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MACROPHYTES, CYANOBACTERIA AND ALGAE OF THE "BRODZKIE LAKE" IN THE MAŁOPOLSKA UPLAND (SOUTHERN POLAND) – PRELIMINARY STUDY

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ABSTRACT. The present paper provides the results of study on the macrophytes, cyanobacteria and algae of the "Brodzkie Lake" in the Małopolska Upland in southern Poland. In total, 290 taxa (including cyanobacteria, algae – *Heterokontophyta*, *Dinophyta*, *Euglenophyta*, *Chlorophyta* and vascular plants) have been recorded in the study area. Qualitative samples were collected in a period from March 2003 to October 2005. All taxa were briefly described and some water quality parameters were also analysed.

KEY WORDS: lake, cyanobacteria, algae, macrophytes, bioindicators

INTRODUCTION

The "Brodzkie Lake" is one of eight reservoirs constructed on the Kamienna River and located within borders of the Staropolski Industrial District (Fig. 1). The Kamienna River is the second largest river of the Świętokrzyskie Province (following the Nida River). It is 151.6 km long and its catchment area is 2007.9 km^2. The Kamienna River is a left tributary of the Vistula River and flows into it on 324.5 km of its course at 127 m altitude near the town of Solec. The Kamienna River basin has been the location of water-consuming mostly smelting and metal industry plants since the times of Stanisław Staszic. A large assembly of valuable natural objects, like interesting and rare vascular plant species (Maciejczak 1988) or unique topographic features (the whole basin is mostly uplandish) have contributed to establishment of the Kamienna Valley Protected Landscape Area. The most important ecological function of this area is the protection of surface and ground waters and restoration and conservation of an ecological corridor function of the Kamienna River Valley. The Staropolski Industrial District (SID), situated in the Vistula-Pilica-Nida intefluve, is the oldest Polish historical region of industrial development with the dominating role of mining and iron smelting industry based on traditional technology, i.e. using water power and charcoal (Szczepański 1997, 2001).

The present plant cover of the study area has been developing under pressure of extraction industry (ore mining, rock extraction, etc.) and a smelting industrial complex developed along the river, that utilized

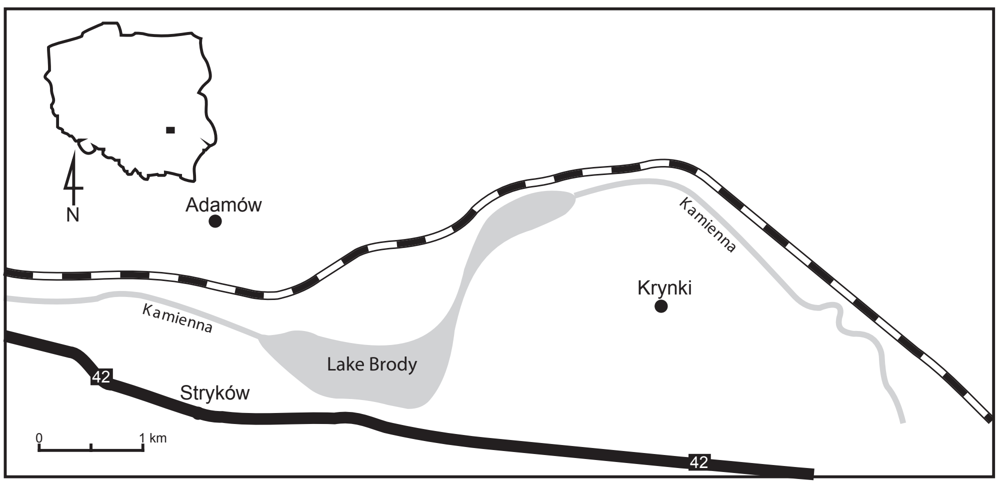

Fig. 1. Localization of study area and general view of the "Brodzkie Lake"

its waters as a hydropower source and transportation means. At the end of 19th century (1885), a railway was built close and parallel to the river channel, that linked industrial towns under development at that time: Ostrowiec Świętokrzyski, Starachowice, Wąchock and Skarżysko-Kamienna. The "Brodzkie Lake" is a multipurpose retention reservoir, used mostly for flood control, which can be used for electrical power production and for recreational purposes.

The above-mentioned historical facts and contemporary human activity in the Kamienna Valley produced enormous changes in its plant cover. First data about vascular plants of this region originated from 19th century (Rostafiński 1872, Ejsmond 1885, Błoński 1892, Puring 1899). However, studies of flora and forest communities (Głazek 1976), and flora of urbanized areas of the Kamienna River Valley (Fijałkowski and Cieśliński 1975, Maciejczak 1988, 1993, 1996, 1998, 2003 a, b, Maciejczak and Rostański 1994) were commenced as late as in the second half of 20th century. The newest floristic investigations were conducted in the Iłża Foreland (Nobis and Piwowarczyk 2003, Nobis 2007). Algological studies of the Kamienna River have been continued from 2000 and aim to establish the structure and ecology of algal and cyanobacterial communities inhabiting the river. In addition, the need for constant monitoring of the Kamienna River has been emphasized (Czerwik-Marcinkowska et al. 2002).

Considering our present knowledge of plant cover of the Kamienna Valley, its synanthropization and increasing anthropogenic pressure, it is absolutely necessary to continue floristic and bioindicative studies of aquatic habitats in this area. The aim of this work is to provide information about macrophytes, cyanobacteria and algae in the "Brodzkie Lake". The studies, conducted in the reservoir provided its preliminary ecological evaluation (some aspects of species ecology).

STUDY AREA

According to physical-geographic division of Poland (Kondracki 2004), the reservoir "Brodzkie Lake" is situated in the Iłża Foreland mesoregion, Małopolska Upland province, whereas from geobotanical standpoint, the study area is located in the northeastern part of the Konecki District, in the Świętokrzyskie Region (Szafer 1977, in ATPOL system, it is located in the quadrants EE 57 and EE 58). Administrative division locates it as a part of Brody Iłżeckie municipality belonging to the Świętokrzyskie Province. "Brodzkie Lake" (equivalent name: Brodzkie Reservoir) is situated close to the southeastern border of the town of Starachowice and was constructed as a result of industrialization of the Kamienna River Basin, according to the concept developed by Staszic (there was a plan to build "a continuous series" of iron manufacturing plants on the Kamienna River). The reservoir was built in the first half of the 19th century (1841) to satisfy the industrial needs of the Staropolski District, and had operated till 1903. Destroyed by flood in the middle of 20th century, it was rebuilt in 1965 and used by mines and industrial plants of new generation, then it was modernized in 1980-1986 and has operated till the present. Now, this reservoir fulfills an important role of water retention and regulation, and alleviation of consequences of flood-wave on the Kamienna River. Owning to its location, it is also used for recreational and touristic purposes. Characteristics of the reservoir (the morphometric features) are listed in Table 1 (Tkaczuk and Wojtasiewicz 2004).

Table 1. The morphometric features of the "Brodzkie Lake"

Total surface area	261 hectares
Surface area at incomplete filling	260 hectares
Gross capacity	7.5 mln m^3
Flood-control capacity	1.0 mln m^3
Total length	5.2 km
Depth	Average 2.0-3.0 m in the middle, maximal near the dam about 7 m
Watershed area	630.1 km^2
Normal water level	194.7 m a.s.l. in northeastern part
Location	76.8 km of the Kamienna River
Dam height	7.6 m
Dam length	362.5 m

In 2003-2005, water of the reservoir (Stan środowiska... 2006) did not comply with any classes of water quality standards, neither in spring nor in autumn. In spring, standard values were exceeded by nitrites and *Escherichia coli* titer. In autumn, many physicochemical parameters, like nitrites, total phosphorus, phosphates, BZT_5 and pH exceeded the standard values. Sanitary state improved and indicator values of bacteriological contamination, i.e. *E. coli* titer were classified into class II. Dam water contamination was caused by wastewaters transported by the Kamienna River, which waters did not meet water quality standards in 2003. The reservoir's bottom is clayey, loessial, abundant in sediments, particularly in the old river channel and in the lower part of the "Brodzkie Lake". Areas surrounding dam's backwater and water flow border are wet sometimes marshy. Besides the Kamienna River, several streams and creeks flow into the reservoir near villages: Styków, Krynki Małe, Górki Brodzkie. Reservoir's southwestern banks are overgrown by pine, fir and mixed forests, while its eastern and northern sides are mostly urbanized. Its contour is usually smooth, while numerous bays are located principally in the area of southeastern backwater and border of water flow. Fertilizers leaching into the reservoir and sewage discharged into it increase water richness in nutrients. It was observed that during hot summer, reservoir's surface is covered by a mats of algae, while windless weather, lack of water mixing and inadequate oxygenation leads to oxygen deficit and fish oxygen starvation. Based on hydrochemical and biological parameters, the present state of the "Brodzkie Lake" can be defined as eutrophic.

MATERIAL AND METHODS

Field studies aimed to investigate water of the reservoir and the section of the Kamienna River within the Brody Iłżeckie municipality, littoral vegetation near the shoreline, sluice with the channel linking reservoir with river channel, and area surrounding the reservoir located no more than 0.5 km away from the shoreline. They were conducted in three vegetative seasons between 2003 and 2005. We used a 1:10 000 map in which 1-km segments along the shoreline were marked. Irregularly-shaped areas were used for detailed listing of vascular plant species (inventory tables) on both sides of the reservoir.

Samples for phycological studies were collected every week from May to October 2003 and from July till November 2005 from previously defined sites (right- or left-shore). Phytoplankton samples were collected from pelagic zone with a 0.5 l container and plankton net no. 25 to obtain the whole spectrum of the assemblage under study. The samples were taken also from the bottom (on the lake shore) with fragments of substratum (gravel or sand), epilithic algae from rocks were sampled by scraping the stones with a clean fine brush. In total, we collected about 100 samples preserved with 4% formalin and stored in plastic containers. Microscopic preparations were examined under Jenamed two light microscope. Taxonomic classification of phyla and classes was done according to Van den Hoek et al. (1995). The diatom nomenclature follows Krammer and Lange-Bertalot (1986, 1988, 1991).

Based on experimental data, an alphabetic list of algal (*Eucaryota*), cyanobacterial (*Cyanoprokaryota*) species and vascular plant species (*Telomophyta*) was compiled (Table 2). Nomenclature of vascular plants in floristic list was adopted from Mirek et al. (2002). Ecological indicator values were presented according to Zarzycki et al. (2002), while other ecological spectra, i.e. humidity (W), trophy (Tr), soil pH (R), resistance to NaCl (S) were defined according to Fałtynowicz (1994). Each species of vascular flora was included in a phytosociological unit according to Matuszkiewicz (2001) and Wysocki and Sikorski (2009).

Table 2. List of vascular plant species recorded in the "Brodzkie Lake"

Species	Number of site
1	2
Agrostis canina L. s. str	3
Alisma plantago-aquatica L.	9
Alnus glutinosa (L.) Gaertn.	9
Alopecurus aequalis Sobol.	3
Alopecurus geniculatus L.	11
Alopecurus pratensis L.	4
Angelica sylvestris L.	1
Berula erecta (Huds.) Coville	2
Bidens cernua L.	4
Bidens frondosa L.	2
Bidens tripartita L.	14
Butomus umbellatus L.	12
Callitriche cophocarpa Sendtn.	8
Callitriche hamulata Kutz. ex W.D.J. Koch	3
Caltha palustris L.	2
Calystegia sepium (L.) R. Br	3
Carex gracilis Curtis	3
Carex nigra Reichard	5
Crepis paludosa (L.) Moench	1
Deschampsia caespitosa (L.) P. Beauv.	5
Eleocharis palustris (L.) Roem. & Schult.	7
Elodea canadensis Michx.	2
Epilobium hirsutum L.	5
Epilobium palustre L.	9
Epilobium parviflorum Schleb.	8
Equisetum palustre L.	6
Filipendula ulmaria (L.) Maxim.	4
Galium palustre L.	7
Galium uliginosum L.	1
Glyceria fluitans (L.) R. Br.	7
Glyceria maxima (Hartm.) Holmb.	10
Gnaphalium uliginosum L.	4
Humulus lupulus L.	1
Hydrocharis morsus-ranae L.	2
Inula britannica L.	2
Iris pseudacorus L.	4
Juncus articulatus L. emend. K. Richt.	8
Juncus bufonius L.	6
Juncus compressus Jacq.	1
Juncus conglomeratus L. emend. Leers	9
Juncus effusus L.	5
Juncus inflexus L.	1
Lemna minor L.	6
Lemna trisulca L.	2
Limosella aquatica L.	3
Lotus uliginosus Sckuchr	9
Lycopus europaeus L.	10
Lysimachia nummularia L.	3
Lysimachia vulgaris L.	6
Lythrum salicaria L.	12
Mentha aquatica L.	5
Myosotis palustris (L.) L. emend. Rchb.	7
Myosoton aquaticum (L.) Moench	5
Myriophyllum verticillatum L.	1
Oenanthe aquatica (L.) Poir.	8
Peplis portula L.	1

Table 2 – cont.

1	2
Peucedanum palustre (L.) Moench	2
Phalaris arundinacea L.	10
Phragmites australis (Cav.) Trin. ex Steud	4
Poa palustris L.	8
Polygonum amphibium L.	11
Polygonum hydropiper L.	10
Polygonum lapathifolium L. ssp. *lapathifolium*	4
Potamogeton compressus L.	1
Potamogeton crispus L.	6
Potamogeton lucens L.	3
Potamogeton natans L.	3
Potamogeton pectinatus L.	1
Potentilla anserina L.	13
Ranunculus flammula L.	3
Rorippa palustris (L.) Besler	10
Rumex hydrolapathum Huds.	3
Rumex maritimus L.	12
Sagittaria sagittifolia L.	6
Salix alba L.	4
Salix cinerea L.	2
Salix fragilis L.	12
Salix pentandra L.	2
Salix purpurea L.	7
Salix viminalis L.	7
Saponaria officinalis L.	4
Schoenoplectus lacustris (L.) Palla	1
Scirpus radicans Schkuhr	10
Scirpus sylvaticus L.	8
Scutellaria galericulata L.	6
Sium latifolium L.	1
Solanum dulcamara L.	6
Sparganium erectum L. emend. s. str.	1
Spirodela polyrhiza (L.) Schleid.	5
Stachys palustris L.	4
Stellaria palustris Retz.	1
Typha angustifolia L.	2
Typha latifolia L.	4
Veronica anagallis-aquatica L.	3
Veronica beccabunga L.	1
Veronica scutellata L.	2

RESULTS

The study material was demonstrated to contain a total of 290 species, including 117 taxa of algae and cyanobacteria occurring in the "Brodzkie Lake" and 77 species from the Kamienna River (the segment within borders of Brody Iłżeckie municipality) and 96 species of vascular plants (Table 2, 3).

Among all systematic groups of algae and cyanobacteria, the most abundant both in the reservoir and in the river were diatoms (Bacillariophyceae) – 65 and 35 taxa and green algae (Chlorophyta) – 32 and 24 taxa, respectively. They formed a significant component of algal and cyanobacterial communities of aquatic biotopes under study. Cyanobacteria (Cyanophyta) were less abundant (eight and 10 species). *Euglenophyta* in the "Brodzkie Lake" were represented by seven taxa and in the Kamienna River by four taxa. Xanthophyceae occurred at small numbers like Dinophyceae of which only one species was found.

Ninety six species of vascular plants belonged to 64 genera and 33 families. According to phytosociological classification, vascular plants of the reservoir belong to plant communities differing in habitat conditions (Matuszkiewicz 2001, Wysocki and Sikorski 2009). Species of fresh-water macrophytes inhabiting meso- and eutrophic inland waters (Potametea), including submerged plants, e.g. *Callitriche cophocarpa*, *C. hamulata*, *Elodea canadensis*, *Myriophyllum verticillatum*, *Potamogeton crispus*, *P. lucens* and floating-leaf plants e.g. *Polygonum amphibium*, *Potamogeton natans* are significant components of the reservoir's vascular flora. Water surface, often near rushes along shorelines is occupied by pleuston assemblages of *Lemna minor*, rarer of *L. trisulca*, *Hydrocharis morsus-ranae* and *Spirodela polyrhiza* (*Lemnetea minoris*).

Species of macrophytes communities occurred along the whole shoreline, but they were the most numerous on stands located closer to the river near Starachowice. Macrophytes composing shore rush communities (Phragmitetea) were profuse and included: *Alisma plantago-aquatica*, *Berula erecta*, *Carex gracilis*, *C. nigra*, *Eleocharis palustris*, *Glyceria fluitans*, *G. maxima*, *Iris pseudacorus*, *Mentha aquatica*, *Oenanthe aquatica*, *Peucedanum palustre*, *Phalaris arundinacea*, *Phragmites australis*, *Sagittaria sagittifolia*, *Scutellaria galericulata*, *Sium latifolium*, *Typha angustifolia*, *T. latifolia* and other plants. Not numerous species growing near the shoreline belonged to the syntaxa *Scheuchzerio-Caricetea nigrae*, e.g. *Agrostis canina*, *Juncus articulatus*, *Ranunculus flammula*, *Veronica scutellata*.

Species of wet habitats: meadows and periodically flooded herbaceous assemblages (*Molinietalia*, *Trifolio fragiferae-Agrostietalia stoloniferae)* developed in close vicinity of marsh plants, particularly on the land side. The following species were observed there: *Alopecurus geniculatus*, *Angelica sylvestris*, *Crepis paludosa*, *Epilobium palustre*, *Lotus uliginosus*, *Lysimachia nummularia*, *Lythrum salicaria*, *Myosotis palustris* and other species. Nitrophilous terophytes (Bidentetea), e.g. *Alopecurus aequalis*, *Bidens cernua*, *B. tripartita*, *Polygonum hydropiper*, *Rorippa palustris*, *Rumex maritimus*, *Scirpus radicans* and small annual plants of summer and autumn (*Gnaphalium uliginosum*, *Juncus bufonius*, *Limosella aquatica*, *Peplis portula*), occurring on humid and wet mineral substrates (*Isoëto Nanojuncetea*) have been also encountered around the reservoir.

The above-listed species were accompanied by assemblages of black alder (*Alnus glutinosa*) and willows: *Salix alba*, *S. fragilis*, *S. purpura*, *S. viminalis* (*Alnetea glutinosae*, *Salicetea purpureae*), and nitrophilous "veil"

TABLE 3. Taxonomic composition of algae and cyanobacteria in the investigated area ("Brodzkie Lake" and Kamienna River)

Taxa	Autecology	Kamienna River	Brodzkie Lake
1	2	3	4
Cyanophyta			
Cyanophyceae			
Anabaena flos-aquae (Lyngb.) Bréb. ex Born. et Flah.		++	+
Gleocapsa minima (Keissler) Holl.			+
Leptolyngbya amplivaginata (Van Goor) Anagn. & Kom.			++
= *Lyngbya amplivaginata* Van Goor			
Leptolyngbya valderiana (Gom.) Anagn. et Kom.		+	
= *Phormidium valderianum* Gom.			
Merismopedia glauca (Ehr.) Kütz.		++	
Microcystis aeruginosa (Kütz.) Kütz		+	+
Oscillatoria maior Vaucher			+
Oscillatoria tenuis Agardh		+	+++
Planktothrix agardhii (Gom.) Anagn. et Kom.		+	+
= *Oscillatoria agardhii* Gom.			
Pleurocapsa sp.		+	
Schizothrix fragilis (Kütz.) Gom.		+	+
Schizothrix sp.		+	
Spirulina maior Kütz.		+	
Heterokontophyta			
Bacillariophyceae			
Achnanthes catenata Bily et Marvan			+
= *Achnanthes microcephala* (Kutz.) Grun.			
Achnanthes lanceolata (Bréb.) Grun.	tol	++	
Achnanthes minutissima Kütz.	tol		++
*Amphora copulata (*Kütz.) Schoeman & Archibald = *Amphora libyca* Ehr.	tol		+
Amphora ovalis (Kütz.) Kütz.	tol		+
Anomoeoneis sphaerophora (Ehr.) Pfitz.	eu		++
Aulacoseira granulata (Ehr.) Simonsen	tol		+
= *Melosira granulata* (Ehr.) Ralfs			
Aulacoseira italica (Ehr.) Simonsen		+	
Brachysira vitrea (Grun.) Ross = *Anomoeoneis vitrea* (Grun.) Ross	oc		+
Caloneis amphisbaena (Bory) Cl.	eu		+++
Caloneis silicula (Ehr.) Cleve	tol	+	+
Cocconeis pediculus Ehr.	eu	+	+++
Cocconeis placentula Ehr.	tol		++
Cocconeis placentula var. *euglypta* (Ehr.) Grun.		++	+
Cyclotella meneghiniana Kütz.	eu	+	+
Cyclotella radiosa (Grun.) Lemm.			+
Cymatopleura elliptica (Bréb.) W. Sm.	tol	+	+++
Cymatopleura solea (Bréb.) W. Sm.	eu	++	+++
Cymbella affinis Kütz.	eu	+	++
Cymbella aspera (Ehr.) Cleve	o	+	
Cymbella cistula (Ehr.) Kirchner	o	+	
Cymbella prostrata (Berk.) Cl.	eu		+
Cymbella tumida (Bréb.) V. Heurek	eu		++

Table 3 – cont.

1	2	3	4
Diatoma ehrenbergii Kütz.	tol	+	+++
Diatoma hyemalis (Roth) Heiberg	od		+++
Diatoma tenuis Agardh = *Diatoma elongatum* (Lyngb.) Ag.	tol		+
Diatoma vulgaris Bory	eu	+	+
Encyonema minutum (Hilse) Kram. = *Cymbella minuta* Hilse	tol		+
Encyonema ventricosum (Agardh) Grun. = *Cymbella ventricosa* Kütz.		+	
Fragilaria arcus (Ehr.) Cleve	tol	+	++
Fragilaria bicapitata Mayer	tol		+
Fragilaria capucina Desmaz.	eu	+	+
Fragilaria capucina Desm. var. *amphicephala* (Grun.) Lange-Bert.	oc		+
Fragilaria capucina Desm. var. *capucina* (Grun.) Lange-Bert.	eu	+	+
Fragilaria construens (Ehr.) Grun.	tol		+
Fragilaria ulna (Nitzsch) Lange-Bert.		+++	+
Fragilaria ulna var. *acus* (Kütz.) Lange-Bert.			+
Frustulia vulgaris (Thw.) De Toni	tol	+++	
Gomphonema acuminatum Ehr.	tol	+	+
Gomphonema acuminatum var. *coronatum* (Ehr.) W. Smith			+
Gomphonema angustatum (Kütz.) Rabenh.		+	++
Gomphonema capitatum Ehr.			+
Gomphonema minutum (Agardh) Agardh	eu		++
Gomphonema olivaceum (Horn.) Bréb.	eu		+
Gomphonema truncatum Ehr.	tol		+
Gomphonema turgidum Ehr.			+
Gyrosigma acuminatum (Kütz.) Rabenh.	eu		+
Gyrosigma attenuatum (Kütz.) Rabenh.	tol		+
Hantzschia amphioxys (Ehr.) Grun.		++	+
Melosira varians Agardh			++
Meridion circulare (Grev.) Agardh	eu	++	+++
Navicula capitatoradiata Germ.	eu	+	
Navicula cincta (Ehr.) Ralfs	eu		++
Navicula gracilis Ehr.		+	
Navicula radiosa Kütz.	tol	++	+
Navicula rhynchocephala Kütz.	tol		+
Neidium affine (Ehr.) Pfitzer	o		+
Neidium amphicephala (Ehr.) Krammer			+
Neidium dubium (Ehr.) Cl.	tol		+
Nitzschia acicularis (Kütz.) W. Sm.	eu		+
Nitzschia dubia Smith		+	
Nitzschia gracilis Hantzsch.	tol	+	
Nitzschia intermedia Hantzsch.	eu		+
Nitzschia nana Grun.	eu	+	
Pinnularia gibba Ehr.	eu	+	+++
Placoneis elginensis (Gregory) Cox		+	+
Rhizosolenia longiseta Zacharias	tol		+
Rhopalodia gibba (Ehr.) Müller			+
Sellaphora pupula (Kütz.) Mereschk.		+	
Stauroneis anceps Ehr.			+
Stauroneis gracilis Ehr.			+

Table 3 – cont.

1	2	3	4
Stauroneis phoenicentron (Nitzsch) Ehr.	tol		+
Surirella amphioxys W. Sm.			+
Surirella angustata Kütz.		+	+
Surirella minuta Bréb.	eu	+	+
Surirella ovalis Bréb.		++	
Tabellaria fenestrata (Lyngb.) Kütz.	tol	+	+
Tabellaria flocculosa (Roth.) Kütz.			++
Tabellaria ventricosa Kütz.	od		++
Chrysophyceae			
Mallomonopsis elliptica Matv.			+
Xanthophyceae			
Characidiopsis ellipsoidea Pascher		+	
Ophiocytium parvulum Braun			+
Tribonema affine G.S. West			+
Tribonema viride Pascher		+	+
Vaucheria sessilis (Vauch.) De Candolle			+
Dinophyta			
Peridiniopsis penardii (Lemm.) Bourrelly		+	
Euglenophyta			
Euglenophyceae			
Euglena acus Ehr.		++	+++
Euglena limnophila Lemm.			++
Euglena spirogyra Ehr.		++	++
Euglena viridis Ehr.		++	+++
Phacus longicauda (Ehr.) Dujardin			+
Trachelomonas armata (Ehr.) Stein		+	+
Trachelomonas volvocina Ehr.			+
Chlorophyta			
Chlorophyceae			
Ankistrodesmus sp.		+	
Bulbochaete sp.			+
Characium obtusum A. Br.			+
Chlamydomonas incerta Pasch.		+	
Chlamydomonas sp.		+	
Chlorella sp.		++	
Chlorococcum infusionum (Schrank) Menegh.		+	+
Chlorococcum sp.		+	
Coelastrum astroideum De-Not.			+
Coelastrum microporum Näg.			++
Coelastrum reticulatum (Dang.) Senn.		+	
Crucigenia tetrapedia (Kirchn.) W. & G.S. West		+	+
Crucigeniella rectangularis (Näg.) Kom.			+
Dictyosphaerium pulchellum Wood		+	
Elakatothrix inflexa Hind.			+
Eudorina elegans Ehr.		+	
Koliella longiseta (Vischer) Hind. = *Rhaphidonema longiseta* Vischer			+
Microspora amoena (Kütz.) Rabenh.		+++	
Microspora floccosa (Vaucher) Thuret		+	+

Table 3 – cont.

1	2	3	4
Microspora sp.		+	
Microthamnion sp.			+
Monoraphidium sp.		+	
Oedogonium sp.		+	
Pediastrum biradiatum Meyen			+
Pediastrum boryanum (Turp.) Menegh.			++
Pediastrum duplex Meyen			+
Pediastrum simplex Meyen			+
Scenedesmus abundans (Kirchn.) Bréb.			+
Scenedesmus acuminatus (Lagerh.) Chod.		+	+++
Scenedesmus acutus Meyen		+	+
Scenedesmus armatus Chod.			+
Scenedesmus bicaudatus (Hansg.) Chod.			+
Scenedesmus denticulatus Lagerh.			+
Scenedesmus linearis Kom.			+
Scenedesmus opoliensis Richt.			++
Scenedesmus quadricauda (Turp.) Bréb.			+
Scenedesmus serratus (Corda) Bohl.			+
Stigeoclonium flagelliferum Kütz		+	
Stigeoclonium sp.		+	
Tetrastrum triangulare (Chod.) Kom.		+	+
Zygnematophyceae			
Closterium acerosum (Schrank) Ehr. ex Ralfs		++	
Closterium leibleinii Kütz. ex Ralfs			+
Closterium lineatum Ehr.		+	+
Closterium praelongum Bréb.			+
Closterium sp.		+	
Spirogyra sp.			++
Staurastrum gracile Ralfs			+
Cladophorophyceae			
Cladophora glomerata (L.) Kütz.		+++	+++

Autecology of *Bacillariophyceae*:
tol – tolerant to a wide range from oligo- to eutrophic waters, oc – oligotrophic predominantly carbonate buffered waters, eu – highest vitality in stronger mesotrophic to eutrophic waters, od – oligotrophic or dystrophic electrolyte poor waters, o – oligotrophic waters of different quality.
Explanation of symbols: frequency of occurrence: + – rare, ++ – frequent, +++ – abundant.

communities (*Convolvuletalia sepium*) with contribution of hydrophilous herbs and climbers, e.g. *Epilobium hirsutum*, *Myosoton aquaticus*, *Poa palustris*, *Saponaria officinalis*, *Urtica dioica*, *Calystegia sepium*.

Characterisation of plant cover involved also the determination of ecological indicator values (Zarzycki et al. 2002), helpful in describing habitat conditions of a study object. Analysis of species composition of cyanobacteria and both phycoflora and vascular flora showed the presence of species typical of relatively nutrient-rich waters, developing, as well in the reservoir as in the Kamienna River's segments under study. Of vascular plants, the following species preferred nutrient-rich water: *Alopecurus aequalis*, *Angelica sylvestris*, *Berula erecta*, *Bidens cernua*, *B. tripartita*, *Butomus umbellatus*, *Humulus lupulus*, *Lythrum salicaria*, *Myriophyllum verticillatum*, *Polygonum amphibium*, *Potamogeton pectinatus*, *Sagittaria sagittifolia*, *Veronica anagallis-aquatica*. Dokulil et al. (1997), Komulaynen (2002), Kitner and Poulíčková (2002), Ács et al. (2003) showed how is important for water quality the algae indicator species. Among algae, the species belonging to eutrophic taxa (22) were e.g.: *Anomoeoneis sphaerophora*, *Caloneis amphisbaena*, *Cocconeis pediculus*, *Cymatopleura solea*, *Cymbella affinis*, *C. tumida*, *Gomphonema minutum*, *Navicula cincta*, *Pinnularia gibba*. Vascular species preferring basic substrate pH included: *Berula erecta, Calystegia sepium, Eleocharis palustris, Epilobium hirsutum, Glyceria maxima, Limosella aquatica, Polygonum amphibium, Potamogeton crispus, P. lucens, P. natans, Sagittaria sagittifolia*. Among diatoms, *Anomoeoneis vitrae* and *Fragilaria capucina* var. *amphicephala* represented oligotrophic calciphilous species. Hydro- and helophytes, and hydrophytes tolerating elevated NaCl levels comprised: *Agrostis canina, Alisma plantago-aquatica, Alopecurus geniculatus, Bidens frondosa, Epilobium palustre, Glyceria fluitans, Iris pseudacorus, Lemna minor, Phragmites australis, Polygonum amphibium, Potamogeton crispus, Typha angustifolia*.

Besides lichens and vascular plants, algae can also be indicative of such environmental factors, as temperature, current velocity, light, salinity, water pH, trophy (i.e. water richness in nutrients and dissolved simple organic compounds), pollution, oxygen level, calcium content, etc. Species from various systematic groups are used for environmental evaluation. Diatoms, filamentous green algae, charophytes, desmids and chrysophytes are usually preferred but according to Kawecka and Eloranta (1994), only a stenotypic organism, living and growing well in a narrow variability range of environmental conditions can be a good indicator. In the present study, we adopted Lange-Bertalot system (1996), that classifies indicator diatom species to the following trophic groups: tolerant, eutrophic, oligotrophic.

Analysis of diatom species composition in water of the "Brodzkie Lake" and adjacent biotopes demonstrated the prevalence of eutrophic and tolerant species (growing well in various types of waters independently of whether they are nutrient-rich or not). The most often encountered tolerant species (25) were: *Cocconeis placentula, Cymatopleura elliptica, Diatoma ehrenbergii, Encyonema minutum, Fragilaria arcus, Frustulia vulgaris, Navicula radiosa,* among others. Oligotrophic waters-preferring diatoms were the least abundant and belonged only to seven species, like *Cymbella cistula, Neidium amphicephala, Tabellaria ventricosa.* It was observed that high concentration of organic substances in the reservoir's water facilitated occurence of euglenoids (*Euglena acus, E. limnophila, E. spirogyra, E. viridis*), which are indicative of water pollution with organic matter.

According to Solomon et al. (1996), elevated phosphorus concentration is responsible for presence of green alga (32 taxa) and cyanobacteria (10 species) in contrast to chrysophytes that tolerate its low concentration. Higher concentrations of phosphorus usually stimulate more algae, especially filamentous, abundance and biomass, but not species diversity. We also observed in the reservoir the communities containing algae distinguished by external features (e.g. large in size or forming shells) as the prevailing component. For instance, we analysed in detail communities in which dominating component were green algae: *Microspora amoena* and *Cladophora glomerata. Microspora amoena* occurred in a majority of biotopes under study (reservoir, Kamienna River segment within Brody Iłżeckie municipality, sluice with the channel linking reservoir with river channel) forming profuse free floating algal mats. Assemblages of this green algae were rich in accompanying species which diversity ranged from 12 to 28 taxa. The most frequent were: *Achnanthes lanceolata*, *Cocconeis placentula* var. *euglypta*, *Diatoma hyemalis*, *Gomphonema angustatum*, *Meridion circulare*, *Rhopalodia gibba.* Accompanying species of *Cladophora glomerata* were: *Melosira varians*, *Navicula radiosa*, *N. gracilis*, *Nitzschia dubia*, *Placoneis elginensis*, *Sellaphora pupula*, *Surirella ovalis*, *Tabellaria flocculosa.* It is worth noting that this community was the best developed in terms of the number of species, diversity and abundance.

Communities of microscopic algae growing within one microhabitat type but on different substrates had usually similar species composition and comparable numerical proportions. No distinct qualitative differences in composition between microphytic communities within one biotope were observed in a majority of cases. However, there were often differences in species numbers and in composition of sporadic species. Both, the reservoir and the Kamienna River segment under study were characterised by a large variability of ecological conditions, as well in terms of trophy in various seasons as biological productivity. It was noted that algal communities in the river were reconstructed quickly in every microhabitat either on the bottom or pelagic zone and periphyton. This phenomenon can be possibly attributed to the fluctuation of water level, current velocity, etc. which significantly modified habitat conditions. Despite similarity of distribution of algal and cyanobacterial taxonomic groups in the whole study period in the reservoir and in the river alike (diatoms and green algae dominated), repeatability of occurrence of a particular species was modest. This is the reason of large taxonomic variability within every biotope under study.

The analysis of phycobiota and vascular flora of the "Brodzkie Lake", conducted herein for the first time, indicates that this reservoir and its closest surroundings should be an object of systematic and thorough studies equivalent to standard monitoring in character (accounting to physicochemical and biological parameters), that would allow for constant analysis of all changes progressing in its aquatic and terrestrial microhabitats.

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