Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2009, 6, 146–152

COMMUNITY STRUCTURE AND DYNAMICS OF PHYTOPLANKTON IN LAKE UZARZEWSKIE

Anna Kozak

Department of Water Protection, Adam Mickiewicz University,
Umultowska str. 89, 61–614 Poznań, akozak@amu.edu.pl

Summary. Lake Uzarzewskie (surface area 10.6 ha, maximum depth 7.3 m) is a hypertrophic lake located on Cybina River (right tributary of Warta River). In the past the lake received a large amount of domestic and industrial sewage. In the year 2008, in order to increase redox potential in the sediments of Lake Uzarzewskie, two tributaries (with a high nitrate concentration) were directly inserted to the hypolimnion. The aim of the study was to analyse the dynamics of the phytoplankton of Lake Uzarzewskie in the year 2008 during restoration. The qualitative and quantitative changes in the phytoplankton community taking place in 2008 in Lake Uzarzewskie were studied. The samples were taken without concentration from two points from the surface, and the depth of 2, 4 and 6 m. All taxonomical groups were counted with an Olympus microscope after sedimentation in a Sedgwick-Rafter chamber of 0.67 cm^3 in volume. The most abundant, in terms of the number of taxa, were green algae. The most numerous were Cyanobacteriae, especially in summer and autumn. The most numerous species observed in Lake Uzarzewskie were *Planktothrix agardhii, Aphanizomenon flos-aquae, Anabaena flos-aquae* and *Limnothrix redeckei.* The maximum density of diatoms was noted in autumn and winter. The most abundant were *Cyclotella, Stephanodiscus, Fragilaria ulna* var. *acus* or *Nitzchia acicularis.* Chrysophyceae and Cryptophyceae were the most numerous groups in the cold period. During spring and summer the most numerous species were *Rhodomonas lacustris* and *Rh. lens*, and also *Cryptomonas marssonii* and *C. reflexa*. The number of green algae increased especially during the spring months, when *Oocystis lacustris, Tetraëdron minimum, Coelastrum astroideum, Actinastrum hantzshii, Monoraphidium contortum, Koliella spiculiformis* and *Scenedesmus communis* were mainly noted.

Key words: phytoplankton, Cyanobacteria, green algae abundance, restoration, seasonal community changes, phytoplankton structure

INTRODUCTION

Lake Uzarzewskie, like most lakes in the Wielkopolska Region, is hypertrophic [Gołdyn and Grabia 1998]. Phytoplankton blooms in the lake have been documented in the ecosystem. In the years 2005 and 2006 one of the most common species, bloom-forming cyanobacteria, *Planktothrix agardhii,* was noted in the lake [Budzyńska *et al*. 2009]. In 2006 and 2007 the lake was being restored by the introduction of a chemical preparation based on iron sulphate (PIX), to reduce the concentration of phosphorus in the water to avoid water blooms.

Stratified eutrophic lakes often suffer from hypolimnetic oxygen depletion during summer. To avoid this problem in Lake Uzarzewskie, some spring water was brought into the hypolimnion using a pipeline. In 2008, water carrying a high nitrate content was applied. The purpose of this research was to analyse the taxonomic composition and abundance of phytoplankton of Lake Uzarzewskie in the year 2008 during the restoration.

STUDY AREA AND METHODS

Lake Uzarzewskie is a postglacial lake, situated along the Cybina River (a right--bank tributary of the Warta River) in the Wielkopolska Region (mid-western Poland, Fig. 1). Its area is 10.6 ha, maximum depth 7.3 m, and mean depth 3.4 m

Fig. 1. Location of Lake Uzarzewskie [from: Gołdyn and Kowalczewska-Madura 2005]

[Jańczak 1996]. The investigated lake is of the dimictic type and kettle-shaped. It is surrounded by forests. The lake is characterised by a short mixing time. In the past the water of the Cybina River carried a large amount of domestic and industrial

sewage to the lake [Gołdyn and Grabia 1998]. The lake was restored in 2006–2007 by the introduction of a chemical preparation based on iron sulphate (PIX-112).

In the year 2008, in order to increase redox potential in the sediments of Lake Uzarzewskie, two tributaries (with a high nitrate concentration) were directly inserted to the hypolimnion (using a pipeline).

Samples for the phytoplankton analysis were taken from two stations. The first one was located near the mouth of the pipeline. The second one on the deepest part of the lake. The samples were taken from the surface and from the depth of 2, 4 and 6 m of water column.

The samples were taken without concentration, using a 5 dm^3 sampler. The phytoplankton samples were taken once a month in 2008. They were preserved with Lugol's solution. All taxonomic groups were counted with an Olympus microscope after sedimentation in a Sedgwick-Rafter chamber of 0.67 cm^3 volume, employing magnification of 400×. The abundance of phytoplankton was expressed as the number of organisms.

RESULTS

Detailed phytoplankton analysis showed that during the investigation 163 taxa of prokaryotic and eukaryotic algae were observed in Lake Uzarzewskie. They represented nine systematic groups (Tab. 1). The most abundant, in terms

Table 1. Number of taxa and percentage contribution of the phytoplankton systematic groups identified in Lake Uzarzewskie in 2008

Taxonomic group	Number of taxa	Contribution, %
Cyanoprokaryota Blue-green algae	20	12
Euglenophyceae Euglenophytes	6	4
Cryptophyceae Cryptomonads	8	5
Chrysophyceae Chrysophytes	14	9
Bacillariophyceae Diatoms	21	13
Chlorophyceae Green algae	79	48
Dinophyceae Dinoflagellates	3	2
Xantophyceae Xantophytes	4	2
Conjugatophyceae Conjugatophytes	8	5
Total	163	100

of the number of taxa, were green algae (mainly members of Chlorococcales) which accounted for 48% of the total number of taxa. The Scenedesmus and Crucigenia genera were particularly vastly represented. Also diatoms, cyanoprokaryotes and chrysophytes were important contributors to phytoplankton diversity. Other groups, such as euglenophytes, cryptomonads, dinoflagellates, xantophytes and conjugatophytes were infrequent and represented by few species (Tab. 1).

Seasonal changes in the contribution of particular taxonomic groups were observed, see Fig. 2. The abundance of the phytoplankton exhibited variations with the season and the depth of the reservoir at which the water sample was collected. The highest densities were noted slightly more often on station 1 than on station 2. The highest abundance of phytoplankton was observed on the surface or at the depth of 2m (see Fig. 3).

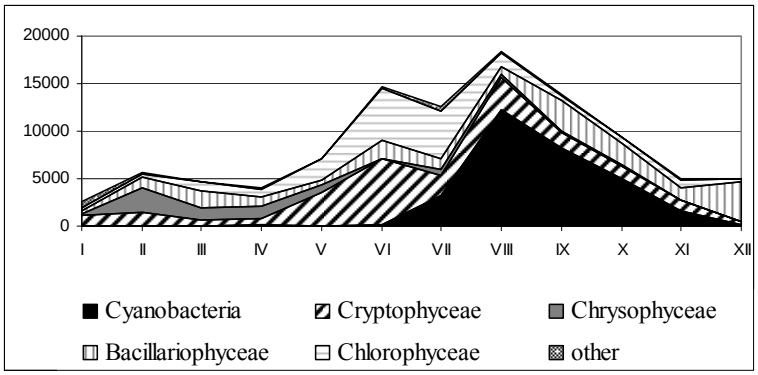

Fig. 2. Changes in the abundance and contribution of particular taxonomic groups in the phytoplankton of Lake Uzarzewskie in 2008 (on the surface)

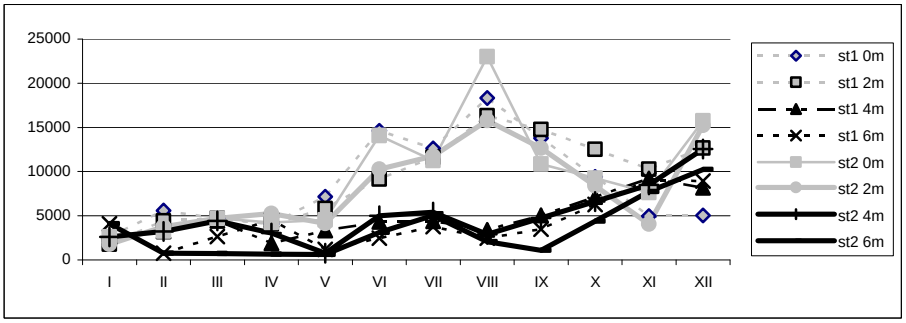

Fig. 3. Seasonal and vertical changes of phytoplankton abundance on station 1 and 2

Quantitative analysis of planktonic algae showed that total phytoplankton abundance within the entire study period was the lowest in March (770 organisms cm^{-3}). On the other hand, the maximum concentration of organisms was noted in August ($23 \cdot 10^3$ organisms cm^{-3} on station 2).

In the beginning of the 2008 year the number of phytoplankton did not exceed 5 ·10^3 organisms cm^{-3}. The most important were Chrysophyceae and Cryptophyceae. The most abundant species were *Cryptomonas marssoni* Skuja, *C. refleksa* Skuja, *C. ovata* Ehrenberg, *C. rostratiformis* Skuja, *Rhodomonas lens* Pascher et Ruttner, Synura uwella Ehrenberg, *Chrysococcus sp.* and *Kephyrion globosa* Bourrelly.

Diatoms of long cells, such as *Fragilaria ulna* var. *acus* (Kützing) Lange-Bertalot, *Nitzchia acicularis* W.Sm., *Asterionella formosa* Hass and centric diatoms such as *Stephanodiscus* sp. and *Cyclotella* sp. were noted in Lake Uzarzewskie in spring. Centric diatoms were dominant in the phytoplankton especially in November and December.

In the beginning of summer of 2008 the contribution of Cryptophyceae and Chlorophyceae in the phytoplankton increased, reaching even 55 and 86%, respectively. The maximum abundance of green algae increased from 5.5 · 10^3 ind. cm^{-3} in May. The most numerous species were *Oocystis lacustris* Chodat*, Scenedesmus communis* Hegew*., Tetraedron minimum* (A. Braun) Hansgirg, *Treubaria planctonica* (GM Smith) Korshikov*, Koliella spiculiformis* (Vischer) Hindák*, Actinastrum hantzshii* Lagerheim*, Crucigeniella rectangularis* (Nägeli) Komàrek.

The most numerous of the phytoplankton of Lake Uzarzewskie were Cyanobacteriae. The group reached even 78% in the abundance of phytoplankton in August. The most numerous species observed in 2008 in summer and autumn months were *Planktothrix agardhii, Aphanizomenon flos-aquae, Anabaena flos-aquae* and *Limnothrix redeckei*

DISCUSSION

A total of 163 algal and cyanobacterial taxa were identified during the study. The results of this investigation show that the structure of pelagic phytoplankton communities in Lake Uzarzewskie is characterised by a great variation in time. Its phytoplankton, in respect to the number of taxa, was dominated by green algae, diatoms and cyanoprokaryotes (Tab. 1), like in many other eutrophic and hypertrophic lakes [Wojciechowska *et al*. 2002, Celewicz-Gołdyn 2005] and reservoirs [Kozak 2005].

Phytoplankton rapidly reacts to alteration of environmental conditions. At lower temperatures in the beginning of the studied year, phytoplankton was dominated in general by nanoplankton algae, especially chrysophytes, centric diatoms and cryptophytes, similarly as at one of the stages of the annual course of plankton succession in the PEG model [Sommer *et al*. 1986].

In terms of diversity, the most important group of algae were Chlorophyceae. The 48% contribution of green algae to the total number of phytoplankton taxa during the growing season suggests that the lake is fertile [Kawecka and

Eloranta 1994]. The richest among the species was *Scenedesmus,* the sign of high trophy [Rosen 1981].

In terms of maximum abundance of phytoplankton, chlorophytes were the most numerous in June ($5.5 \cdot 10^3$ organisms in 1 cm^3 noted on the surface). Abundance of green algae such as *Oocystis lacustris, Phacotus lenticularis* (Ehrenberg) Srein, and *Tetraëdron minimum* increased particularly in June and July. *Phacotus* is an alga observed in various ecological states: from deep stratified oligotrophic lakes to shallow polymictic hypertrophic waters [Schlegel *et al*. 2004]. The abundance of green algae were outnumbered by Cyanobacteriae in summer and autumn, Cryptophyceae in spring and Chrysophytes in winter.

The appearance of diatoms of long cells such as *Fragilaria ulna* var. *acus*, *Nitzchia acicularis*, *Asterionella formosa* was characteristic in Lake Uzarzewskie in spring. It is usually reported as typical of further stages of succession [Sommer *et al*. 1986]. Usually the diatom genera *Asterionella* and *Fragilaria* are characteristic of eutrophic waters [Reynolds 1998]. In autumn the abundance of diatoms increased. The most numerous were centric ones, such as Cyclotella and Stephanodiscus than.

The calm and warm period was characterised by water blooms dominated by *Planktothrix agardhii, Aphanizomenon flos-aquae, Anabaena flos-aquae* and *Limnothrix redeckei*. The group has lower light-energy requirements than the greens and diatoms [Shapiro 1990], so the species develop dense populations. The species *Planktothrix agardhii* is an indicator of organic matter in a lake and it is associated with anthropogenic eutrophication of a water body [Rosen 1982, Kango *et al*. 2005]. A lower content of soluble reactive phosphorus and lower light supply are considered as possible advantages for *Limnothrix redekei* over *Planktothrix agardhii* dominations in lakes [Rücker *et al*. 1997].

Future investigations should be undertaken to study the influence of the further hypolimnetic oxygenation and restoration of the lake.

REFERENCES

Budzyńska A., Gołdyn R., Zagajewski P., Dondajewska R., Kowalczewska-Madura K., Fabiś M., 2009. The dynamics of a *Planktothrix agardhii* population in a shallow dimictic lake. Oceanol. Hydrobiol. Stud. 38 (in press).

Celewicz-Gołdyn S., 2005. Pelagic Phytoplankton in four basins of the Rosnowskie Duże Lake in the Wielkopolska National Park. Rocz. Akademii Rolniczej w Poznaniu CCCLXXII, 11–25.

Gołdyn R., Grabia J., 1998. The protection programme of Cybina River waters (in Polish). Urząd Miasta Poznania, Wydział Ochrony Środowiska, Poznań.

Gołdyn R., Kowalczewska-Madura K., 2005. Chlorophyll *a* and other Water Quality Variables in Lentic and Lotic Sections of the Cybina River. Oceanol. Hydrobiol. Stud. 34 (1), 87–98.

Jańczak J. (ed.), 1996. The atlas of lakes in Poland (in Polish). Sc. Publ. Bogucki, Poznań, pp. 268.

Kango K., Laugaste R., Nõges P., Ott I., 2005. Long-term changes and seasonal development of phytoplankton in a strongly stratified, hypertrophic lake. Hydrobiologia 547, 91–103.

Kawecka B., Eloranta P.V., 1994. Outline of the ecology of freshwater and inland ecosystems (in Polish). PWN, Warszawa, 11–250.

Kozak A., 2005. Seasonal changes occurring over four years in a reservoir's phytoplankton composition. Polish J. Environ. Stud. 14 (4), 451–465.

Reynolds C.S., 1998. What factors influence the species composition of phytoplankton in lakes of different trophic status? Hydrobiologia 369/370, 11–26.

Rosén G., 1981. Phytoplankton indicators and their relations to certain chemical and physical factors. Limnologica (Berlin) 13 (2), 263–290.

Rücker J., Wiedner C., Zippel P. 1997. Factors controlling the dominance of P*lanktothrix agardhii* and *Limnothrix redekei* in eutrophic shallow lakes. Hydrobiologia 342/343, 107–115.

Schlegel I., Koschel R., Krienitz L., 2004, On the occurrence of *Phacotus lenticularis* (Chlorophyta) in lakes of different trophic state. Hydrobiologia 369/370, 353–361.

Shapiro J., 1990. Current beliefs regarding dominance by blue-greens: The case for the importance of CO_2 and pH. Verh. Internat. Verain. Limnol. 24, 38–54.

Sommer U., Gliwicz Z.M., Lampert, W., Duncan A., 1986. The PEG-model of succession of planktonic events in fresh waters. Arch. Hydrobiol. 106, 433–471.

Wojciechowska W., Solis M., Pasztaleniec A., Poniewozik M., 2002. Summer phytoplankton composition in 26 lakes of Łęczna-Włodawa Lakeland. Annales UMCS, sec. C, LVII, 1–12.

STRUKTURA I DYNAMIKA FITOPLANKTONU JEZIORA UZARZEWSKIEGO

Streszczenie. Jezioro Uzarzewskie (powierzchnia 10,6 ha, maksymalna głębokość 7,3 m) jest hipertroficznym jeziorem położonym na rzece Cybinie (prawobrzeżnym dopływie Warty). W przeszłości było ono odbiornikiem ścieków komunalnych i przemysłowych. W latach poprzedzających niniejsze badania (2005–2006) w Jeziorze Uzarzewskim zastosowano preparat na bazie siarczanu żelaza (PIX-112), co miało na celu obniżenie stężenia fosforu w wodzie oraz wyeliminowanie sinicowych zakwitów wody. W 2008 r., aby zwiększyć potencjał redox, do wód hipolimnionu badanego jeziora, poprzez rurociągi, skierowano dwa dopływy (niosące dużą zawartość azotanów). Celem badań było określenie dynamiki fitoplanktonu Jeziora Uzarzewskiego w roku 2008 w związku z podjętymi zabiegami rekultywacyjnymi. Analizowano skład jakościowo-ilościowy oraz biomasę fitoplanktonu. Próbki do analiz fitoplanktonu pobierane były bez zagęszczenia, z dwóch stanowisk. Każdorazowo pobierano materiał z powierzchniowej warstwy wody oraz z głębokości 2, 4 i 6 m. Do badań wykorzystano mikroskop świetlny Olympus oraz komorę Sedgwick-Raftera o pojemności 0,67 ml. W składzie gatunkowym fitoplanktonu przeważały zielenice. Pod względem liczebności dominowały sinice, zwłaszcza w miesiącach letnich i jesiennych. Najliczniej reprezentowane były wówczas: *Planktothrix agardhii*, *Aphanizomenon flos-aquae*, *Anabaena flos-aquae* i *Limnothrix redeckei.* Po ustąpieniu sinicowych zakwitów wody przeważały okrzemki centryczne z rodzaju *Cyclotella* i *Stephanodiscus* oraz *Fragilaria ulna* var. *acus* czy *Nitzchia acicularis.* Złotowiciowce i kryptofity najliczniej występowały w miesiącach chłodnych. Na przełomie wiosny i lata licznie reprezentowane były kryptofity, głównie przez *Rhodomonas lacustris* i *Rh. lens*, a także *Cryptomonas marssonii* i *C. reflexa*. Liczebność zielenic wzrastała zwłaszcza w miesiącach wiosennych. Najliczniejsze były: *Oocystis lacustris, Tetraëdron minimum, Coelastrum astroideum*, *Actinastrum hantzshii, Monoraphidium contortum, Koliella spiculiformis* i *Scenedesmus communis.*

Słowa kluczowe: fitoplankton, Cyanobacteria, liczebność zielenic, rekultywacja, sezonowe zmiany, struktura fitoplanktonu