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Research Article

EVALUATION OF CHEMICAL AND PHYSICO-CHEMICAL INDICATORS OF WATER OF THE LAKES IN THE CITY OF SZCZECIN ON THE BASIS OF THE EU WATER FRAMEWORK DIRECTIVE

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ABSTRACT
The work shows the evaluation of physico-chemical parameters the city of Szczecin of the landscape based on the European Union Water Framework Directive. The study was conducted on three lakes within the boundaries of the city of Szczecin on the three lakes: Glebokie, Rusalka, Szmaragdowe. Szczecin is situated in North-West Poland, in the western part of West Pomeranian Voivodeship at Polish-German border. Research was carried out in the years 2008–2012, in the period from April to October. Water samples were taken from three stations on each of the three lakes. Sample water pH was measured. The water tests were taken according to the Polish Standards. The collected water samples were fixed in accordance with the recommendations in the Polish Standards. Other indicators for the quality of the waters have been tagged within 24 hours from the moment of sampling.

Keywords: water, lake, chemical and physico-chemical indicators, European Union Water Framework Directive

INTRODUCTION

After the accession to the European Union Poland is committed to the implementation of the European Union Water Framework Directive (2000/60/EC), whose main objective is to achieve good ecological and chemical surface water status by 2015 [7-9, 10, 16, 19, 23, 27, 29].

Evaluation of the quality of the structure and the functioning of aquatic ecosystems, by comparing the status of the existing undisturbed conditions expected in status (reference), is a requirement for monitoring and evaluation systems of classification by the European Directive 2000/60/EC, known as the European Union Water Framework Directive [10, 11, 16, 20, 23, 25, 29, 30].

In Poland, there are more than 7080 natural lakes larger than 1 ha. Most of the lakes in the North Polish focused on central part of Polish, on tracks within the limits of the last ice age, creating a clearly identified Lake [13].

EXPERIMENTAL

The study was conducted on three lakes within the boundaries of the city of Szczecin on three lakes: Glebokie, Rusalka and Szmaragdowe.

Szczecin is situated in North-West Poland, in the western part of West Pomeranian Voivodeship at Polish-German border [13].

Głebokie Lake is classified as an eutrophic lake, shallow type. The catchment area of the lake is almost entirely forested. The area to the east of the lake is developed with buildings. The Lake is a basin reservoir for the endorheic river, with only a small periodical outflow. Lake morphometric data: area 31.3 ha, length – 1550 m, 300 m, maximum depth – 6.0 m, volume – 751 thousand m^3 [13].

Rusałka Lake, also called the Sea Eye, is located in Szczecin Kasprowicz Park in Niebuszewo district. This is the reservoir formed by a medieval Mill River House Osówka [13]. Lake morphometric data: Length – 670 m, width – 70 m, the height of the mirror – 16 m above sea level, type of lake: prohibitive [13].

The Szmaragdowe Lake – the origin is artificial in the Beech Forest, it was formed on 26 July 1925 as a result of flooding the mines existing there before the World War I. The water colour owes its name to lake's origin (the effect of the content of calcium carbonate) [13]. Lake morphometric data: area – 4.5 ha, average depth – 8.2 m, maximum depth – 15.8 m [13].

The research was carried out in the years 2008–2012. Upon sampling, the water pH was measured. Water was tested in compliance with the Polish Standards. The collected water samples were stabilised pursuant to the guidelines of the Polish Standards [4, 8, 9].

Other indicators of water quality were marked within 24 hours of sampling. The oxidation of dissolved organic matter was measured with the COD-Mn method, in accordance with Polish Standards [4, 8, 9].

Dissolved oxygen was marked in accordance with the methodology described by Winkler in Daniszewski's work [4, 8, 9].

The degree of water oxygenation was specified by arrays described by Nemerov [23]. The levels of Total Suspended Solids, BOD_5, NH_4^+, NO_2^-, NO_3^-, $PO_4^{3-}{}_{diss,}$ and $P_{tot.}$ were marked – in accordance with the methodology described by Daniszewski [4, 8, 9].

The quality objectives were evaluated according to the criteria recommended for assessing inland surface waters as set out in the European Union Water Framework Directive (Directive 2000/60/EC) [10].

RESULTS AND DISCUSSION

The results of the seven lakes in the city of Szczecin along with the classification in accordance with the European Union Water Framework Directive are presented in tables 1 to 3.

The level of water pH in the lakes was influenced by physico-chemical and biotic interactions of environmental factors [1, 4, 7, 9, 14, 16, 17].

Among others, the degree of acidity directly affects life processes occurring in ecosystems. It is responsible for the correct uptake of nutrients by organisms. High alkalinity is beneficial for assimilation, and therefore, the nitrogen and phosphorus compounds found in water are much more accessible than in an acid medium. Apart from high acidity, excessive alkalinity of natural waters (pH above 9) also has a clearly detrimental impact on organisms [2, 12, 13, 14, 24, 27].

pH level in the studied lakes was close to neutral pH: 7.59 to 7.97. All lakes, in accordance with the classification of the European Union Water Framework Directive, have been included in the first class.

The aquatic ecosystems of the studied lakes experienced loss on ignition and non-corresponding values of COD-Mn according to the estimates, which were based on the measurements of "loss on drying" and "residue on ignition" in accordance with the methodology set out by Macioszczyk (1987) and on the basis of COD-Mn results, which invariably matched III class water quality. In the tested lake waters, considerable levels of organic matter, including reducing agents, were maintained throughout the year. The reasons for this state of affairs should also be sought in the lake bed sediment, which is rich in organic matter [4-9, 18, 20-24, 28, 30].

The most important elements involved primary production of phosphorus and nitrogen [8, 12, 13, 15, 23, 24, 25].

The presence of these substances determines the productivity of water body, as well as its quality. One nutrient significantly affecting the quality of water is phosphorus [1, 4, 7, 14-17]. It is the primary factor which constrains the development of phytoplankton, and thus, affects massive algal blooms. It can occur in water bodies in a form of inorganic phosphorus as well as dissolved organic forms [1, 2, 12, 13, 15, 24, 25].

Phosphates, or the mineral forms of phosphorus, are best absorbed by organisms and play a huge role in the primary production of a reservoir [19, 23]. They are involved in the circulation of matter in any water body. Therefore, one should pay attention to phosphorus compounds in the demersal zone [1, 2, 8, 9, 12, 13, 15, 24, 25].

Nitrogen occurs in a form of gas dissolved in the water, ammonium ions, nitrate and nitrite. In lakes, it is the main factor limiting the growth of organisms [1, 2, 8, 12, 13, 15, 24, 25, 29, 31].

The tests have demonstrated that water quality in the lakes varied with regards to the tested indicators. By analyzing average annual values, one can note that the pH, O_{2diss} and NO_3^- concentrations showed relatively small variations in all the investigated lakes.

The level of the General Suspension in Szmaragdowe Lake, the peasant was on level II class,

Table 1. Results of the quality of surface water of Glebokie Lake (spring, summer and autumn 2008-2012) along with the classification values of indicators according to the criteria of the European Union Water Framework Directive (2000/60/EC)

Glebokie Lake					
2008 year					
No	Water quality indices	Units	17.04.2008 Spring	24.07.2008 Summer	15.10.2008 Autumn
1.	General Suspension	mg $O_2 \cdot dm^{-3}$	38.7 (III)	47.3 (III)	42.8 (II)
2.	pH	-	7.73 (I)	7.76 (I)	7.73 (I)
3.	COD-Mn	mg $O_2 \cdot dm^{-3}$	9.6 (III)	10.4 (III)	8.4 (III)
4.	BOD_5	mg $O_2 \cdot dm^{-3}$	4.9 (III)	5.6 (III)	4.1 (III)
5.	$O_{2\ diss.}$	mg $O_2 \cdot dm^{-3}$	5.7 (III)	5.4 (III)	5.7 (III)
6.	NO_3^-	mg $N \cdot dm^{-3}$	2.52 (I)	3.63 (I)	1.48 (I)
7.	NO_2^-	mg $N \cdot dm^{-3}$	0.041(II)	0.061 (II)	0.056 (II)
8.	NH_4^+	mg $N \cdot dm^{-3}$	0.68 (II)	0.82 (II)	0.61 (II)
9.	$PO_4^{3-}{}_{diss.}$	mg $PO_4 \cdot dm^{-3}$	0.41 (III)	0.57 (III)	0.46 (III)
10.	P_{tot}	mg Pdm^{-3}	0.49 (III)	0.55 (III)	0.48 (III)
2009 year					
No	Water quality indices	Units	15.04.2009 Spring	22.07.2009 Summer	21.10.2009 Autumn
1.	General Suspension	mg $O_2 \cdot dm^{-3}$	48.2 (III)	51.7 (III)	47.4 (III)
2.	pH	-	7.62 (I)	7.79 (I)	7.61 (I)
3.	COD-Mn	mg $O_2 \cdot dm^{-3}$	6.3 (III)	9.8 (III)	7.9 (III)
4.	BOD_5	mg $O_2 \cdot dm^{-3}$	4.7 (III)	5.8 (III)	5.6 (III)
5.	$O_{2\ diss.}$	mg $O_2 \cdot dm^{-3}$	5.7 (III)	5.2 (III)	5.4 (III)
6.	NO_3^-	mg $N \cdot dm^{-3}$	3.58 (I)	4.53 (I)	2.58 (I)
7.	NO_2^-	mg $N \cdot dm^{-3}$	0.062 (II)	0.085 (II)	0.071 (II)
8.	NH_4^+	mg $N \cdot dm^{-3}$	0.78 (II)	0.94 (II)	0.71 (II)
9.	$PO_4^{3-}{}_{diss.}$	mg $PO_4 \cdot dm^{-3}$	0.45 (III)	0.59 (III)	0.46 (III)
10.	P_{tot}	mg Pdm^{-3}	0.48 (III)	0.57 (III)	0.42 (III)
2010 year					
No	Water quality indices	Units	21.04.2010 Spring	14.07.2010 Summer	20.10.2010 Autumn
1.	General Suspension	mg $O_2 \cdot dm^{-3}$	37.9 (III)	46.8 (III)	36.4 (III)
2.	pH	-	7.64 (I)	7.71 (I)	7.74 (I)
3.	COD-Mn	mg $O_2 \cdot dm^{-3}$	8.9 (III)	11.5 (III)	9.7 (III)
4.	BOD_5	mg $O_2 \cdot dm^{-3}$	5.3 (III)	5.9 (III)	5.6 (III)
5.	$O_{2\ diss.}$	mg $O_2 \cdot dm^{-3}$	5.6 (III)	5.2 (III)	5.4 (III)
6.	NO_3^-	mg $N \cdot dm^{-3}$	2.96 (I)	4.72 (I)	4.19 (I)
7.	NO_2^-	mg $N \cdot dm^{-3}$	0.067 (II)	0.089 (II)	0.079 (II)
8.	NH_4^+	mg $N \cdot dm^{-3}$	0.86 (II)	0.95 (II)	0.82 (II)
9.	$PO_4^{3-}{}_{diss.}$	mg $PO_4 \cdot dm^{-3}$	0.49 (III)	0.59 (III)	0.46 (III)
10.	P_{tot}	mg Pdm^{-3}	0.46 (III)	0.63 (III)	0.48 (III)
2011 year					
No	Water quality indices	Units	20.04.2011 Spring	20.07.2011 Summer	19.10.2011 Autumn
1.	General Suspension	mg $O_2 \cdot dm^{-3}$	43.2 (III)	48.7 (III)	42.4 (III)
2.	pH	-	7.79 (I)	7.95 (I)	7.88 (I)
3.	COD-Mn	mg $O_2 \cdot dm^{-3}$	8.4 (III)	11.2 (III)	9.5 (III)
4.	BOD_5	mg $O_2 \cdot dm^{-3}$	4.1 (III)	5.9 (III)	5.2 (III)
5.	$O_{2\ diss.}$	mg $O_2 \cdot dm^{-3}$	5.6 (III)	5.2 (III)	5.5 (III)
6.	NO_3^-	mg $N \cdot dm^{-3}$	3.28 (I)	4.31 (I)	2.62 (I)
7.	NO_2^-	mg $N \cdot dm^{-3}$	0.079 (II)	0.084 (II)	0.061 (II)
8.	NH_4^+	mg $N \cdot dm^{-3}$	0.85 (II)	0.95 (II)	0.59 (II)
9.	$PO_4^{3-}{}_{diss.}$	mg $PO_4 \cdot dm^{-3}$	0.46 (III)	0.68 (III)	0.43 (III)
10.	P_{tot}	mg Pdm^{-3}	0.45 (III)	0.57 (III)	0.48 (III)
2012 year					
No	Water quality indices	Units	18.04.2012 Spring	18.07.2012 Summer	27.09.2012 Autumn
1.	General Suspension	mg $O_2 \cdot dm^{-3}$	35.2 (III)	43.9 (III)	38.5 (III)
2.	pH	-	7.72 (I)	7.79 (I)	7.74 (I)
3.	COD-Mn	mg $O_2 \cdot dm^{-3}$	8.1 (III)	10.3 (III)	8.7 (III)
4.	BOD_5	mg $O_2 \cdot dm^{-3}$	5.2 (III)	5.8 (III)	5.5 (III)
5.	$O_{2\ diss.}$	mg $O_2 \cdot dm^{-3}$	5.8 (III)	5.2 (III)	5.6 (III)
6.	NO_3^-	mg $N \cdot dm^{-3}$	3.74 (I)	4.18 (I)	3.91 (I)
7.	NO_2^-	mg $N \cdot dm^{-3}$	0.083 (I)	0.075 (II)	0.079 (II)
8.	NH_4^+	mg $N \cdot dm^{-3}$	0.74 (II)	0.77 (II)	0.62 (II)
9.	$PO_4^{3-}{}_{diss.}$	mg $PO_4 \cdot dm^{-3}$	0.43 (III)	0.66 (III)	0.48 (III)
10.	P_{tot}	mg Pdm^{-3}	0.41 (III)	0.63 (III)	0.45 (III)

Explanation: I, II, III - classification of values of examined indicators in accordance with the European Union Water Framework Directive (2000/60/EC)

Table 2. Results of the quality of surface water of Rusalka Lake (spring, summer and autumn 2008-2012) along with the classification values of indicators according to the criteria of the European Union Water Framework Directive (2000/60/EC)

No	Water quality indices	Units	Spring	Summer	Autumn
Rusalka Lake					
2008 year					
No	Water quality indices	Units	17.04.2008 Spring	24.07.2008 Summer	15.10.2008 Autumn
1.	General Suspension	mg O_2·dm^{-3}	32.4 (III)	41.2 (III)	36.8 (III)
2.	pH	-	7.93 (I)	7.78 (I)	7.85 (I)
3.	COD-Mn	mg O_2·dm^{-3}	9.4 (III)	11.3 (III)	10.2 (III)
4.	BOD_5	mg O_2·dm^{-3}	4.8 (III)	5.2 (III)	5.1 (III)
5.	$O_{2\ diss.}$	mg O_2·dm^{-3}	5.7 (III)	5.1 (III)	5.3 (III)
6.	NO_3^-	mg N·dm^{-3}	1.29 (I)	3.69 (I)	2.39 (I)
7.	NO_2^-	mg N·dm^{-3}	0.051 (II)	0.079 (II)	0.058 (II)
8.	NH_4^+	mg N·dm^{-3}	1.43 (III)	1.82 (III)	1.55 (III)
9.	PO_4^{3-} diss.	mg PO_4·dm^{-3}	0.51 (III)	0.66 (III)	0.43 (III)
10.	$P_{tot.}$	mg Pdm^{-3}	0.45 (III)	0.68 (III)	0.49 (III)
2009 year					
No	Water quality indices	Units	15.04.2009 Spring	22.07.2009 Summer	21.10.2009 Autumn
1.	General Suspension	mg O_2·dm^{-3}	39.5 (III)	47.1 (III)	41.6 (III)
2.	pH	-	7.76 (I)	7.73 (I)	7.91 (I)
3.	COD-Mn	mg O_2·dm^{-3}	9.2 (III)	10.8 (III)	7.1 (III)
4.	BOD_5	mg O_2·dm^{-3}	5.2 (III)	5.9 (III)	4.5 (III)
5.	$O_{2\ diss.}$	mg O_2·dm^{-3}	5.8 (III)	5.2 (III)	5.4 (III)
6.	NO_3^-	mg N·dm^{-3}	3.24 (I)	4.46 (I)	3.71 (I)
7.	NO_2^-	mg N·dm^{-3}	0.054 (II)	0.071 (II)	0.063 (II)
8.	NH_4^+	mg N·dm^{-3}	1.32 (III)	1.87 (III)	1.48 (III)
9.	PO_4^{3-} diss.	mg PO_4·dm^{-3}	0.49 (III)	0.53 (III)	0.51 (III)
10.	$P_{tot.}$	mg Pdm^{-3}	0.45 (III)	0.64 (III)	0.48 (III)
2010 year					
No	Water quality indices	Units	21.04.2010 Spring	14.07.2010 Summer	20.10.2010 Autumn
1.	General Suspension	mg O_2·dm^{-3}	31.2 (III)	49.4 (III)	35.8 (III)
2.	pH	-	7.82 (I)	7.65 (I)	7.59 (I)
3.	COD-Mn	mg O_2·dm^{-3}	8.4 (III)	11.3 (III)	10.6 (III)
4.	BOD_5	mg O_2·dm^{-3}	5.1 (III)	5.6 (III)	4.8 (III)
5.	$O_{2\ diss.}$	mg O_2·dm^{-3}	5.3 (III)	5.1 (III)	5.7 (III)
6.	NO_3^-	mg N·dm^{-3}	3.09 (I)	4.26 (I)	2.63 (I)
7.	NO_2^-	mg N·dm^{-3}	0.031 (II)	0.085 (II)	0.049 (II)
8.	NH_4^+	mg N·dm^{-3}	1.58 (III)	1.75 (III)	1.51 (III)
9.	PO_4^{3-} diss.	mg PO_4·dm^{-3}	0.46 (III)	0.62 (III)	0.57 (III)
10.	$P_{tot.}$	mg Pdm^{-3}	0.51 (III)	0.69 (III)	0.64 (III)
2011 year					
No	Water quality indices	Units	20.04.2011 Spring	20.07.2011 Summer	19.10.2011 Autumn
1.	General Suspension	mg O_2·dm^{-3}	34.1 (III)	46.0 (III)	38.5 (III)
2.	pH	-	7.74 (I)	7.89 (I)	7.73 (I)
3.	COD-Mn	mg O_2·dm^{-3}	9.3 (III)	10.8 (III)	9.7 (III)
4.	BOD_5	mg O_2·dm^{-3}	4.7 (III)	5.7 (III)	4.9 (III)
5.	$O_{2\ diss.}$	mg O_2·dm^{-3}	5.3 (III)	5.1 (III)	5.8 (III)
6.	NO_3^-	mg N·dm^{-3}	2.75 (I)	4.53 (I)	3.47 (I)
7.	NO_2^-	mg N·dm^{-3}	0.062 (II)	0.075 (II)	0.071 (II)
8.	NH_4^+	mg N·dm^{-3}	1.48 (III)	1.84 (III)	1.62 (III)
9.	PO_4^{3-} diss.	mg PO_4·dm^{-3}	0.45 (III)	0.68 (III)	0.48 (III)
10.	$P_{tot.}$	mg Pdm^{-3}	0.48 (III)	0.65 (III)	0.54 (III)
2012 year					
No	Water quality indices	Units	18.04.2012 Spring	18.07.2012 Summer	27.09.2012 Autumn
1.	General Suspension	mg O_2·dm^{-3}	34.7 (III)	39.3 (III)	31.3 (III)
2.	pH	-	7.91 (I)	7.84 (I)	7.85 (I)
3.	COD-Mn	mg O_2·dm^{-3}	8.7 (III)	10.3 (III)	8.3 (III)
4.	BOD_5	mg O_2·dm^{-3}	4.2 (III)	5.3(III)	3.8 (III)
5.	$O_{2\ diss.}$	mg O_2·dm^{-3}	5.2 (III)	5.1 (III)	5.7 (III)
6.	NO_3^-	mg N·dm^{-3}	2.37 (I)	3.72 (I)	1.72 (I)
7.	NO_2^-	mg N·dm^{-3}	0.081 (II)	0.096 (II)	0.062 (II)
8.	NH_4^+	mg N·dm^{-3}	1.72 (III)	1.86 (III)	1.59 (III)
9.	PO_4^{3-} diss.	mg PO_4·dm^{-3}	0.55 (III)	0.68 (III)	0.43 (III)
10.	$P_{tot.}$	mg Pdm^{-3}	0.48 (III)	0.52 (III)	0.57 (III)

Explanation: I, II, III - classification of values of examined indicators in accordance with the European Union Water Framework Directive (2000/60/EC)

Table 3. Results of the quality of Szmaragdowe Lake surface water (spring, summer and autumn 2008-2012) along with the classification values of indicators according to the criteria of the European Union Water Framework Directive (2000/60/EC)

Szmaragdowe Lake					
2008 year					
No	Water quality indices	Units	17.04.2008 Spring	24.07.2008 Summer	15.10.2008 Autumn
1.	General Suspension	$mg\ O_2 \cdot dm^{-3}$	19.7 (II)	22.8 (II)	16.7 (II)
2.	pH	-	7.69 (I)	7.85 (I)	7.73 (I)
3.	COD-Mn	$mg\ O_2 \cdot dm^{-3}$	3.4 (II)	5.8 (II)	4.3 (II)
4.	BOD_5	$mg\ O_2 \cdot dm^{-3}$	2.1 (II)	2.7 (II)	2.4 (II)
5.	$O_{2\ diss.}$	$mg\ O_2 \cdot dm^{-3}$	6.8 (II)	6.1 (III)	6.2 (II)
6.	NO_3^-	$mg\ N \cdot dm^{-3}$	2.42 (I)	3.64 (I)	1.45 (I)
7.	NO_2^-	$mg\ N \cdot dm^{-3}$	0.053 (II)	0.065 (II)	0.059 (II)
8.	NH_4^+	$mg\ N \cdot dm^{-3}$	0.45 (II)	0.59 (II)	0.73 (II)
9.	$PO_4^{3-}\ _{diss.}$	$mg\ PO_4 \cdot dm^{-3}$	0.32 (II)	0.37 (II)	0.25 (II)
10.	P_{tot}	$mg\ Pdm^{-3}$	0.27 (II)	0.35 (II)	0.29 (II)
2009 year					
No	Water quality indices	Units	15.04.2009 Spring	22.07.2009 Summer	21.10.2009 Autumn
1.	General Suspension	$mg\ O_2 \cdot dm^{-3}$	20.7 (II)	23.1 (II)	18.2 (II)
2.	pH	-	7.79 (I)	7.86 (I)	7.61 (I)
3.	COD-Mn	$mg\ O_2 \cdot dm^{-3}$	4.1 (II)	5.3 (II)	4.8 (II)
4.	BOD_5	$mg\ O_2 \cdot dm^{-3}$	2.1 (II)	2.7 (II)	2.3 (II)
5.	$O_{2\ diss.}$	$mg\ O_2 \cdot dm^{-3}$	6.7 (II)	6.3 (II)	6.5 (II)
6.	NO_3^-	$mg\ N \cdot dm^{-3}$	3.15 (I)	3.94 (I)	3.67 (I)
7.	NO_2^-	$mg\ N \cdot dm^{-3}$	0.047 (II)	0.069 (II)	0.052 (II)
8.	NH_4^+	$mg\ N \cdot dm^{-3}$	0.38 (II)	0.75 (II)	0.54 (II)
9.	$PO_4^{3-}\ _{diss.}$	$mg\ PO_4 \cdot dm^{-3}$	0.31 (II)	0.36 (II)	0.24 (II)
10.	P_{tot}	$mg\ Pdm^{-3}$	0.26 (II)	0.39 (II)	0.33 (II)
2010 year					
No	Water quality indices	Units	21.04.2010 Spring	14.07.2010 Summer	20.10.2010 Autumn
1.	General Suspension	$mg\ O_2 \cdot dm^{-3}$	19.2 (II)	23.8 (II)	21.4 (II)
2.	pH	-	7.86 (I)	7.89 (I)	7.85 (I)
3.	COD-Mn	$mg\ O_2 \cdot dm^{-3}$	3.9 (II)	5.7 (II)	4.8 (II)
4.	BOD_5	$mg\ O_2 \cdot dm^{-3}$	2.3 (II)	2.6 (II)	2.4 (II)
5.	$O_{2\ diss.}$	$mg\ O_2 \cdot dm^{-3}$	6.7 (II)	6.1 (II)	6.8 (II)
6.	NO_3^-	$mg\ N \cdot dm^{-3}$	3.48 (I)	4.69 (I)	3.29 (I)
7.	NO_2^-	$mg\ N \cdot dm^{-3}$	0.058 (II)	0.082 (II)	0.063 (II)
8.	NH_4^+	$mg\ N \cdot dm^{-3}$	0.49 (II)	0.84 (II)	0.47 (II)
9.	$PO_4^{3-}\ _{diss.}$	$mg\ PO_4 \cdot dm^{-3}$	0.25 (II)	0.38 (II)	0.24 (II)
10.	P_{tot}	$mg\ Pdm^{-3}$	0.33 (II)	0.37 (II)	0.29 (II)
2011 year					
No	Water quality indices	Units	20.04.2011 Spring	20.07.2011 Summer	19.10.2011 Autumn
1.	General Suspension	$mg\ O_2 \cdot dm^{-3}$	19.5 (II)	23.1 (II)	18.6 (II)
2.	pH	-	7.83 (I)	7.97 (I)	7.78 (I)
3.	COD-Mn	$mg\ O_2 \cdot dm^{-3}$	3.9 (II)	5.8 (II)	4.5 (II)
4.	BOD_5	$mg\ O_2 \cdot dm^{-3}$	2.5 (II)	2.8 (II)	2.5 (II)
5.	$O_{2\ diss.}$	$mg\ O_2 \cdot dm^{-3}$	6.7 (II)	6.2 (II)	6.6 (II)
6.	NO_3^-	$mg\ N \cdot dm^{-3}$	2.84 (I)	4.62 (I)	2.73 (I)
7.	NO_2^-	$mg\ N \cdot dm^{-3}$	0.086 (II)	0.093 (II)	0.069 (II)
8.	NH_4^+	$mg\ N \cdot dm^{-3}$	0.73 (II)	0.86 (II)	0.45 (II)
9.	$PO_4^{3-}\ _{diss.}$	$mg\ PO_4 \cdot dm^{-3}$	0.36 (II)	0.38 (II)	0.27 (II)
10.	P_{tot}	$mg\ Pdm^{-3}$	0.26 (II)	0.34 (II)	0.31 (II)
2012 year					
No	Water quality indices	Units	18.04.2012 Spring	18.07.2012 Summer	27.09.2012 Autumn
1.	General Suspension	$mg\ O_2 \cdot dm^{-3}$	17.4 (II)	22.9 (II)	21.4 (II)
2.	pH	-	7.84 (I)	7.70 (I)	7.87 (I)
3.	COD-Mn	$mg\ O_2 \cdot dm^{-3}$	4.7 (II)	5.6 (II)	5.2 (II)
4.	BOD_5	$mg\ O_2 \cdot dm^{-3}$	2.3 (II)	2.9 (II)	2.6 (II)
5.	$O_{2\ diss.}$	$mg\ O_2 \cdot dm^{-3}$	6.4 (II)	6.1 (II)	6.7 (II)
6.	NO_3^-	$mg\ N \cdot dm^{-3}$	1.84 (I)	3.62 (I)	2.04 (I)
7.	NO_2^-	$mg\ N \cdot dm^{-3}$	0.068 (II)	0.089 (II)	0.072 (II)
8.	NH_4^+	$mg\ N \cdot dm^{-3}$	0.67 (II)	0.83 (II)	0.51 (II)
9.	$PO_4^{3-}\ _{diss.}$	$mg\ PO_4 \cdot dm^{-3}$	0.31 (II)	0.37 (II)	0.26 (II)
10.	P_{tot}	$mg\ Pdm^{-3}$	0.24 (II)	0.32 (II)	0.28 (II)

Explanation: I, II, III - classification of values of examined indicators in accordance with the European Union Water Framework Directive (2000/60/EC)

while in Lakes Głebokie, Rusałka it was on level III class.

The concentration in the surface layer of P_{tot}. Lakes is little differentiated, it is at level II and III quality class according to the classification of the European Union Water Framework Directive. The concentration of total phosphorus is 0.41 – 0.68 mg·dm^{-3}. The largest concentration of phosphorus total recorded in Lakes Głebokie and Rusałka.

The concentrations of the $PO_4^{3-}{}_{diss}$ – in the tested water lakes were changing; these concentrations correspond to water quality from II to III. The increase of the concentrations of phosphorus in the Lake may indicate a decrease in the amount of oxygen in the waters of the shallow and changes their status to release phosphorus compounds accumulated redox in sediment bottom. [5-7, 11, 16, 17, 24].

In case of nitrogen-compounds, nitrates and nitrites values for these indicators were at level I and III class in all the surveyed lakes in accordance with the classification of the European Union Water Framework Directive.

Indicator which indicates the high productivity of Lakes is the biochemical oxygen demand (BOD_5). The level of this indicator values on the studied Lakes was on level II and III class.

The highest concentration of oxygen in the waters of Lakes occur in the Lakes Glebokie and Rusalka.

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