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Quality of Water in Dabie Lake (North-West Poland) During Different Seasons (2008-2012)

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This paper presents the evaluation of physico-chemical parameters of lake water in Dabie Lake based on the European Union Water Framework Directive.The research was carried out in the years 2008-2012, between April and October. From each of the three measuring stations located in the lake included the study, two separate water samples were taken for chemical analysis. Dabie Lake is located within the administrative borders of the city of Szczecin. It constitutes a large sedimentation basin being a part of hydrographically complex Odra river estuary (the other one is Zalew Szczecinski-the Szczecin Lagoon). The accumulation of allochthonous and autochthonous sediments has taken place in these basins for few thousand years. The studied lake had pH values in the neutral range from 7.65 to 7.87. According to the classification of the European Union Water Framework Directive, all lake were classified as first class. By analyzing the average annual values, one can note that pH, O_{2diss} and NO_3^- concentration showed a relatively small variation in all the investigated lake. The total suspended solids in Dabie Lake, fell into the II class. The $P_{tot.}$ concentrations in the surface layer of lake was little differentiated, reaching the levels appropriate for III quality class. The total phosphorus concentration was 0.41-0.69 mgP dm^{-3}. The concentrations of $PO_4^{3-}{}_{diss}$ in the tested lake waters varied more significantly corresponding to water quality classes ranging from IV. The concentrations saturation with O_2 was 44.8-96.4 %. In case of nitrogen compounds, nitrates and nitrites values for these indicators fell into the I and II class in all the surveyed lake. The indicator which proves high productivity of lake is biochemical oxygen demand (BOD_5). The level of this indicator in the studied Lake Dabie was at level III. The highest concentration of oxygen in lake waters was found in Lake Dabie about 8.6 mg O_2 dm^{-3}.

Keywords: Water, Dabie Lake, Physico-chemical indicators, European Union Water Framework Directive.

INTRODUCTION

To address the increasing degradation of surface waters in the European Union, the approach to the evaluation and protection of water resources was changed. This approach was formulated in the European Union Water Framework Directive (2000/60/EC), which calls for the protection of water, as well as an environment-friendly and comprehensive approach to water assessment[1-4]. The ecological status of surface waters and groundwater is assessed on the basis of the ecological potential of the biological and physico-chemical and hydro-morphological indicators[5-8].

The goal of the Water Framework Directive is to achieve good water status in all the Member States of the European Union. This paper presents the evaluation of physico-chemical parameters of water in Dabie Lake based on the European Union Water Framework Directive.

The Dabie Lake is the last component of estuary complex of Pomeranian Bay and Szczecin Laguna. Genetically it belongs to the delta lake. The lake is being very intensively flushed by waters of the Regalica River and at the same time it is transient accumulative basin of the most part on the Odra's waters[9,10]. The Dabie Lake has a well developed shore-line with several smaller and bigger islands. Nowadays, the form of the lake is the result of human activity in Szczecin Harbour, which began in the middle of the 19th century. Especially the south-west part of the lake has been changed because of it. Scientific research shows that the Dabie Lake has the very complicated hydrological conditions[9,10]. One can notice two-way flows and the vertical water levels stratification. The Dabie Lake belongs to the shallow basins. The nearshore (up to 2 m deep) is 100-200 meters wide and it takes 20 % of lake area. More than 50 % of the area is 2-3 meters deep. The area of the lake deeper than 3 meters takes 21.7 % of all area. According to the lay-out of the bottom, Dabie Lake is the shallow bowl, which shores raise nearly ortogonally in the east part of the basic and less steep in the western and northern part.

Dabie Lake is located within the administrative borders of the city of Szczecin (Fig. 1). It constitutes a large sedimentation basin being a part of hydrographically complex Odra

Fig. 1. Location of Dabie Lake in the hydrographic system of Odra river estuary

river estuary (the other one is Zalew Szczecinski - the Szczecin Lagoon). The accumulation of allochthonous and autochthonous sediments has taken place in these basins for a few thousand years. The same processes which have shaped the bottom and present day shoreline of the lake, now act in the direction of its demise. The lake undergoes alluvial filling, with eastern arm of Odra river, Regalica, playing the main part by bringing large amounts of sediments. At the outlet of Regalica (as well as Plonia and Ina rivers), eroded material carried by the river settles and moves along sands, silt and settling suspension.

EXPERIMENTAL

The research was carried out in the years 2008-2012, between April and October. From each of the three measuring stations located in the lake included the study, two separate water samples were taken for chemical analysis.

RESULTS AND DISCUSSION

The results for the Dabie Lake, along with the classification in accordance with the European Union Water Framework Directive are presented in Table-1.

The pH of the water in the lake is influenced by the physico-chemical and biotic interactions of environmental factors[11-14]. 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 < 9) also has a clearly detrimental impact on organisms[14,15].

The studied lake had pH values in the neutral range from 7.65 to 7.87. According to the classification of the European

TABLE-1
RESULTS OF THE QUALITY OF SURFACE WATER OF LAKE DABIE (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)

2008 year					
No	Water quality indices	Units	17.04.2008 Spring	24.07.2008 Summer	15.10.2008 Autumn
1	Total suspended solids	mg O_2 dm^{-3}	19.3 (II)	22.3 (II)	20.2 (II)
2	pH	-	7.76 (I)	7.78 (I)	7.86 (I)
3	COD-Mn	mg O_2 dm^{-3}	7.6 (III)	8.3 (III)	8.8 (III)
4	BOD_5	mg O_2 dm^{-3}	4.5 (III)	5.4 (III)	4.9 (III)
5	$O_{2\ diss.}$	mg O_2 dm^{-3}	7.5 (I)	8.3 (I)	7.4 (I)
6	NO_3^-	mg N dm^{-3}	0.28 (I)	0.37 (I)	0.23 (I)
7	NO_2^-	mg N dm^{-3}	0.034 (II)	0.038 (II)	0.031 (II)
8	NH_4^+	mg N dm^{-3}	0.55 (II)	0.71 (II)	0.57 (II)
9	$PO_4^{3-}{}_{diss.}$	mg PO_4 dm^{-3}	0.73 (IV)	0.83 (IV)	0.78 (IV)
10	$P_{tot.}$	mg P dm^{-3}	0.43 (III)	0.69 (III)	0.42 (III)
11	Saturation with O_2	%	55.1 (-)	95.3 (-)	44.8 (-)
12	Residue after ignition	mg dm^{-3}	183 (-)	196 (-)	171 (-)
2009 year					
No	Water quality indices	Units	15.04.2009 Spring	22.07.2009 Summer	21.10.2009 Autumn
1	Total suspended solids	mg O_2 dm^{-3}	20.4 (II)	21.6 (II)	19.6 (II)
2	pH	-	7.65 (I)	7.79 (I)	7.74 (I)
3	COD-Mn	mg O_2 dm^{-3}	7.5 (III)	8.2 (III)	8.1 (III)
4	BOD_5	mg O_2 dm^{-3}	4.3 (III)	5.2 (III)	4.8 (III)
5	$O_{2\ diss.}$	mg O_2 dm^{-3}	7.4 (I)	8.2 (I)	8.0 (I)
6	NO_3^-	mg N dm^{-3}	0.34 (I)	0.38 (I)	0.32 (I)
7	NO_2^-	mg N dm^{-3}	0.032 (II)	0.037 (II)	0.035 (II)
8	NH_4^+	mg N dm^{-3}	0.50 (II)	0.82 (II)	0.59 (II)
9	$PO_4^{3-}{}_{diss.}$	mg PO_4 dm^{-3}	0.71 (IV)	0.88 (IV)	0.76 (IV)
10	$P_{tot.}$	mg P dm^{-3}	0.51 (III)	0.68 (III)	0.44 (III)
11	Saturation with O_2	%	52.9 (-)	89.3 (-)	47.9 (-)
12	Residue after ignition	mg dm^{-3}	179 (-)	198 (-)	188 (-)

			2010 year		
No	Water quality indices	Units	21.04.2010 Spring	14.07.2010 Summer	20.10.2010 Autumn
1	Total suspended solids	mg O_2 dm^{-3}	19.4 (II)	21.9 (II)	20.6 (II)
2	pH	-	7.68 (I)	7.74 (I)	7.78 (I)
3	COD-Mn	mg O_2 dm^{-3}	7.2 (III)	7.8 (III)	7.3 (III)
4	BOD_5	mg O_2 dm^{-3}	4.8 (III)	5.1 (III)	4.8 (III)
5	$O_{2\ diss.}$	mg O_2 dm^{-3}	7.6 (I)	7.8 (I)	8.2 (I)
6	NO_3^-	mg N dm^{-3}	0.26 (I)	0.39 (I)	0.36 (I)
7	NO_2^-	mg N dm^{-3}	0.035 (II)	0.039 (II)	0.033 (II)
8	NH_4^+	mg N dm^{-3}	0.61 (II)	0.83 (II)	0.74 (II)
9	$PO_4^{3-}{}_{diss.}$	mg PO_4 dm^{-3}	0.77 (IV)	0.82 (IV)	0.72 (IV)
10	$P_{tot.}$	mg P dm^{-3}	0.48 (III)	0.61 (III)	0.47 (III)
11	Saturation with O_2	%	58.7 (-)	89.2 (-)	50.8 (-)
12	Residue after ignition	mg dm^{-3}	179 (-)	203 (-)	175 (-)
			2011 year		
No	Water quality indices	Units	20.04.2011 Spring	20.07.2011 Summer	19.10.2011 Autumn
1	Total suspended solids	mg O_2 dm^{-3}	20.8 (II)	22.1 (II)	21.8 (II)
2	pH	-	7.75 (I)	7.83 (I)	7.72 (I)
3	COD-Mn	mg O_2 dm^{-3}	7.4 (III)	8.6 (III)	7.9 (III)
4	BOD_5	mg O_2 dm^{-3}	4.1 (III)	4.9 (III)	4.4 (III)
5	$O_{2\ diss.}$	mg O_2 dm^{-3}	7.1 (I)	8.6 (I)	7.5 (I)
6	NO_3^-	mg N dm^{-3}	0.31 (I)	0.46 (I)	0.28 (I)
7	NO_2^-	mg N dm^{-3}	0.035 (II)	0.042 (II)	0.037 (II)
8	NH_4^+	mg N dm^{-3}	0.71 (II)	0.86 (II)	0.63 (II)
9	$PO_4^{3-}{}_{diss.}$	mg PO_4 dm^{-3}	0.71 (IV)	0.79 (IV)	0.73 (IV)
10	$P_{tot.}$	mg P dm^{-3}	0.43 (III)	0.58 (III)	0.41 (III)
11	Saturation with O_2	%	68.5 (-)	93.8 (-)	51.6 (-)
12	Residue after ignition	mg dm^{-3}	183 (-)	202 (-)	175 (-)
			2012 year		
No	Water quality indices	Units	18.04.2012 Spring	18.07.2012 Summer	27.09.2012 Autumn
1	Total suspended solids	mg O_2 dm^{-3}	22.1 (II)	23.5 (II)	19.3 (II)
2	pH	-	7.73 (I)	7.87 (I)	7.85 (I)
3	COD-Mn	mg O_2 dm^{-3}	8.0 (III)	8.7 (III)	7.4 (III)
4	BOD_5	mg O_2 dm^{-3}	4.2 (III)	5.2 (III)	4.5 (III)
5	$O_{2\ diss.}$	mg O_2 dm^{-3}	7.3 (I)	8.2 (I)	8.0 (I)
6	NO_3^-	mg N dm^{-3}	0.43 (I)	0.51 (I)	0.39 (I)
7	NO_2^-	mg N dm^{-3}	0.033 (II)	0.037 (II)	0.031 (II)
8	NH_4^+	mg N dm^{-3}	0.65 (II)	0.72 (II)	0.67 (II)
9	$PO_4^{3-}{}_{diss.}$	mg PO_4 dm^{-3}	0.71 (IV)	0.77 (IV)	0.72 (IV)
10	$P_{tot.}$	mg P dm^{-3}	0.41 (III)	0.67 (III)	0.43 (III)
11	Saturation with O_2	%	62.5 (-)	96.4 (-)	50.1 (-)
12	Residue after ignition	mg dm^{-3}	171 (-)	195 (-)	193 (-)

Explanation: I, II, III, IV, (-) – classification of values of examined indicators in accordance with the European Union Water Framework Directive (2000/60/EC) and not classified data – respectively.

Union Water Framework Directive, all lake were classified as first class.

The aquatic ecosystems of the studied lake 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[16] and on the basis of COD-Mn results, which invariably matched III class water quality. In the lake waters tested, 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[17,18].

The most important elements involved in primary production are phosphorus and nitrogen. The presence of these substances determines the productivity of a water body, as well as its quality. One nutrient significantly affecting the quality of water is phosphorus. Phosphates or the mineral forms of phosphorus, are best absorbed by organisms and play a huge role in the primary production of a reservoir. They are involved in the circulation of matter in any water body. Therefore, one should pay attention to phosphorus compounds in the demersal zone[19].

It is the primary factor which constrains the development of phytoplankton and thus affects massive algal blooms. It can occur in water bodies in the form of inorganic phosphorus as well as dissolved organic forms[20].

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

The total suspended solids in the Dabie Lake, fell into the II class. The $P_{tot.}$ concentrations in the surface layer of the lake was little differentiated, reaching the levels appropriate for the III quality class according to the classification of the European

Union Water Framework Directive. The total phosphorus concentration was 0.41-0.69 mgP dm^{-3}. The highest concentration of total phosphorus was recorded in Lake Dabie-summer 2008 (about 0.69 mgP dm^{-3}).

The concentrations of $PO_4^{3-}{}_{diss}$ in the tested lake waters varied more significantly-corresponding to water quality classes ranging from IV. An upswing in the concentration of phosphorus compounds in a lake may indicate a decreased amount of oxygen in the benthic waters and changes in their redox status leading to releasing phosphorus compounds accumulated in the bed sediment[17].

The concentrations saturation with O_2 was 44.8-96.4 %. The highest concentration of saturation with O_2 was recorded in Lake Dabie during summer 2012.

In the case of nitrogen compounds, nitrates and nitrites values for these indicators fell into the I and II class in all the surveyed lake in accordance with the classification of the European Union Water Framework Directive.

The indicator which proves high productivity of the lake is the biochemical oxygen demand (BOD_5). The level of this indicator in the studied lake was at level III. The highest concentration of biochemical oxygen demand was recorded in Lake Dabie-summer 2008 (about 5.4 mg O_2 dm^{-3}).

The highest concentration of oxygen in the lake waters was found in the Lake Dabie (about 8.6 mg O_2 dm^{-3}). In the remaining lake oxygen levels were similar (still in I class).

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