Water Quality Assessment of the Ruda River as Rybnik Special Resource

Elżbieta Dziubak, Zuzanna Błatoń, Szymon Szeliga

IV Liceum Ogólnokształcące im. Mikołaja Kopernika in Rybnik, Poland,

katarzyna.romaniuk@ivlorybnik.pl, hapy@interia.pl

Abstract

The subject of the study was the Ruda River (Upper Silesia, Poland). The research was based on the physicochemical and biological parameters in order to compare the quality of water in 2002 and 2013. The following physicochemical parameters were evaluated: transparency, pH level, dissolved oxygen, biochemical oxygen demand BZT5 and total phosphorus content. The Belgian Biotic Index (BBI) was used to identify the composition of the benthic macroinvertebrates. The studies were carried out in the spring (March- June) and autumn (September- October) cycles. The analysis of the results showed an improvement in water quality from 3 to 2 class. The areas around the Ruda River are increasingly used for Recreational purposes.

Keywords

macroinvertebrates, biotic indices, physical and chemical parameters

1. Introduction

Rybnik has a population of 141 thousand inhabitants and is situated in the Silesian Agglomeration in the south of Poland. Rybnik area is located in the basin of the Ruda River and belongs entirely to the Odra basin. The main and biggest body of water in the area is Rybnik Reservoir. It was built to provide and cool process water for Rybnik Power Plant (currently known as EDF Poland). Nowadays the reservoir, also called The Rybnik Sea, is not only an industrial facility but also a place essential from the nature study viewpoint. Moreover, it performs both flood control and recreational functions. [1] One of the most interesting facilities within Rybnik Reservoir is Gzel Reservoir which constitutes a natural habitat for the following characteristic species: yellow water-lily *(Nuphar luteum)*, frogbit *(Hydrocharis morsus)*, water arum *(Calla palustris)*, lesser wintergreen *(Pyrola minor)* and round-leaved wintergreen *(Pyrola rotundifolia)*. [2] Within the town there are some forms of nature conservation connected with hydrogenic habitats, among others the Landscape Park "Cistercian Landscape Compositions of Rudy Wielkie" [3] and ecological areas, eg "Okrzeszyniec". [4]

Rybnik constituted the centre of Rybnik Coal Area and so it was the core of mining and metallurgy industries. Energy, metal and food industries developed as well. Since 1990s intensive industrial restructuring processes [5] and actions aimed at improving the quality of surface waters have been operating. The main sources polluting the water flowing through the town were municipal sewage, agricultural waste, domestic and industrial waste, as well as wastewater falls and salty mine waters. [1] Rybnik's significant problem was caused by the lack of a sewage system – only the central part of the town (12% of the town surface) contained a sewerage. The lack of a sewage system in the remaining part of the town and insufficient wastewater treatment were the reasons for a big load of pollutants carried into the Ruda River and contaminating both the river and Rybnik Reservoir . This, in turn, had an influence on the poor water quality of the Odra River and finally led to the Baltic Sea pollution.

As a result of implementing the recovery processes mentioned above, the sewage treatment plant , built in 1970-1976 and located in Rybnik-Orzepowice, was expanded and modernized in 2000. [1] Currently it meets the requirements of both the Polish and the European Union Directives. In 2001 the project "Construction of the Sewage System in Rybnik" was started. [6] The expansion of the sewage treatment plant allowed to obtain the throughput of 27500 m3/d and the construction of the

sewage system enables to connect 150 thousand inhabitants to the target system. The ecological aim of the project was to reduce pollution and improve water quality of the Ruda River, Rybnik Reservoir and the Odra River as well as to protect the Landscape Park "Cistercian Landscape Compositions of Rudy Wielkie."

2. The purpose of investigation.

The purpose of the project is to monitor the condition of the Ruda River. We have been conducting research on the physicochemical and biological (BBI) assessment of water since 2002 when a youth project known as "Cascade" and aimed at monitoring surface waters was started. [7] The basis of the research is formed by the expectations of the improved quality of surface waters resulting from the projects which have been implemented in Rybnik, connected with the expansion of the sewage system.

The present report constitutes the comparison of the current river condition to its state in 2002. We aim to show that providing Rybnik with the sewage system and draining wastewater into the existing sewage treatment plant improve water quality and thus increase both the biodiversity and attractiveness of the area for recreational purposes.

3. Method

The 50,6-km-long Ruda River is a right tributary of the Odra River and has its source in Żory. It flows through the Cistercian Landscape Compositions of Rudy Wielkie and into the Odra River in the village of Turza. The sampling site was located above Rybnik Reservoir. [Fig.1]

Fig.1 Map of Rybnik reservoir in southern Poland

At this height the river is regulated and has a muddy bottom. The river banks are reinforced and covered with vegetation. The surrounding area contains meadows and reforested areas. There is a cycle path located along the Ruda River. The studies were carried out in the spring (March- June) and autumn (September- October) cycles.

According to the Polish standards, the following physical and chemical parameters were evaluated: transparency, pH level, dissolved oxygen, biochemical oxygen demand BZT5 and total phosphorus content.

The transparency was determined in the field using a Secchi disk suspended with a cord. The white disk is lowered into the water until it is no longer visible. That point is the Secchi disk depth which is the measurement of water transparency [9].

For the determination of phosphorus content a colorimetric method, with ammonium molybdenum and Tin (II) chloride as a reducing agent, was used. Determination of phosphorus in surface waters is very important, because large amounts of this compound get into waters with detergents and their excess causes eutrophication of waters [9].

An electrometric method using a pH meter was used to measure the pH.

The content of dissolved oxygen is one of the most significant indicators of water quality. The smaller content of dissolved oxygen, the bigger water contamination. To determine the content of dissolved oxygen we used the Winkler titration method [9].

Also the BZT5 indicator, defining the biochemical oxygen demand and indicating organic loading in wastewater, was determined. The dilution method was used [9]. The physicochemical research was carried out in the laboratories belonging to the Silesian University of Technology, the sanitary and epidemiological station, the sewage treatment plant and in our school laboratory.

On the basis of the obtained parameters, the water was classified to the appropriate class of water quality in accordance with the act of the Minister of Environmental Protection from Feb. 11, 2004 (Journal of Laws No 32, item 283 and 284, 2004] [8] [Table1].

Table 1. The admissible values of some physical and chemical parameters of surface waters, biotic indices: BBI, and related water quality classes.

Water quality indices	Surface water quality classes				
	1	2	3	4	5
Oxygen [mgO2dm-3]	≥7	6	5	4	<4
Phosphate [mgPO4dm-3]	≤0,2	0,4	0,7	1,0	>1,0
[pH]	6,5 – 8,5	6,0 - 8,5	6,0 - 9,0	5,5 – 9,0	< 5,5 , >9,0
BZT5 [O2dm-3]	2	3	6	12	>12
BBI	10-9	8-7	6-5	4-3	2-0
Water quality	very good – very clean waters	Good – clean waters	Satisfactory – slightly contaminated waters	Unsatisfactory – contaminated waters	Poor – highly contaminated waters

The biological studies included collecting macroinvertebrates and the analysis of their qualitative composition. The material was collected interchangeably on both sides of the river over a distance of about 20m, on the same day as the water for physicochemical determinations. The samples were taken with a scoop. Each time 5 samples were collected from the area of approximately 0,25m2. The collected species were preserved in alcohol (80%) and the taxonomic identification of macroinvertebrates was done with the usage of appropriate sources [10,11, 13].

The results of the macroinvertebrates analysis were used for the biological evaluation of the Ruda River water quality. We used the Belgian Biotic Index (BBI).

This index has been serving us for the determination of water quality on the basis of macrobenthos since the "Cascade" programme was started. Although in recent years a number of indices used to assess the biological condition of surface waters have appeared, including the BMWP-PL index, [13,14,15,16], the BBI index has several important advantages for us, namely, it is clear and based on the determination of particular taxa in macrobenthos. Different taxonomic groups should be marked to the level of family or genus in accordance with the guidelines. [Table 2] The biotic index is derived from the Standard Table for Calculation of the Belgian Biotic Index.**[**Table 3] Having determined the biotic index, we defined the water quality class. [Table 1]

Table 2. Practical limits to identify taxa in the **Belgian Biotic Index [12]**

Taxonomic group	Identification level of taxonomic groups
Plathyhelminthes	Genus
Oligochaeta	Family
Hirudinea	Genus
Mollusca	Genus
Crustacea	Family
PLecoptera	Genus
Ephemeroptera	Family
Trichoptera	Family
Odonata	Genus
Megaloptera	Genus
Hemiptera	Genus
Coleoptera	Family
Diptera	Family
Hydracarina	Presence

Fig.2 *Simulidae*

Table 3. Standard table for Calculation of the Belgian Biotic Index [12].

Indicator group	**Class frequency**	**Number of taxa**				
		0-1	**2-5**	**6-10**	**11-15**	**>16**
Plecoptera, Heptagenidae	≥ 2 1	- 5	7 6	8 7	9 8	10 9
Trichoptera	≥ 2 1	- 5	6 5	7 6	8 7	9 8
Ancylidae,Acroloxus, Ephemoptera (exc.Heptageniidae)	>2 1-2	- 3	5 4	6 5	7 6	8 7
Aphelocheirus, Odonata, Gammaridae, Mollusca (exc. Ancylidae, acroloxus, Sphaeridae, Corbicula)	≥ 1	3	4	5	6	7
Asellidae, Hirudinea, Sphaeridae, Hemiptera (exc. Aphelocheirus)	≥ 1	2	3	4	5	-
Tubificidae, Chironomidae thummi-plumosus	≥ 1	1	2	3	-	-
Syrphidae- Eristalinae	≥ 1	0	1	1	-	-

4. Results

The physicochemical parameters of the water in the Ruda river were averaged and presented in Table 4.

The obtained results were compared to the 2002 parameters. [Fig.3]

Table 4. The results of the physicochemical study of the water in the Ruda River in 2013.

	2013			2002
Water quality indices	Minimum value	Maximum value	Average value	Average value
Oxygen [mgO2dm-3]	7,2	12,1	10,5	6,5
Phosphate [mgPO4dm-3]	0,25	0,5	0,3	0,9
[pH]	6,9	7,9	7,1	6,0
BZT5 [O2dm-3]	1	5,5	3,5	9,4
Transparency [m]	0,55	0,65	0,60	0,48
Water class	----------	----------	2	3-4

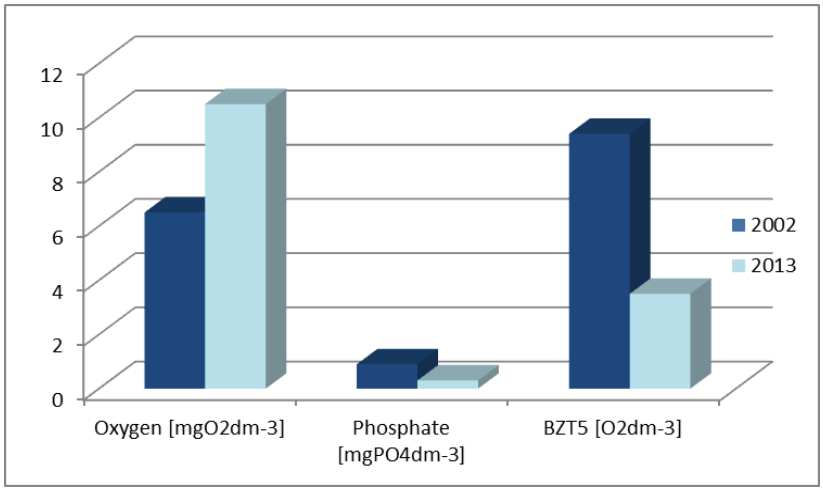

Fig 3. The comparison of the water parameters in the Ruda River during the years 2002-2013

In the Ruda River the presence of 17 taxa was revealed, belonging to Coleoptera, Hemiptera, Mollusca, Hirudinea, Crustacea, Odonata, Diptera, Oligochaeta (Table 5, Fig.3), which served for the determination of the water quality. The majority of taxa identified in the test area was characteristic for moderate clarity of waters and for waters characterized by a muddy or sandy bottom. The comparison of the taxa number to the year 2000 shows a significant rise of taxa (by 11 taxonomic groups) including Odonata and Hemiptera that were not present before. After the results were analysed, it was shown that the Ruda River could be currently classified, according to its biological condition, as being second class water which means the improvement of the water quality by one class compared to 2002.

Table 5 The summary of the designated macrobenthos. The comparison of the results to 2002

Taxon	2013	2002
Coleoptera		
Dytiscidae	+	-
Hemiptera		
Nepa	+	-
Mollusca		
Lymnaea	+	+
Pisidium	+	-
Anodonta	+	-
Hirudinea		
Glossiphonia	+	-
Helobdella	+	+
Eropobdella	+	+
Dina	+	-
Piscicola	+	-
Crustacea		
Asellidae	+	+
Odonata		
Libellula	+	-
Diptera		
Simuliidae	+	-
Culicidae	+	-
Chironomidae	+	-
Oligochaeata		
Tubificidae	+	+
Lumbriculidae	+	+
Taxa number	17	6
BBI index	7	5
Water class	2	3

5. Conclusion

Our research and observations have shown unambiguously that the water quality of the Ruda River has been gradually improving. Since 2002 oxygenation of the water has increased, there has been a decrease in the phosphate concentration which has led to a significant decrease in the oxygen consumption after 5 days (BZT5 has fallen from 9,4 (2002) to 3,5 (2013). The improvement of the physicochemical parameters is reflected in the biological condition of the Ruda River. There has been an increase in the biodiversity of organisms. The number of taxa groups of macroinvertebrates identified at the sampling site has risen by 11 since 2002.

The results of the measurements on the Ruda River are compatible with the tendency presented in the Report of the Regional Inspectorate for Environmental Protection. A gradual improvement of water quality has been noticed in the Silesia Province [17].

The obtained results and tendencies to the improving river condition allow to conclude that fewer pollutants, mainly municipal ones, flow into the regional waters as well as Rybnik Reservoir. It is extremely important in the context of the improvement of the ecosystems qualities as well as the local residents' living standards.

For several years intensive work has been carried out which is aimed at increasing the attractiveness of the area around Rybnik reservoirs:

- Along the Ruda River a recreation path, which is eagerly used by cyclists, runners and walkers, has been created;
- Canoeing events are organised on the Ruda River, which was impossible a few years ago due to the river condition;
- New projects are implemented to develop the areas around the waters for recreational purposes. This year several new investments are supposed to start operating, including the construction of new playgrounds, parks and recreation centres;
- Diving, fishing and sailing clubs are active on Rybnik Reservoir; sailing regattas are organised;
- The areas located near the water reservoirs constitute a significant venue where numerous outdoor photography competitions are held.

Our school, IV Liceum im. Mikolaja Kopernika, also contributes significantly to raising young people's ecological awareness and promoting an active lifestyle. For many years Environmental Awareness Workshops have been organised at our school as well as the annual "Raft" happening. Within the framework of the latter project students from Rybnik secondary schools make rafts from PET bottles. Next the rafts are used in regattas, the idea of which is to provide fun for students and integrate the local community. Finally, the rafts are dismantled and the PET bottles get recycled.

All the ecological and economical activities are designed to make the water areas more attractive. The improvement of water quality changes people's mentality and, as a result, they are more willing to protect the environment and take care of their own physical condition.

References

[1] Environmental Protection Programme for the City of Rybnik – act]

[2] The nature of Upper Silesia, 1997, nr 9, Centrum Dziedzictwa Przyrody Górnego Śląska

[3] Regulation of Katowice Governor No 181/93 from Nov. 23,1993 (Katowice Journal of Laws No 15, item 130).

[4] City Council Resolution No 836/XLIII/2002, the City of Rybnik, from Oct. 4, 2002 (Silesian Journal of Laws No 80/02, item 2898).]

[5] changes in surface water quality of the upper part of the Odra River basin as a result of the restructuring of the coal mining

[6] http://www.rybnik.eu/index.php?id=365] .

[7] Kaskada "Cascade" (2003-2010), Śląskie ABC

[8] Ordinance of the Minister of Environmental Protection of 11 Feb. 2004 concerning the classification which is used to present surface and underground waters state, and the ways of monitoring and interpreting the results and presenting the waters state (Journal of Laws No 32, item 283 and 284, 2004)

[9] Hermanowicz W. (1999) Physicochemical Research on Water and Sewage , Arkady, Warszawa, pp.54,159-160, 260-264, 333-334

[10] Rybak J.I.(2000) Freshwater Invertebrates. A guidebook. PWN, Warszawa pp.85

[11] Rybak J.I. (1986) A Guidebook for Identification of Freshwater Invertebrates. PWRiL, Warszawa pp.75

[12] De Pauw N., Ghetti P.F, Manzini P., Spaggiari R. (1992) Biological Assessment Methods for Running Water. In: Ecological Assessment and Control, P.J Newman, M.A. Pivaux, R.A. Sweeting (ed.), Comission of the European Communities, Brussels, pp.217-248

[13] Bis B., (2012) A Guidebook to Assessing the Ecological Condition of Rivers on the Basis of Benthic Macroinvertebrates, NFOŚ, Warszawa pp. 19-26

[14] Gorzel M., Korijów R., (2004) Biological Methods of River Water Quality Assessment, Kosmos, 2, pp.183-191

[15] Kownacki A., Soszka H., Fleituch T., Kudelska D.,(2002) River Biomonitorning and Benthic Invertebrate Communities, Institute of Environmental Protection, Warszawa-Kraków, pp. 71-88,

[16] Kułakowski P., Bieniek P., (2003) New Methods of Classification of Surface Waters in Poland. Technical Magazine/ Czasopismo Techniczne z.4-Ś, 200, pp.9-21

[17] The Regional Inspectorate for Environmental Protection, (2013), The State of the Environment in the Silesia Province in 2012, Biblioteka Monitoringu Środowiska, Katowice pp. 58-66