

Pelagic Phytoplankton of Shallow Lakes

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Abstract

Our study was undertaken to perform comparative analysis of five lakes in the area of the Promno Landscape Park: Brzostek, Dębiniec, Dobre, Kazanie, and Wójtostwo. The physico-chemical parameters of the lakes, including water temperature, chlorophyll-a, dry mass of seston, dissolved oxygen, pH, conductivity, visibility, nitrogen concentrations (ammonium, nitrate, and nitrite), and phosphorus (water-dissolved phosphates and total phosphorus) were measured.

The species composition, abundance, and biomass of phytoplanktonic organisms were studied in five lakes. Water samples were collected in summer 2007. The analysis exhibited extensive variability, both in respect to the number of taxa and phytoplankton abundance. The most numerous group of algae, in respect to the number of taxa, were green algae.

Keywords: phytoplankton abundance and biomass, midforest shallow lakes, Promno Landscape Park

Introduction

Promno Landscape Park, founded in 1993 is the smallest landscape park in Wielkopolska. It is located 20 km NE of Poznań, in the Wielkopolskie Lake District region and in the mezoregion Gnieźnieńskie Lake District, and occupies 2,077 ha. The area is mostly covered with forests, with a typically post-glacial sculpture of moraine hills and lakes. It is located in the catchment area of the two tributaries of the Warta River: Główna and Cybina, flowing through the outskirts of the park in the north and south, respectively. In the park there are relatively few small lakes, the larger are: Dębiniec, Dobre, Wójtostwo, and Brzostek, while Lake Kazanie belongs to small lakes. The greatest attraction of the park is the forest covering over 60% of the park area and three nature reserves: Lake Dębiniec, Lake Drażynek, and Deciduous Forest in Promno [1].

The main aim of our study was qualitative and quantitative analysis of the phytoplankton community of five lakes: Brzostek, Dębiniec, Wójtostwo, Dobre, and Kazanie in summer 2007 (Fig. 1).

Study Area and Methods

Lake Dębiniec has been a nature reserve since 1959. Its area is 37.08 ha covering the inforest eutrophic, lake together with the surrounding rushes, marshes, meadows, and marshy forest [2]. The morphometric data characterizing the lakes studied are given in Table 1.

The phytoplankton samples were collected once, in summer 2007 without concentration using 5 dm³ sampler from one site in the middle of the lakes. Samples were taken from the surface, and every one meter to the bottom of the lake. They were preserved using Lugol solution in Utermöhl's modification. All taxonomical groups were counted with an Olympus microscope after sedimentation in a Sedgwick-Rafter chamber, employing magnification of 400×. A minimum of 300 organisms (cells, colonies or filaments) were counted in each sample. Phytoplankton biomass estimated from the shape of the organisms and cell volume was calculated on the basis of geometric models [5].

The similarity of the phytoplankton composition *S* was determined on the basis of the abundance of particular taxa represented in analyzed lakes, according to the formula:

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Table 1. Morphometric properties of water in investigated reservoirs.

Lake	Surface (ha)	Maximum depth (m)	Mean depth (m)	Volume (10 ³ m ³)	Reference
Brzostek	6	7.8	4.5	270	[3]
Dębiniec	15	7.4	3.4	510	[3]
Dobre	12	15	6.4	768	[3]
Kazanie	1.8	6.0	-	-	[3]
Wójtostwo	9.2	5.7	2.7	248.4	[4]

$$S = \frac{w100}{(a + b - w)}$$

...where:

w – is the number of common species found in both analyzed samples,

a – is the number of species in the first sample,

b – is the number of species in the second sample [6].

Also the physico-chemical parameters of the lakes were measured directly in the lake profiles using WTW Multi 350, including measurements of temperature, water-dissolved oxygen, pH, and electrolytic conductivity. The clarity of water was estimated by measuring the depth of Secchi disk visibility. In the samples of water collected from vertical profiles, the concentrations of nitrogen (ammonium, nitrate and nitrite), phosphorus (water dissolved phosphates and total phosphorus), chlorophyll-a, and seston dry mass were measured. All analyses were made according to the Polish Norms [7, 8].

Results and Discussion

The greatest depth of Secchi disk visibility of 2.5 m was noted in Lake Dębiniec, and a close value of 2.4 m was measured in Lake Kazanie. For Lakes Brzostek and Dobre the depth of the Secchi disk visibility was of 2.0 m, and in Lake Wójtostwo it was 1.2 m. The lowest mean concentration of chlorophyll-a was noted in Lake Dobre, of 6.8 $\mu\text{g}\cdot\text{dm}^{-3}$. Relatively low were the concentrations of chlorophyll-a in Dębiniec, below 6.7 $\mu\text{g}\cdot\text{dm}^{-3}$, but at the depth of

6 meters the concentration increased to 134.3 $\mu\text{g}\cdot\text{dm}^{-3}$. The increase in the chlorophyll-a concentration in the near bottom layer was also observed for Wójtostwo, Kazanie, and Brzostek (Table 2).

The dry mass of seston took small values in all the lakes studied; its mean value along the vertical profile varied from 3.0 $\text{mg}\cdot\text{dm}^{-3}$ in Dobre to 8.27 $\text{mg}\cdot\text{dm}^{-3}$ in Brzostek. The highest electrolytic conductivity of the mean value of 816.6 $\mu\text{S}\cdot\text{cm}^{-3}$ was measured in Kazanie, while the lowest of the mean value of 306.3 $\mu\text{S}\cdot\text{cm}^{-3}$ was in Brzostek.

The highest mean concentrations of the water-dissolved phosphates and total phosphorus were obtained for Dobre, of 0.1 $\text{mgP}\cdot\text{dm}^{-3}$ and 0.2 $\text{mg P}\cdot\text{dm}^{-3}$, while the lowest in Brzostek of 0.01 $\text{mg P}\cdot\text{dm}^{-3}$ and 0.04 $\text{mgP}\cdot\text{dm}^{-3}$, respectively. The highest mean concentration of ammonia nitrogen 1.44 $\text{mgN}\cdot\text{dm}^{-3}$ was measured in Kazanie, while the lowest of 0.6 $\text{mgN}\cdot\text{dm}^{-3}$ was in Brzostek. The presence of nitrite nitrogen was detected only in Dobre, Kazanie, and Wójtostwo, in which the mean values along the profile did not exceed 0.1 $\text{mgN}\cdot\text{dm}^{-3}$. The concentrations of nitrate nitrogen were also low and did not exceed 0.6 $\text{mgN}\cdot\text{dm}^{-3}$.

A total of 94 taxa have been identified in the studied lakes (Fig. 2). Chlorophytes contributed the highest number of taxa (36), followed by diatoms (13), chrysophytes (11), and cyanobacteria (10). Phytoplankton taxa of lakes Brzostek, Kazanie, and Wójtostwo were represented by eight taxonomic groups while in Dębiniec we identified taxa belonged to seven and in Dobre to six groups. The greatest number of taxa were noted in Brzostek (51), followed by Dębiniec (37), Kazanie (32), Wójtostwo (29), and Dobre (22). In some temperate and subarctic lakes of north-

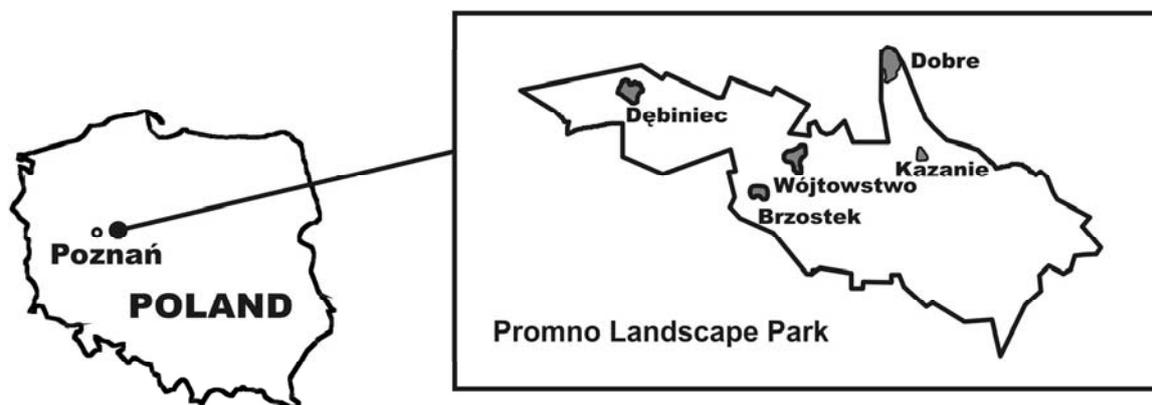


Fig. 1. Map of Promno Landscape Park reservoirs showing the sampling stations.

Table 2. Chlorophyll a concentrations on analyzed sites ($\mu\text{g}\cdot\text{dm}^{-3}$).

Sample	Dębiniac	Dobre	Brzostek	Kazanie	Wójtostwo
Surface	4.86	8.15	7.62	6.4	11.6
1 m	2.67	7.22 (epi)	4.49	7.9	8.82
2 m	4.17	7.51 (meta)	6.42	8.1	10.42
3 m	2.67	4.12 (hypo)	18.18	6.6	6.36
4 m	6.74	-	45.65	18.1	12.03
5 m	6.36	-	83.40	45.8	66.11
6 m	134.25	-	-	23.9	-
Mean values	23.10	6.8	27.63	16.69	19.2

western Russia and the Prebaltic, the number of species varied from 25 to 160 [9].

Analysis of the phytoplankton of these five lakes has shown that the group represented by the greatest number of taxa in all of them was Chlorophyceae (Fig. 2). Their contribution in the abundance and biomass was also high. The highest percent contribution of green algae of 71% in the abundance and total biomass was noted in Dobre (Fig. 3). The most abundantly represented species were *Coelastrum reticulatum*, *Tetraedron minimum*, and *Scenedesmus ellipticus*. The species abundantly represented in the other lakes were *Phacotus lenticularis* in Wójtostwo and Kazanie, and *Pteromonas aculeata* in Dębiniac. In the other lakes the contribution of Chlorophyceae was smaller than 47% in abundance in Kazanie, and only 8% in abundance and 4% in biomass in Brzostek. In all lakes studied, *T. minimum* was abundantly present; this species was also noted in other lakes from the Wielkopolska District, e.g. in Budzyńskie [10], Wielkowiejske [11], Malta Reservoir [12], Strzeszyńskie [13], and some fish ponds near Poznań [14].

The greatest differentiation of the number of phytoplankton between two lakes was exhibited in Dębiniac and

Dobre (only 12% of common taxa). The greatest similarity of the phytoplankton composition ($S=31.7$) was noted between Kazanie and Dobre. The 46 % of taxa were common in both lakes.

From among the lakes in the Landscape Park Promno, Lake Brzostek showed the greatest abundance of phytoplankton, concentrated in particular in deeper layers. At a depth of 3 m the highest concentration of $15.5\cdot 10^3$ organisms per 1ml was determined. At this depth the highest phytoplankton biomass of $15.4\ \mu\text{g}\cdot\text{cm}^{-3}$ was found. In this lake the most abundantly represented were cyanobacteria, making even up to 81% of the phytoplankton at a depth of 3 m. The dominant species was *Limnothrix redekei*, accompanied by *Aphanizomenon gracile*, *Pseudanabaena aciculare*, and *Planktothrix agardhii*. In the other lakes studied in this area the representation of cyanobacteria was much smaller; up to 11% in Dębiniac, 8% in Wójtostwo and 3% in Kazanie and Dobre.

The domination of Cyanobacteria in lakes depends on many different factors. Among them the most important are nutrient concentration, lake morphometry, water-temperature, underwater light availability, mixing conditions,

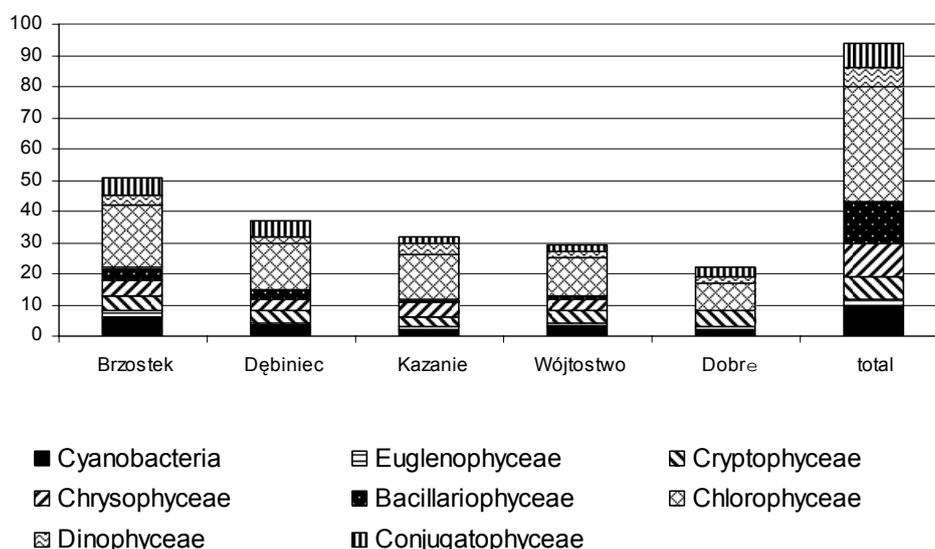


Fig. 2. Number of taxa identified in the studied lakes.

and foodweb structure [15]. One of the hypotheses that explain blue-green dominance says that cyanobacterial blooms can be observed with low N/P ratios (less than 29/1) [16]. *Limnothrix redekei* was noted especially in a deeper layer of water, reaching 500 org. cm^{-3} on the surface and $11.3 \cdot 10^3 \text{ org. cm}^{-3}$ at a depth of 3 m in Brzostek. The same species dominated in the phytoplankton of the urban Lake Jeziorak Mały – a strongly eutrophicated water body, where some positive correlations of the relationships between water temperature, orthophosphate concentration and the abundance of blue-green species were shown [17]. Filamentous cyanophytes as *Limnothrix redekei* and also chlorophytes are described by many authors as typical of advanced eutrophy [18]. *L. redekei* is quite a popular species noted in many eutrophic lakes and reservoirs, in turbid mixed layers of lakes in central and northern Europe [19]. It is mostly described as a species with mass developments in spring and autumn. It

seems to be more successful in smaller lakes with lower water turbulence [12, 20, 21], but also has been noted in deep stratified lakes in protected areas [22].

In Brzostek phytoplankton, the second most abundantly represented group were Chrysophyceae, making up to 22% of all organisms. The highest represented species of chrysophytes were *Dinobryon bavaricum* $0.9 \cdot 10^3 \text{ org. cm}^{-3}$ and *Kephyrion rubri-claustrii* $0.1 \cdot 10^3 \text{ org. cm}^{-3}$. These are the mixotrophic flagellates. In the same lake rather high was the contribution of Conjugatophyceae, making up to 15% in abundance and 21% of biomass of the phytoplankton. The most abundant species were *Staurastrum tetracerum* and those from the genus *Cosmarium*.

In Dębiniec the most abundantly represented were Bacillariophyceae and Chlorophyceae (up to 42% of the phytoplankton), and Conjugatophyceae (27%), besides Cryptophyceae and Chrysophyceae (14% and 16%,

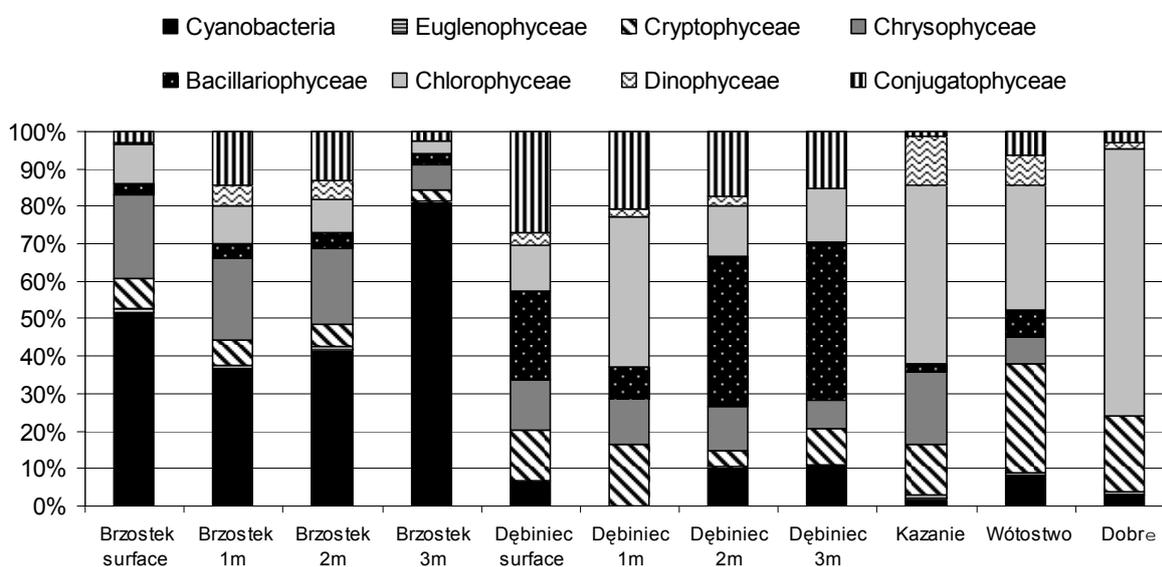


Fig. 3. Percent contribution of particular taxonomic groups in the phytoplankton identified in the investigated lakes.

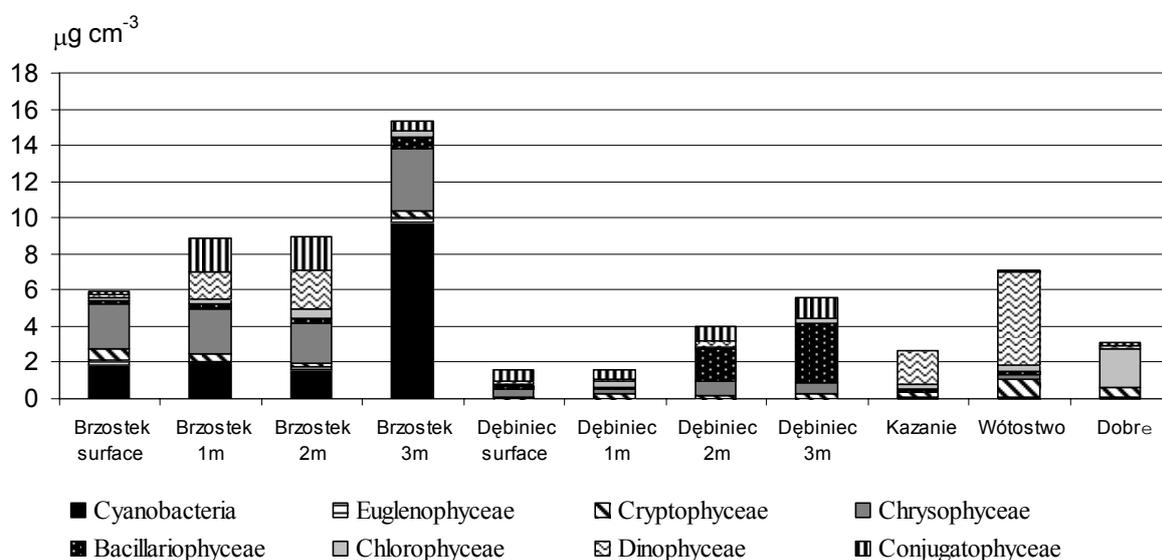


Fig. 4. Changes in the biomass and contribution of particular taxonomic groups in the phytoplankton of the investigated lakes.

respectively). Qualitative analysis confirmed the chlorophytes-diatoms-cyanopytes character of the phytoplankton of the lake established in 2003 [23]. The diatoms were mainly represented by the species of the genus *Cyclotella*, *Stephanodiscus*, and *Nitzschia*. Similarly as in Brzostek, in Dębiniac the concentration of phytoplankton organisms increased with increasing depth; at a depth of 3 m it was from 0.5 to $1.6 \cdot 10^3$ org. \cdot cm $^{-3}$ and the biomass at this depth reached almost $6 \mu\text{g}\cdot\text{cm}^{-3}$ (Fig. 4). Chlorophyceae were mostly represented by *Tetraedron minimum*, *Scenedesmus ecornis*, and *Pteromonas aculeata*.

In Wójtostwo and Kazanie the great contribution of Dinophyceae was noted. Because of the large size of their cells, their contribution was particularly great in the biomass of the phytoplankton. In these two lakes Cryptophyceae and Chrysophyceae also were found in great numbers. These groups were mostly represented by *Cryptomonas marssonii*, *Cryptomonas ovata*, *Bicoeca planctonica*, and *Dinobryon divergens* – the species noted in Wójtostwo.

Conclusions

Phytoplankton abundance and biomass was different in analyzed lakes. From among the lakes situated in the Landscape Park Promno, Brzostek showed the greatest abundance and biomass of phytoplankton, concentrated in particular in deeper layers ($15.5 \cdot 10^3$ org. \cdot cm $^{-3}$, $15.4 \mu\text{g}\cdot\text{cm}^{-3}$). A total of 94 taxa have been identified in studied lakes and their number ranged from 22 in Dobrze to 51 in Brzostek. The greatest similarity according to determined taxa was noted between lakes Kazanie and Dobrze ($S=31.7$). The biggest difference of taxonomic composition was observed between Dębiniac and Dobrze ($S=15.7$).

The highest mean concentrations of the water-dissolved phosphates and total phosphorus were obtained for Dobrze, while the lowest in Brzostek. The highest mean concentration of ammonia nitrogen was measured in Kazanie, while the lowest was in Brzostek. The presence of nitrite and nitrate nitrogen were low in studied lakes.

Acknowledgements

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