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BIOLOGICAL WATER QUALITY ASSESSMENT OF THE ŚCINAWA NIEMODLIŃSKA RIVER BASED ON THE BIOTIC INDEX METHOD

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BIOLOGICZNA OCENA JAKOŚCI WÓD ŚCINAWY NIEMODLIŃSKIEJ NA PODSTAWIE METODY INDEKSU BIOTYCZNEGO

Biorąc pod uwagę fakt, iż programy monitoringu jakości wód w Polsce oparte są w większości na parametrach fizyczno-chemicznych i systemie saprobów, istotnym jest oszacowanie możliwości zastosowania metody indeksu biotycznego w ocenie jakości wód. Badania prowadzono na rzece Ścinawa Niemodlińska (woj. opolskie). Próbki makrobezkręgowców bentosu pobierano z siedmiu stanowisk dwukrotnie w roku 1999. Na podstawie wyników analizy jakościowej i ilościowej zespołu makrobezkręgowców obliczano Belgijski Indeks Biotyczny, jako przykład zastosowania indeksu biotycznego. Wartości BBI wskazywały na niski, lecz zróżnicowany pomiędzy poszczególnymi stanowiskami, poziom zanieczyszczenia badanego akwenu.

Summary

Considering the fact that water quality monitoring programs in Poland are mostly based on physico-chemical variables and saprobic systems, it is important to evaluate also the possibility of applying biotic index methods for water quality assessment. The investigation was carried out at the Ścinawa Niemodlińska river (Opole Voivodeship). Benthic macroinvertebrates from seven sampling sites were sampled twice in 1999. Belgian Biotic Index values were calculated on the basis of the results of qualitative and quantitative analyses of the macroinvertebrate community, as the example of the biotic index application. BBI values indicated a low, but different in particular sites, pollution level of the studied ecosystem.

INTRODUCTION

Changes in aquatic ecosystems, among them surface water pollution, require a complex approach to the issue of water protection from progressive degradation. The policy of ecosystem management, which aimed at the restoration of a high ecological quality of aquatic ecosystems, has been carried out in European Union countries for years. In the ecological classification not only water quality assessment (physical-chemical and biological) is taken into account, but also characteristics of a reservoir or

a river together with their surroundings (morphometric-hydrographic parameters and catchment ones) [6].

Among water quality assessment methods, a biological component is of essential importance. Results of biological estimation of surface water quality are presented in the form of various indices, of which the biotic index based on the analysis of the macroinvertebrate community is the one that is most often used in European countries [5]. The need for biological indices is well explained by Woodiwiss [11].

The purpose of the present study was to evaluate the reliability and possible use of the biotic index for biological water quality assessment of Polish lowland rivers. The Ścinawa Niemodlińska river and Belgian Biotic Index (BBI) method were selected for the study, as a specific example.

STUDY AREA

The study was carried out at the Ścinawa Niemodlińska river, a right - bank tributary of the Nysa Kłodzka river, of about 57 km length (Fig. 1).

Characterization of seven sites selected along the river course for periodic sampling is presented in Table 1.

MATERIALS AND METHODS

Benthic macroinvertebrate samples were collected in May and September of 1999. During the sampling procedure the technique worked out and described by De Pauw and Vanhooren [2] was applied. River invertebrates were sampled using a standard handnet made of a metal frame of 30 cm width and 20 cm height, and a conical net of 50 cm length with a mesh size of 500 μm. Material for the biological investigation was collected in longitudinal and transversal direction of the river, exploring all accessible aquatic habitats covering a river stretch of 5–7 m in particular stations. In addition, aquatic vegetation, stones and other artificial elements of the substratum were rinsed over a bucket of water, in order to remove the attached organisms. The contents of each sample were washed in the field by the sieves with a mesh size of 0.5 mm and preserved with 70% alcohol, then returned to the laboratory for identification and enumeration. All individual organisms were identified to the lowest practicable taxon, i.e. the family and the genus level. Values of the biotic index BBI were set on the basis of the obtained results.

The procedure of the Belgian Biotic Index calculation:

BBI was calculated on the basis of the results of quantitative and qualitative analysis of benthic macroinvertebrates identified to the genus level within: *Turbellaria, Hirudinea, Crustacea, Ephemeroptera, Odonata, Heteroptera, Megaloptera, Mollusca*; as well as the family level within: *Oligochaeta, Trichoptera, Coleoptera* and *Diptera*. Moreover, within dipterans the groups of *Chironomidae thummi-plumosus* and *Chironomidae* non *thummi-plumosus* were distinguished. The total amount of systematic units present in particular samples and the most sensitive taxa for aquatic pollution were used to determine biotic index values, by means of Tuffery's and Verneaux's standard table. When interpreting the data obtained, Belgian classification was applied, according to which index values from 0 to 10 correspond with five classes of water pollution (Tab. 2) [2].

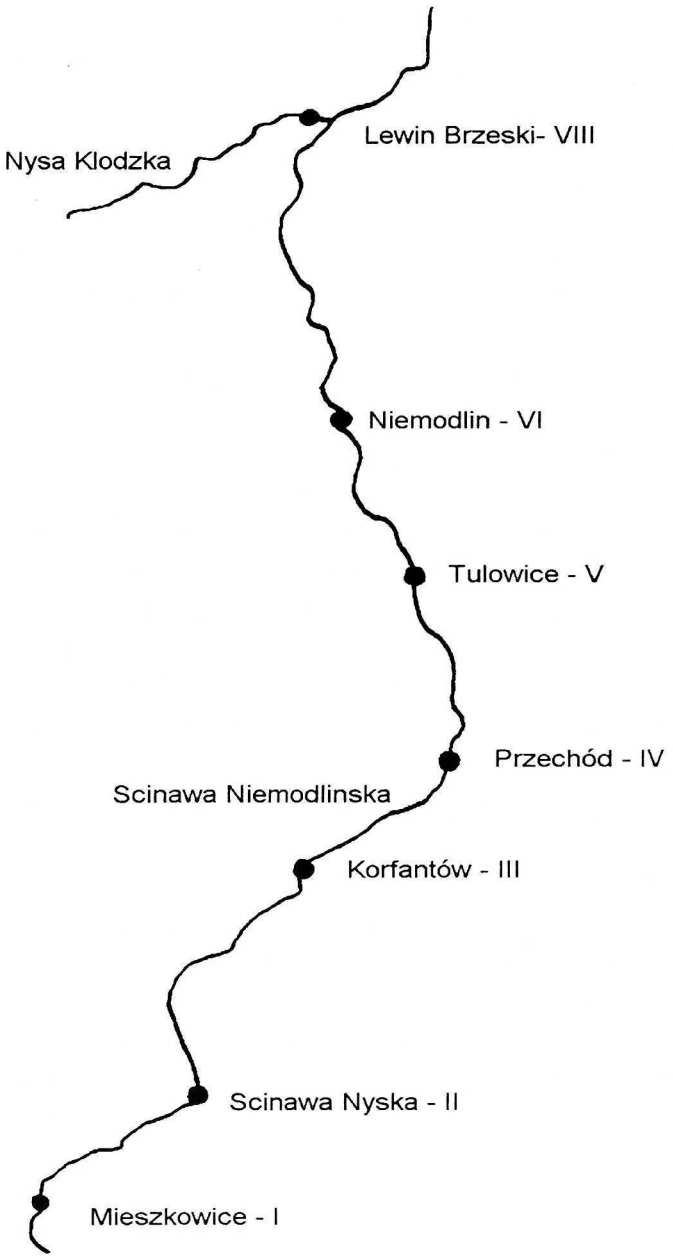

Fig. 1. Localization of the selected sampling sites at the Ścinawa Niemodlińska river

Tab. 1. Characteristics of the sampling sites at the Ścinawa Niemodlińska river

Features of the site	Localization of sites						
	Mieszkowice	Ścinawa Nyska	Korfantów	Przechód	Tułowice	Niemodlin	Lewin Brzeski
River depth [cm]	30	40	50	50	70	100	100
River width [cm]	100	400	300	400	300	450	500
Mean current speed [m/s]	0.4	0.2	0.2	0.2	0.3	0.3	0.2
Substrate type	stony -sandy	sandy-muddy*	sandy-stony	grovel-sandy	sandy	stony-sandy	sandy muddy*
Coastal vegetation	alder, willow	alder	grass	grass	willow	alder	grass
Exposure (0–10)	9	8	3	0	6	9	9
Surrounding environment	agriculture	country area	urban area	country area	arable land	urban area	agriculture

*muddy substrate near the outflow of the household sewage

Tab. 2. Belgian classification of the river water quality according to the BBI method

Water quality class	Biotic index values	Significance (pollution scale)	Color mark
I	10-9	Lightly or unpolluted	Blue
II	8-7	Slightly polluted	Green
III	6-5	Moderately polluted-critical situation	Yellow
IV	4-3	Heavily polluted	Orange
V	2-0	Very heavily polluted "0" value-absence of bio-indicators	Red

RESULTS

The qualitative analysis of the benthic samples collected from seven sites revealed the presence of numerous organisms representing the following groups of invertebrates: *Oligochaeta, Hirudinea, Crustacea, Trichoptera, Ephemeroptera, Odonata, Coleoptera, Megaloptera, Diptera, Gastropoda* and *Bivalvia* (Tab. 3). 38 taxonomic units were identified, among them 18 to the family level and 20 to the genus one. The amount of taxonomic units identified in particular sites was different and ranged from 10 to 20. Mieszkowice and Tułowice, sites below relatively undeveloped areas, generally exhibited the greatest diversity along the Ścinawa Niemodlińska river, with 20 and 19 taxa collected, respectively. a slight decrease in taxa richness was apparent at sites below more developed areas of the watershed, with 13 to 15 taxa collected at Ścinawa Nyska, Korfantów, Przechód and Niemodlin. At the Lewin Brzeski site, the most downstream station on the river, total taxa collected declined to 10. The most numerously represented groups of invertebrates were dipterans, mainly from the family of *Chironomidae* as well as caddies flies from the families of *Hydropsychidae* and *Limnephilidae,* especially at the Mieszkowice site.

Tab. 3. List of the systematic units found in the Ścinawa Niemodlińska river 1 = 1 individual, 2 = 2-50 individuals, 3= >50

Taxa	Station						
	I	II	III	IV	V	VI	VII
Oligochaeta							
Naididae		2					
Lumbriculidae			2	2	2		
Tubificidae	2	2	2	2	2	2	2
Hirudinea							
Erpobdella sp.	2	2	2	2		2	
Glossiphonia sp.	1	1	2	1			
Gastropoda							
Ancylus sp.			2				
Radix sp.							
Lymnaea sp.	2					2	
Galba sp.							
Valvata sp.							1
Viviparus sp.							1
Anisus sp.						1	
Gyraulus sp.						2	2
Bivalvia							
Pisidium sp.	2	2			1	1	2
Sphaerium sp.		2					
Ephemeroptera							
Ecdyonurus sp.	2						
Heptagenia sp.	2						
Paraleptophlebia sp.	1						
Baetis sp.	3	2	2	3	2	2	
Trichoptera							
Hydropsychidae	3	2	2	2	2	2	
Polycentropodidae	2				2		
Limnephilidae	3	2	2	2	2	2	2
Leptoceridae	2				1		2
Lepidostomatidae					2		
Phryganeidae					1		
Odonata							
Calopteryx sp					1		
Platycnemis sp.				1			
Pyrrhosoma sp.						1	
Megaloptera							
Sialis sp.					1		
Coleoptera							
Dytiscidae		1				2	2
Gyrinidae					2		
Helodidae	2						
Crustacea							
Asellus sp	2		2	2	2	2	
Gammarus sp.	2						
Diptera							
Athericidae	1			2	1		
Limoniidae	2		2	2	2	2	
Simuliidae			2	3	2		
Tipulidae			1		1		
Tabanidae		1					
Chironomidae non thummi	3	3	2	2	2	3	2
Chironomidae thummi	2	2				2	2

The results of macroinvertebrate analyses and values of the Belgian Biotic Index together with the final classification of water quality of the Ścinawa Niemodlińska river are presented in Table 4. In compliance with the BBI criterion, taxonomic units represented in the sample only by a single individual were disregarded during calculation, considering the possibility of the accidental occurrence at the investigated site. Thus, the amount of the identified taxonomic units varied between 6 at Lewin Brzeski and 13 at the Mieszkowice site during the spring sampling, as well as between 4 at Lewin Brzeski and 11 at the Tułowice site during the autumn one. The presence of very sensitive groups for water pollution, such as *Ephemeroptera* from the family of *Heptagenidae* or cased *Trichoptera*, caused the high values of the calculated BBI index. According to BBI, good quality characterized the waters of the Ścinawa Niemodlińska river, except for the Ścinawa Nyska and Lewin Brzeski sites. The second class of purity indicated only its low pollution; however at the Mieszkowice site, the spring stretch of the river, the highest value of the index corresponded with the first class was obtained. a diminution of water quality to the third class was stated at the Ścinawa Nyska and Lewin Brzeski sites. This classification is consistent with the increased nutrient loading suspected to occur at these sites, as they were situated near point sources of pollution, i.e. outlets of domestic sewage.

Tab. 4. Biotic index values and the water quality classification of the Ścinawa Niemodlińska river in particular sites

Data of the BBI method	Sites' name						
	Mieszkowice	Ścinawa Nyska	Korfantów	Przychód	Tułowice	Niemodlin	Lewin Brzeski
The total amount of taxonomic units	17	10	12	11	12	12	8
The most sensitive taxa for water pollution	*Heptagenidae*	*Trichoptera*	*Trichoptera*	*Trichoptera*	*Trichoptera*	*Trichoptera*	*Trichoptera*
The index values	10	6	8	7	7	7	6
The water quality class	I	III	II	II	II	II	III

DISCUSSION

The composition of the benthic macroinvertebrate community, represented by organisms which have a different range of tolerance to water pollution, revealed the good water quality of the Ścinawa Niemodlińska river. Among invertebrates, many forms have been suggested as indicators: molluscs, aquatic worms, and insects among others [3]. It was stated that representatives of invertebrates recognized by Hellawell [4] as sensitive to pollution, like *Ephemeroptera*, cased *Trichoptera*, and *Ancylus fluviatilis* (L.), occurred in the investigated river. As it is known from the analyses of the benthos coming from different Polish rivers and performed by Turoboyski [10], both larvae of *Ephemeroptera* and *Trichoptera* reveal saproksenic properties, typical for slightly polluted waters where organic matter is almost mineralized. They occurred in pure oligosaprobic waters and also in the intermediate zone between α and β mezosaprobic, under the circumstances of a fast current and an intensive oxygen saturation. The rela-

tively good quality of the Ścinawa Niemodlińska waters is also confirmed by the results of physical – chemical analyses carried out within the program of the surface water quality monitoring by the Provincial Inspectorate of Environmental Protection in Opole [7].

The data collected from the Ścinawa Niemodlińska river revealed also that water quality gradients were modified by agricultural and urban pollution. Values of the BBI biotic index indicated low but different levels of water pollution in particular sites. According to the Belgian scale, water was characterized as slightly to moderately polluted, i.e. from the first class to the third one. The sites at Ścinawa Nyska and Lewin Brzeski were particularly affected by pollution. Of course, in evaluating aquatic organisms as indicators of pollution conditions, great caution must be used because several ecological factors other than the presence of a pollutant may limit the distribution of certain taxa; for example, erosion, floods, the type of bottom, and the flight range of the insect. The lower position of these sites in the final classification of water quality was almost certainly the result of point sources of pollution. All sites had similar substrates, current velocities and water depths.

A strict dependence occurring among the biotic index values, the macroinvertebrate community structure and the level of water pollution has been confirmed by many investigations carried out in European and other countries, such as in Holland, Spain and Indonesia [1, 8, 9]. The authors pointed out the necessity of verification of sensitive taxon lists that are included into the calculation methods of the index. First of all, that refers to the rivers from climatic zones where representatives of macroinvertebrates belonging to the families not found in Europe have often been noted. In the case of the research carried out at the Ścinawa Niemodlińska river, there is no need for the supplement, as the identified taxons of the differential range of tolerance to pollution have been included in the BBI standard table.

However, the lack of data on the biological assessment of water quality on the basis of biotic indices prevents me from drawing a comparative analysis between the results obtained for the Ścinawa Niemodlińska river and other Polish regions.

CONCLUSIONS

1. The bottom fauna of the Ścinawa Niemodlińska river is represented by many groups of invertebrates revealing various range of tolerance to water pollution.
2. The calculated BBI biotic index values indicated low, but different in particular sites, levels of water pollution. BBI values characterized water as slightly and moderately polluted, i.e. from the first class (Mieszkowice) to the third one (Ścinawa Nyska and Lewin Brzeski).
3. The investigation confirmed that the usage of the biotic index method based on the analysis of the macroinvertebrate community for the assessment of river water quality has, from the practical point of view, many advantages, such as the easy sampling procedure, the simplified organisms identification (not requiring identification to the species level as it is in the case of the saprobic system) and the possibility of less frequent sampling than in physical-chemical investigations.
4. It was stated that biological assessment based on the analysis of macroinvertebrates and the biotic index method may provide useful information on water quality of Polish lowland rivers.

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