

ASSESSMENT OF WATER INFLOWING, STORED AND FLOWING AWAY FROM MŚCIWOJÓW RESERVOIR

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Summary

The hydrochemical analyses of water inflowing, stored and flowing away from Mściwojów water reservoir were conducted from April to November 2012. Measured were 27 physico-chemical indices of surface water sampled at 8 dates from four measurement-control points. Analysis of results revealed that water inflowing into Kałużnik river was the best quality – corresponded to class III, but only due to nitrate nitrogen. In the water Wierzbiak from the river, only two from among 16 indices exceeded class II (nitrate nitrogen and phosphates). Water in the reservoir was classified to quality class III because of the temperature and BOD₅, similar as water flowing away from the reservoir. Moreover, the paper assessed usable values of inflowing water, stored in the reservoir and flowing away from it. On the basis of the analysis, it was stated that water cannot be supplied to people since it does not meet the requirements stated in the Minister's regulations concerning the conditions of the natural habitat of cyprinids and salmonids.

Keywords

water quality • Wierzbiak river • Kałużnik river • usable values

Introduction

In view of the subject of on paper presented, it is necessary to state and assess changes of quality (features) of water flowing in the main watercourse but also water from the tributaries immediately feeding the reservoir. Generally, the current quality status of surface waters in Poland, particularly rivers is considered as poor. It is usually, the outcome of unbalanced water resources management, particularly the supply untreated or insufficiently treated sewage into rivers [Szczykutowicz et al. 2003, Krzanowski et al. 2005].

Water degradation is apparent as unfavourable changes of their physicochemical and biological features, both owing to introduction of excessive amounts of organic and inorganic substances and heated water discharge, or radioactive substances [Dobrzańska et al. 1997]. In result, the balance between pollutant concentrations caused by human activity and potential of self-purification of water environment

become disturbed. This was the cause of destruction and annihilation of numerous aquatic biocenoses, excessive increase in productivity and eutrophication of waters [Pawełek 2002].

Surface and underground waters are also polluted with other substances coming from various sources. These are both natural sources, such as: geological substratum, vegetation or atmosphere [Rajda et al. 2002] and anthropogenic. This would be connected with life and economic activities of humans [Rajda and Kanownik 2005]. Natural sources of pollution are less dangerous for water purity than anthropogenic ones. In villages, and farms the most dangerous are household wastewater and animal excrements (manure, slurry or liquid manure) but also landfill sites. Agricultural lands are perceived as one of the basic sources of area pollution [Taylor 1988, Ilnicki et al. 2002, Rajda and Kanownik 2007]. In these areas surface waters are polluted mainly due to the application of excessive doses of nitrogen and phosphorus fertilizers [Pawlik-Dobrowolski 1983, Grunert et al. 2004].

At the initial stage of operation, Dam reservoirs accumulate chemical substances inflowing from the catchment, including biogens. These may also function as a kind of treatment plants, biologically favourably changing physical features and chemical composition of waters below the reservoir. The result, water flowing away is generally more deficient in biogens but richer in organic matter. However, with time, the result of chemical elements release from bottom sediments, water reservoirs may become a hazard to the natural environment [Kostecki 1992].

Research on the chemistry and degree of pollution of Mściwój reservoir water is quite extensive [Czamara and Wiatkowski 2002, 2004, Czamara and Grześków 2008, Szafrąński and Stefanek 2008, Czamara et al. 2008, Dąbrowska 2008, 2010].

Concentrations of chemical elements and basic physical properties of water sampled from watercourses and the reservoir are assessed in the paper. On the basis of the data, on water quality indices, an attempt was made to assess the quality of water inflowing, stored and flowing away from Mściwój reservoir.

2. Material and methods

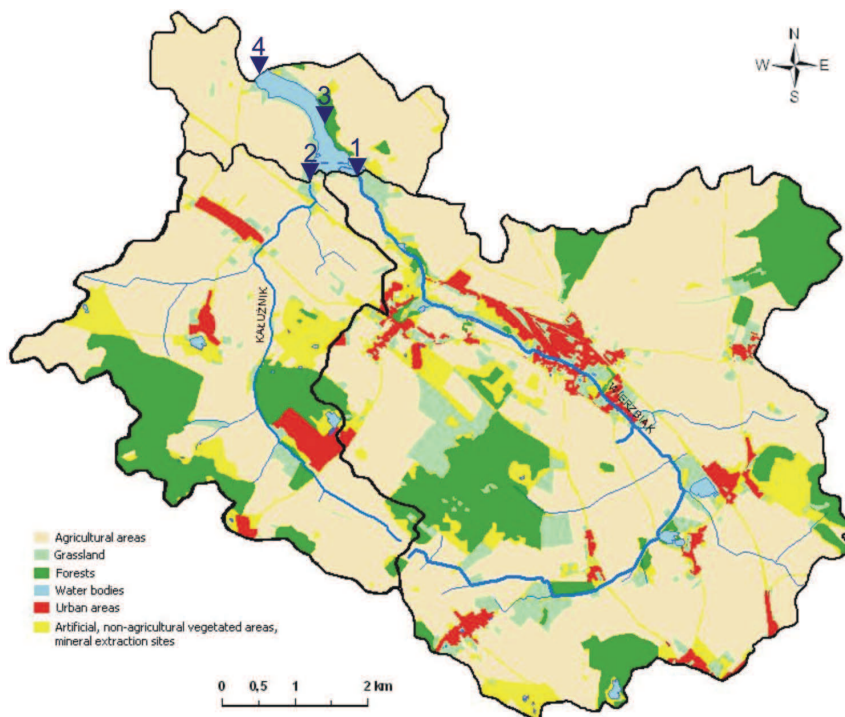
Quality of water in the Wierzbiak and Kałużnik rivers and in Mściwój reservoir were assessed on the basis of the Author's own physiochemical analyses. These were conducted during the period from April to November 2012. Water for analyses was sampled at one month intervals, on randomly chosen days, in measurement-control points situated in the following cross sections (Figure 1):

- inflow to the reservoir: the Wierzbiak river – point No. 1, the Kałużnik river – No. 2,
- outflow from the reservoir – point No. 3,
- outflow from the reservoir below the dam – point No. 4.

Assessed were 27 physicochemical indices. The temperature and oxygen saturation were measured on site by means of CO-411 oxygen meter, water reaction by means of CP-104 pehameter and electrolytic conductivity (EC) by CC-102 conduc-

tometer. In the laboratory, total suspended solids (TS) were determined using the gravimetric method, total dissolved solids (TDS) by evaporation, concentrations of Ca^{2+} , Na^+ , K^+ , Mg^{2+} , Mn^{2+} ions and content of Cr, Zn, Cd, Cu, Ni, Pb and Fe_{org} were assessed by means of atomic absorption spectrometry on UNICAM SOLAR 969 spectrometer. Concentration of ammonium nitrogen (N-NH_4^+), nitrite (N-NO_2^-), nitrate nitrogen (N-NO_3^-), PO_4^{3-} and Cl^- were determined by means of flow colorimetric analysis on FIAstar 5000 apparatus. Concentration of SO_4^{2-} was assessed using precipitation method, BOD_5 by Winkler's method while COD_{Mn} (oxidability) was determined by means of permanganate method [Hermanowicz 1999]. Also chlorophyll "a" was determined in water.

Minimum and maximum values were established for all indices and then arithmetic means were calculated. Water quality was assessed on the basis of the previous Regulations of the Minister the Environment, dated 20 August 2008. On the method of classification of the status of surface water bodies (Dz. U. Nr 162, poz.1008) because the new Regulation of the Minister of the Environment, dated 9 November 2011, is less exacting than the one mentioned above. Water usable values were estimated from the perspective of potable water supply [Rozporządzenie... 2002] and as fish habitat under natural conditions [Rozporządzenie... 2002].



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Fig. 1. Localization of measurement-control points

Table. Range and mean values of physicochemical features of inflowing waters (1 – Wierzbak river, 2 – Kałużnik river), stored (3 – main reservoir) and flowing away (4 – Wierzbak river) and assessment of its usable values

Index		Maximum-Minimum Average				Water quality class [8]				Usefulness of surface water											
										Drinking water [9]				As a natural environment for fish [10]							
						salmonids								cyprinids							
Measurement-control points																					
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Temperature	[°C]	$\frac{2,9-21,2}{12,1}$	$\frac{3,0-19,0}{11}$	$\frac{2,6-27,5}{15,1}$	$\frac{3,1-25,1}{14,1}$	I	I	III	III	A1	A1	no	no	yes	yes	no	no	yes	yes	yes	yes
pH		$\frac{7,00-7,98}{7,49}$	$\frac{7,04-8,01}{7,52}$	$\frac{7,20-8,72}{7,96}$	$\frac{7,19-9,09}{8,14}$	I	I	II	III	A1	A1	A2	no	yes	yes	yes	no	yes	yes	yes	no
EC	$\mu\text{S} \cdot \text{cm}^{-1}$	$\frac{296-578}{437}$	$\frac{360-490}{425}$	$\frac{288-560}{424}$	$\frac{462-545}{504}$	I	I	I	I	A1	A1	A1	A1	-	-	-	-	-	-	-	-
BZT ₅	[mg O ₂ · dm ⁻³]	$\frac{2,9-4,0}{3,5}$	$\frac{3,0-4,6}{3,8}$	$\frac{2,6-6,8}{4,7}$	$\frac{3,1-10,1}{6,6}$	II	II	III	III	A2	A2	A3	no	no	no	no	no	yes	yes	no	no
ChZT _{Mn}		$\frac{3,1-9,0}{6,1}$	$\frac{3,0-6,0}{4,5}$	$\frac{2,9-11,0}{7,0}$	$\frac{3,4-8,8}{6,1}$	II	I	II	II	A1	A1	A1	A1	-	-	-	-	-	-	-	-
O ₂	%	$\frac{55-75}{65}$	$\frac{53-64}{59}$	$\frac{47-80}{64}$	$\frac{64-67}{66}$	I	I	I	I	A1	A2	A1	A2	-	-	-	-	-	-	-	-

Dissolved solids	mg · dm ⁻³	$\frac{76-458}{267}$	$\frac{85-428}{257}$	$\frac{135-442}{577}$	$\frac{188-408}{298}$	I	I	I	I	-	-	-	-	-	-	-	-	-	-	
Total suspended solids		$\frac{1-2}{1,5}$	$\frac{3-5}{4}$	$\frac{0-0,6}{0,3}$	$\frac{2-3}{2,5}$	I	I	I	I	A1	A1	A1	A1	yes	yes	yes	yes	yes	yes	yes
N-NH ₄ ⁺		$\frac{0,03-0,05}{0,04}$	$\frac{0,08-0,453}{0,27}$	$\frac{0,08-0,10}{0,09}$	$\frac{0-0,09}{0,05}$	I	I	I	I	-	-	-	-	yes	yes	yes	yes	yes	yes	yes
N-NO ₃ ⁻		$\frac{0,28-5,26}{2,77}$	$\frac{0,34-14,78}{7,56}$	$\frac{0,0-0,10}{0,05}$	$\frac{0,03-0,07}{0,05}$	III	III	I	I	-	-	-	-	-	-	-	-	-	-	-
NO ₂ ⁻		$\frac{0,04-0,19}{0,62}$	$\frac{0,03-1,87}{0,95}$	$\frac{0,00-0,03}{0,01}$	$\frac{0,00-0,04}{0,02}$	-	-	-	-	-	-	-	-	no	no	no	no	no	no	yes
PO ₄ ³⁻		$\frac{0-0,42}{0,21}$	$\frac{0,11-0,27}{0,19}$	$\frac{0,05-0,26}{0,16}$	$\frac{0,04-0,27}{0,16}$	III	II	II	II	A2	A1	A1	A1	-	-	-	-	-	-	-
P _{total}		$\frac{0-0,24}{0,12}$	$\frac{0,04-0,09}{0,07}$	$\frac{0,02-0,08}{0,05}$	$\frac{0,01-0,09}{0,05}$	II	I	I	I	-	-	-	-	no	yes	yes	yes	yes	yes	yes
SO ₄ ²⁻		$\frac{31-109}{70}$	$\frac{43-111}{77}$	$\frac{27-110}{69}$	$\frac{32-105}{69}$	I	I	I	I	A1	A1	A1	A1	-	-	-	-	-	-	-
Fe ^{2+/3+}		$\frac{0,11-0,21}{0,16}$	$\frac{0,09-0,15}{0,12}$	$\frac{0,05-0,08}{0,07}$	$\frac{0,03-0,05}{0,04}$	-	-	-	-	A1	A1	A1	A1	-	-	-	-	-	-	-
Mn ²⁺		$\frac{0,03-0,06}{0,05}$	$\frac{0,02-0,03}{0,03}$	$\frac{0,04-0,05}{0,05}$	$\frac{0,0-0,02}{0,01}$	-	-	-	-	A2	A1	A1	A1	-	-	-	-	-	-	-
Ca ²⁺		$\frac{16-62}{39}$	$\frac{15-60}{38}$	$\frac{20-57}{39}$	$\frac{30-56}{43}$	I	I	I	I	-	-	-	-	-	-	-	-	-	-	-
Mg ²⁺		$\frac{2-16}{9}$	$\frac{3-12}{8}$	$\frac{4-5}{5}$	$\frac{5-17}{11}$	I	I	I	I	-	-	-	-	-	-	-	-	-	-	-
Cl ⁻		$\frac{14-54}{34}$	$\frac{5-38}{22}$	$\frac{10-62}{36}$	$\frac{11-61}{36}$	I	I	I	I	A1	A1	A1	A1	-	-	-	-	-	-	-

EC – Electrolytic conductivity, A1– water requiring simple physical treatment, A2 – water requiring typical physical and chemical treatment, A3 – water requiring high-performance physical and chemical treatment

3. Results

Considering their thermal characteristics, the analyzed water samples were classified to quality class III (points 3 and 4), except points 1 and 2, where water was in class I (see Table).

Values of the natural river water reaction, oscillate around neutral. It is connected with calcium concentrations in water, which are small at high but big at low CaCO_3 content [Chelmiński 2002]. In the Wierzbiak and Kałużnik rivers (direct tributaries to Mściwój reservoir), water pH ranged from 7 to 8.01, i.e. in class I. Water in the reservoir revealed the reaction similar to alkaline (8.72) but already on the outflow from the reservoir the reaction was alkaline (9.09). Therefore, this classifies the water to class III according to the regulation of 2008 [Rozporządzenie... 2008]. In neither of the investigated points, electrolytic conductivity exceeded $1000 \mu\text{S} \cdot \text{cm}^{-1}$ – i.e. the value permissible for I class quality. BOD_5 concentrations in the Wierzbiak and Kałużnik river waters were similar and placed them in II quality class, whereas water stored and flowing away from the reservoir to class III. The degree of oxygen saturation, dissolved solid concentration, total suspended solids and ammonium nitrogen corresponded to water quality class I in all studied points. Regulations of 2008, which takes into consideration nitrate nitrogen, classifies waters of the Wierzbiak and Kałużnik rivers as quality class III. Phosphate concentrations placed water at all points to class II, except point 1, where the concentration exceeded values permissible for class III. The total phosphorus concentration slightly exceeded the limit for class I only in point 1, whereas in the other points in remained on the level of class I. Water assessment in the analyzed points, conducted on the basis of minerals values (sulphates, chlorides, magnesium and calcium) revealed that they did not exceed permissible values for water quality for class I on any date of measurement (see Table).

According to the regulations in force, on water usability for potable water supply, three out of 12 analysed indices (temperature – point 1,2, water pH and BOD_5 – point 4) do not meet the requirements stated for these categories in the regulations of 2002 [Rozporządzenie... 2001] (see Table). Water in measurement-control point 3 was classified to A3 category because of BOD_5 concentrations, whereas to A2 category due to concentrations of manganese and phosphates in point 1, degree of oxygen saturation (in points 2 and 4) and water pH only in point 3. Values of the other indices were in the A1 category. Summing up: when analyzed water was to be used for water supply, it should be taken only from points 1 and 2 and only used after typical physical and chemical treatment appropriate for A2 category.

Water analyzed in measurement-control points, does not meet the requirements for salmonid or cyprinid fish habitat. According to the regulations of 2002 in-force [Rozporządzenie... 2002], BOD_5 and nitrite concentrations exceeded values permissible for both fish species in almost all analysed points, except points 1 and 2 for the oxygen index and point 3 for nitrites (see Table). Considering living conditions for salmonids, in points 1 and 3, only four among 7 analysed indices meet the standards, five indices in point 2 and three indices in point 4. On the other hand, considering cyprinids, water of the studied river section in points 1,2 and 3 might provide a viable habitat for them due to six indicators and in point 4 – due to four indicators.

Average content of chlorophyll "a" in the Wierzbiak river water (point 1) was $2.4 \mu\text{g} \cdot \text{dm}^{-3}$, $0.2 \mu\text{g} \cdot \text{dm}^{-3}$ in the Kałużnik (point 2), $73.4 \mu\text{g} \cdot \text{dm}^{-3}$ in the reservoir (point 3) and $35.52 \mu\text{g} \cdot \text{dm}^{-3}$ on the outflow from the reservoir (point 4).

4. Conclusion

Water quality and the resulting usable values change with the changing anthropogenic pressure in the catchment area [Rajda and Kanownik 2007, Ilnicki et al. 2002]. Pollution may be counteracted through sanitation of settlement areas. This would require construction of sewerage system and efficient sewage treatment plants [Ostrowski et al. 2005]. Quality of water in Mściwoj reservoir was affected mainly by surface runoffs from the nearest reservoir catchment which comprise forests, arable fields, meadows and pastures and also by precipitation.

Analysis of the research results, revealed that water flowing with the Kałużnik river was of the best quality – categorised to class III but only due to nitrate nitrogen. In the water of the Wierzbiak river, only two (nitrate nitrogen and phosphates) among 16 indices exceeded values for class II. Similarly in the reservoir, where the temperature and BOD_5 water was classified to quality class III. On the outflow from the reservoir, the water was revealed the worst quality because of its temperature, pH and BOD_5 – class III. All inflowing water should be monitored because it feeds the Mściwojów water reservoir. The which fulfils numerous functions, including a recreational one. Moreover, it also provides a refuge for avifauna [<http://lto.most.org.pl>] and habitats of rare wetland and aquatic plants. The waters flowing away from the reservoir should also be monitoring. They affect the quality of the Wierzbiak river water below the reservoir.

Studies on usable values of water inflowing, stored and flowing away from the reservoir demonstrated that they cannot be used for water supply because of high temperature and water pH and BOD_5 concentration. Moreover, on the inflow to the reservoir, the Wierzbiak river does not meet the requirements for natural salmonid habitat because of BOD_5 , nitrites and total phosphorus. The Kałużnik river only exceeded concentrations of nitrites and total phosphorus. Waters of the Wierzbiak and Kałużnik rivers may provide natural habitat conditions for cyprinids due to six indices: the temperature, BOD_5 , total suspended solids, ammonium, nitrate nitrogen and total phosphorus. One of the analyzed indices, did not meet the requirements posed in the regulations in force of 2002 [Rozporządzenie... 2002]. Conclusion, each analysed point values permissible for fish habitats as stated in the regulation in force, were exceeded.

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