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Quality Analysis of Waters from Selected Small Watercourses within the River Basins of Odra River and Wisła River

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1. Introduction

Eutrophication of inland waters, in connection with increase in phosphorus (P) and nitrogen (N) content is a global issue, especially in agricultural areas. Excessive increase in the content of mineral components in rivers is the result of such substances being carried from the areas of intensive agriculture (Withers et al. 2008). Increase in nitrogen and phosphorus content causes fluctuations in water quality, and the excess of nutrients promotes the growth of phytoplankton (water blooming) and macrophytes, resulting in loss of habitats and beneficial species of plants and animals (Smith 2003). In 19th ct. Europe this process was considered as a significant environmental protection issue and it continues to be a long-term challenge to sustainable management of aquatic ecosystems (Leaf, 2017). This resulted in undertaking a number of water quality tests for major rivers and their major tributaries, including their content of anthropogenic mineral ingredients – mostly of farming origin (Domagała & Kondratowicz 2006, Dupas et al. 2015) and investigating the possibility of reducing such content (Keck & Lepori 2012). It needs to be stressed that small tributaries - watercourse of third and higher orders, lay a material role in shaping the quality of water in large rivers (Alexander et al. 2007). Small watercourses located within agricultural areas play an important role in water retention; they are used in economy and improve the landscape value. They also form a refugium for multiple species of aquatic plants and animals, and affect the biodiversity of land (Williams et al. 2003). In addition, it is commonly known that small watercourses play critical role in biogeochemical connectivity of aquatic and terrestrial ecosystems and are a vital part of the macrocomponent supply line to a receptacle – a higher-order river (Withers & Jarvie 2008). Usually they bring in disproportionally higher quantity of biogenic substances than contained in the receptacle, and despite being thinned they still constitute a serious source of charge causing degradation of water quality (Biggs et al. 2017, Kelly-Quinn et al. 2017). In spite of that, as compared with larger rivers, European countries do not have systems in place for strategic monitoring of physical and chemical properties of small watercourses (Biggs et al. 2017, Lassaletta et al. 2010). Also in Poland, except for a few studies (Liberacki & Szafrański 2008, Sojka et al. 2016), no comprehensive evaluation of the volume of charge carried by small rivers to higher-order rivers, including its potential impact.

The purpose of this study is to assess the ecological status of small watercources of lowlands tributaries of Odra and Wisła rivers on the basis of selected concentrations of physicochemical parameters (nitrogen and phosphorus compounds).

2. Study area

Studies were conducted on 10 small watercourses within the Odra river basin and Wisła river basin (Fig. 1). In the north-western section of Odra river basin, the following rivers were selected for the study: Płonia, Myśla, Tywa, Rurzyca and Wardynka, and in Central Poland the area of Wisła river basin was represented by Kanał Habdziński, Zielona, Czarna-Cedron, Kraska and Molnica. Three measuring stations were established on each river, mostly on agricultural land.

The characteristics of the adjacent areas were based on calculations in the QGIS program using data of Corine Land Cover.

In the catchments of all 10 examined rivers, land cover was mainly agricultural. This particularly concerned rivers in the central part of Poland (B), where the catchment areas of the Molnica and Kraska rivers were dominated by agricultural land (Kraska 88.3% and Molnica 84.2%). The catchment areas of the Habdziński Canal were also dominated by agricultural areas (79.1%), but anthropogenic areas (16.8%) also had a significant share. The catchment areas of the Zielona and Czarna Cedron rivers, apart from agricultural areas (72.6% and 60.9%, respectively) also consisted of forests and semi-natural ecosystems (20.8% and 30.8%). Areas in western Poland (A) were also dominated by agricultural areas (in the catchments of all rivers in this region, it constituted over 50% of the area coverage).

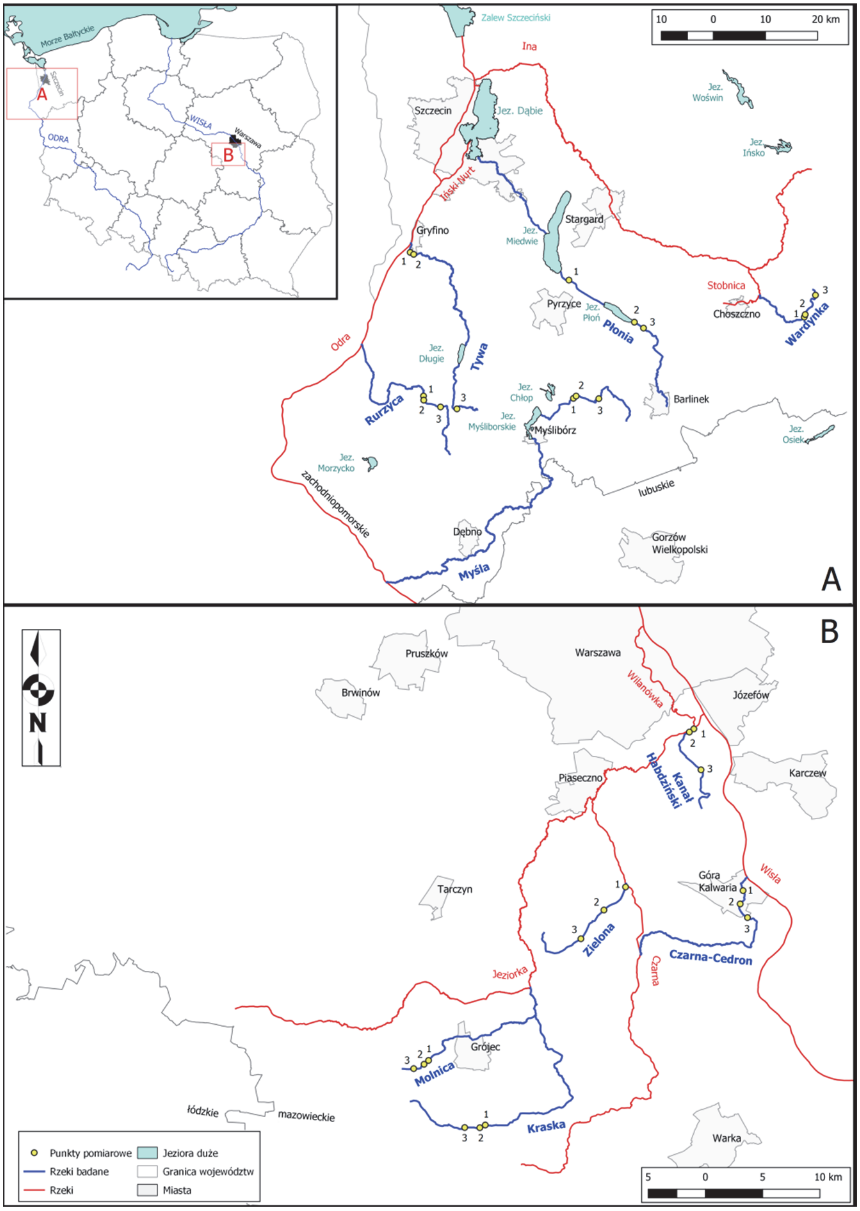

Fig. 1. Location of small rivers in the Odra (A) and Wisła catchments (B)

In the Płonia river catchment area 73.5% was agricultural, 5.2% was anthropogenic and 4.7% was water area. In the catchment areas of the Tywa and Wardynka rivers, apart from agricultural areas (constituting over 65%), forested areas (approx. 30%) and a small amount of anthropogenic areas were annotated. However, despite the fact that the river basin Myśla and Rurzyca dominated by agricultural land (over 56%), a significant part they are also forests and natural ecosystems.

Characteristics of individual rivers are shown in Table 1.

Table 1. Characteristics of small watercourses of the Odra and Wisła catchments

Name of the watercourse	Total surface of the watercourse [km^2]	Total length of the watercourse [km]	Average decrease for positions [‰]	Average depth* [m]	Abiotic type of surface waters (according to the Regional Inspectorate for Environmental Protection Szczecin and Warsaw
Odra catchment					
Płonia	1 129.0	73.0	2.7	0.84	23
Myśla	1 298.0	104.0	3.6	0.31	20
Tywa	264.5	47.9	1.9	0.40	16
Rurzyca	430.7	44.4	2.3	0.44	24
Wardynka	101.2	21.3	2.8	0.20	18
Wisła catchment					
Kanał Habdziński	28.1	9.9	0.9	0.43	17
Zielona	37.0	11.6	1.1	0.16	17
Czarna-Cedron	71.0	15.5	0.5	0.70	17
Kraska	36.0	11.5	3.7	0.21	17
Molnica	59.0	15.5	3.9	0.07	17

*own measurement (average of all positions)

3. Material and methods

Field examinations were conducted within the 2018 vegetation period (Apr to Oct). Temperature and pH of water were measured directly in the field, using the multi-parameter mobile measuring instrument HACH, also dissolved oxygen (DO) content was measured (multi-parameter measuring instrument Multi 3400 by WTW with oxygen probe type Cellon 323 was used). Also, field measurements were accompanied by taking water samples (3 samples from each station) every 30 days from rivers subject to study. Test samples were taken in compliance with the applicable standards. Concentration in water was determined: $N\text{-}NO_3^-$, $N\text{-}NH_4^+$ and $P\text{-}PO_4^{3-}$. Concentrations of nitrogen and phosphorus forms were determined by the Environmental Chemistry Research Laboratory of ITP in Falenty by colorimetric method, using automatic flow analyzer manufactured by Skalar. In addition, depth was determined at individual measuring stations, using measuring staff.

Water quality indices have been evaluated with reference to requirements included in the Regulation by Minister of Environment of July 21, 2016 on classification of the state of uniform parts of surface waters and on environmental quality standards for priority substances (JoL 2016 item 1187). Water test results were statistically processed in the software tool Statistica 12.5 PL. Since the data obtained failed to meet the assumptions necessary to conduct the variance analysis (i.a. no normal distribution, no homogeneity of variance), Kruskal-Wallis test ($p < 0.05$) has been used to determine statistically significant differences.

4. Results and discussion

Physical and chemical properties of river waters change in time and space, resulting in continuity of ecological processes and gradient nature of river zones, so-called river continuum (Vannote et al. 1980, Neal et al. 2006). Width and depth of river bed, inflow of biogens, temperature, general suspended matter, oxygen content, as well as the water flow rate change continuously from the river-head to the river mouth (Kanclerz et al. 2018). Since matter and energy are transferred with the flow of a water course, gradual increase in concentration of substances dissolved in water is natural. Such factors as change in decline and flow rate, land improvement related reshaping of river bed, contamination of waters, hydro-engineering structures may interfere with the concept of river continuum. Small watercourses – tributaries to higher-order river, may supply waters of such river with organic matter and pollutants.

When analyzing results of water quality tests from waters of five (5) rivers within Odra river basin, four water quality indicators out of seven, namely conductance, dissolved oxygen, $N\text{-}NO_3^-$ and $P\text{-}PO_4^{3-}$ concentration, were elevated and failed to meet the requirements as per Regulation by ME of 21/07/2016 (Tab. 2). The highest, 15-fold excess of the permitted content of phosphate phosphorus (≤ 0.101 mg $P\text{-}PO_4\cdot dm^{-3}$ for water quality class II) was recorded in waters of Płonia river. It is probably connected with local dumping of fertilizer compounds, noted in its upper course. Differences between obtained concentrations of phosphate phosphorus were statistically significant from those recorded for rivers Myśla, Tywa and Rurzyca. In the latter one, however, nearly 4-fold exceeding of permitted $N\text{-}NO_3^-$ content (≤ 1.7 mg $N\text{-}NO_3^-\cdot dm^{-3}$ for water quality class II) was observed. Elevated values of $N\text{-}NO_3^-$ and $P\text{-}PO_4^{3-}$ has impact on low content of oxygen dissolved in waters of examined rivers. It was in the range 1.16 $mg\cdot dm^{-3}$ (item 3, river Myśla) to 6.27 $mg\cdot dm^{-3}$ (item 2, river Tywa) and at no point did it meet the requirements of water quality class II (Tab. 2). In the context of the regulation in force, considering mean values of electrolytic conductance of waters from those 5 rivers, a slight exceeding of limit value for water quality cat. II, which has been observed in, Tywa and Wardynka, and in Myśla and Rurzyca the limit value has been exceeded by 53.3 and 73.6% respectively. Values of remaining indices, as per requirements in the regulation, were not exceeded and complied with requirements for water quality class I and II (Tab. 2).

Having assessed the quality of those 5 rivers, it is waters of Rurzyca river that carry the largest quantities of pollutants. This is probably due to local dumping of municipal sewage recorded by stations 1 and 2, whereas station 3 was located at the municipal sewage treatment plant.

Table 3 presents the results of water quality analysis for small rivers of Wisła river basin. As is the case with Odra river basin, indices that complied with the requirements of water quality class I and II in Regulation by ME of 21/7/2016 were temperature, pH and $N\text{-}NH_4^+$ content. Considering mean values of electrolytic conductivity, the highest mean value was observed in waters of river Kraska (813 µs/cm), and the lowest in waters of Czarna Cedron (519 µs/cm) and only in the latter water course values obtained complied with requirements for water quality class I as per the a.m. regulation (≤ 549 µs/cm). Small quantity of oxygen dissolved in water was observed in all watercourses of the Wisła river basin. Mean values were in the range 3.96 to 5.63 $mg\cdot dm^{-3}$ and differences between them were not statistically significant (Tab. 3).

Table 2. Average values and standard deviation (SD) of physico-chemical parameters at individual research stations located on selected watercourses of the Odra river catchment

Water-course	P	Temp °C	pH	EC [µs/cm]	O_2 [mg·dm^{-3}]	N-NO_3^- [mg·dm^{-3}]	P-PO_4^{3-} [mg·dm^{-3}]	N-NH_4^+ [mg·dm^{-3}]
Płonia	1	16.0	7.9	552	4.85	3.973	1.230	0.169
	2	15.0	7.9	555	5.25	4.530	1.278	0.123
	3	14.4	7.9	585	5.52	4.385	2.008	0.114
	avg.	**15.2^{bc} ±0.8**	**7.9^{a} ±0.1**	**564^{a} ±18**	**5.21^{a} ±0.34**	**4.296^{ab} ±0.289**	**1.505^{b} ±0.437**	**0.135^{a} ±0.030**
Myśla	1	15.8	8.0	656	5.68	2.983	0.417	0.090
	2	14.2	7.5	772	4.13	5.645	0.453	0.091
	3	15.0	7.4	954	1.16	2.023	0.335	0.070
	avg.	**15.0^{bc} ±0.8**	**7.7^{a} ±0.3**	**794^{bd} ±150**	**3.66^{a} ±1.90**	**3.550^{a} ±1.877**	**0.401^{a} ±0.006**	**0.084^{a} ±0.012**
Tywa	1	13.7	7.9	606	6.0	4.632	0.420	0.087
	2	15.0	8.1	601	6.27	5.597	0.597	0.111
	3	13.5	7.6	879	3.99	2.103	0.650	0.080
	avg.	**14.0^{ac} ±0.8**	**7.7^{a} ±0.2**	**695^{ab} ±159**	**5.42^{a} ±1.25**	**4.101^{ab} ±1.793**	**0.555^{a} ±0.120**	**0.092^{a} ±0.016**

Table 2. cont.

Water-course	P	Temp °C	pH	EC [µs/cm]	O_2 [mg·dm^{-3}]	N-NO_3^- [mg·dm^{-3}]	P-PO_4^{3-} [mg·dm^{-3}]	N-NH_4^+ [mg·dm^{-3}]
Rurzyca	1	14.8	7.4	886	3.07	6.997	0.533	0.127
	2	14.2	7.6	855	4.97	8.428	0.703	0.672
	3	14.0	7.5	740	3.84	6.537	0.470	0.251
	avg.	**14.5^{bc} ±0.4**	**7.5^{a} ±0.1**	**828^{bd} ±77**	**3.96^{a} ±0.96**	**7.321^{b} ±0.987**	**0.643^{a} ±0.247**	**0.350^{a} ±0.285**
Wardynka	1	12.8	7.8	594	5.96	4.375	1.183	0.089
	2	12.2	8.0	627	6.19	4.000	1.073	0.093
	3	12.4	7.5	608	2.57	2.903	0.510	0.221
	avg.	**12.5^{a} ±0.3**	**7.8^{a} ±0.3**	**610^{ae} ±16**	**4.90^{a} ±2.0**	**3.759^{a} ±0.765**	**0.922^{ab} ±0.361**	**0.134^{a} ±0.075**

Colour coded: green – values conforming to requirements concerning water in water quality class I, yellow – in class II, red – above class II. Variance analysis ANOVA $p < 0.05$; mean values in verses marked with the same do not differ statistically significantly at $p > 0.05$ (Kruskal-Wallis post-hoc test)

Table 3. Average values and standard deviation (SD) of physico-chemical indicators determined at individual research stations located on selected watercourses of the Wisła river basin

Waterco-urse	P	Temp °C	pH	EC [µs/cm]	O_2 [mg·dm^{-3}]	N-NO_3 [mg·dm^{-3}]	P-PO_4^{3-} [mg·dm^{-3}]	N-NH_4^+ [mg·dm^{-3}]
Kanał Habdziński	1	17.6	7.4	611	5.32	5.295	0.980	0.520
	2	17.2	7.4	558	5.71	4.893	0.615	0.162
	3	15.7	7.0	519	3.52	4.297	0.958	0.198
	avg.	**16.8^{ab} ±1.0**	**7.3^{a} ±0.3**	**562^{abc} ±46**	**4.85^{a} ±1.17**	**4.828^{a} ±0.502**	**0.851^{b} ±0.205**	**0.293^{a} ±0.197**
Zielona	1	18.8	7.4	529	6.02	3.892	0.083	0.084
	2	18.1	7.5	566	5.72	4.422	0.752	0.111
	3	17.2	7.3	671	5.16	2.315	0.553	0.083
	avg.	**18.0^{b} ±0.8**	**7.4^{ab} ±0.1**	**589^{abc} ±74**	**5.63^{a} ±0.44**	**3.543^{a} ±1.096**	**0.462^{ab} ±0.344**	**0.093^{a} ±0.016**
Czarna Cedron	1	17.7	7.3	543	5.18	2.990	0.060	0.164
	2	18.8	7.2	527	3.88	2.363	0.069	0.073
	3	19.0	7.2	486	3.64	2.598	0.037	0.107
	avg.	**18.5^{b} ±0.7**	**7.2^{a} ±0.1**	**519^{a} ±29**	**4.23^{a} ±0.83**	**2.651^{a} ±0.317**	**0.055^{a} ±0.017**	**0.115^{a} ±0.046**

Table 3. cont.

Watercourse	P	Temp °C	pH	EC [µs/cm]	O_2 [mg·dm^{-3}]	N-NO_3 [mg·dm^{-3}]	P-PO_4^{3-} [mg·dm^{-3}]	N-NH_4^+ [mg·dm^{-3}]
Kraska	1	15.4	7.7	835	3.98	3.495	0.288	0.118
	2	15.5	7.7	782	4.71	4.303	0.352	0.117
	3	15.0	7.6	822	3.44	3.923	0.871	0.119
	avg.	**15.3[a] ±0.3**	**7.7[ab] ±0.1**	**813[c] ±28**	**4.04[a] ±0.64**	**3.907[a] ±0.404**	**0.503[ab] ±0.320**	**0.118[a] ±0.001**
Molnica	1	16.7	7.7	621	4.53	7.638	2.253	0.049
	2	16.8	7.6	988	2.46	4.478	1.753	0.084
	3	15.2	8.0	609	4.88	3.160	2.063	0.088
	avg.	**16.2[ab] ±0.9**	**7.8[b] ±0.2**	**739[abc] ±215**	**3.96[a] ±1.31**	**5.092[a] ±2.301**	**2.023[c] ±0.252**	**0.074[a] ±0.022**

Markings as in Table 1

Very high excesses were noted for concentrations of $N\text{-}NO_3^-$ and $P\text{-}PO_4^{3-}$. The highest mean value of $P\text{-}PO_4^{3-}$ was obtained for Molnica river. It exceeded the limit value for water quality class II as much as 20-fold ($P\text{-}PO_4^{3-} \leq 0.101\ mg \cdot dm^{-3}$ for water quality class II). This small watercourse was fully covered by aquatic vegetation, which often accumulates charges of nitrogen and phosphorus (Ilnicki 2014). Also, the depth of Molnica river was the smallest, reaching on average as little as 0.07 m (Tab. 1). In Czarna Cedron river, the concentration of $P\text{-}PO_4^{3-}$ was small – 0.055 $mg \cdot dm^{-3}$, and consistent with requirements for water quality class I (Tab. 3). The lowest concentration of $N\text{-}NO_3^-$ has been determined also in waters of Czarna Cedron river and the value determined exceeded permitted value 3.4 $mg \cdot dm^{-3}$ for water quality class II (Tab. 3). The highest mean value of this index was obtained for river Molnica, and in item 1 the quantity of $N\text{-}NO_3^-$ was exceeded two times, considering requirements included in Regulation by ME of 21/7/2016. The whole course of this small river runs through agricultural areas, in sections adjacent to farm households. During the study period the growth of aquatic plants there was intense, completely covering the watercourse surface, which combined with the outflow of biogenic components, could have accelerated eutrophication of the watercourse subject to study.

Summarizing the values of water quality indices for examined water it may be concluded that river Molnica is the most contaminated watercourse in the Wisła river basin, whereas river Czarna Cedron is the least contaminated one.

In the spring and summer season phytoplankton and macrophytes inhabiting rivers increase their absorption of nutrients, while higher availability of light and higher temperatures promote and intensify nitrogen and phosphorus absorption processes (Jarvie et al. 2013). Increase in biogen concentration during the vegetation season, observed in the study, may be the testimony to anthropogenic contamination of waters, originating in farming and industrial operations running in the area.

5. Summary

Study completed confirmed the assumed thesis on contamination of small, lowland watercourses going through agricultural land. Analyzed samples from all rivers demonstrated elevated content of phosphate phosphorus. Material exceeding of $P\text{-}PO_4^{3-}$ in Zachodniopomorskie region has been recorded for river Płonia (1.505 $mg \cdot dm^{-3}$ on average), whereas in Mazowsze region the highest excess has been recorded for Molnica watercourse (2.023 $mg \cdot dm^{-3}$ on average). Despite those two rivers being so different in length and surface area of river basin, local dumping of fertilizer compounds and intensive farming use of the land adjacent to the river were observed in both cases. Also the highest content of nitrate nitrogen were recorded in Molnica river (2.023 $mg \cdot dm^{-3}$ on average), which may be explained by intense growth of aquatic plants in the watercourse. In addition, the smallest quantity of water (0.07 m on average) was observed in the watercourse, which could trigger biogenic charges in bottom deposits. The highest content of the same compound in waters of Western Poland has been determined in Rurzyca river (7.321 mg·dm^{-3} on average), probably due to local dumping of municipal sewage. In both examined areas the situation was better with contamination of small rivers with ammonia nitrogen compounds – waters could be classified as water quality class I and II as per Regulation by ME of 21/7/2016. High content of biogenic compounds in examined waters translated into low oxygen concentration and elevated conductance. Aforementioned significant increase in phosphorus and nitrogen content in minor lowland watercourses may be the evidence for biogens ingress to major rivers, such as Odra and Wisła, and in the absence of control and monitoring measures, municipal sewage and fertilizer sewage dumping spots may be the significant source of contamination.

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Abstract

An important source of contamination of inland waters is the content of nitrogen and phosphorus compounds, which in agricultural areas constitute a significant threat by getting into flowing waters. The runoff of mineral substances from areas with high intensification of agriculture contribut to increase of nutrient content in rivers, which often causes disturbances in water quality, with excess nutrients supporting the growth of phytoplankton (algae receipts) and macrophytes and associated with it loss of habitats and desirable plant and animal species. The small rivers play an important role in the water quality of large rivers. The purpose of this work is to assess the quality of water in small lowland rivers, which are tributaries of the Odra and Wisła rivers, with particular emphasis on the content of biogenic compounds (nitrogen and phosphorus forms). The study was carried out on 10 small rivers from the Odra river basin (Płonia, Myśla, Tywa, Rurzyca and Wardynka River), and the Wisła river basin (Habdziński Channel, Zielona, Czarna-Cedron, Kraska and Molnica River). The analyzed water samples in all rivers had increased content of reactive phosphorus, which allows to classify the waters into non-class waters. The highest exceedences were recorded in the Płonia River (on average 1.505 mg P-PO_4^{3-}/L) in the Odra river basin, while in the in the Wisła basin the highest exceedances were recorded in the Molnica watercourse (average 2.023 mg P-PO_4^{3-}/L). Also high concentrations of the nitrate-nitrogen content were recorded, and the highest amounts of N-NO_3^-/L were found in the Rurzyca River (the Odra catchment – 7.321 mg N-NO_3^-/L) and in Molnica River (Wisła catchment – 5.092 mg N-NO_3^-/L). Lower values of ammonium nitrogen were found in all tested watercourses, classifying water to the first class of water quality according to Minister of the Environment Regulation (21.07.2016r.). Only increased concentrations classifying the examined waters up to the 2nd water quality class were recorded in the Rurzyca river (Odra catchment - 0.350 mg N-NO_3^-/L average, and in the Habdziński Channel (Wisła catchment - 0.293 mg N-NO_3^-/L). Significant increases in the content of biogenic compounds classifying tested waters to the 2nd class and above, were also conducive to low values of oxygen concentration in water and high conductance. For example in the Molnica river, high nitrate nitrogen and phosphate content influenced on low water oxygenation. In addition, there was a very low water level in the watercourse, which could have triggered nutrient loads in bottom sediments. Contamination of waters from agricultural areas with nitrogen and phosphorus compounds may pose a threat to larger rivers to which they can pass without proper monitoring.

Keywords:
watercourses, catchment, water quality, pollution

Analiza jakości wód wybranych małych cieków zlokalizowanych w zlewni rzek Odry i Wisły

Streszczenie

Istotnym źródłem zanieczyszczenia wód śródlądowych są zawartości związków azotu i fosforu, które na obszarach rolniczych stanowią znaczące zagrożenie przedostając się do wód płynących. Do nadmiernego wzrostu zawartości związków biogennych w rzekach przyczyniają się spływy substancji mineralnych z terenów o dużej intensyfikacji rolnictwa, co niejednokrotnie jest przyczyną zaburzeń jakości wody, przy czym nadmiar składników odżywczych sprzyja wzrostowi fitoplanktonu (zakwitów glonów) i makrofitów oraz związanej z tym utraty siedlisk i pożądanych gatunków roślin i zwierząt. Dużą rolę w kształtowaniu jakości wody dużych rzek pełnią niewielkie dopływy stanowiące małe cieki wodne. Celem niniejszej pracy jest ocena jakości wód w wybranych małych nizinnych ciekach wodnych będących dopływami rzeki Odry i rzeki Wisły ze szczególnym uwzględnieniem zawartości związków biogennych (formy azotu i fosforu). Badaniami objęto 10 niewielkich cieków z obszaru zlewni rzeki Odry (rzeki: Płonia, Myśla, Tywa, Rurzyca i Wardynka), oraz zlewni rzeki Wisły (Kanał Habdziński, Zielona, Czarna-Cedron, Kraska i Molnica). Analizowane próby wody we wszystkich rzekach

miały podwyższone zawartości fosforu fosforanowego, co pozwala zaklasyfikować badane wody do wód pozaklasowych. W zlewni rzeki Odry największe przekroczenia norm odnotowano w rzece Płonia (średnio 1.505 mg $P\text{-}PO_4^{3-}$/L), natomiast w zlewni Wisły największe przekroczenia zanotowano w cieku Molnica (średnio 2.023 mg $P\text{-}PO_4^{3-}$/L). Również wysokie stężenia odnotowano analizując wody pod kątem zawartości azotu azotanowego, a największe ilości $N\text{-}NO_3^-$ stwierdzono w rzece Rurzyca (zlewnia Odry – 7.321 mg $N\text{-}NO_3^-$/L) i w Molnicy (zlewnia Wisły – 5.092 mg $N\text{-}NO_3^-$/L). We wszystkich badanych ciekach stwierdzono niższe ilości azotu amonowego, klasyfikując wody do I klasy czystości wg Rozp. MŚ z 21.07.2016r. Jedynie podwyższone stężenia klasyfikujące badane wody do 2 klasy czystości wód zanotowano w rzece Rurzyca (zlewnia Odry – średnio 0.350 mg $N\text{-}NH_4^+$/L, oraz w Kanale Habdzińskim (zlewnia Wisły – 0.293 mg $N\text{-}NH_4^+$/L). Znaczące podwyższenia zawartości związków biogennych klasyfikujące badane wody do II klasy i powyżej II klasy czystości wód sprzyjały również niskim wartościom stężenia tlenu w wodzie oraz wysoką konduktancją. Przykładem jest tu rzeka Molnica, w której wysokie zawartości azotu azotanowego oraz fosforanów przekładały się na niskie natlenienie wody i wysokie przewodnictwo właściwe. Ponadto w cieku była bardzo niski stan wód, co mogło uruchomić pokłady ładunków biogennych w osadach dennych. Zanieczyszczenia wód z terenów rolniczych związkami azotu i fosforu mogą stanowić zagrożenie dla większych rzek, do których bez odpowiedniego monitoringu mogą się przedostawać.

Słowa kluczowe:
cieki wodne, zlewnia, jakość wody, zanieczyszczenie