Archives of Environmental Protection
Vol. 41 no. 1 pp. 15–23

PL ISSN 2083-4772
DOI 10.1515/aep-2015-0002

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Cyanobacterial blooms in kaliski region water reservoirs and water quality parameters

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Keywords: artificial lakes, eutrophication, cyanobacterial blooms, cyanotoxins.

Abstract: Cyanobacterial blooms occur frequently in artificial lakes, especially in water reservoirs with small retention exposition to anthropopressure. The abundant occurrence of cyanobacteria is accompanied by danger of oxygen imbalance in the aquatic environment and the secretion of toxins that are possible threat to human health and life. Cyanobacterial cell growth depends on a number of physical (temperature, light exposure), chemical (pH, concentration of compounds containing nitrogen and phosphorus) and biological (the presence of other organisms) factors. This paper presents the results of the analysis of water from reservoirs located in southern Wielkopolska region (Pokrzywnica-Szałe, Gołuchów and Piaski-Szczygliczka). Some important physico-chemical parameters of water samples taken from investigated reservoirs as well as cyanotoxins concentration were determined. Furthermore, the cyanobacterial species were identified. There was also an attempt made to correlate the water parameters with the cyanobacteria development and cyanotoxins production. On the basis of the results obtained in the analyzed season, it can be concluded that water from Pokrzywnica and Gołuchów reservoirs was rich in nutrients, hence the intense cyanobacterial blooms and cyanotoxins in water were observed.

Introduction

The climatic changes and increasing water pollution with biogenic compounds cause that in stagnant water reservoirs or those with slow water flow, the massive growth of phytoplankton is observed which results in the formation of the so-called blooms. Particularly affected by this phenomenon are small retention reservoirs subjected to multidirectional influences (including intensified agricultural activities and livestock), resulting in the pollutants accumulation and the decrease of self-regulation and self-purification processes (Małecki 2006, Ciesielczuk et al. 2014). The massive growth of microorganisms in water reservoirs used for water supply or recreation is a phenomenon particularly troublesome and undesirable. Blooms lower water quality, affect its taste, odour and colour and, in consequence, impede the process of water treatment and purification (Cyran et al. 2005, Kabziński et al. 2004a, Kabziński et al. 2006a, Szczukocki et al. 2010). Abundant occurrence of cyanobacteria is also accompanied by the dangers of disturbance of oxygen balance in the aquatic environment and toxins secretion that pose threat to human health and life. These toxins may cause allergic skin changes, irritate the respiratory tract and eyes, damage liver, kidney, pancreas and can cause tumours of these organs; they have also negative impact on muscle cells (Dawson 1998). The toxic compounds are secreted by such genus of cyanobacteria as *Microcystis, Anabaena, Oscillatoria and Nostoc*.

The growth of cyanobacterial cells depends on many physico-chemical parameters and the most important are temperature, quantity of illumination, nutrients availability and water pH. The optimal temperature for cyanobacteria growth varies within the 15–32°C but the most intensive toxins production proceeds in 18–25°C, however there is some evidence that even different strains of the same species may prefer different temperature conditions (Sivonen 1990). The needs for value of sunlight exposure among cyanobacteria are very different as well. Some species produce lower amount of toxins when high radiation intensity is observed but simultaneously their cells growth rate is unchanged while other species show very fast cells growth and production of high amount of toxins in the same sunlight conditions (Lehtimäki et al. 1994, Sivonen 1996, Sivonen 1990, Watanabe et al. 1985). Cyanobacteria growth depends also on the amount of nutrients in ambient medium. Cyanobacteria fix nitrogen from inorganic and organic compounds containing this element but the easiest bioavailable forms are ammonium ions. If the latter ions occur in insufficient quantities cyanobacteria use urea or nitrate ions. Some of blue-green algae species such as *Nodularia spumigena, Aphanizomenon flos-aque or Anabaena sp.* could easily assimilate nitrogen in molecular form, which is dissolved in high amounts in aquatic systems (Gu et al. 1993, Lehtimäki et al. 1995, Sivonen 1990). No less important element for cyanobacterial living is phosphorus which very often limits their population growth. The main source of phosphorus is phosphates(V) ion but it is also present in inorganic polyphosphates, glucose, glycerol, guanine or cytosine phosphates. Cyanobacteria assimilate 3–5 times lower amounts of phosphorus than nitrogen but even little changes in its availability can have a significant impact on cyanobacteria increase. A high concentration of the phosphates has positive influence on cyanobacteria growth and toxins production. Cyanobacteria are able to live and synthesize toxins even in conditions with unnaturally high concentration of phosphorus compounds because they can store this element in specific polyphosphate chains or cyclic metaphosphate(V) and exploit them in case of deficiency of phosphorus in the environment (Lehtimäki et al. 1994).

There is also influence of pH of the water environment on cyanobacteria occurrence. The optimal pH for the increase of most cyanobacteria species vary from 6 to 9 but this range not always coincides with the best pH for toxins production. For example *M. aeruginosa* UV-006 rises most quickly at pH 9 but it synthesizes the most toxins above and below this value (Van der Westhuizen et al. 1983).

This paper presents the results of the analysis of water from reservoirs of southern Wielkopolska region (Pokrzywnica-Szałe, Gołuchów and Piaski-Szczygliczka). Physico-chemical parameters of water samples collected from the investigated reservoirs were determined. Furthermore, cyanobacterial species were identified and cyanotoxins concentrations were measured. There was also an attempt made to correlate the water parameters which have impact on the cyanobacteria development and cyanotoxins production.

Characteristic of studied objects

The studies were performed on water from three retention reservoirs: Pokrzywnica-Szałe, Gołuchów and Piaski-Szczygliczka located in the southern part of the Wielkopolska District belonging to the Prosna drainage basin which is one of the largest rivers in this area (Kondracki 2002).

Pokrzywnica-Szałe reservoir (Fig. 1) was constructed upon the Pokrzywnica river in the Opatówek commune in 1976–1978. This river is the right tributary of the Prosna river, its length is equal to 36.1 km, and its area is equal to 234.4 km^2. About 300 m from the reservoir to the river upper course there is Trojanówka tributary confluence; the total length of this tributary is equal to 27.0 km; the drainage basin area is equal to 230.6 km^2. The total area drained by the Pokrzywnica river is equal to 476 km^2 (Małecki et al. 2010).

Szałe reservoir is located on the border line of two places: the town of Kalisz and Szałe village. Its main functions contain water damming and water storage for the following purposes: irrigation, smoothing flood-waves, recreation and fish-culture (Raport o stanie środowiska 2005).

The southern bank of the reservoir is covered by Szałe village buildings and developing summer-resort housing. From the northern side, the reservoir is surrounded by forests (Winiarski Forest complex) the whereas south-western side is covered by wetlands and peatbogs (Torfowisko Lis reserve) (Małecki 2005).

The Gołuchów dam reservoir (Fig. 2) is the oldest one in southern Wielkopolska. It was constructed in 1970 upon the Ciemna river in a distance of 5,6 km from the river-confluence with the Prosna river towards the upper course from Gołuchów village. The Ciemna river valley occupies the area of 3 500 ha including 1, 260 ha of forests, 2 030 ha of agricultural lands and 70 ha of waters. Gołuchów reservoir is also supported by waters flowed from the Rów Jedlec (Jedlec Ditch). The main functions of the reservoir are following: flood-wave smoothing, water storage for agriculture, fish-culture and recreation (Małecki 2008).

The northern part of the reservoir is located in Gołuchów village, whereas the southern one – in Czerminek village. The reservoir direct surroundings from the western and southern sides are fields under cultivation, whereas the eastern side is overgrown by forests with a majority of mixed coniferous forests (Paluch et al. 2009).

Piaski-Szczygliczka reservoir (Fig. 3) was constructed and put into operation in 1977. It is located in the northern part of the town of Ostrów Wielkopolski. The reservoir came into being as the result of the deepening of the river's Ołobok valley and damming waters of the Rów Franklinowski (Franklinowski Ditch).

The Ołobok river is the left tributary of the Prosna river. Its confluence is in the middle course of the Prosna river.

Fig. 1. Pokrzywnica-Szałe reservoir

Fig. 2. Gołuchów reservoir

This river is 36.5 km long and its drainage basin is 447.9 km^2. The Ołobok river receives municipal sewage from Raszków and Ostrów Wielkopolski, it is also contaminated by the agricultural activity carried out in its drainage basin (Przybyłek 2005, Strategia Rozwoju Powiatu Ostrowskiego 2004).

The reservoir consists of two parts: the upper one 4 ha large and the lower one 29 ha large, they are separated by a dam with a spillway. The northern and western parts of the basin are covered by forests. On a southern side the reservoir is separated by a dyke from urban development and, contaminated with municipal sewage, the Ołobok river (Dąbrowski et al. 2010).

Methods

Water samples were collected from artificial lakes from April to September 2011, at 0.5 m depth to the dark glass bottles and were stored at +4°C temperature. The following physicochemical parameters of water samples were determined according to Polish Standards (Hermanowicz et al. 1999): temperature, pH, conductivity, turbidity, colour, dissolved oxygen, BOD, oxidability, chlorides, total calcium and magnesium (hardness), nitrites, nitrates, ammonium and sulphates concentrations.

For the determination of cyanobacterial toxins, the water samples (1 dm^3) were pre-purified and separated by SPE method on C18 microcolumns (J.T. Baker, USA). Microcolumns were conditioned with methanol (5 cm^3) and deionised water (Hydrolab system, Poland) (5 cm^3) with 2–3 cm^3/min volume speed (SPE-12G from J.T. Baker, USA). After sample preconcentration, microcolumns were washed with deionised water (5 cm^3) and 10% methanol in water solution (5 cm^3). Then the toxins were eluted from microcolumns with methanol (5 cm^3). The alcohol fraction was collected and evaporated. The samples were dissolved in the solutions with purity for HPLC analysis and filtered through Millex – HV 0.45 μm filter cap (Millipore, USA). Prepurified and concentrated by SPE samples were separated by HPLC on reverse phase (Agilent 1200 DAD, USA) on column Zorbax Eclipse XBD (C18, 150 × 4.6 mm ID, Agilent, USA), with the injector loop volume of 20 mm^3. The separation was isocratic using a mixture of acetonitrile, methanol and 0.01 M ammonium acetate with a flow rate of 1 cm^3/min. The detector was set at 240 nm wavelength. The cyanobacteria species were determined using a microscope Olympus CX 41 RF with camera Olympus UC30 and on the basis of Algaebase online database (http://www.algaebase.org).

Fig. 3. Piaski-Szczygliczka reservoir

Results and discussion

The results of physico-chemical water parameters are presented in Tables 1–3 and the nutrients and toxins concentrations in Figures 4–6.

The increase of nutrients concentration in water ecosystems can lead to intensive phytoplankton blooms. The data of described investigations show that such situation was also noticed in artificial lakes of Kalisz environs in which the occurrence of cyanobacteria was observed. The mentioned reservoirs are mainly used as recreational area and for that reason the control of water quality, eutrophication, cyanobacteria and the presence of toxins should be strictly monitored.

A huge impact on the water class of Pokrzywnica-Szałe reservoir has the water quality of the Pokrzywnica river and its tributary the Trojanówka. The catchment basin of Szałe is a flat area of agriculture nature. That fact entails the worsening of the water quality parameters caused by the inflow of remains of pesticides and fertilizers from the neighbouring fields. The reservoir gets also sludge and industrial wastewater especially from meat industry, there are also discarded pretreated and treated wastes from municipal wastewater treatment plants *inter alia* Brzeziny and Saczyn (to the Pokrzywnica) and Opatówek and Błaszki (to the Trojanówka) (Bieroński 2005).

In water of Pokrzywnica-Szałe reservoir quite high nitrates concentrations (20.6 mg/dm^3) were observed especially at the beginning of summer season 2011 (Fig. 4).

Similar phenomenon, increased nitrates concentrations in winter and spring seasons, was observed in Goczałkowice Lake (Bucka et al. 1993) and in Kozłowa Góra (Zimoch et al. 2003) and Czorsztyn (Raczak 2002) reservoirs as well. The presence of these ions and simultaneously low nitrites and ammonium concentrations prove that self-purification processes occur in aquatic environment and as results of these processes pollutants containing nitrogen are predominantly oxidized to nitrates.

High nitrates concentrations and temperature within the range of 14.7–27.0°C, which corresponds to optimal temperature conditions for cyanobacteria growth and toxins production (Sivonen 1990), contributed to the occurrence of cyanobacterial blooms and their toxins in water of Pokrzywnica reservoir. Intensive multiplying of phytoplankton cells lead to a significant decrease in the concentrations of ions containing nitrogen in consecutive weeks of summer season 2011. Similar observations regarding the Goczałkowickie Lake were described in the work of Czaplicka-Kotas et al. (Czaplicka-Kotas et al. 2012). The increase in the concentrations of ammonium and nitrates were observed in water samples from 29 June and 4 September 2011, which may indicate a flow of sludge or confluence of nitrogen compounds from agricultural fields. Phosphates contents in Szałe water ranged from 0.1–9.8 mg/dm^3 and lower concentrations of these ions were observed during cyanobacterial blooms.

In 1994, on the river Ciemna above the reservoir Gołuchów an ecological sedimentation trap with an area of 1 ha and a storage volume of 8 000 m^3 was built, in which reed and algae act as biological filters and reducers of the nutrients concentrations. This settler is usually used from early spring

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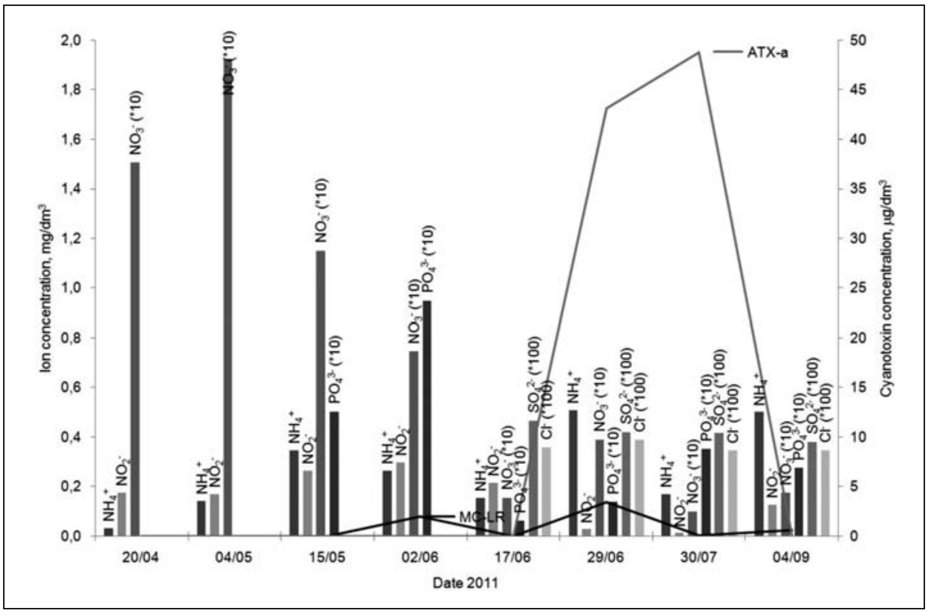

Fig. 4. The concentrations of nutrients and cyanotoxins in water of Pokrzywnica-Szałe reservoir

to late autumn. According to Małecki (Małecki 2008), after the flow of the Ciemna river through the settler, in the case of the flow of overflowing water, the stability of sediments in the settling tank can be disturbed. In the Gołuchów reservoir waters, the highest concentrations of nitrates were observed (Fig. 5) in comparison with the other investigated artificial lakes. In mid-May this concentration reached the level of 50.6 mg/dm^3. At the same time very low level of phosphates (V) – 1.6 mg/dm^3 was observed.

Thus this does not confirm the theory of instability of deposited sediments. However, the obtained results show that in this aquatic system a problem with high nitrates concentration occurs. Furthermore, there were very high values of conductivity (595–910 µS/cm) and total hardness (239–390 mgCaCO$_3$/dm^3) in the water taken from this reservoir, particularly in samples in which the high nitrates concentration was measured. These data indicate that contaminated water masses were discharged to the reservoir.

In comparison with the conductivity values of water from Dobczyce reservoir (200–332 µS/cm) (Szarek-Gwiazda et al. 2009) the other two monitored reservoirs – Piaski-Szczygliczka and Szałe show relatively high values of this parameter – 426–546 µS/cm and 474–625 µS/cm respectively.

Poor hydro-technical condition of Piaski-Szczygliczka reservoir (as a result of too high location of dam's spillway and a low level of water inflow what was the reason of too low damming level and therefore insufficient flow for water exchange) required the water level regulation and providing its adequate purity. To achieve this effect the water from the Ołobok river was directed to the small reservoir. Then water was treated

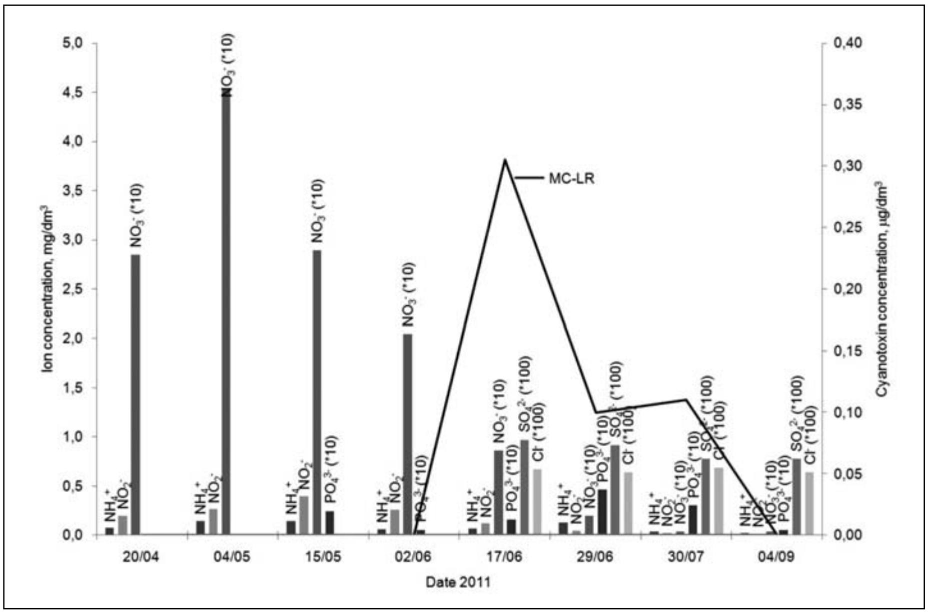

Fig. 5. The concentrations of nutrients and cyanotoxins in water of Gołuchów reservoir

in the process of infiltration through the aquifer layer and was drawn from drilled wells and then went to the large reservoir raising its level (Przybyłek 2005, Strategia Rozwoju Powiatu Ostrowskiego 2004). At the beginning of the summer season 2011 in water samples from Szczygliczka reservoir, as well as from Szałe, a high concentration of nitrate (22.6 mg/dm^3 and 20.6 mg/dm^3 respectively) and low concentration (the lowest of the tested reservoirs) of ammonium and nitrite were observed (Fig. 6).

Dissolved oxygen, present in the surface water, originates mainly from the atmosphere and photosynthesis processes occurring in water plants and microorganisms. Its content shows the contamination of the aquatic system. In summer season 2011, in both reservoirs Piaski-Szczygliczka and Gołuchów fairly good oxygen conditions were observed, 5.6–10.1 and 6.0–13.4 mg/dm^3, respectively. Similar values (7.6–9.8 mg/dm^3) were noticed during the summer months in Dobczyce reservoir (Szarek-Gwiazda et al. 2009). Additionally, in Gołuchów and Szałe reservoirs there was observed an increase in oxygen content in water during the occurrence of algal blooms, which could be related to the intense process of photosynthesis with the participation of cyanobacteria. A significant decrease of this gas occurred in the Szałe waters (down to the value of 0.6 mg/dm^3) during the periods of blooms decay and decomposition of cyanobacteria biomass (Table 1). A completely different situation was observed in the Goczałkowice Lake, where the concentration of dissolved oxygen decreased during cyanobacteria blooms (Czaplicka-Kotas et al. 2012).

The physico-chemical parameter that has a huge impact on cyanobacteria growth is pH of the water. The optimal range of pH for most cyanobacteria species is within 6 to 9 (Van der Westhuizen et al. 1983). Water in Pokrzywnica reservoir in summer season 2011 showed pH 5.9–8.5 but higher values of this parameter were observed in the period of cyanobacterial blooms. Such dependence is in agreement with the hypothesis posed by Unrein (Unrein 2002) according to which intensive photosynthesis in aquatic environment leads to pH increase. Higher pH values facilitate the growth of cyanobacteria with heterocysts, which are and able to fix nitrogen in molecular form (N_2) (Unrein et al. 2010).

In the waters of Gołuchów reservoir (tab. 2) such relationships were not similar. pH of the water changes insignificantly during the monitored season. Small fluctuations in water pH 7.3–8.6, were also noticed by Szarek-Gwiazda et al. in Dobczyce reservoir (Szarek-Gwiazda et al. 2009). The greatest differences in pH – 3 units (6.7–9.7) were observed in water from Piaski-Szczygliczka reservoir and what is interesting that variation of this parameter was not connected with the blue-green algae bloom in this aquatic system.

The parameters described above caused that from April to September in summer season 2011 in Pokrzywnica-Szałe reservoir three maxima of cyanobacterial blooms were noticed: at the beginning and at the end of June and at the beginning of September. In Gołuchów reservoir cyanobacteria occurred twice: a very intensive bloom at the end of June and less intensive at the beginning of September. In Piaski-Szczygliczka reservoir cyanobacterial blooms did not appeared. Such result has been achieved by renovation of this reservoir made in the last few years. This project covered the removing of accumulated bottom sediments and providing a new source of water supply. The pure quality of water as well as the frequent mass algae-blooms appearing over entire water surface were the crucial reasons that forced the management of the reservoir to perform the abovementioned renovation.

In water samples from Szałe and Gołuchów reservoirs 16 cyanobacterial species were identified, among which there were both, toxic and nontoxic ones. The most abundant groups were these from *Microcystis* (*M. aeruginosa, M. wesenbergii, M. viridis, M. flos-aque, M. firma*) and *Oscillatoria* (*O. sancta, O. tenuis, O. limosa, O. brevis, O. curviceps, O. mougeotii*) genera, furthermore in the investigated reservoirs there were also *Anabaena*, *Aphanizomenon* and *Phormidium* species identified. The presence of cyanobacterial cells caused increase in turbidity and colour of the analysed water samples. Additionally the threat connected with the presence of

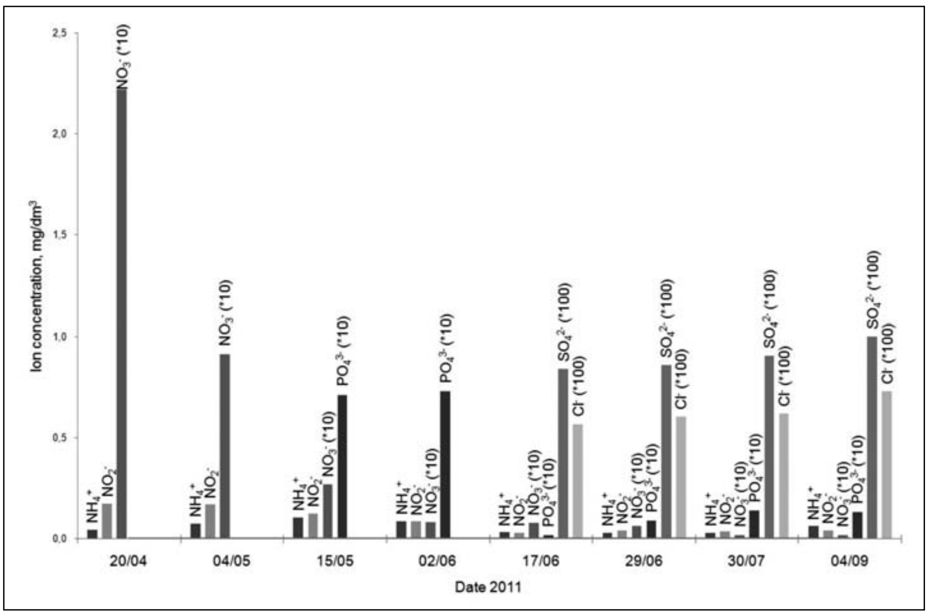

Fig. 6. The concentrations of nutrients in water of Piaski-Szczygliczka reservoir

Table 1. Physico-chemical parameters of water from the Pokrzywnica-Szałe reservoir

Date 2011	Temperature, °C	pH	Conductivity, µS/cm	Turbidity, NTU	Colour, mgPt/dm^3	Hardness, mgCaCO$_3$/dm^3	Dissolved oxygen, mgO$_2$/dm^3	BOD, mgO$_2$/dm^3	Oxidability, mgO$_2$/dm^3
Po1									
20/04	16.9	7.3	516	66.4	33	190	-	-	-
04/05	17.0	7.4	524	6.1	30	198	8.0	2.3	-
15/05	22.3	7.0	511	7.8	32	201	8.0	3.6	-
02/06	22.8	8.5	502	269.0	90	209	8.7	6.0	-
17/06	24.5	7.5	474	33.4	37	198	10.4	9.6	14.1
29/06	21.3	7.3	506	869.0	284	206	0.6	0.7	32.7
30/07	17.0	7.6	576	95.4	51	210	5.0	2.9	37.0
04/09	26.0	7.5	531	82.8	60	210	6.9	1.6	37.9
Min	16.9	7.0	474	6.1	30	190	0.6	0.7	14.1
Max	26.0	8.5	576	869.0	284	210	10.4	9.6	37.9
Mean	21.0	7.5	518	178.7	77	203	6.8	3.8	30.4
Po2									
20/04	14.7	8.3	519	32.2	62	211	-	-	-
04/05	16.1	7.7	563	5.8	35	253	8.5	1.9	-
15/05	21.2	7.6	625	6.2	33	262	5.9	3.8	-
02/06	17.2	7.6	589	6.6	34	254	6.0	4.9	-
17/06	24.6	6.9	536	40.5	73	212	1.3	0.3	26.1
29/06	21.4	5.9	520	1062.0	422	201	1.1	0.4	35.0
30/07	17.0	7.1	579	250.3	77	226	3.0	1.3	94.9
04/09	27.0	7.0	532	15.5	33	228	5.9	4.5	17.2
Min	14.7	5.9	519	5.8	33	201	1.1	0.3	17.2
Max	27.0	8.3	625	1062.0	422	262	8.5	4.9	94.9
Mean	19.9	7.3	558	177.4	96	231	4.5	2.4	43.3

Table 2. Physico-chemical parameters of water from the Gołuchów reservoir

Date 2011	Temperature, °C	pH	Conductivity, µS/cm	Turbidity, NTU	Colour, mgPt/dm^3	Hardness, mgCaCO$_3$/dm^3	Dissolved oxygen, mgO$_2$/dm^3	BOD, mgO$_2$/dm^3	Oxidability, mgO$_2$/dm^3
G1									
20/04	15.7	7.2	865	4.1	20	380	-	-	-
04/05	16.3	7.2	872	4.2	24	379	8.1	1.5	-
15/05	21.6	7.2	892	5.3	25	379	6.0	1.8	-
02/06	23.8	7.5	814	44.7	74	361	6.1	4.1	-
17/06	25.4	7.3	679	69.4	91	286	8.5	7.7	11.2
29/06	26.1	7.1	647	136.7	59	239	13.4	12.6	19.0
30/07	16.5	7.1	595	34.6	37	273	7.6	5.6	28.7
04/09	24.0	7.3	695	24.4	35	274	6.8	2.8	11.7
Min	15.7	7.1	595	4.1	20	239	6.0	1.5	11.2
Max	26.1	7.5	892	136.7	91	380	13.4	12.6	28.7
Mean	21.2	7.2	757	40.4	46	321	8.1	5.2	17.7
G2									
20/04	15.4	7.2	878	3.0	15	390	-	-	-
04/05	16.0	7.3	900	12.5	15	390	8.8	1.6	-
15/05	21.3	7.2	910	3.7	16	390	8.0	1.7	-
02/06	23.5	8.1	791	3.2	21	362	7.5	3.6	-
17/06	24.4	6.8	740	28.0	38	299	7.1	5.6	12.8
29/06	25.4	7.1	669	26.9	31	365	13.0	12.0	11.7
30/07	16.5	7.2	660	43.6	37	256	11.4	6.4	11.7
04/09	24.0	7.8	687	26.1	39	260	6.7	3.6	10.8
Min	15.4	6.8	660	3.0	15	256	6.7	1.6	10.8
Max	25.4	8.1	910	43.6	39	390	13.0	12.0	12.8
Mean	20.8	7.3	779	18.4	27	339	8.9	4.9	11.8

Table 3. Physico-chemical parameters of water from the Piaski-Szczygliczka reservoir

Date 2011	Temperature, °C	pH	Conductivity, μS/cm	Turbidity, NTU	Colour, $mgPt/dm^3$	Hardness, $mgCaCO_3/dm^3$	Dissolved oxygen, mgO_2/dm^3	BOD, mgO_2/dm^3	Oxidability, mgO_2/dm^3
Pi1									
20/04	14.5	8.3	543	65.9	65	197	-	-	-
04/05	15.5	8.9	529	17.3	41	191	9.8	4.6	-
15/05	22.4	6.9	544	23.3	48	197	10.1	4.9	-
02/06	22.9	9.7	482	26.2	47	146	8.6	7.2	-
17/06	25.9	9.1	502	31.8	15	178	7.6	4.9	15.1
29/06	26.1	6.7	541	14.5	37	179	8.6	7.1	11.3
30/07	16.0	6.7	515	21.7	38	197	5.7	2.7	9.1
04/09	26.0	6.8	426	15.1	30	190	6.7	3.7	9.5
Min	14.5	6.7	426	14.5	15	146	5.7	2.7	9.1
Max	26.1	9.7	544	65.9	65	197	10.1	7.2	15.1
Mean	21.2	7.9	510	27.0	40	184	8.2	5.0	11.2
Pi2									
20/04	14.3	7.9	540	63.1	57	161	-	-	-
04/05	15.3	8.0	538	16.0	40	169	9.3	3.4	-
15/05	22.9	8.1	505	27.2	48	173	7.4	3.7	-
02/06	24.4	9.0	495	45.5	90	155	5.6	4.3	-
17/06	25.5	8.6	529	43.9	69	191	5.8	4.9	10.8
29/06	24.5	7.0	546	15.9	44	178	9.2	7.9	12.1
30/07	16.0	6.7	500	14.4	39	194	7.3	3.1	10.1
04/09	26.0	6.7	476	13.9	29	192	6.4	3.2	10.6
Min	14.3	6.7	476	13.9	29	155	5.6	3.1	10.1
Max	26.0	9.0	546	63.1	90	194	9.3	7.9	12.1
Mean	21.1	7.8	516	30.0	52	177	7.3	4.4	10.9

cyanotoxins in reservoirs' water appeared. The highest values of the determined concentrations of cyanotoxins were 3.45 and 48.78 μg/dm³, for microcystin-LR and anatoxin, respectively. Higher content of neurotoxin was probably due to the fact that in the blooms biomass, predominated species from genus *Oscillatoria*, which together with *Anabaena* are regarded as the main producers of this type of toxins. PCR (Polymerase Chain Reaction) is a technique that gives an answer to the question which of the species is responsible for the toxins production (Saker et al. 2007). In subsequent research seasons applying this technique for monitoring and early detection of toxigenic species is being planned. Nevertheless, the obtained values are comparable with the literature data. For example, the maximum concentrations of microcystin-LR and anatoxin in Sulejowskie Lake in 2003–2004 were 12.7 and 97.6 μg/dm³ respectively (Kabziński et al. 2004b, Kabziński et al. 2006b). On the other hand, in Irish lakes the concentrations of main representative of neurotoxins reached even 444 μg/dm³ (James et al. 1997).

Conclusions

The highest concentrations of cyanotoxins in the analysed samples was noticed in Pokrzywnica reservoir. The presented results clearly indicate that the renovation done on Piaski--Szczygliczka reservoir has a significant influence on improving the water quality. Moreover physico-chemical parameters of this aquatic system did not undergo such violent changes as it was in the case of the other two monitored water reservoirs. The study should be continued in subsequent seasons and include also analysis with the use of molecular diagnostic techniques, such as PCR.

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Zakwity sinicowe w zbiornikach okolic Kalisza a wskaźniki jakości wody

Zakwity sinicowe występują szczególnie często w zbiornikach małej retencji poddanych wielokierunkowej antropopresji. Obfitemu występowaniu sinic towarzyszy niebezpieczeństwo związane z zachwianiem równowagi tlenowej w środowisku wodnym oraz wydzielaniem toksyn, które niosą ze sobą zagrożenie dla zdrowia i życia ludzi. Wzrost komórek sinic uzależniony jest od wielu czynników fizycznych (temperatura, naświetlenie), chemicznych (pH, stężenie związków zawierających azot i fosfor) i biologicznych (obecność innych organizmów). W niniejszym artykule przedstawiono wyniki badań wody ze zbiorników retencyjnych południowej Wielkopolski (Pokrzywnica-Szałe, Gołuchów oraz Piaski-Szczygliczka). Scharakteryzowano parametry fizyko-chemiczne wód, określono gatunki sinic występujące w badanych zbiornikach, a także podjęto próbę skorelowania scharakteryzowanych parametrów wód z rozwojem sinic i produkcją cyjanotoksyn. Na podstawie uzyskanych rezultatów można stwierdzić, że wody zbiorników Pokrzywnica i Gołuchów wykazywały dużą żyzność w badanym sezonie, czego efektem były intensywne zakwity sinicowe, w czasie których odnotowano w ich wodach występowanie cyjanotoksyn.