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Research Article

# CYANOBACTERIA WATER BLOOMS ASSOCIATED WITH VARIOUS EUKARYOTIC ALGAE IN THE SULEJÓW RESERVOIR

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## Abstract

The Sulejów Reservoir is a lowland dam reservoir that was constructed in 1973 on the Pilica River at the village of Smardzewice. It is 15.5 km long and has an elongated, trough-like shape. It is characterized by a low depth (mean - 4.5 m), and its mean annual retention time ranges from a dozen to four dozen days. The reservoir is strongly eutrophic due to large loads of phosphorus and nitrogen entering its catchment area.

Since the creation of the reservoir, strong water blooms have been caused by *Aphanizomenon flos-aquae*, *Anabaena flos-aquae*, *Microcystis aeruginosa*, and *Microcystis wessenbergii*. These blooms were associated with the intensified development of green algae, mainly of the genera *Coelastrum*, *Dictyosphaerium*, *Pandorina*, *Pediatrum*, and *Scenedesmus*. Beside the blue-green and green algae, the diatoms were the richest in species, of which *Asterionella formosa*, *Aulacoseira granulata*, *Cyclotella meneghiniana*, *Diatoma tenuis*, *Fragilaria capucina*, *F. Pinnata*, *F. Ulna*, *Melosira varians*, and *Stephanodiscus hantzschii* constantly dominated. These three groups were accompanied by *Dinobryon sertularia*, *Ceratium hirundinella*, and *Peridinium inconspicuum*.

## INTRODUCTION

The Sulejów Reservoir was created in 1973 by impounding the Pilica River with a dam at the village of Smardzewice. This basin has an elongated, trough-like shape. It is 15.5 km long with a maximal width of 2.1 km and maximal depth of 4.5 m. Its functions include retention, recreation, and energy production. It is also one of the Łódź urban area's water sources in addition to artesian wells and water intake at the village of Bronisławów. Thus, it should meet the quality requirements of Purity Class I surface waters.

The quality of the Sulejów Reservoir water depends primarily on the quality of the water in the Luciąża and Pilica rivers that feed it. The concentrations of nutrient indicators were within the norms for Class II in the Pilica and Class III in the Luciąża. In addition to the pollutants that enter with these river waters, the reservoir is heavily polluted by point sources in its catchment area, the intermediate pumping station at the village of Podklasztorze and the water treatment facility in the town of Sulejów, and also by three bathing spots located in Zarzęcin, Bronisławów, and Borki. The physico-chemical analyses of the water indicated that diverse pollutant concentrations occur in the reservoir. The basic indicators that determine water quality belonged to Purity Class I, although several of them, such as $BOD_5$, $COD_{MN}$, $COD_{Cr}$, suspended matter, nitrates, phosphates, total phosphorus, and manganese, were at values that correspond to classes II and III (Anonym 2003). Thus, the overall water quality in the reservoir did not conform to the specifications of Purity Class I.

The first complex investigations of phytoplankton were carried out by the Łódź Provincial Council Office (Rakowska and Rakowski 1992), and then in 1982-1993 by the University of Łódź (Galicka et al. 1992, 1998; Izydorczyk 2002; Tarczyńska 1998).

The aim of the present study was to describe the species structure of phytoplankton associations, mainly in 2003, compare it with earlier years (1982-1993), and present the dynamics of alga development in the Sulejów Reservoir.

## MATERIALS AND METHODS

The materials were comprised of plankton samples collected at three sites (1 - Zarzęcin, 2 - Bronisławów, 3 - Tresta) from May to September 1979-1980, (Rakowska et al. 1992) and in April and September 2003. The samples were obtained by filtrating 10 l of water through a no. 25 planktonic net. These were used to determine the qualitative and quantitative composition of the phytoplankton.

The qualitative composition of *Chlorophyta* was determined by the droplet method (Starmach 1989). All of the samples were also preserved according to the methods of Starmach (1989). Microscopic slides were prepared from the phytoplankton samples; these were used to identify the species and count the number of a given species. Algae were calculated in three strips running across the whole of the microscope slide cover glass. The number of specimens of a given species (X) in 1 ml of water was calculated using the following formula:

$$X = a \times p / p_1 \times V \times z$$

where:
a – number of specimens of a given species in three stripes
p – total area of the slide
$p_1$ – areas of the investigated part of the slide (three stripes)
V – volume of the droplet studied
Z – concentration coefficient (volume of the sample before concentration divided by its volume after concentration)

Qualitative and quantitative investigations of diatoms were conducted based on permanent slides prepared using the cold parching method (Siemińska 1964). The algological material was treated with condensed sulfuric and chromic acids. After parching and rinsing with distilled water, the material was fixed in Pleurax resin. The percentages of given diatom taxa were calculated on the basis of 400 specimens (Cholnoky 1968).

Species whose abundance exceeded 5% of all the individuals were considered dominant, while those with abundance between 2 and 5% were classified as subdominant (Trojan 1975). The data for the green algae were obtained by calculating them in three stripes.

The diatom taxa were identified using the Krammer and Lange-Bertalot (1986, 1988, 1991a, b) and Lange-Bertalot (2000-2003) keys, while Cyanobacteria, blue-green algae, and green algae taxa and some other species were determined using the Förster (1982), Hindák (1977, 1984, 1988, 1990), Komárek and Fott (1983) and Komárek and Jankovská (2001) keys.

## RESULTS AND DISCUSSION

The planktonic samples were mostly dominated by algae belonging to the three phyla *Cyanophyta*, *Chlorophyta*, and *Chrysophyta.*

In 1979-1980 mainly Cyanobacteria - *Microcystis aeruginosa* Kützing, and *Aphanizomenon flos-aque* (L.) Ralfs formed water blooms at all the investigated

sites. In 2003, the mass development of *Microcystis aeruginosa* was recorded at all three sites. In August *Microcystis wesenbergii* Komárek also contributed to water blooms in Zarzęcin and Tresta, while *Anabaena flos-aquae* Brébisson did so in Tresta in September.

The order *Chlorococcales* was the richest species among the *Chlorophyta.* In the first period of study (1979-1980), 149 taxa were distinguished in this phylum. The most abundant were *Coelastrum microporum* Nägeli, *Pandorina morum* (O. F. Müller) Bory, *Scenedesmus acuminatus* (Lagerheim) Chodat, *S. acutus* Meyen, *S. carinatus* (Lemmermann) Chodat, *S. granulatus* W. & G. S. West, *S. quadricauda* (Trupin) Brébisson, *S. spinosus* Chodat (Rakowska et al. 1992). In 2003, a total of 45 green algae taxa were identified. They included species such as *Coelastrum astroideum* De Notaris, *Dictyosphaerium pulchellum* Wood, *Eudorina elegans* Ehrenberg, *Pandorina morum* (O. F. Müller), *Pediastrum biradiatum* Meyen, *P. boryanum* (Turpin) Meneghini, *P. duplex* Meyen, *P. tetras* (Ehrenberg) Ralfs, *Scenedesmus acuminatus* (Lagerheim) Chodat, *S. opoliensis* P. Richter, *S. quadricauda* (Turpin) Brébisson.

The *Chrysophyta* phyllum was very abundantly represented, mainly by its class of *Bacillariophyceae*. In 1979-1980, a total of 315 diatom taxa were identified. The dominants occurring at the Zarzęcin site were *Asterionella formosa* Hassall, *Aulacoseira granulata* (Ehrenberg) Simonsen, *Cyclotella meneghiniana* Kützing, *Fragilaria capucina* Desmazières, *F. construens* (Ehrenberg) Grunow, *F. construens* var. *venter* (Ehrenberg) Grunow, *F. pinnata* Ehrenberg, *F. ulna* (Nitzsch) Lange-Bertalot, *F. ulna* var. *acus* (Kützing) Lange-Bertalot, and *Stephanodiscus hantzschii* Grunow. Those at the Bronisławów site included *Asterionella formosa* Hassall, *Aulacoseira italica* (Ehrenberg) Simonsen, *A. granulata* (Ehrenberg) Simonsen, *Cyclotella meneghiniana* Kützing, *Fragilaria construens* var. *venter* (Ehrenberg) Grunow, *F. construens* var. *binodis* (Ehrenberg) Grunow, *F. crotonensis* Kitton, *F. pinnata* Ehrenberg, *Melosira varians* Agardh, *Navicula gregaria* Donkin, *Nitzschia acicularis* (Kützing) W. Smith, *N. fonticola* Grunow, *N. linearis* (Agardh) W. Smith, *N. recta* Hantzsch, and *Stephanodiscus hantzschii*. Lastly, at the Tresta site there were *Asterionella formosa*, *Aulacoseira granulata*, *Fragilaria crotonensis*, and *Stephanodiscus hantzschii.*

In the second period of investigation 128 diatom taxa were identified. The nine following taxa dominated at the Zarzęcin site: *Asterionella formosa*, *Aulacoseira granulata*, *Diatoma tenuis* Agardh, *Fragilaria crotonensis*, *F. ulna* var. *acus*, *Nitzschia fonticola*, *N. palea* (Kützing) Smith, *Rhizosolenia longiseta* Zacharias, *Stephanodiscus hantzschii*. *Asterionella formosa*, *Aulacoseira granulata*, *Diatoma tenuis*, *Fragilaria crotonensis*, *F. ulna* var. *acus*, *Nitzschia*

*fonticola*, *N. palea*, *Rhizosolenia longiseta*, *Stephanodiscus hantzschii* dominated at the Bronisławów site, while *Asterionella formosa*, *Aulacoseira granulata*, *Fragilaria crotonensis*, *Nitzschia fonticola*, *N. palea*, *N. supralitorea* Lange-Bertalot, *Rhizosolenia longiseta* dominated at the Tresta site.

In both study periods the occurrence of *Dinobryon sertularia* Ehrenberg, *Ceratium hirundinella* (F. B. Müller) Bergh, and *Peridinium inconspicuum* Lemmermann was noted.

During the investigated years (1982-1993) (Galicka et al. 1992), the share of Cyanobacteria in the phytoplankton varied both during given years and from year to year. Alga blooms occurred in the summer months of July and August, except in 1985 and 1991. Water blooms can be caused by a single, two or many species of algae (Bucka 1987, 1989, Burchardt 1987). In the Sulejów Reservoir (1983, 1984, 1987, 1989 and 1993) single-species blooms were caused by *Microcystis aeruginosa*, *Aphanizomenon flos-aquae* or *Oscillatoria* sp.. A single-species bloom caused by *Aphanizomenon flos-aquae* was also described in the Goczałkowicki Reservoir (Krzyżanek et al. 1986, Pająk 1986), Rożnowski Reservoir (Bucka 1987) and in the Jeziorsko Reservoir (Galicka and Lesiak 1996). Two-species blooms of the Cyanobacteria *Microcystis aeruginosa* and *Anabaena spiroides* Klebahn were recorded in the Goczałkowicki Reservoir (Pająk 1986) and in the hypertrophic Lake Brielle in the Netherlands, where a bloom of *Microcystis aeruginosa* was preceded by the strong development of *Aphanizomenon flos-aquae* and *Anabaena spiroides* (Kappers 1980) .

The flagellates of *Trachelomonas volvocina* Ehrenberg and *Peridinium* sp. were the second in terms of abundance; they were followed by the diatoms *Asterionella formosa*, *Aulacoseira granulata*, *Fragilaria crotonensis*, *Nitzschia acicularis* and *Stephanodiscus hantzschii*. With regards to other alga groups in 1982-1993, a bloom of *Ceratium hirundinella* was recorded in August 1986 and September 1989. Of the green algae, *Chlamydomonas* sp., *Coelastrum microporrum*, and *Pediastrum* sp. were noted.

## CONCLUSIONS

The qualitative analysis of identified algal taxa occurring in the Sulejów Reservoir in the studied periods indicated that the water quality had deteriorated. This was manifested by the decreased species diversity of green algae and diatoms and the appearance of species that are characteristic of eutrophic waters, such as *Nitzschia palea*, *Nitzschia supralitorea*, and *Rhizosolenia longiseta.* A similar species composition of Cyanobacteria, which is dominated by *Anabaena flos-aquae*, *Aphanizomenon flos-aquae*, and

*Microcystis aeruginosa*, has survived since the creation of the reservoir and throughout the study period (1979-2003).

The algal species composition has not changed. Since the ratios of nitrogen to phosphorus and silicon are essential for water blooms, these ratios were monitored during the investigation periods.

As a result, it was determined that Cyanobacteria dominated at low N:P ratios, while green algae or diatoms did so at high N:P values. High Si:P ratio values were also favorable for diatoms.

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