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THE USE OF BMWP-PL INDEX FOR ASSESSMENT OF WATER QUALITY IN THE LOWLAND LIWIEC RIVER AND ITS LONGEST TRIBUTARIES (CENTRAL-EASTERN POLAND)

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ZASTOSOWANIE INDEKSU BMWP-PL DO OCENY JAKOŚCI WÓD NIZINNEJ RZEKI LIWIEC I JEJ NAJDŁUŻSZYCH DOPŁYWÓW (ŚRODKOWO-WSCHODNIA POLSKA)

W pracy przedstawiono wyniki badań wybranych parametrów chemicznych wody i składu taksonomicznego makrobezkręgowców rzeki Liwiec i jej wybranych dopływów (środkowo-wschodnia Polska). Dokonano chemicznej i biologicznej klasyfikacji badanych wód. Przetestowano cztery indeksy biotyczne: belgijski BBI, francuski IBGN, opracowany w Wielkiej Brytanii BMWP/OQR oraz opracowany na potrzeby biologicznej klasyfikacji rzek w Polsce indeks biotyczny BMWP-PL. Korelacja pomiędzy wartościami indeksu BMWP-PL a parametrami chemicznymi wody wskazuje na przydatność indeksu BMWP-PL do oceny jakości nizinnych rzek (typu Liwiec) w Polsce.

Summary

In this paper, the results of the analyses of selected chemical water quality parameters and taxonomic composition of macroinvertebrates of the Liwiec River and its chosen tributaries (central-eastern Poland) are presented. Chemical and biological water quality assessment was performed, and four biotic indices were tested: Belgian BBI, French IBGN, British BMWP/OQR, and biotic index BMWP-PL developed for Polish rivers. Correlations between the values of the latter and chemical water parameters show that BMWP-PL is a useful tool for the assessment of water quality of lowland rivers in Poland (similar to the Liwiec).

INTRODUCTION

The Water Framework Directive [13] from October 23, 2000, specifying water protection policy of the EU countries, introduced the obligation of surface water biomonitoring. The biological assessment of waters based on macroinvertebrate communities, commonly used in numerous European countries [e.g. 6, 12, 14, 20, 33] was widely discussed also in Poland after its accession to the EU.

The directive of the Minister of Environment concerning classification of Polish surface waters issued in March 2004 [32] introduces the obligation of the biological assessment of water quality. Riverine water quality classification involves, besides the phy-

sical and chemical criteria, also biotic indices based on the analysis of macroinvertebrate taxonomic composition.

A modification of the British BMWP score [2] applicable to the Polish rivers was developed. The values of BMWP-PL index are calculated from the table of taxa differing in sensitivity to water pollution, scored 1–10 [25]. Taxa sensitive to pollutions, for example *Ephemeroptera, Plecoptera, Trichoptera* larvae receive a greater number of scores, while taxa tolerant of pollution, for example *Oligochaeta*, some families of *Diptera* (*Chironomidae*, *Culicidae*), *Hirudinea* (*Erpobdellidae, Hirudinidae*), *Crustacea* (*Asellidae*) receive a smaller number of scores. The final result which is the sum of scores of all taxa identified to the family allows for the classification of water to one of five quality classes: 1st class > 100, 2nd class 70–99, 3rd class 40–69, 4th class 10–39, 5th class < 10 [32].

The studies of invertebrate macrofauna and selected chemical water properties of the Liwiec River and its chosen tributaries were carried out in the Department of Ecology and Environmental Protection of the University of Podlasie, beginning in 1998. This data was used for biological and chemical assessment of water quality, and evaluation of the usefulness of the BMWP-PL index.

The aims of the study were:

- the assessment of the Liwiec River and its chosen tributaries on the basis of selected chemical parameters;
- the assessment of the water quality of the Liwiec River and its chosen tributaries with the use of BMWP-PL, Belgian biotic index BBI, French IBGN, and British BMWP/OQR;
- the relationship between BMWP-PL index and chemical water parameters.

STUDY AREA

The study was carried out in the Liwiec River and its three tributaries: the Muchawka, the Kostrzyń and the Osownica rivers. The catchment of the Liwiec River is located in the area of South Podlasie and Central Mazovian Lowlands [21], in the ecoregion – 16 [13].The Liwiec River is the largest (126.2 km long) left tributary of the Bug River. The river-head is situated 160 m a.s.l. and the mouth of the river lays 85 m a.s.l. The mean river gradient is 0.6‰. The catchment of the Liwiec is made of limestone [1]. It has a well preserved valley and natural bed, except for the upper and a part of the lower course. It also has a rich hydrographic network of watershed with 10 tributaries, the longest of which are the studied ones: the Muchawka (29.7 km), the Kostrzyń (53.4 km) and the Osownica (44.9 km) rivers. Watershed area of the Liwiec River is 2779 km^2. The catchment area of the Liwiec is classified as big [13]. Grasslands comprise about 75% of watershed area, forests – 20% and wastelands – 5% [1]. The land directly adjacent to the river is used mainly as meadows and pastures [19]. The Liwiec River is polluted mainly by the discharge (about 23000 m^3 per day) of treated sewage from the Siedlce sewage treatment plant.

MATERIALS AND METHODS

The studies were carried out in 1998–2000 and in 2002 at 12 sampling sites located at the Liwiec, in 2002 at 4 sampling sites located at the Osownica, and in 2005 at 5

sites located at the Muchawka and another 5 located at the Kostrzyń River (Fig. 1). The description of the studied sites is given in Table 1. The sites were chosen to consider any dispersed source of pollution. Biological samples and water for chemical analyses were taken at the same time, 3 times each year in spring, summer and autumn.

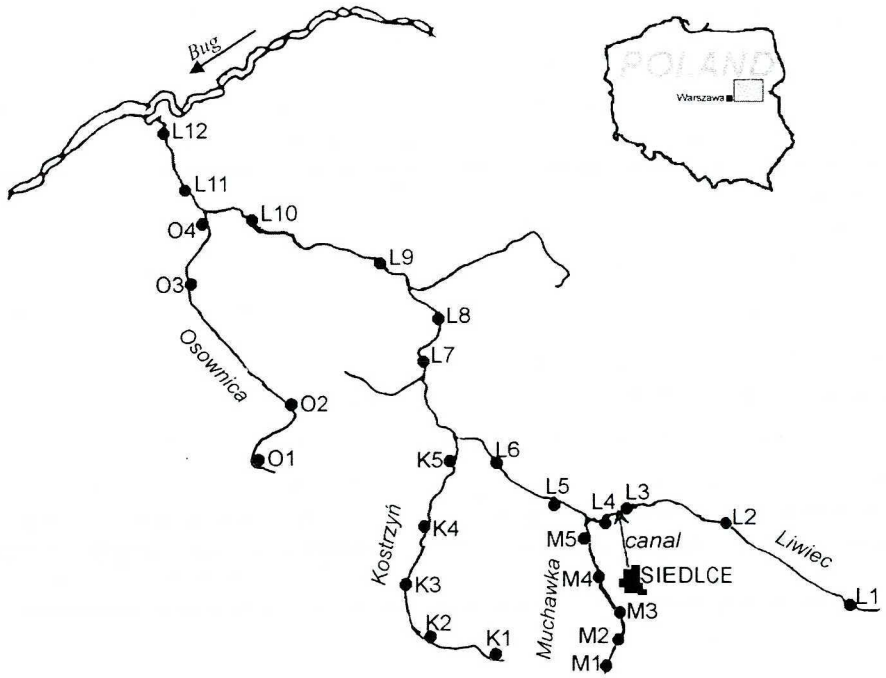

Fig. 1. Location of sampling sites along the Liwiec River (L1–L12) and its tributaries: the Muchawka (M1–M5), the Kostrzyń (K1–K5) and the Osownica (O1–O4) rivers

All together, 186 samples of water for chemical analyses and 186 biological samples (macroinvertebrates) were taken.

In the water, according to the Polish standards, the following chemical parameters were determined: dissolved oxygen, phosphate and nitrate ions concentrations, and electrolytical conductivity. The values obtained were compared with standards for five water quality classes, according to the Directive of the Minister of Environment from February 11, 2004 [32].

Biological analyses included macroinvertebrates samples collected by the semi-quantitative method, with a scraper whose edge was 0.2 m. The sampling procedure covered all the habitats at each site (including the riffles, current, plants and the different bottom substrata). 5 sub-samples were taken from each sampling site of a bottom surface of about 1 m^2 (each of the sub-samples from the surface of about 0.2 m^2). The collected material was washed in a sieve of 0.5 mm mesh size. Taxonomic identification of macroinvertebrates was done to family, and in the case of *Hirudinea, Mollusca, Plecoptera, Ephemeroptera, Odonata, Megaloptera* – to genus.

Table 1. Environmental conditions at the Liwiec River sampling sites (A) and the Liwiec tributaries: the Muchawka, the Kostrzyń and the Osownica rivers (B)

A

Site	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Mean depth [m]	0.5	0.5	1	2	1	1	1.5	1.5	1	0.4	0.5	0.4
Flow velocity [m s^{-1}]	0.33	0.33	0.25	0.2	0.4	0.3	0.5	0.6	0.7	0.3	0.6	0.7
Bottom substrate	Sandy	Sandy	Muddy and clayey	Muddy	Muddy	Sandy and muddy	Muddy	Sandy and muddy	Sandy	Sandy	Sandy and gravelly	Sandy and gravelly

B

River	Muchawka					Kostrzyń					Osownica			
Site	1	2	3	4	5	1	2	3	4	5	1	2	3	4
Mean depth [m]	0.5	1	0.5	0.5	0.5	0.5	0.6	2	1	0.5	0.5	0.5	0.5	0.7
Flow velocity [m s^{-1}]	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.25	0.33	0.33	0.6	0.3	0.3	0.6
Bottom substrate	Sandy and muddy	Sandy and muddy	Sandy and muddy	Sandy and muddy	Sandy and muddy	Sandy and stony	Muddy	gravelly	Sandy and muddy	Sandy and muddy	Sandy and muddy	Sandy and muddy	Sandy and muddy	Sandy-stony and sandy-muddy

For taxonomic identification, various keys and guides were applied and consultations with authorities were carried out. The results of macroinvertebrate community analysis were used for the biological assessment of the Liwiec River water quality, applying selected biotic indices: Belgian Biotic Index BBI [11], French IBGN [30], British BMWP/OQR [14] and BMWP-PL index, developed for the assessment of Polish rivers water quality [25, 32].

The relationship between BMWP-PL index and chemical parameters was evaluated with the use of the Spearman's correlation coefficient.

RESULTS

Hydrochemistry

The values of the chemical water parameters of the Liwiec River and its chosen tributaries were within the following ranges: dissolved oxygen concentration 0.32–12.0 mg O_2 dm^{-3}, nitrate concentration 0.5–19.0 mg NO_3^- dm^{-3}, phosphate concentration 0.1–3.4 mg PO_4^{3-} dm^{-3} and electrolytical conductivity 230 –1642 μS cm^{-1}. The average values were calculated for each year and the results are shown in Figure 2 (the Liwiec) and Figure 3 (the Liwiec tributaries).

The lowest oxygen concentration of the Liwiec occurred at site L4, located downstream from the discharge of the Siedlce sewage treatment plant (Fig. 2A); it allowed for the classification of water at site L4 as 4th and 5th quality classes. Downstream from Siedlce, water oxygenation gradually improved and at the river mouth oxygen concentration was typical of the 1st quality class. The lowest oxygen concentration of the studied Liwiec tributaries was measured in the Osownica River. In the Muchawka and the Kostrzyń, it was similar to the oxygen concentration of the upper and the lower course of the Liwiec (compare Fig. 2A and 3A). The average nitrate concentration in the Liwiec River and its tributaries was typical of the 1st and 2nd quality classes over the entire study period. The lowest nitrate level (below 5 mg dm^{-3}) was observed in the upper course of the Liwiec (sites 1 and 2) and in its tributaries, except for site M1 at the Muchawka. The highest nitrate concentration (over 12 mg NO_3^- dm^{-3}) was measured at sites L3–L6 located at the Liwiec (Fig. 2B and 3B). The average concentrations of phosphate in the studied rivers varied over the study period and changed within the 1st–5th quality classes. The highest phosphate level occurred in the Liwiec River at the sites downstream from the Siedlce sewage treatment plant (site L4), and it gradually decreased. At the river mouth (sites L10–L12) it did not exceed 0.4 mg PO_4^{3-} dm^{-3}, a limit for the 2nd quality class (Fig. 2C). The average phosphate concentration did not exceed 0.7 mg PO_4^{3-} dm^{-3} in the Liwiec tributaries (Fig. 3C). The average values of electrolytical conductivity at most of the study sites were lower than 1000 μS cm^{-1} and they were typical of the 2nd class of water quality (Fig. 2D and 3D).

Macroinvertebrate communities

The number of macroinvertebrate families found at various sampling sites ranged from 6 (site L4) to 36 (site K1) (Tab. 2A and 2B). The list of taxa found at chosen sampling sites at the Liwiec River and its tributaries is given in Tables 3A and 3B. During the whole study period, the lowest number of families (6–10) was found at site L4. In the upper course of the Liwiec (sites L1–L3), 18 to 30 families were found, while in the lower

course (sites L10–L12), 15 to 25 families were noted (Tab. 2A). In the Liwiec tributaries, 20 to 36 families were noted. The greatest number of families was found in the samples taken from the Kostrzyń River (Tab. 2B).

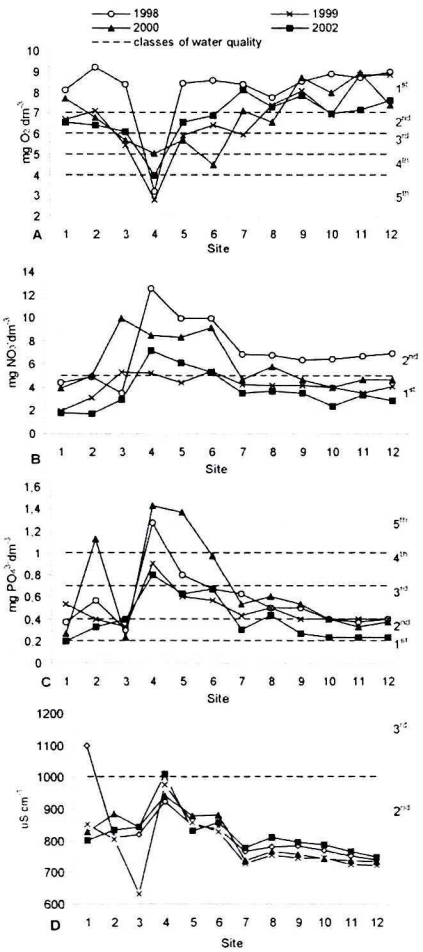

Fig. 2. Mean values of oxygen (A), nitrate (B) and phosphate (C) concentrations, and electrical conductivity (D); classes of water quality of the Liwiec River water in 1998–2000 and 2002

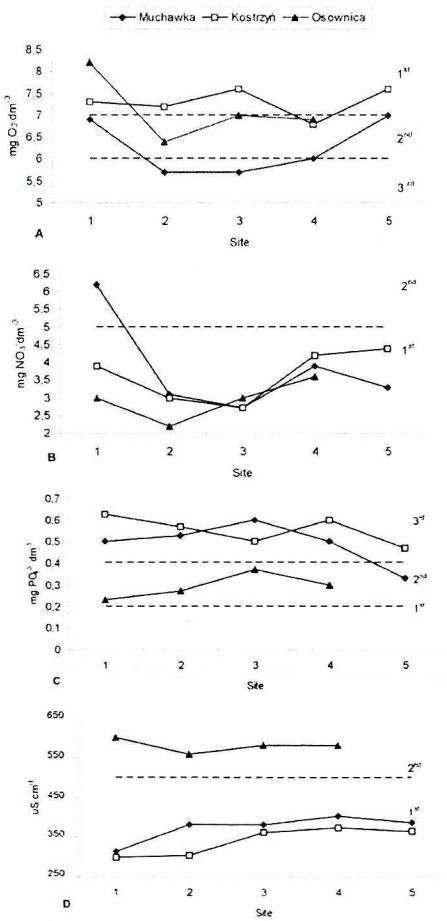

Fig. 3. Mean values of oxygen (A), nitrate (B) and phosphate (C) concentrations, and electrical conductivity (D); classes of water quality in the Liwiec River tributaries: the Muchawka, the Kostrzyń and the Osownica rivers

Table 2. The number of macroinvertebrate families found in the Liwiec River (A) and its tributaries: the Muchawka, the Kostrzyn and the Osownica rivers (B); the number of samples for each sampling site n = 3

A

Year	Site											
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
1998	18	23	18	8	13	19	28	26	25	25	24	21
1999	23	20	25	8	25	22	15	25	20	15	20	21
2000	21	28	24	6	18	18	24	28	16	25	24	21
2002	27	27	30	10	22	31	27	24	20	18	18	25

B

Muchawka					Kostrzyń					Osownica			
Site													
M1	M2	M3	M4	M5	K1	K2	K3	K4	K5	O1	O2	O3	O4
22	22	20	26	28	36	20	23	29	29	22	21	27	23

Table 3A. The taxonomic composition at chosen sampling sites in the Liwiec River in 2002 (Sp – spring, Su – summer, Au – autumn)

Taxa	Site L2			Site L4			Site L11		
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au
OLIGOCHAETA	+		+	+	+	+	+		
HIRUDINEA									
Glossiphoniidae			+			+			
Erpobdellidae	+	+	+	+	+	+		+	+
CRUSTACEA									
Asellidae	+	+		+	+	+			
Gammaridae						+			+
Cambaridae		+	+						
INSECTA									
Ephemeroptera									
Heptageniidae									+
Baetidae	+	+	+						
Caenidae		+							
Ephemeridae			+						
Ephemerellidae		+							
Odonata									
Calopterygidae	+	+	+					+	+
Gomphidae								+	+
Trichoptera									
Hydropsychidae			+					+	+
Polycentropodidae		+							
Limnephilidae	+	+	+					+	
Sericostomatidae	+								
Hydroptilidae	+								
Megaloptera									
Sialidae					+	+		+	

Coleoptera									
Dytiscidae			+			+			
Gyrinidae	+								
Elmidae		+							
Heteroptera									
Corixidae							+		
Aphelocheiridae	+	+	+						+
Gerridae					+				
Diptera									
Athercidae								+	
Simuliidae	+	+							
Limoniidae		+							
Chironomidae	+	+	+		+	+	+	+	+
Gastropoda									
Valvatidae									+
Bithyniidae		+	+					+	+
Physidae	+								
Lymnaeidae		+	+					+	
Planorbidae				+					
Bivalvia									
Unionidae	+	+	+					+	+
Sphaeriidae	+		+					+	+

Table 3B. The taxonomic composition at chosen sampling sites in the Muchawka, Kostrzyń and Osownica rivers (Sp – spring, Su– summer, Au – autumn)

Taxa	Muchawka – M1			Kostrzyń – K5			Osownica – O4		
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au
OLIGOCHAETA					+			+	
HIRUDINEA									
Glossiphoniidae	+	+	+						
Erpobdellidae	+	+	+			+	+		
CRUSTACEA									
Asellidae	+	+	+			+	+		
Gammaridae									+
Cambaridae				+		+			
INSECTA									
Ephemeroptera									
Heptageniidae					+		+	+	
Baetidae		+			+				
Caenidae					+			+	
Leptophlebiidae				+			+		
Ephemeridae	+		+	+					
Plecoptera									
Nemouridae	+								
Capniidae								+	
Odonata									
Calopterygidae						+	+	+	+

Platycnemididae				+		+			
Gomphidae				+	+	+	+	+	+
Cordullidae					+				
Trichoptera									
Hydropsychidae			+	+	+		+	+	
Polycentropodidae				+	+		+		
Limnephilidae	+	+		+	+		+	+	
Molannidae		+				+			
Leptoceridae								+	
Sericostomatidae									+
Megaloptera									
Sialidae	+	+	+			+			
Coleoptera									
Dytiscidae		+		+	+	+	+		+
Gyrinidae			+	+	+		+		
Elmidae								+	
Heteroptera									
Corixidae			+			+			
Aphelocheiridae	+					+		+	+
Notonectidae						+			
Diptera									
Tipulidae									+
Tabanidae	+			+	+			+	
Chironomidae	+	+		+	+	+	+	+	
Gastropoda									
Viviparidae	+	+	+						
Valvatidae					+				
Bithyniidae		+							
Physidae			+						
Lymnaeidae		+	+			+			
Planorbidae	+								
Bivalvia									
Unionidae				+	+	+			
Sphaeriidae		+		+	+	+	+	+	+

Assessment of water quality

All the results were used to calculate biotic indices. The range of values of the tested biotic indices is shown in Tables 4A and 4B.

Table 4. The ranges of values of biotic indices calculated for the Liwiec River (A) in 1998–2000 and 2002 (the number of samples for each sampling site n = 12) and the Muchawka, the Kostrzyń and the Osownica rivers (B) (the number of samples for each sampling site n = 3)

A

Index	Site											
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
BMWP-PL	28–112	16–100	46–106	3–28	3–80	24–104	8–102	52–86	18–93	20–74	10–118	29–100
BBI	5–9	4–7	5–8	2–5	4–7	3–9	3–8	6–9	3–8	4–8	3–10	3–8
IBGN	2–10	2–9	3–10	0–3	0–5	0–10	1–9	3–10	0–8	0–7	1–11	3–8
BMWP/OQR	3–6	3–6	3.5–6	1–3.5	2.5–4.5	2–5.5	3–6	5–6	2.5–6	2.5–5.5	1.5–6.5	3.5–6

B

Index	Site												
	Muchawka					Kostrzyń					Osownica			
	M1	M2	M3	M4	M5	K1	K2	K3	K4	K5	O1	O2	O3	O4
BMWP-PL	47–63	35–99	47–78	59–93	63–81	74–106	33–45	56–67	56–73	74–83	49–69	58–76	62–77	48–80
BBI	5–7	6–9	5–8	6–7	5–8	7–8	5–6	3–6	6–7	6–7	5–6	6–7	6–8	5–8
IBGN	5–8	4–10	6–10	5–8	4–9	8–10	3–5	4–6	5–9	3–8	8–9	6–7	6–9	4–7
BMWP/OQR	4.5–5	3–6	5–5.5	4–6	4.5–5.5	4.5–6	4–5	5–5.5	5–5.5	5–6	4–5	4–5	4–5.5	4–5.5

The values of BMWP-PL index ranged from 3 to 118 over the entire study period. Mean values of 3 study seasons, for each site located at the Liwiec, are shown in Figure 4, and for the Liwiec tributaries, in Figure 5. The lowest value was noted at site L4, located downstream from the Siedlce sewage treatment plant; it was characteristic of the 4th class of water quality. The scores for most sites, however, allowed for qualification of the Liwiec River and its chosen tributaries to the 3rd class.

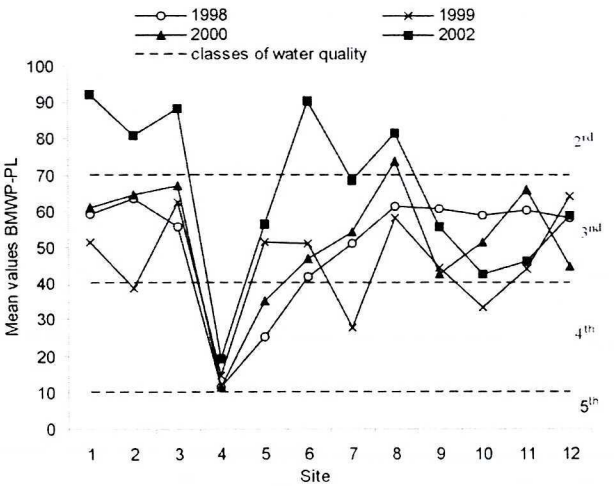

Fig. 4. Mean values of biotic index BMWP-PL at 12 sampling sites of the Liwiec River in 1998–2000 and 2002

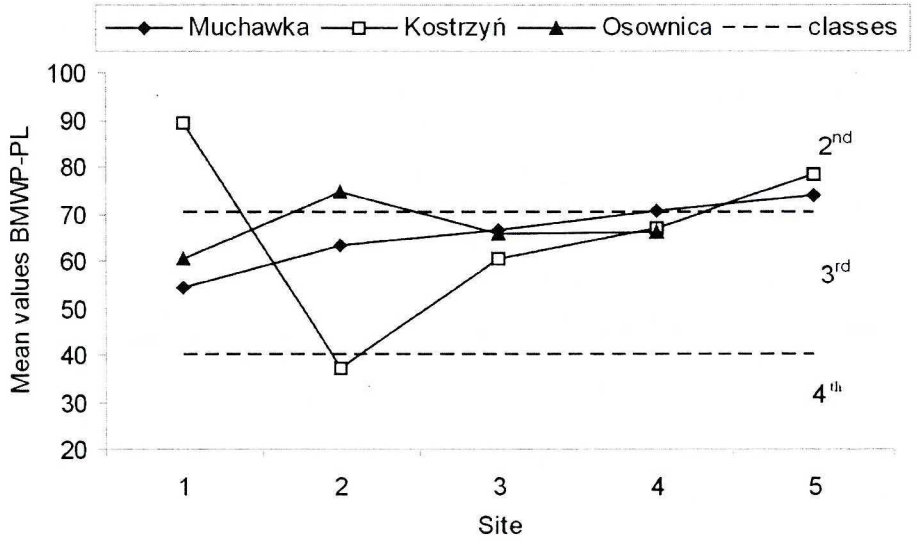

Fig. 5. Mean values of biotic index BMWP-PL in the Liwiec River tributaries: the Muchawka, the Kostrzyń and the Osownica rivers

The values of BBI index in chosen rivers changed within the range of 2–10 (Tab. 4A and 4B). About 50% of the samples were scored 5 or 6 which (in the 10 grade scale) meant moderately polluted water (the 3rd class of quality) (Tab. 5). Water of the worst quality was noted in the Liwiec River at site L4.

Table 5. Percentage contribution of water quality classes of the Liwiec River and its chosen tributaries based on tested indices

Index	Quality class				
	I	II	III	IV	V
BMWP-PL	5	25	50	17	3
BBI	3	31	49	15	2
BMWP/OQR	55	30	9	6	0
IBGN	0,5	0	12,5	42	45

The values of the French index (IBGN) changed within the range of 0–11 (Tab. 4A and 4B), (within the 20 grade scale) which was related to the 3rd–5th quality classes. In most cases (about 87%) poor (5–8 points) or very poor water quality (0–4 points) was noted (Tab. 5).

About 85% of the values of the British BMWP/OQR index (over 4 points) indicated that the waters of the Liwiec River and its tributaries were of excellent (the 1st class) or good quality (the 2nd class) (Tab. 5). Only at site L4, poor or very poor water quality was noted (Tab. 4A).

The studies performed with the use of BMWP-PL and BBI indices gave similar assessment of water quality. On the other hand, there were many discrepancies between BMWP/OQR and IBGN indices (Tab. 5).

The calculated values of the correlation coefficient between the indices showed significant relationships between BMWP-PL and BBI ($R = 0.77$, $p < 0.001$). Statistically significant correlation was also found between BMWP-PL index and chemical parameters: dissolved oxygen concentration ($R = 0.16$, $p < 0.05$), nitrate concentration ($R = - 0.28$, $p < 0.05$), phosphate concentration ($R = - 0.23$, $p < 0.05$) and electrolytical conductivity ($R = - 0.24$, $p < 0.05$).

DISCUSSION

Biotic indices based on the taxonomic composition of macroinvertebrates are related to conditions characteristic of a given geographical region. They are currently used in the several countries of Western Europe [6, 12, 14, 20, 33] and other parts of the world, for example in Canada [3], Argentina [7] and Thailand [29].

The BMWP-PL index, recommended for the assessment of the quality of water of Polish rivers [25, 32] is still being tested. It has been used, so far, by Czerniawska-Kusza [9] who assessed the quality of the Nysa Kłodzka River water, and by Błachuta [5] who assessed the quality of rivers flowing across the Sudety Mountains and the Submountain Region of the Sudety Mountains. Also in eastern Poland, the BMWP-PL index has been used to evaluate the quality of the Liwiec River water and of its chosen tributaries. The rivers turned out to be an interesting object of studies.

Most of the study sites located at the Liwiec and its chosen tributaries showed sandy or sandy-muddy bottoms and good oxygen saturation. Nutrient level (particularly of phosphate) was within the range of average values for the 3rd quality class [32]. These conditions affected taxonomic diversity of macroinvertebrates: the most diversified samples were collected from the sites in the upper and the lower reaches of the Liwiec River and from its chosen tributaries where the number of families ranged from 15 to 36. The discharge of sewage from the Siedlce sewage treatment plant deteriorates the quality of the Liwiec waters at site L4; the results of this deterioration are: lower oxygen concentration, increased concentrations of nitrate and phosphate ions, and increased electrolytical conductivity at the site. At site L4, the smallest number of macroinvertebrates families was found, while the values of tested biotic indices indicated that water quality was worse than at other sampling sites. Taxa, such as *Ephemeroptera, Plecoptera* and *Trichoptera* do not occur in waters chemically polluted [16, 18]; (they were not found at site L4). However, site L4 waters were abundant in *Tubificidae*, the family tolerant of some chemical water pollutants, for example phosphate [35]. At site L4, water was also rich in leeches from the family *Erpodbellidae*; *Erpobdella octoculata* (L.), tolerant of oxygen deficits [28], high nitrate concentrations and water salinity [22], was the most numerous.

Plecoptera was represented by *Nemouridae, Perlidae* and *Perlodidae*. The families were found at sites located in the upper (sites L1 and L2) and the lower (sites L8–L12) reaches of the Liwiec River. In the Liwiec tributaries, only *Nemouridae* was noted: in the Muchawka at sites M1–M3, in the Kostrzyń at sites K1 and K3, and in the Osownica at sites O1 and O4. Among *Ephemeroptera*, nine families were observed, including the clean water ones: *Heptageniidae* (sites: L7–L12, K1, K4, K5, O2 – O4), *Leptophlebiidae* (sites: L8, L11 and L12, K1, K4, K5, O4) and some more tolerant ones: *Ephemerellidae* (sites: L2, L9–L12) and *Siphlonuridae* (site L9) [26, 27].

Diversity of macroinvertebrate communities in the Liwiec River and its tributaries allowed for testing various biotic indices, including BMWP-PL, developed especially for Polish rivers.

According to the BMWP-PL index [25, 32] the Liwiec (at most study sites) and its inflowing waters may be classified as pure (the 2nd quality class) and as moderately polluted (the 3rd quality class). Over the entire study period, the lowest values of the index were found at site L4, the water of which was classified as 4th quality.

The applied indices showed considerable discrepancy in the assessment of water quality of rivers studied. According to BBI, most sites were placed in the 2nd and the 3rd quality classes, as in the case of the BMWP-PL index. The values of BMWP/OQR were typical of the 1st and 2nd classes, and they indicated waters of excellent and very good quality. According to the IBGN index, studied waters were of poor or very poor quality (the 4th and 5th classes).

The results presented in this paper show the need to adjust biotic indices to environmental conditions characteristic of a given geographical region [17, 24].

The BMWP-PL and BBI indices seem to give the most accurate assessment of the studied rivers. Czerniawska-Kusza [9] noted values of BMWP-PL and BBI indices for the Nysa Kłodzka River and its tributaries similar to the values noted for the Liwiec and its tributaries. Lowland rivers, flowing across agricultural areas, are exposed to different types of pollution [e.g. 4]. Thus, they are quite unlikely to carry waters of excellent or very good quality, which, however, was shown in the assessment of the Liwiec waters quality based on BMWP/OQR index.

Biological methods indicate not only organic pollutants of waters, but also other forms of chemical pollution [15]. Our studies showed also a correlation between BMWP-PL index values and chosen chemical parameters of water, such as nitrate and phosphate concentrations and electrolytical conductivity. Lower values of the BMWP-PL index are related to higher values of the abovementioned chemical parameters. The relationships between selected chemical parameters of waters and biotic indices were noted by, for example, Fleituch [15], Cao *et al.* [8] and Czerniawska-Kusza [9].

The BMWP-PL index seems to be reliable for the assessment of lowland rivers water quality. This is confirmed by significant correlations between its values and the chemical parameters. This index is also quite simple in use – it requires identification of organisms to family (and not to genus, as e.g. BBI) [11]. It does not require the development of indicatory groups (as the French index) [30] that must include at least 3 and in some cases even 10 individuals. The BMWP-PL index does not set any limits on the number of individuals in a sample. Moreover, it does not require quantitative sampling, which is (e.g. using the Surber's net) sometimes difficult, particularly at sites of high and steep banks, or muddy and invisible bottoms. Such conditions occur at the Liwiec site L4, where sampling with Surber's net would be quite impossible. Low usefulness of this tool for sampling lowland rivers was reported by Solimini *et al.* [33] who applied it for sampling in the Tiber River.

Presented results are the first attempt at biological assessment of the water quality of the Liwiec River and its tributaries using the BMWP-PL index. They allow for the verification of the assumptions of BMWP-PL for the classification of lowland rivers and for the evaluation of relationships between chemical parameters of water and macroinvertebrate community composition.

The studies of the taxonomic composition of macroinvertebrates of chosen lowland rivers in Poland, for example, of the Liwiec River at its two sites [34] were carried out in 1999; their aim was the assessment of the influence of sewage treatment plants on the occurrence of macrofauna. On the basis of the obtained results the BMWP-PL index was developed [25].

Macroinvertebrate taxa found in the Liwiec and its chosen tributaries are typical of many lowland rivers in Poland. A similar taxonomic composition was noted by Czerniawska-Kusza [10] in the Nysa Kłodzka River, Kornijów and Lachowska [23] in the Bystrzyca Lubelska River, and Bis *et al.* [4] in the Grabia River. The taxa are also typical of Lithuanian rivers [31, 36].

According to the assumptions of the Water Framework Directive [13], the assessment of riverine water quality should involve not only physico-chemical parameters but also biological, morphometric, hydrographic, physiocoenotic indicators, and characteristics of a catchment. All these parameters contribute to the ecological classification of a river. In Poland, physico-chemical and biological parameters used in the assessment of river quality have already been prepared and are currently being put into practice. However, other parameters of ecological assessment of rivers are still underdeveloped. The results presented in this paper are, therefore, only a small part of a complex evaluation of lowland rivers.

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