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ANALYSIS OF THE CONTENT OF POLLUTANTS IN SURFACE WATER IN THE COMMUNE OF OSTRZESZÓW

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Abstract

This paper presents the results of physical and chemical tests of surface water samples taken from the areas of the Ostrzeszów Commune, which is part of the Ostrzeszów County, located in the southern part of the Wielkopolska Province. The Ostrzeszów commune is included in the urban-rural areas. The physicochemical analysis of surface waters covered samples taken from seventeen measurement and control points from places as accessible as possible. The water quality was assessed in accordance with the applicable regulations of the Minister of the Environment. Surface waters were characterized by typical variability for agricultural areas, i.e. slightly alkaline, pH in the range of 7.5-8.45; specific conductivity in the range of 246-512 µS/cm; turbidity in the range of 1.7-10.5 NTU; total hardness in the range of 1.6-3.2 mmol·dm^{-3} Ca^{2+}, Mg^{2+}; alkalinity in the range of 66-142 mg·dm^{-3} $CaCO_3$; chloride content in the range of 19-47 mg/dm^3 Cl^-; content of biogenic compounds, ie: nitrites in the range of 0.02-0.36 mg·dm^{-3} N-NO_2^-; nitrates in the range of 0.05 – 4,9 mg·dm^{-3} N-NO_3^-; ammonium ion in the range of 0.04-0.94 mg·dm^{-3} N-NH_4^+; the content of orthophosphate in the range of 0.11-1,56 mg·dm^{-3} P-PO_4^{3-}. The content of metals, i.e. manganese Mn, Fe iron, was characterized by high variability depending on the location of the sampling site (Mn manganese in the range of 0.006-0.22 mg·dm^{-3}, Fe iron in the range of 0.02 – 0.28 mg·dm^{-3}, potassium K in the range of 10-13 mg·dm^{-3}). In all analyzed samples, the presence of copper Cu, nickel Ni and zinc Zn was not detected. The quality of surface waters of the Ostrzeszów commune, in addition to natural hydrological factors, is affected by areas covered by agricultural activity and the evident lack of developed sewerage system in the analyzed sampling regions.

The research carried out at the turn of the year showed that the use of artificial and natural fertilizers in cultivated areas contributed to the increase in the content of biogenic and mineral substances in surface.

Key words: surface waters, eutrophication, water quality, water composition, agriculture, Ostrzeszów commune

INTRODUCTION

Surface waters are a basic element of the environment of enormous importance not only for the economy, but also for the living conditions of man and many other organisms. The presence of mineral and organic compounds in surface waters most often leads to eutrophication, i.e. increased fertility of water reservoirs. The eutrophication process is primarily associated with the presence of nitrogen and phosphorus compounds (Wilk-Woźniak 2003, Chapra and Dobson 1981, Duszczyk and Chojnacka 2013). The process of natural eutrophication is intensified by human activity (Rynkiewicz 2007). The main sources of occurrence of accelerated eutrophication include in particular discharges of domestic wastewater in areas not covered by the sewage system (point sources), surface runoffs and diffuse sources (Duszczyk and Chojnacka 2013, Dojlido 1995, Kajak 2011). Surface waters are also an element of the environment which is most often contaminated with compounds of natural and anthropogenic origin. Research conducted in the field of water protection is primarily focused on creating the right conditions thanks to which stimulated development processes will have the least negative impact on the natural environment. The increase in surface water eutrophication results in the excessive development of microorganisms, which in effect disrupts the natural microecosystem (Mazurkiewicz-Boroń 2000).

The excessive development of microorganisms, including phytoplankton, negatively affects the physical properties of water such as change in color, odor and aerobic conditions. Cyanobacteria are particularly harmful. Cyanobacteria bloom represents above all a grave danger for the health and life of people. Cyanobacteria are capable of producing hepatotoxins, neurotoxins, and cyanotoxins (Tarczyńska and Zalewski 1994). Substances which belong to the aforementioned groups for example saxitoxin, anatoxin-a, microcystin-LR, – RR, – YR and –LA cause in low concentrations deformations of the cytoskeleton proteins that give the liver cells their proper shape. This can lead to a build-up of blood in the liver and result in death. Toxic effects of microcystins were observed in fish, snails, crabs, crayfish and mussels. Fish are a special group of organisms exposed to microcystins because the changes occur as a result of direct absorption of these substances by the gills. Microcystins have the ability to accumulate in higher organisms, hence their high concentrations in predatory fish species. The consumption of such a fish may in extreme cases lead to death. The first symptoms of poisoning include weakness, nausea, blurred vision, hepatomegaly and consequently death. An example of microcystin poisoning is the case from Caruaru hospital in Brazil (1980s) where 60 patients died as a result of administration of water containing microcystin (Bownik 2010, Sivonen *et al.,* 1989, Wiegand and Pflugmacher 2005). The composition of surface waters of rural areas depends on numerous external factors, i.e. anthropogenic factors, which include: land use, type of agricultural crops, or type of animal production (Bombówna 1983, Koc *et al.,* 1996, Pawlik-Dobrowolski 1990, Sapek 1996, Sapek 1995). Another factor determining the threat to surface water quality is the production of vegetables and root crops in a large area (Hartz 2006, Ilnicki 2004, Nett 2012, Szmigiel and Kołodziejczyk 2004, Zupanc *et al.,* 2011). Crops take only part of the dose of nutrients supplied. In the case of nitrogen, this uptake is in the range of about 30%, phosphorus in the range of 20-30%, and potassium at the level of 60% from the delivered dose of fertilizer (Ilnicki 2004). Based on the assessment of some researchers, losses in the uptake of mineral substances such as nitrogen may exceed 200 kg $N{\cdot}ha^{-1}$ (Neeteson and Carton 2000), whereas in the cultivation of tuberous plants such as potatoes these losses may amount to 100 kg $N{\cdot}ha^{-1}$ (Sapek 1995).

The area of the Ostrzeszów Commune amounts to 187 km^2, of which 12.1 km^2 is located in the town of Ostrzeszów (CSO 2017). The greater part of the Ostrzeszów Commune is dominated by arable land, the total area of which amounts to 9,991.13 ha (53%), including land used for sowing 5,780.7 ha (31%) as well as pastures and meadows 1,912.4 ha (10%). Forestland amounting to 7,531.3 ha (40%) constitutes the remainder. Areas belonging to the urbanized and developed part account for less than 5% of the area. The town and the commune of Ostrzeszów are located on the border of the Wielkopolska Lowland and the Silesian Lowland. The relief of the area includes small water reservoirs and extensive forest areas. The area of the Ostrzeszów Commune is mostly made up of brown and podzolic soils with small areas of fluvisols and bogs. In terms of climate, the Ostrzeszów Commune belongs to the Łódź (X) District. The average annual air temperature amounts to 8^{o}C, the annual rainfall is in the range of 500-550 mm. There are several large companies operating in the Ostrzeszów Commune, including Pollena Ostrzeszów, a producer of household chemistry, Mayr Poland, a producer of metallurgical components and DROP S.A., a producer of poultry products. A part of the commune is connected to the sewage system. Only 27% of the entire length of the sanitary network constitutes sanitary sewage system, except for villages such as Rogaszyce, Turze, Kochłowy (Uwarunkowania 2011). The Commune of Ostrzeszów belongs to areas with medium urbanization. The majority of large companies are located in the town of Ostrzeszów. These include household chemistry, machine processing, food processing and construction companies.

The purpose of the research was to determine the content of pollutants, including biogenic compounds found in surface waters in the Commune of Ostrzeszów.

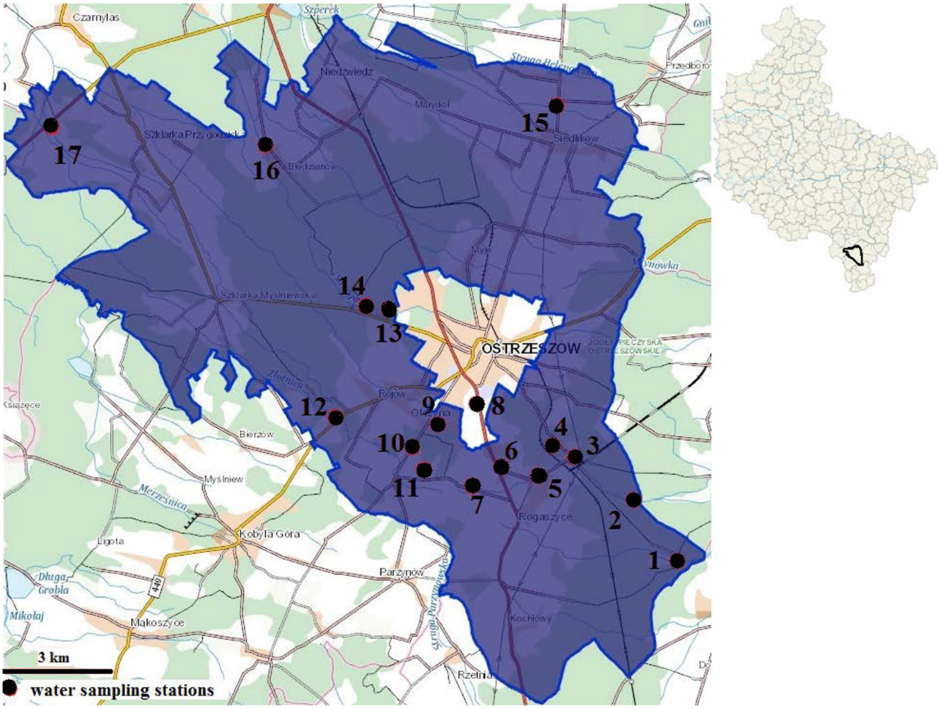
RESEARCH METHODOLOGY

Physical and chemical tests of surface water were carried out for twelve months from September 2018 to September 2019 at the same measurement and control points. Test of water samples were conducted in the Ostrzeszów Commune. Due to the extent of the area, the research was limited to 17 measurement and control points (mcp) so as to cover the entire studied area of the commune. Three samples were taken from each sampling point. The location of water sampling points for testing is shown in Figure 1 and in Table 1.

Samples were taken once a week in accordance with the Polish Standard regarding the collection of water samples for physicochemical tests using a dipper. Physicochemical analyzes were carried out compliant with the methodologies of current Polish Standards in the author's laboratory in order to determine the content of biogenic compounds, physical indicators and metal content.

Physical parameters of water such as pH, electrical conductivity, dissolved oxygen content as well as temperature were determined using a CX-601 multifunction meter (ELMETRON, Poland). Turbidity was measured using a 2100Q turbidity meter (HACH, USA). The content of biogenic compounds: nitrate nitrogen (V) $N\text{-}NO_3$, nitrate nitrogen (III) N-NO, ammonium nitrogen $N\text{-}NH_4$, orthophosphates (V) $P\text{-}PO_4$ and metals Mn, Fe, Cu, were established utilizing the spectrophotometric method using a spectrophotometer (METASH, China). The content of mineral substances such as alkalinity of water, total hardness and chlorides was calculated by means of titration methods. Potassium, nickel and zinc were determined by a colorimetric method using the Macherey-Nagel cuvette tests by means of a PF-12 photometer (Macherey-Nagel, Germany) (detection limit of the method for nickel: 0.04 $mg \cdot dm^{-3}$, for zinc: 0.05 $mg \cdot dm^{-3}$). All devices had been calibrated before use as stated by the manufacturer's instructions.

Among the selected sampling points for physiochemical analysis were areas of a typical economic and agricultural character, i.e. the measurment and control point No. 4: "Królewski" Pond in Rogaszyce and point No. 12 "Rojowskie" ponds with „Złotnica" watercourse in Rojów as well as point No. 8: watercourse at the national road No. 11 in the area of the Casimir the Great Allotment Gardens in Ostrzeszów.



Source: author's own elaboration based on www.geoportal.pl

Figure 1. Ostrzeszów commune with the location of water sampling points for testing

The research points 1-7 were located in the village of Rogaszyce. The larger area of the village is made up of agricultural areas and residential buildings. There is no typical industrial activity in the village which produces industrial wastewater containing hazardous substances. This village does not have a sewage system. The research point 8 was located in the town of Ostrzeszów, the area fully covered by the sewage system. The research points 9-11 were located in the village of Olszyna, mostly agricultural areas. The areas are fully covered by the sewage system. Figure 2 shows the extent of the sewage system in the town and commune of Ostrzeszów.

Point No. 12 was located within the village of Rojów, which has a sewage system. This village is of agricultural character. Agricultural areas and residential buildings constitute a larger area of the village. Industrial activities are also carried out in the village, in which industrial wastewater containing hazardous substances is generated. However, this wastewater is discharged into the sewage system. Research points 13, 14 were located in the settlement of Aniołki, a village partly covered by a sewage system. Most of these areas are of agricultural character. Research point 15 was located in the village of Siedlików which was characterized by agricultural land without efficient sewage system.

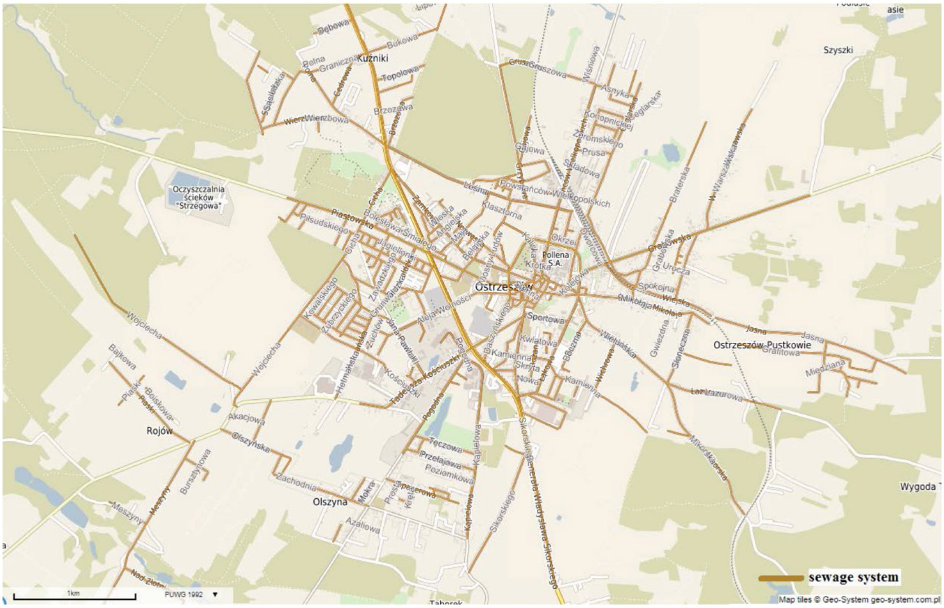
Table 1. Measurment and control points

Measurement and control points (mcp)	Sample number	Land management	Watercourse type
"Malinów" ponds	1	Ł, WSR	0
"Wiązownia" ponds	2	LZ, WSR	0
"Zalesianka" watercourse	3	LZ	17
"Królewskie" ponds	4	LZ	0
"Zalesianka" watercourse, Kolonia	5	BR	17
Ostrzeszów watercourse by national road No. 11	6	BR	0
Rogaszyce watercourse in the hilltop region of "Bałczyn"	7	LZ	0
Ostrzeszów watercourse by national road No. 11 in the area of the Casimir the Great Allotment Gardens	8	B	0
reservoir at Pogodna Street in Ostrzeszów	9	BR	0
„Złotnica" watercourse	10	Ł	17
Water reservoir after clay mining	11	LZ	0
Rojowskie ponds with „Złotnica" watercourse	12	Ł,B,WSR	0
"Strzegowa" watercourse	13	B, BR	17
"Strzegowa" watercourse by sewage treatment plant	14	B	17
Watercourse in Siedlików	15	B	0
The Strzegowa River in Bledzianów	16	B	17
The Złotnica River in Szklarka Przygodzka	17	B	17

Explanations: B = residential areas; BR= developed agricultural land; Ł = meadows; LZ = wooded land; R = arable land; L = forests; WSR = land for ponds, 0 = undefined water type, 17 = sandy lowland stream

The research point 16 was located in the village of Bledzianów which was characterized by agricultural land without a sewage system. The research point 17 was located in the village of Kotowskie which was characterized by agricultural land without a sewage system.

The town of Ostrzeszów has an efficient sewage system. Adjacent towns are connected to this sewage system. There are six villages outside the agglomeration of Ostrzeszów: Rogaszyce, Potaśnia, Rejmanka, Zajączka, Siedlików and Korpysy. This is synonymous with the exclusion of the possibility of connecting these villages to an efficient sewage system (Fig. 2).



Source: author's own elaboration based on polska.e-mapa.net

Figure 2. Ostrzeszów town with the location of the sewage system

RESULTS AND DISCUSSION

The average results of physicochemical analyzes of water samples for the 12-month research period are presented in Table 2. The obtained results indicate that the quality of surface waters in the Ostrzeszów Commune is influenced not only by agriculture but also by the lack of a uniform sewage system. Due to the lack of a sewage system, illegal discharge of sewage into surface waters and even directly into closed wells is a common practice. This was confirmed by increased contamination values for orthophosphate content, which were found in all tested water samples. The quality of water reservoirs and water courses was also influenced by the nutrient loads that reached the aforementioned areas from arable land (Jachniak 2010; Duszczyk i Chojnacka 2013).

The conducted tests showed that the measured values of pollutants in surface waters in the commune of Ostrzeszów exceeded the normative values for the 1st and 2nd class of water purity (Regulation of the Ministry of Environment of 21 June 2016). The limit values are shown in Table 3.

Table 2. Average results of analysis of surface water samples at measurment and control points

Sample number (mcp)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
pH value	8.4	7.8	7.6	7.5	7.6	6.4	6.3	7.5	8.7	7.8	7.8	7.3	7.4	7.2	7.1	7.4	8.0
Dissolved oxygen $mg \cdot dm^{-3}$	9.11	5.4	5.6	6.95	6.1	4.85	4.8	5.75	8.55	4.75	6.8	6.2	4.95	4.8	6.75	5.85	5.95
Electrical conductivity $\mu S \cdot cm^{-1}$	460	334	291	320	396	246	250	512	438	381	403	363	419	429	311	296	334
Turbidity (FNU)	10.5	5.73	2.8	5.11	5.71	2.93	2.5	3.82	2.22	1.76	2.73	6.44	2.51	2.49	2.2	1.88	3.11
Alkalinity $mg \cdot dm^{-3}$ $CaCO_3$	140	76	66	66	86	90	122	142	130	104	142	94	118	122	110	115	88
Total hard-ness $mg \cdot dm^{-3}$ $CaCO_3$	230	165	170	170	180	150	200	410	240	320	230	200	210	230	180	170	160
Chlorides $mg \cdot dm^{-3}$	25	21	14	19	31	22	26	47	24	17	14	18	39	29	21	15	19
Ammonium ion $mg \cdot dm^{-3}$	0.04	0.94	0.09	0.10	0.21	0.11	0.25	0.30	0.04	0.07	0.06	0.16	0.11	0.19	0.06	0.05	0.10
Nitrates (III) $mg \cdot dm^{-3}$	0.06	0.04	0.04	0.08	0.36	0.05	0.08	0.09	0.03	0.04	0.02	0.09	0.04	0.11	0.04	0.03	0.02
Nitrates(V) $mg \cdot dm^{-3}$	2.2	1.0	1.2	1.9	5.1	2.2	1.3	3.5	0.05	3.4	1.0	4.9	0.07	1.05	2.1	1.6	2.8
Phos-phates(V) $mg \cdot dm^{-3}$	1.32	0.42	0.53	0.48	1.56	0.44	0.24	0.48	0.24	0.42	0.56	1.34	0.25	0.14	0.21	0.33	0.19
Manganese $mg \cdot dm^{-3}$	0.06	0.095	0.044	0.18	0.208	0.11	0.05	0.107	0.057	0.088	0.006	0.22	1.09	1.12	0.08	0.16	0.22
Iron $mg \cdot dm^{-3}$	0.28	0.15	0.07	0.27	0.04	0.05	0.02	0.12	0.17	0.19	0.19	0.2	0.44	0.36	0.06	0.08	0.26
Potassium $mg \cdot dm^{-3}$	11	13	10	12	11	11	12	10	11	11	11	12	12	13	13	10	11

Source: author's own elaboration

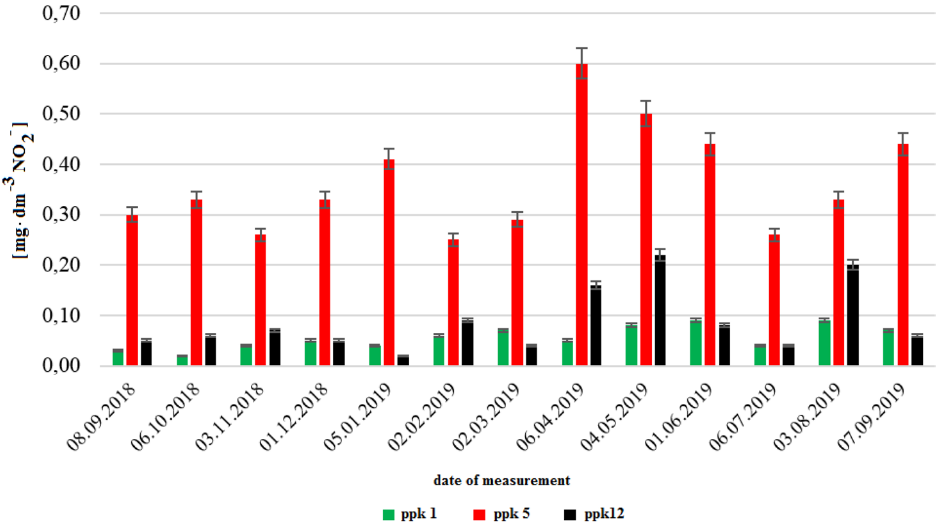
Table 3. Limit values of water indicators referring to homogeneous parts of surface water

Indicator number	Name of the water quality indicator	Watercourse type	Unit	Limit value of water quality indicator appropriate for the class:				
				I	II	III	IV	V
3.1.1	Water temperature	1-26	°C	≤ 22	≤ 24	Not determined		
3.2.1	Dissolved oxygen	0 unspecified type	$mg\ O_2 \cdot dm^{-3}$	≥ 7,0	≥ 5,0	Not determined		
		17 sandy lowland stream		≥ 7,5	≥ 6,8			
3.3.2	Conductivity at 20 °C	0 unspecified type	µS/cm	≤ 1000	≤ 1500	Not determined		
		17 sandy lowland stream		≤ 549	≤ 620			
3.3.5	Chlorides	0 unspecified type	$mg \cdot dm^{-3}$	unk-nown	Unk-nown	Unk-nown	Unk-nown	Unk-nown
		17 sandy lowland stream		≤ 26	≤ 33,7	Not determined		
3.3.8	Total hardness	0 unspecified type	$mg \cdot dm^{-3}$ $CaCO_3$	Unk-nown	Unk-nown	Unk-nown	Unk-nown	Unk-nown
		17 sandy lowland stream		≤ 263	≤ 274	Not determined		
3.4.1	pH value	0 unspecified type	pH	6,0 – 8,5	6,0 – 9,0	Not determined		
		17 sandy lowland stream		7-7,9	7-7,9			
3.4.2	Alkalinity	0 unspecified type	$mg \cdot dm^{-3}$ $CaCO_3$	Unk-nown	Unk-nown	Unk-nown	Unk-nown	Unk-nown
		17 sandy lowland stream		≤ 232,3	≤ 242,2	Not determined		
3.5.1	Ammonium nitrate	0 unspecified type	$mg\ N^{-N-}{}_{H4} \cdot dm^{-3}$	Unk-nown	Unk-nown	Unk-nown	Unk-nown	Unk-nown
		17 sandy lowland stream		≤ 0,25	≤ 0,738	Not determined		
3.5.3	Nitrate nitrogen (V)	0 unspecified type	$mg \cdot dm^{-3}$ NO_3^-	≤ 2,2	≤ 5,0	Unk-nown	Unk-nown	Unk-nown
		17 sandy lowland stream		≤ 2,2	≤ 3,4	Not determined		

Indicator number	Name of the water quality indicator	Watercourse type	Unit	Limit value of water quality indicator appropriate for the class:				
				I	II	III	IV	V
3.5.4	Nitrate nitrogen (III)	0 unspecified type	mg·dm^{-3} NO_2^-	Unk-nown	Unk-nown	Not determined		
		17 sandy lowland stream		≤ 0,01	≤ 0,03			
3.5.6	Fosfor fosfo-ranowy(V)	0 unspecified type	mg P$^-$ $_{PO4}$·dm^{-3}	≤ 0,065	≤ 0,130	Not determined		
		17 sandy lowland stream		≤ 0,065	≤ 0,101			

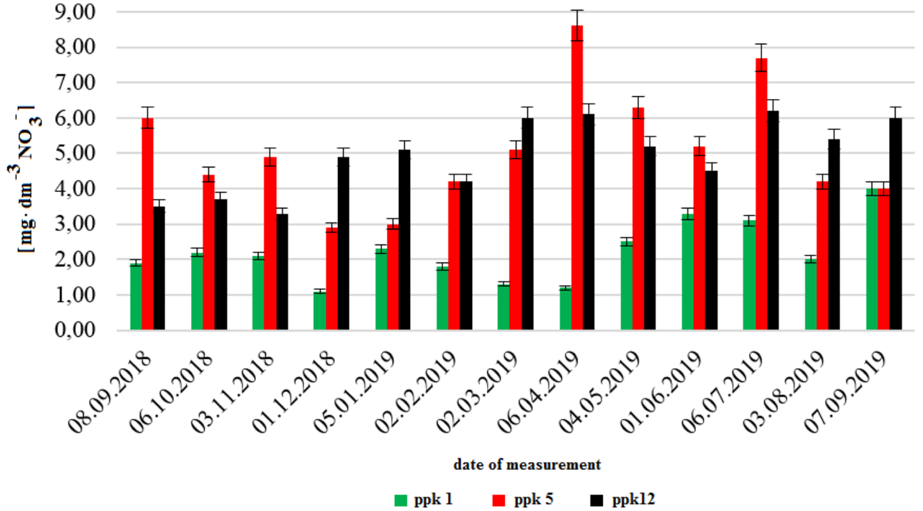
Source: author's own elaboration based on Regulation of the Minister of the Environment of July 21, 2016 on the method of classifying homogeneous status of surface water bodies and environmental quality standards for priority substances. item 1187.

Figures 3, 4 and 5 show the variability in the content of biogenic compounds, i.e. nitrates (III), nitrates (V) and orthophosphates for sampling points throughout the measurement period.



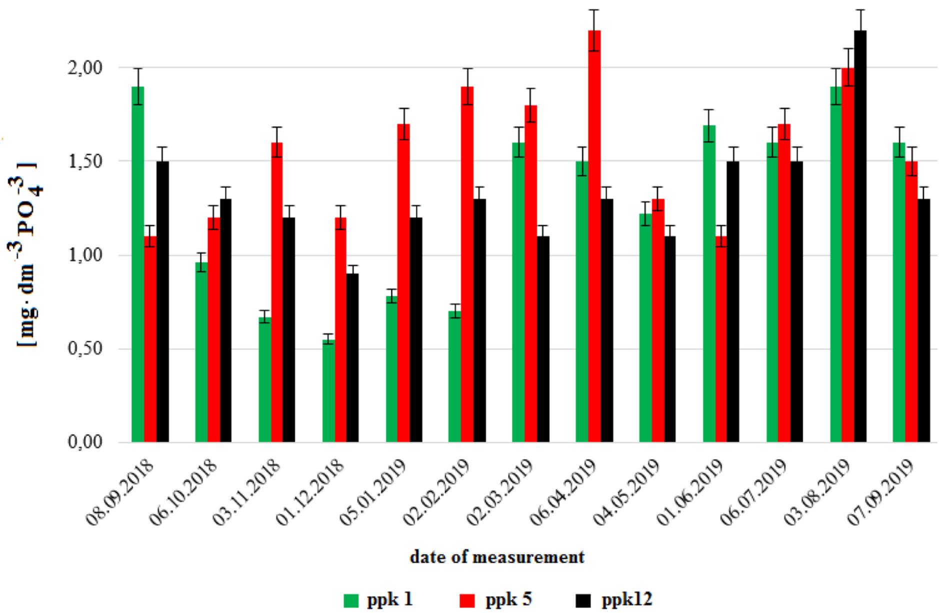
Source: author's own elaboration

Figure 3. Fluctuations in the content of nitrites(III) at selected control points



Source: author's own elaboration

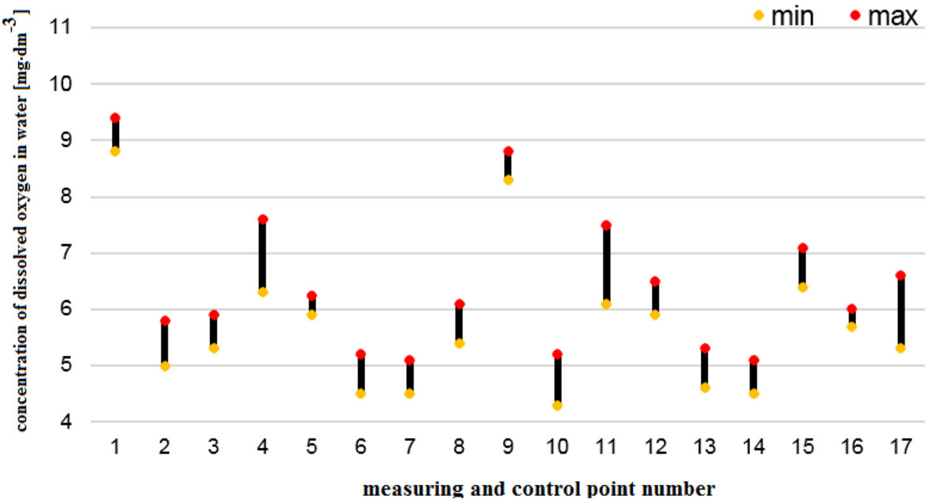
Figure 4. Fluctuations in the content of nitrates(V) at selected control points



Source: author's own elaboration

Figure 5. Fluctuations in orthophosphate contents at selected control points

Comparing the results of the content of nitrogen compounds in water samples, their increase at the turn of March and April should be noted. A similar trend was noticeable in the phosphate content. It is also worth paying attention to oxygen conditions at the measurement and control points tested (Fig. 6). The best oxygen conditions prevail in the "Malinów" ponds and the reservoir at Pogodna Street in Ostrzeszów (these reservoirs are breeding tanks in which, among others, the carp can be found). Among the five measurement and control points, the average dissolved oxygen concentration was in the range below 5 mg·dm^{-3}. These changes were caused by the impact of intensively used artificial fertilizers at the beginning of April, which was confirmed by the increase in nutrients at the turn of March and April.



Source: author's own elaboration

Figure 6. Averaged results for concentration of dissolved oxygen at measurement and control points

The conducted research on the quality of surface water made it possible to determine the quality of the aquatic environment of the area of the commune of Ostrzeszów, which is characterised by relatively intensive farming. Most large industrial companies are located in the town of Ostrzeszów or within the town borders where there is a sewage system.

Based on the tests carried out, differences were found in the content of other minerals. The most stable indicators in the 17 measurement and control points analyzed were potassium and copper content. The poor state of surface water is indicated by the presence of nitrogen and phosphorus compounds (for orthophosphates, the limit value for lowland stream was below 0.101 mg·dm^{-3}

for second class, for nitrates (V) the limit value amounted to 3.4 mg·dm^{-3}, for nitrates (III) the limit value was below 0.03 mg·dm^{-3}). Among the nutrients, nitrate nitrogen (V) NO_3 was characterized by the greatest diversity. The highest content in the range above the limit value of 5.1 mg·dm^{-3} (5.1 mg•dm^{-3} N-NO_3) was determined in point 5, i.e. in the sample of water taken from a watercourse characterized by intense agricultural influence and the impact of human existence (no sewage system). At the measurement and control point No. 10 elevated nitrate (V) concentration of 3.4 mg·dm^{-3} NO_3-N was determined. This point was located outside the town of Ostrzeszów. Due to the agricultural nature of this area, the fertilizers used flow naturally to this watercourse. Diversified values of pH, conductivity and dissolved oxygen content indicate the type of watercourse and its location.

The most likely source of nitrates (V) in the waters belonging to the "Złotnica" watercourse is the economic use of the water for carp farming. P-PO_4 concentration in surface waters was in the high range of 0.11-1.56 mg·dm^{-3} P-PO_4. The poor sanitary state of the surface waters tested (all mcps in the case of phosphorus content and also in the case of nitrate (V) content) indicates the eutrophication processes taking place in the surface waters of the commune of Ostrzeszów resulting from the discharge of sewage from houses and farms to nearby watercourses. The highest content of nutrients in surface waters were visible in areas not covered by the sewage system (measurement and control points number 1-7, 15,16,17). The obtained test results could not be referred to any data or measurement results due to the lack of literature data regarding surface water purity in the commune of Ostrzeszów. These values can be compared to tests of the chemical status of surface water bodies flowing in 2017. For the areas of the Ostrzeszów Poviat and Commune, this state was described to be below the good status (VIEP Report). The research presented is the first to deal with the purity of surface water in the Ostrzeszów commune on such a wide scale.

CONCLUSION

Chemical compounds present in surface waters of the area of the Ostrzeszów commune clearly show that agriculture has a huge impact on its quality, because at all measurement and control points phosphorus content exceeded limit values. The presence of biogenic compounds and mineral substances, including metals such as manganese, iron and copper in the surface waters of the commune of Ostrzeszów has a great impact on their quality. High concentrations of biogenic compounds found in agricultural areas and in rural areas not covered by a uniform sewage system confirm the occurrence of point and diffuse sources of pollution (such as illegal discharges, pollution from surface runoffs). The highest concentration of biogenic compounds occurred in agricultural areas at measurement and control points No. 5 "Zalesianka" Watercourse in Rogaszyce, No. 8 (Watercourse in Ostrzeszów by the national road No. 11, in the area of the Casimir the Great Allotment Gardens) and No. 12 (Rojowskie Ponds with the "Złotnica" watercourse). The best oxygen conditions were characterized by water reservoirs at measurement and control points: No. 1 ('Malinów' Ponds) and No. 9 (Water reservoir in Ostrzeszów at Pogodna St.).

Based on the results of the research, it can be unequivocally stated that in the Ostrzeszów commune, intensive farming poses a real threat to the quality of surface waters. The lack of a sewage system in communities outside the Ostrzeszów agglomeration means that all pollutants go directly to the environment, which results in an increased content of biogenic compounds in surface waters. The noticeable increase in the concentration of these compounds confirms the use of artificial fertilizers in agriculture and the practice of discharges of household sewage directly into the aquatic environment. The aggravated nitrate (V) concentrations could be seen at measurement and control points: 1 – $mg \cdot dm^{-3}$; 4 – $mg \cdot dm^{-3}$, 5 – $mg \cdot dm^{-3}$ located in the village of Rogaszyce, as well as at points No. 15 Siedlików: 2.1 $mg \cdot dm^{-3}$; No. 16 Bledzianów: 1.6 $mg \cdot dm^{-3}$; No. 17 Szklarka Przygodzka – 2.8 $mg \cdot dm^{-3}$, i.e. areas that do not have a sewage system.

At the measurement and control points analyzed, heavy metal concentrations (Ni, Cu, Zn) were below the detection limit for the analytical methods used, which proves the absence of sewage and industrial waste. The presence of S^{2-} sulphides was not demonstrated either. At all measurement and control points, the S^{2-} sulphide concentration was in the range below 0.05 $mg \cdot dm^{-3}$ S^{2-}, which precludes putrefaction at the analyzed measurement and control points of the watercourses.

REFERENCES

Bombówna, M. (1983). *Chemical composition of water. W: Stream ecosystem in mountain grassland (West Carpathians).* Acta Hydrobiologica, 24: 321-335.

Bownik, A. (2010). *Harmful algae: effects of alkaloid cyanotoxins on animal and human health*. Toxin Reviews, 29: 99-114, DOI: doi.org/10.3109/15569543.2010.516464.

Chapra, S.C., Dobson, H.F.H. (1981). *Quantification of the lake trophic typologies of Naumann (surface quality) and Thienemann (oxygen) with special references to the Great Lakes*. Journal of Great Lakes Research, Internat. Assoc. Great Lakes Res., 7(2): 182-193.

Dojlido, J.R. (1995). *Chemia wód powierzchniowych*. Białystok: Wydawnictwo Ekonomia i Środowisko, 1-342.

Duszczyk, J., Chojnacka, M. (2013). *Analiza zawartości związków biogennych w wodach powierzchniowych na przykładzie rzeki Prosny*. Kalisz: Wydawnictwo Uczelniane PWSZ w Kaliszu, 79-86.

GUS, Statystyczne Vademecum Samorządowca, 2017

Hartz, T.K. (2006). *Vegetable production best management practices to minimize nutrient loss*. Hort Technology, 16(3): 398-403.

Ilnicki, P. (2004). *Polskie rolnictwo a ochrona środowiska*. Poznań: Wydawnictwo Akademii Rolniczej, 485, ISBN 83-7160-369-X.

Kajak, Z. (2011). *Hydrologia-Limnologia. Ekosystemy wód śródlądowych*. Warszawa: PWN, 1-360.

Koc, J., Ciećko, C., Janicka, R., Rochwerger, A. (1996). *Czynniki kształtujące poziom mineralnych form azotu w wodach obszarów rolniczych*. Zeszyty Problemowe Postępów Nauk Rolniczych, (440): 177-183.

Mazurkiewicz-Boroń, G. (2000). Eutrofizacja – przyczyny i skutki – Zbiornik Dobrzycki. Kraków: Ekologia-Eutrofizacja – Ochrona PAN, 43-54.

Neeteson, J.J, Carton, O.T. (2000)The environmental impact of Nitrogen in Field Vegetable Production. In proceedings of ISHS/ENVEG conference 1999. Acta Hort. 563, 21-28.

Nett, L. (2012). *N use efficiency in field vegetable production systems – Catch crop strategies and fertilization history effects on organic fertilizer turnover* [online]. Humbolt Universität zu Berlin. Praca doktorska. ss. 105 [Dostęp: 09.09.2019].
Dostępny: https://edoc.hu-berlin.de/handle/18452/17115.

Pawlik-Dobrowolski, J. (1990). *Źródła substancji chemicznych w zlewni, ich klasyfikacha i metody obliczania*. Materiały Seminaryjne IMUZ, Falenty, Wydaw. IMUZ, 26: 7-15.

Rozporządzenie Ministra Środowiska z dnia 21 lipca 2016r. w sprawie sposobu klasyfikacji jednolitych stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych. Poz. 1187.

Rynkiewicz, A. (2007). *Problemy eutrofizacji wód w Polsce i och ograniczanie w sposób naturalny*. Poznań: Krajowy Zarząd Gospodarki Wodnej, 1-13.

Sapek, A. (1996). *Zagrożenie zanieczyszczenia wód azotem w wyniku działalności rolniczej*. Zeszyty Problemowe Postępów Nauk Rolniczych, 440: 309-329.

Sapek, B. (1995). *Wymywanie azotanów oraz zakwaszenie gleby I wód gruntowych w aspekcie działalności rolniczej*. Materiały Informacyjne, Falenty, Wydaw. IMUZ, (30): 31, ISSN 08060-1410.

Sivonen, K., Kononen, K., Carmichael, W.W., Dahlem, A.M., Rinehart, K.L., Kiviranta, J., Niemela, S.I. (1989). *Occurrence of the hepatotoxic cyanobacterium Nodularia spumigena in the Baltic Sea and structure of the toxin*. Appl. Environ. Microbiol., 55: 1990-1995.

Uwarunkowania, Studium Uwarunkowań i Kierunków Zagospodarowania Przestrzennego Miasta i Gminy Ostrzeszów, 2011

Jachniak, E. (2010). *Wpływ czynników fizykochemicznych oraz hydrologicznych na przebieg procesów eutrofizacyjnych w wybranych zbiornikach zaporowych południowej Polski*. Rozprawa doktorska, Kraków: UR, 1-236.

Szmigiel, A., Kołodziejczyk, M. (2004). *Wybrane wskaźniki efektywności nawożenia ziemniaka*. Annales UMCS, Sec. E., 59 (3): 1445-1453.

Tarczyńska, M., Zalewski, M. (1994). Toksyczność zakwitów sinicowych w eutroficznych zbiornikach, Materiały konf.: Zalewski M. (red.), Zintegrowana strategia ochrony i zagospodarowania ekosystemów wodnych, Woj. Inspektorat Ochrony Środowiska w Łodzi, Zakład Ekologii Stosowanej UŁ., 79-89.

Wiegand, C., Pflugmacher, S. (2005). *Ecotoxicological effects of selected cyanobacterial secondary metabolites – A short review*. Toxicol Appl. Pharm, 203, 201-218.

Wilk-Woźniak, E. (2003). *Phytoplankton – formation reflecting variation of trophy in dam reservoirs*. Ecohydrology and Hydrobiology, Proceedings of the XX th International Phycological Symposium, Warszawa: PAN, 3 (2): 213-219.

Raport WIOŚ, stan wód dla Województwa Wielkopolskiego, raport 2018

Zupanc, V., Strum, M., Lojen, S., Marsic-Kacjan, N., Adu-Gyamfi, J., Bracic-Zeleznik, B., Urbanc, J., Pintar, M. (2011). *Nitrate leaching under vegetable field above a shallow aquifer in Slovenia*. Agriculture, Ecosystem and Environment, 144 (1): 167-174

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