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Research Article

ANALYSIS OF ECOLOGICAL STATUS OF SURFACE WATERS IN THE BYSTRZYCA RIVER IN LUBLIN

Antoni Grzywna[1], Krzysztof Jóźwiakowski[1], Magdalena Gizińska-Górna[1], Michał Marzec[1], Andrzej Mazur[1], Radomir Obroślak[1]

[1] Department of Environmental Engineering and Geodesy, University of Life Sciences in Lublin, Leszczyńskiego 7 Str., 20-069 Lublin, Poland, e-mail: antoni.grzywna@up.lublin.pl, krzysztof.jozwiakowski@up.lublin.pl, madziagizinska@tlen.pl, michal.marzec@up.lublin.pl, amazur70@op.pl, radomir.obroslak@up.lublin.pl

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ABSTRACT
The quality of surface water in watercourses in the region of Lublin agglomeration was studied in 2012–2014. Biological and chemical indicators of the study for various sampling sites were detected and the resulting values of the indicators were processed statistically. Rivers characterized by small size and the flow and modification of the riverbed. The resulting low values of macrophyte river index and infusorial index pointed to a poor quality of surface waters. Chemical indicators of the quality of surface waters reached low values, only BOD and phosphates reached high values. The river is located outside the city and it is characterized by moderate potential ecological (III quality class), and the river within Lublin is insufficiently potential ecological (IV quality class). Statistical analysis showed high variability index values between the studied positions.

Keywords: water, ecological status, region of Lublin, quality indicators.

INTRODUCTION

The most important ecological and economic task in the world is providing regular supplies of water in sufficient amounts and adequate quality. In Poland 190 litres of water are used per person per 24 hours. It is estimated that 100 litres per 24 hours is a sufficient amount for household purposes (Koc and Deska 2003). The evaluation of water quality requires determining physical, chemical and biological indicators.

The quality of water is unsatisfactory. However, starting from 1990's, it has regularly improved. A contributing factor was the fact that many industrial plants that caused considerable water pollution were closed and other plants changed their production technology. Numerous wastewater treatment plants constructed recently have been of significance and they have contributed to improving water quality [Rajda et al. 2008].

The river ecosystem is a whole combined in terms of functions and it is determined by variable physical and chemical conditions, which in turn leads to changes in fertility and productivity of biocenosis. In consequence, there are fluctuations within the structure and dynamics of respective groups of organisms and within the general cycle of respective elements [Radzka at al 2008]. The main environmental factors affecting the biocenosis of waters include temperature, light, content of oxygen, phosphorus, nitrogen, calcium, iron, carbon, organic substance and reaction [Augustynowicz et al. 2015].

According to Kajak [1998], water temperature has influence on the count of bacteria as this is a condition of biochemical processes for which they are responsible. On the other hand, the results of studies carried out by Świątecki [1997] indicate that the intensity of biochemical processes and thus bacterial count increase along with the temperature of water. It was also observed that the count of the analysed groups of bacteria increased along with the increase in the content of total organic carbon. As recounted by Kajak

[1998], the distribution of bacteria is the main source of organic substance dissolved in water. He also claims that the intensity of the occurrence of carbon in water is seasonal, which is conditioned by different supply in the vegetation period and in winter and weather changes throughout the year. According to Frąk [2010], excessive concentration of phosphorus contributes to the development of certain groups of microorganisms.

The purpose of monitoring surface waters is to obtain information about the status of waters in river basins for the needs of water management planning and evaluating the accomplishment of environmental goals. The ecological status of waters is determined by biological elements (phytoplankton, phytobenthos, macrophytes) and chemical elements (oxygen conditions, salt content, biogenic substances) (Rajda et al. 2010, Pietruczuk and Szoszkiewicz 2012, Grzywna 2010).

The changes in the quality of water were evaluated using the macrophyte and phytobenthos index and major physico-chemical parameters of waters in the rivers of the Lublin region. The aim of the work was to determine the ecological potential of watercourses using biological and chemical elements.

MATERIAL AND METHODS

The paper presents the results of surveys into the ecological status of Bystrzyca river (Lublin city region). Lublin is the largest city in Poland east of the Vistula, situated on the northern edge of the Wyżyna Lubelska, at 163–238 m above sea level. It is ranked ninth in Poland in terms of population, and 16-th in terms of area. The Bystrzyca Valley divides the city into two parts with separate landscapes: the left-bank portion forming a part of the Płaskowyż Nałęczów with a varied relief, deep valleys and old loess gorges and the right-bank portion forming a part of the Świdnicki Płaskowyż and the Giełczewska Wyniosłość, with flatter and less varied relief. Industry is mainly concentrated in the north-eastern and south-eastern parts of the city. Recreation grounds are concentrated in the south-western part of the city around lake Zemborzycki Artificial Lake. The Śródmieście is a compact area (GUS 2015, Kozyra 2002). In the 21st century the communes adjoining the city have been subject to intensive suburbanization – single-family housing. In 2013 ten wastewater treatment plants were in operation in the river Bystrzyca basin: 5 municipal and 5 industrial. Evaluation of the level of the risk of eutrophication caused by sewage effluents from municipal sources revealed that the phenomenon did occur.

On its 184 km the river Wieprz is supplied by the Bystrzyca being the largest left-bank tributary and the main river in the Lublin Upland. The Bystrzyca river has its spring in Cretaceous formations in Sulów at 232 m above sea level. The total length of the river is 70.3 km, and the area of the river basin 1315.5 km^2. In Osmolice the River Kosarzewka flows into 43th km of the river Bystrzyca. Within the city of Lublin three more tributaries flow into the river: Krężniczanka from the west, Czerniejówka from the south and Czechówka from the northwest. The River Bystrzyca, and its tributaries Czerniejówka and Czechówka, flow through Lublin city from the south to the northeast. The last tributary outside the city limits is Ciemięga. The Zalew Zemborzycki is situated on the river in the southern part of Lublin – a place for leisure and recreation, with a base of tourist and sports services (Michalczyk i Wilgat 1998). Below Spiczyn at 152 m above sea level it flows into the River Wieprz. The spring and flow is land use agriculture. Agriculture is the main source of pressure on the environment. The use of mineral fertilizers and pesticides leads to increased load of nitrogen and phosphorus compounds in waters.

Analyses were carried out at the following checkpoints on the rivers (fig. 1): Bystrzyca (1 – Osmolice, 48th km of the river, flow 2 m^3/s; 2 – Zemborzyce, 38th km; 3 – Dąbrowa, 34th km; 4 – Spiczyn, 5th km, flow 4,5 m^3/s, subcatchment 838 km^2) (Czarnecka 2005). Between 2012–2014 were analysed biological and chemical elements.

Biological indices were determined: Polish Macrophyte Index for Rivers (MIR) according to macrophyte species, diatom index (IO) according to the species of diatoms (Picińska-Fałtynowicz and Błachuta 2008; Szoszkiewicz et al. 2010). The following chemical indices were determined in water samples: pH, conductivity at 20^{o}C (Con), BOD_5, general hardness (Hard), total nitrogen (N), ammonia nitrogen ($N\text{-}NH_4$), nitrate nitrogen ($N\text{-}NO_2$), phosphates (PO_4), total phosphorus (P) (Grzywna 2010).

The planning of surface waters monitoring network was based on the regulation concerning the forms and method of monitoring of uniform parts of surface waters and ground waters. The quality of water was evaluated according

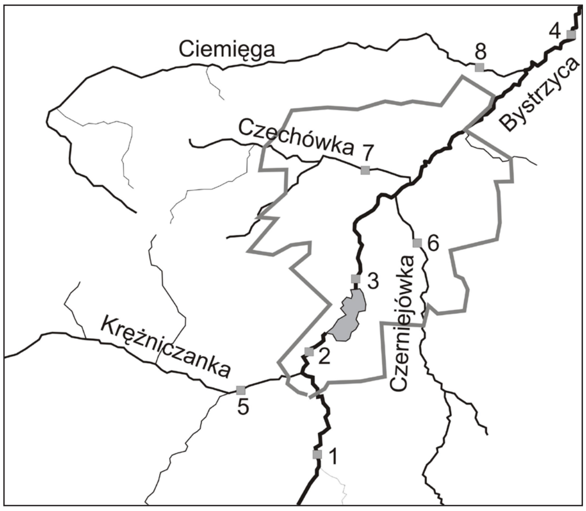

Figure 1. The hydrographic network in the region of Lublin. 1–8 location research points

to the regulation on the method of classification of uniform parts of surface waters and environmental quality standards for priority substances. The results obtained were processed by statistical methods including the determination of the differentiation of water quality ratios as regards the measuring site and the year of measurement. To this end, methods Anova analysed using Statistica 10 software.

RESULTS

It is assumed that the life of the analysed biological and physico-chemical elements in operating monitoring is 3 years. Every biological element has different sensitivity to pressure.

Diatom phytobenthos (IO) is a sensitive indicator of eutrophication. However, this is a short-term indicator referring to a river habitat. Short life cycles of diatoms and fast production rate prevent conclusions on long-term changes in the environment. On the other hand, these organisms quickly respond to the deteriorating condition of the environment. The IO values were average and they mostly ranged from 0.3 – 0.5. However, for site Zemborzyce the value was lower than 0.3 (tab. 1). In single cases for Osmolice site the index exceeded 0.5. Depending on the station and the year of study the watercourses are classified as waters of deferent quality classes. Diatoms were predominantly species with a wide range of ecological tolerance, often found in waters subject to anthropogenic pollution from surface run-off.

Depending on the year, MIR values made it possible to classify the watercourses into class II and III of water quality. The overall number of macrophyte species was average and ranged from 5 to 10. In the structure of dominance, the largest share was that of emergent macrophytes and pleustonic species. The structure of macrophyte species was typical of anthropogenic reservoirs or was subject to continuing influx of biogenic substances from the catchment area. MIR values most often ranged from 37 to 41. However, for site Zemborzyce they were lower than 37. Analysis showed biological indicators a no significant variability in values between the analysed sites. No significant variability in the values of indices was recorded between years (tab. 2).

The pH of water meeting the quality requirements should range from 6.5 to 8.5. The

Table 1. The mean values of the analyzed indicators of water quality

Point	IO	MIR	BOD_5	pH	Con	Hard	$N\text{-}NH_4$	$N\text{-}NO_2$	N	PO_4	P
1	0.500	40.93	2.33	7.8	491.6	301.3	0.090	2.15	3.15	0.277	0.150
2	0.291	36.53	2.90	7.4	518.6	316.3	0.128	2.55	3.77	0.363	0.170
3	0.461	39.36	7.36	7.1	358.0	288.3	0.183	1.23	2.52	0.167	0.153
4	0.332	38.40	4.90	7.9	552.3	237.6	0.271	1.97	3.46	0.297	0.213
Total	0.361	37.61	4.06	7.4	526.7	324.4	0.179	2.32	3.54	0.317	0.202

Table 2. Coefficients of variation for the analyzed indicators

Point	IO	MIR	BOD_5	pH	Con	Hard	$N\text{-}NH_4$	$N\text{-}NO_2$	N	PO_4	P
1	27.0	2.2	22.0	8.7	4.8	11.8	22.1	2.3	5.5	11.6	6.7
2	14.1	1.4	21.5	6.8	3.6	14.0	20.0	8.6	20.7	13.0	5.9
3	22.2	1.4	10.0	13.1	7.3	2.6	15.7	58.1	6.1	8.7	54.7
4	4.8	1.4	30.9	25.6	25.0	23.5	42.2	22.9	23.3	32.4	40.4
Total	27	7	45	23	20	21	47	40	27	39	38

most frequent reason for decreasing the pH of water is the acidifying effect of rainwater. Throughout the study period there were no records of exceeded reaction.

Water in the rivers can be considered hard as its general hardness at most study periods ranged from 300 to 400 mg $CaCO_3 \cdot dm^{-3}$ (tab. 1). The mean values of salt content from many years at the site below and above the city were 301 and 238 mg Ca-$CO_3 \cdot dm^{-3}$ respectively, which made the water eligible for class I.

In terms of BOD_5 at Dabrowa site, the mean value exceeded the acceptable limit (6 mg $O_2 \cdot dm^{-3}$) for class II. At sites Osmolice and Zemborzyce BOD_5 was within the range acceptable for waters of very good quality. At other sites surface waters were classified as II class of purity in terms of BOD_5. Statistical analysis revealed that biochemical oxygen demand was higher below Spiczyn site. Electrolytic conductivity was low in comparison to values acceptable for waters with class I ecological status.

In the river at Spiczyn site the mean concentrations of all biogenic indices were higher than recorded above the city at Osmolice site. Inorganic nitrogen occurs in nine forms, including most frequently compounds such as ammonia, nitrites, and nitrates. Nitrogen compounds in their different forms and depending on the concentration and environmental conditions pose a hazard because they can stimulate the growth of algae, reduce the level of dissolved oxygen and cause toxic effect on aquatic organisms. However, in the case of nitrate nitrogen the values were identical, while for other indices the concentrations were significantly higher from 1.3 (total nitrogen) to 2.5 times (ammonia nitrogen). Despite large differences between the sites the ecological status of water was very good since the average values of total nitrogen and ammonia nitrogen did not exceed standard limits for class I. The watercourses were most varied in terms of nitrate nitrogen content (limit value 2.2 mgN-$NO_3 \cdot dm^{-3}$) and total phosphorus (limit value 0.2 mgP$\cdot dm^{-3}$), and depending on the site waters were classified as purity class I or II. In the case of Kjeldahl nitrogen (1–2 mgN$\cdot dm^{-3}$) and phosphates (0.2–0.4 mg$PO_4 \cdot dm^{-3}$) the analysed waters are classified in quality class II.

CONCLUSIONS

The analysed river waters were characterised by very low content of ammonia nitrogen below 0.4 mgN-NH_4/l, total nitrogen below 5 mgN$\cdot dm^{-3}$, the pH in border at 6.5 to 8.5 and conductivity below 600 uS/cm. These values are characteristic of class I of water quality. The content of phosphates within the range 0.2–0.4 mg$PO_4 \cdot dm^{-3}$, nitrate nitrogen 2–5 mgN-$NO_3 \cdot dm^{-3}$ and phosphorus 0.2–0.4 mgP$\cdot dm^{-3}$ makes the analysed waters eligible for quality class II. BOD_5 in Zalew Zemborzycki continuously exceeded the limit value for class II – 6 mg $O_2 \cdot dm^{-3}$.

Irrespective of its recreational function the reservoir plays a positive role in increasing water resources and natural values of the landscape (Mioduszewski 2004). The significant problem in its management is the quality of water. As it is located within the catchment basin used for agricultural purposes, it accumulates biogenic substances and different pollutants (Rajda et al. 2008). As a result, the quality of water in the reservoir is deteriorated, and eutrophication and mudding occur. These phenomena can disturb rational utilisation of the reservoir and its functions (Wiatkowski and Paul 2009).

The results were considerably worse for biological indices. For MIR the index was poniżej 41, which made the waters eligible for quality class II. At Zalew Zemborzycki the value of the index lower than 37 made the water eligible for quality class III. For IO the index most often ranged from 0.3 to 0.4, which corresponds to class III of water purity. A decrease in the index below 0.3 in Zalew Zemborzycki made the water eligible for quality class IV. An increasein the index above 0.5 in Osmolice made the water eligible for quality class II.

The main reason for the poor ecological status of water was a high content of phosphates and a low diatom index. The largest variability in the value of the index was characteristic of the analysed watercourses for nitrate nitrogen and ammonia nitrogen and oxygen level. Anova analysis showed a significant variability in values between the analysed sites. In most cases no significant variability in the values of indices was recorded between years at respective stations, which is not applicable to phosphates and total phosphorus.

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