/08), the biotic index was eliminated as one of the biological indicators of water quality.

The results shown in this paper allow for certain conclusions to be drawn on the efficacy and possibilities of using macrozoobenthos in determining water quality, using two methods: the Saprobc Index (SI) and the Extended Biotic Index (EBI) (Ghetti, 1986). The objective of this paper was to establish the extent to which results obtained in these two indices on the rivers of the Croatian hydrographic network can be compared. The use of SI, currently the only legitimate biological method in Croatia, can have certain limitations in routine water quality assessments. Namely, it implies the determination of indicators to the species level, which requires highly specialised determination experts. This slows the analysis and makes it more costly.

STUDY SITES

For the purpose of comparative study and assessment of the level of applicability of SI and EBI, macrozoobenthos were collected at seven sampling sites in the Croatian hydrographic network during 2003 and 2004. Sampling on the Sava River was conducted at two stations: Otok (upstream from Zagreb) and Oborovo (downstream from Zagreb) in all four seasons: summer (July), autumn (December), winter (February) and spring (May). Macrozoobenthos of the Kraljevec Stream was also sampled at two sites. The first (Kraljevec 1) was downstream of the Queen's Well on Mt. Medvednica, while the second (Kraljevec 2) is in the Mihaljevac area (Zagreb) where the creek enters the covered area. The last three study sites were on the Korana River near Veljun and at the spring of the Krka River near Knin (at Topoljski buk) and the Crna rijeka near the Plitvice Lakes. Samples at the sites on the Kraljevec Stream and the Krka River were collected in summer (July), autumn (November/December) and winter (February). At the spring of the Crna rijeka (Plitvice Lakes) and the Korana River near Veljun, samples were collected in summer (July), autumn (December) and spring (May).

MATERIALS AND METHODS

At all study sites, qualitative samples of macrozoobenthos was collected in depths down to 1m using a hand net (mesh size 0.5 mm) from all available microhabitats. Collected samples were placed in wide–neck bottles and conserved in 70% ethanol. In the laboratory, organisms were removed from the substratum, counted, and identified to the lowest possible taxonomic category.

DESCRIPTION OF BIOLOGICAL METHODS

Saprobic index (SI)

The value of the SI is calculated according to the following formula (Pantle and Buck, 1955):

$$SI = \frac{\Sigma \; s \times h}{\Sigma \; h}$$

s = saprobic value;

h = relative abundance (h = 1, 3 or 5 if organisms of the taxon are found incidentally, frequently or abundantly, respectively),

According to Baur (1987), instead of an assessment of relative abundance, the actual abundance of taxa was used. The obtained SI values were corrected based on the established number of indicator taxa, as follows:

Number of indicator taxa	Saprobic Index
1–2	S + 0.3
3–5	S + 0.2
6–12	S
13–15	S — 0.2
16 or more	S — 0.3

The saprobic values (s) for individual indicator taxa were obtained from the literature (Wegl, 1983; Moog, 1995).

Extended Biotic Index (EBI)

For assessments of water quality, qualitative samples of macrozoobenthos were collected using a benthos net, from as many different microhabitats as possible, in order to obtain the best possible overview of the structure of the community. Some groups were determined to the genus level (Plecoptera, Ephemeroptera, Mollusca...), some to the family level (Trichoptera, Oligochaeta, Crustacea...), while for others it was sufficient to note presence at the group level (Nematoda, Porifera...). Determination need not be carried out to the species level, but only to higher systematic levels. The value of the EBI is determined based on the presence of representatives of invertebrate groups of varying sensitivity to pollution, and based on the number of taxa (Ghetti, 1986). It should also be noted that due to this simplification in determination, the basic shortcoming of the method is a slightly lower sensitivity than when using SI.

RESULTS

The results of water quality analyses using benthic macroinvertebrates are shown in Fig. 1, where the values of the SI and EBI are given. Based on these, individual results are shown as quality class pursuant to the Water Classification Act (Narodne novine, 77/98) and the Regulation on amendments to the Water Classification Act (Narodne novine, 137/08). According to this legislation, water is classified into five classes based on the value of the Saprobic Index ranging from 1 to 4, and values of the Biotic Index from 1 to 10. Considering that the EBI is used in this study, whereby the values can be (and are) over 10, we proposed that EBI values for quality class I be from 10 to 12, and with higher values indicating fully clean water, which should be considered as xenosaprobic quality class. The situation with the SI is similar, as according to the Water Classification Act, the lowest value is 1, while the present study indicates that values can be lower, which would also be values characteristic of exceptionally clean or xenosaprobic waters.

Kraljevec Stream

At the site Kraljevec 1, the highest SI values were found in July and lowest in February, when one of the values was within the bounds of xenosaprobic (0.99). All other values are characteristic for quality class I, and the highest measured value was in July (1.39). The EBI values were high in July and February, indicating higher water quality than shown by the SI values.

Greater fluctuations of SI and EBI values are also present by season at the station Kraljevec 2. In July, all values were within the levels of quality class III, in December for quality class class II and in February, the SI values were within levels of quality class III (Fig. 1).

Sava River

In the Sava River near Otok, the SI values indicated somewhat poorer water quality in July and February than in December and May. The obtained values indicate the water is quality class III. There were no significant deviations of the SI and EBI values.

In the Sava River near Oborovo, the seasonal differences in water quality showed greater variation that at the upstream station. The poorest water quality was confirmed in July and May (quality class V). Quality was slightly better in December (quality class IV) and highest in February, when SI values indicate quality class III, while EBI values indicate quality class IV. This is also a larger deviation of the EBI and SI values at this station.

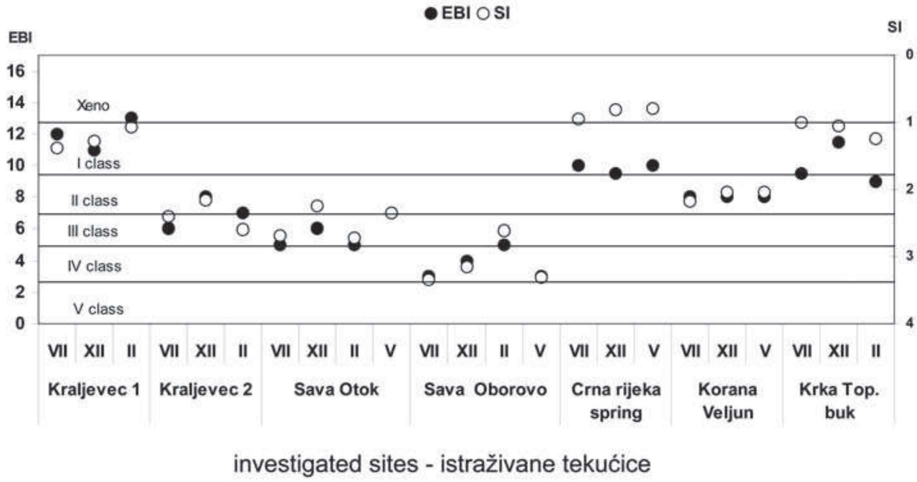

Fig. 1. Values of the Saprobic Index (SI) and Extended Biotic Index (EBI) on the investigated sites
Slika 1. Vrijednosti indeksa saprobnosti (SI) i proširenoga biotičkog indeksa (EBI) na istraživanim tekućicama

Crna rijeka — spring

Water quality based on macrozoobenthos analyses at this station varied very little in individual seasons. All values of the SI were less than 1, i.e. in the boundaries of xenosaprobic water. However, significant deviations of values were obtained using the EBI method at this station, as this method indicated quality class I in all seasons.

Korana River — Veljun

All obtained values of the SI and EBI indices were within the boundaries characteristic for quality class II. Somewhat higher SI values (i.e. slightly poorer water quality) were recorded in July.

Krka River — spring (Topoljski buk)

The results indicate that at the station Topoljski buk, the SI values in all seasons are either at the border of xenosaprobic water and quality class I, or in the initial values for quality class I. Significant fluctuations of water quality indicators were established based on the EBI. During the summer period, these values indicate poorer water quality (quality class II).

DISCUSSION AND CONCLUSIONS

Over the past decade, numerous water quality studies having been conducted comparing the SI and EBI methods (Božak, 2004; Dragojević, 2006; Molak, 2009; Primc–Habdija, Kerovec et al., 2005). Based on these studies, the following conclusions can be drawn. First, the interpolation of results obtained using these methods can present a significant problem, i.e. determining the boundary levels of individual water classes, and there will likely be other issues and ambiguities concerning this. Second, the EBI has a much coarser spread of values, which could also be the source of the larger deviations from those values obtained using the SI method. And third, based on experiences to date, both in Croatia and abroad (Zabric and Šot Pavlovič, 1989), larger fluctuations have been recorded in both clean and heavily polluted waters, than is the case with only moderately polluted waters.

Based on the results presented here, it can be concluded that both described methods, SI and EBI, are suitable for use in the assessment of river water quality. With regard to the EBI method, it can be said that it proved to be very good in assessing water quality, especially in poorly to heavily polluted water. The results indicate that in such waters (Kraljevec Stream, Sava River, Korana River) there are no greater deviations from the SI values. However, when this method is applied for fully clean and clean waters (xenosaprobic and oligosaprobic), there are larger deviations from the results obtained by the SI method. The most significant deviations were obtained in xenosaprobic waters, i.e. at the springs of the Krka River and Crna rijeka, where the values of the EBI typically indicated poorer water quality. For the Crna rijeka, the two methods gave results that differed by a class, i.e. EBI indicated quality class I while SI indicated xenosaprobic water. Even greater deviations were observed at the springs of the Krka River (Topoljski buk), where one sample differed by two classes. These differences are due to the relatively low diversity of macrozoobenthos, stemming from the relatively extreme ecological conditions found in these springs. Considering that one of the criteria for determining the EBI values and community diversity (number of taxa), it is clear that in such habitats those values are smaller, and thus suggest poorer water quality. Namely, these are sites were groundwater, containing less oxygen and organic material, springs to the surface. Furthermore, water temperature is constant and relatively low, which are also limited factors for the development of macrozoobenthic diversity.

Based on the above, it can be concluded that both methods (SI and EBI) have certain advantages and shortcomings, but with additional explanation, instructions and education of users, both methods could be suitable for determining the quality of rivers in Croatia. The EBI method is advantageous for routine and rapid assessments of water quality, and should be reinstated in the Water Framework Directive.

Sažetak

USPOREDBA DVIJU BIOLOŠKIH METODA ZA OCJENU KAKVOĆE TEKUĆIH VODA NA TEMELJU ANALIZE ZAJEDNICE MAKROZOOBENTOSA

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Na temelju analize zajednice makrozoobentosa, u radu su prikazani rezultati dvaju indeksa (indeksa saprobnosti i proširenoga biotičkog indeksa) koji se koriste kao biološki pokazatelji u procjeni kakvoće voda tekućica. Cilj je rada bio utvrditi u kojoj su mjeri međusobno usporedivi rezultati dobiveni primjenom dvaju navedenih indeksa. Rezultati pokazuju da su oba indeksa pogodna za procjenu kakvoće tekućica hidrografske mreže Hrvatske. Veća su odstupanja utvrđena samo u ksenosaprobnim vodama, tj. na izvorima Krke i Crne rijeke, gdje su vrijednosti proširenoga biotičkog indeksa uglavnom upućivale na lošiju kakvoću vode.

Ključne riječi: makrozoobentos, indeks saprobnosti, biotički indeks, Hrvatska

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