

THE INFLUENCE OF ENVIRONMENTAL PARAMETERS ON QUANTITY AND STRUCTURE OF THE PHYTOPLANKTON IN EUTROPHIC GŁĘBOKIE UŚCIMOWSKIE LAKE

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Summary. Light conditions, nutrient concentration and phytoplankton species composition were studied in shallow eutrophic Głębokie Uścimowskie Lake. During two seasons (2006 and 2007) between June and September, clear-cut dominance (80%) of *Cyanobacteria* was recorded: *Planktolyngbya limnetica* and species of the genus *Limnothrix* spp. Statistical analyses showed that the following factors influenced phytoplankton quantity and taxonomic composition: water temperature, light intensity in water depths and the amount of dissolved nutrients (P-PO₄, NO₃⁻, NH₄⁺). In particular, considerable light absorption in turbid, frequently mixed waters and dissolved phosphorus shortage affected the structure of algae communities.

Key words: phytoplankton, cyanobacteria dominance, *Planktolyngbya limnetica*, *Limnothrix* spp., light, nutrients

INTRODUCTION

Effects of various environmental factors on algae development and species composition have been commonly known for years [Wetzel 2001, Reynolds 2006]. Generally, environmental factors operate complementarily, although just one or few of them may have decisive effect on phytoplankton development under conditions of advanced eutrophy [Reynolds 2006]. In lakes characterized by a rich nutrient pool in the pelagial, plankton algae usually grow massively to produce spring or summer biomass peaks. The spring peak is most often caused by diatoms, and the summer peak – by cyanobacteria, dinoflagellates, chlorophytes or diatoms [Sommer *et al.* 1986]. To a large degree development and species composition depend on light, temperature, availability of nitrogen and phosphorus compounds, and water mixing [Reynolds 2006]. In the Łęczycza-

-Włodawa Lake District, shallow and eutrophic lakes predominate and phytoplankton studies have been carried out for years there [Wojciechowska and Krupa 1992, Wojciechowska *et al.* 2002].

The study aim was to analyze phytoplankton structure in an eutrophic lake in relation to a set of physicochemical parameters.

STUDY AREA AND METHODS

Głębokie Uścimowskie Lake is located in the western part of the Łęczycza-Włodawa Lake District. It is an eutrophic water body and its area is 20.5 ha and maximum depth – 7.1 m [Radwan and Kornijów 1998]. The lake is endangered by particularly strong human impact as it is located in an agricultural land, where arable land accounts for 73% of the catchment basin [Furtak *et al.* 1998].

The study was carried out in 2006 and 2007 between June and September. Water samples for chemical and biological analyses were collected once a month in the euphotic zone.

Intensity of photosynthetically active radiation (PAR) was measured with a Licor Li-250A light meter equipped with Li-192 probe as a number of light quanta that fall in a square meter over the course of one second ($\mu\text{mol m}^{-2} \text{s}^{-1}$). Measurements were performed immediately under water surface (0.1 m) and in water depths, every 0.25 m. The same pattern was applied for temperature measuring with a WTW OXI 96 meter equipped with a WTW EOT 196 probe.

Each time water samples to assay chlorophyll *a* and nutrient levels were collected from two depths (0.5 m and at the boundary of the euphotic zone as determined by 1% PAR- Z_{EUF}). The values presented in the paper are averages calculated for all the euphotic zone. Chlorophyll concentration was measured with the spectrophotometric method [Nusch 1980]. The domination structure was assessed through calculation of phytoplankton numbers with the Utermöhl method using an inverted microscope [Vollenweider 1969]. Concentration of dissolved nutrients (P- PO_4 , NH_4^+ and NO_3^-) was determined with the use of the commonly accepted methods [Bezák-Mazur 1995, Hermanowicz *et al.* 1999]. In statistical analyses Spearman's rank correlation (r_s) was used [Sokal and Rohlf 1995] at $p < 0.05$ significance level and $n = 16$.

RESULTS

In both study years, cyanobacteria accounting for 80% of phytoplankton dominated in the Głębokie Lake community (Fig. 1). Twenty species of cyanobacteria were recorded and they were mainly thread-like species. Only *Planktolytnbya limnetica* (Lemmerman) Komárková-Legnerová et Cronberg and *Limnithrix planctonica* (Woloszyńska) Meffert or *Limnithrix redekei* (van Goor) were dominating species throughout the study period (Fig. 2). In spite of domi-

nance of cyanobacteria in the phytoplankton, their numbers significantly differed between the two years of the study. In June 2006 and 2007 their numbers equalled 30 thousand and 6 thousand individual per dm^3 , and in July – 20 and 30 thousand, respectively.

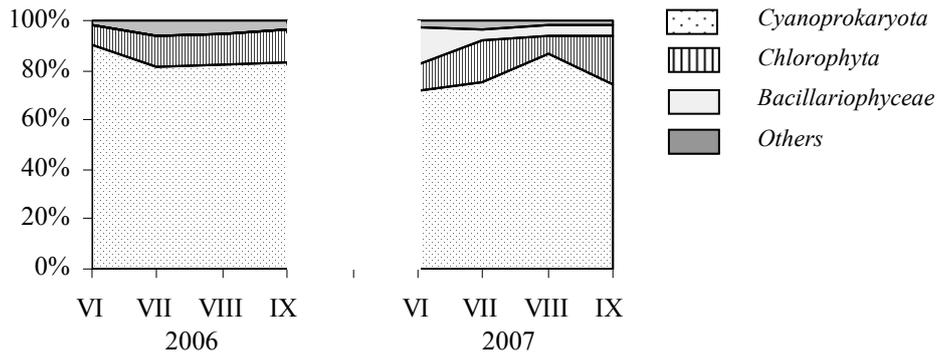


Fig. 1. Percentage share of taxonomic groups in total number of the phytoplankton in Lake Głębokie Uścimowskie

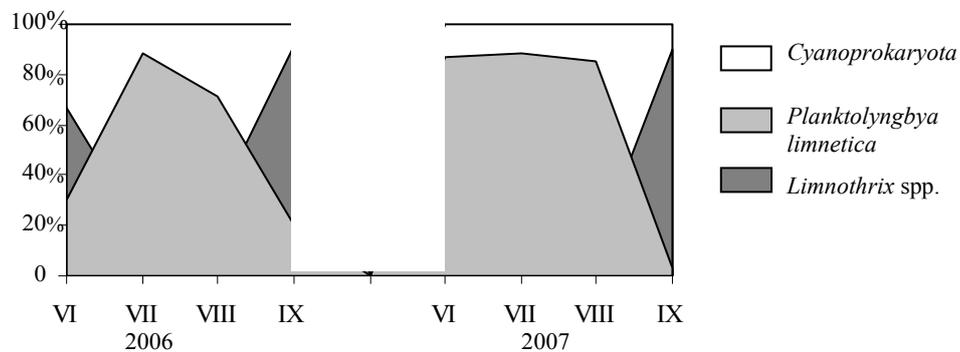


Fig. 2. Percentage share of *Planktolyngbya limnetica* and *Limnothrix* spp. in total number of blue-green algae

Variation in cyanobacteria numbers affected general numbers and chlorophyll concentration in individual months of both years (Tab. 1). Quantitative phytoplankton variation resulted in variable water transparency and the light attenuation coefficient value. In general, K_d values grew in periods of increased algae density (Tab. 2), and correlation coefficient between K_d and chlorophyll concentration was very high ($r = 0.76$ at $p < 0.05$, $n = 16$).

In the period 2006–2007, from June through September, the highest density (40 thousand ind. dm^{-3}) and chlorophyll *a* concentration (60 mg dm^{-3}), and the poorest water transparency ($Z_{SD} = 0.5$ m) and the highest *K_d* level (1.8 m^{-1}) were recorded in June 2006.

Table 1. The average value of individual number of phytoplankton and concentration of chlorophyll *a* (Chl *a*) in months of investigations in Lake Głębokie Uścimowskie

Month	Ind. numbers, $\text{N } 10^3 \text{ dm}^{-3}$		Chl <i>a</i> , mg m^{-3}	
	2006	2007	2006	2007
June	40	8	62	14
July	27	38	30	29
August	32	38	22	21
September	25	36	31	40

Table 2. The value of physical and chemical factors in Lake Głębokie

Months	Year	Z_{SD} , m	Temp., °C	I_0 , $\mu\text{mol m}^{-2} \text{ s}^{-1}$	<i>K_d</i> , m^{-1}	P- PO_4 , mg dm^{-3}	NO_3^- , mg dm^{-3}	NH_4^+ , mg dm^{-3}
June	2006	0.5	23	1283	1.8	0.003	0.043	0.20
	2007	1.8	22	138	1.0	0.004	0.042	0.20
July	2006	0.7	24	1122	1.7	0.008	0.037	0.35
	2007	1.3	23	898	1.2	0.007	0.043	0.22
August	2006	1.4	23	838	1.2	0.007	0.053	0.32
	2007	1.5	22	843	1.1	0.004	0.054	0.17
September	2006	1.2	18	613	0.9	0.002	0.041	0.29
	2007	1.0	15	241	1.7	0.004	0.022	0.15

Temp. – the value of temperature, *K_d* – vertical attenuation's coefficient and the concentration of biogens as average for the euphotic zone

Table 3. Values of Spearman's correlation coefficient (*r_s*), among number and percentage share in algae's number of chosen species and taxonomical groups and some physical and chemical factors ($n = 16$, $p < 0,05$)

Chosen species and taxonom groups	PAR, $\mu\text{mol m}^{-2} \text{ s}^{-1}$	Temp., °C	P- PO_4 , mg dm^{-3}	NO_3^- , mg dm^{-3}	NH_4^+ , mg dm^{-3}
Indiv. number of algae, $\text{N thous. ind. dm}^{-3}$	-	0.43	0.50	0.34	0.31
Share of blue-green algae, %	-	0.60	-	-	-
Share of <i>Limnothrix</i> spp., %	-0.34	-	-	-	0.40
Share of <i>Planktolyngbya limnetica</i> , %	0.25	-	-	-	-0.44

Undoubtedly, thermal and light conditions contributed to the quantitatively diversified algae growth in the two vegetation seasons covered with the study. The year 2007 was cooler in comparison to 2006, which meant somewhat lower

water temperature and more days with heavy overcast and precipitation, which resulted in less light penetrating the water. In 2007 PAR intensity measured immediately under the surface (I_0) was lower than that in the same months in 2006 (Tab. 2).

Rank correlation analyse confirmed that temperature and dissolved nutrient concentration affected development of all the phytoplankton community (Tab. 3). In contrast, environmental factors determining dominance of individual species in the lake are more difficult to verify in terms of statistical significance, however, impact of light and temperature is significant which is confirmed by the values of correlation coefficients (Tab. 3).

DISCUSSION

In eutrophic Lake Głębokie Uścimowskie both quantity and predominance of thread-like cyanobacteria confirmed its trophic status. Dominance of cyanobacteria in the vegetation season in a shallow eutrophic lake was been reported by many authors [Mischke and Nixdorf 2003, Reynolds 2006]. In the 1990s phytoplankton in the lake under study was dominated chlorophytes [Wojciechowska *et al.* 2002], and from 2002 the proportion of cyanobacteria has been growing, with the dominating *Microcystis* sp. and *Woronichinia* sp. genera and then thread-like cyanobacteria of the *Planktolyngbya* sp., *Limnothrix* sp., *Anabena* sp. and *Aphanizomenon* sp. genera.

Species representing the *Planktothrix* sp., *Limnothrix* sp. and *Planktolyngbya* sp. genera are classified in the S₁ functional group [Reynolds *et al.* 2002] and very often they dominate in eu- and hypertrophic waters, and their growth depends first of all on low light intensity [Reynolds 2006].

In Głębokie Uścimowskie Lake water transparency was low (0.5–1.8 m) and at the depth of roughly 1 m, PAR intensity declined by approximately 50% in relation to its level immediately under the surface (I_0). Additionally, e.g. *Limnothrix redekei* is the species which grows well under conditions of water depths mixing, which occurred in non-stratified Głębokie Lake.

Concentrations of nutrient fractions assayed in Głębokie Uścimowskie Lake were similar to those recorded in others shallow eutrophic lakes by another authors [Rücker *et al.* 1997]. Their impact on phytoplankton communities is obvious [Wetzel 2001, Reynolds 2006]. Particularly strong correlation between algae numbers and P-PO₄ is the relationship, which is often found in lakes where cyanobacteria predominate. That may indicate deficiency of dissolved inorganic phosphorus in periods of intense algae growth and be one of the reasons for dominance of species representing the *Limnothrix* sp., and *Planktolyngbya* sp. genera, which do better in those conditions than other thread-like cyanobacteria such as *Planktothrix* sp. [Rücker *et al.* 1997].

CONCLUSION

On algae's quantity (numbers and chlorophyll concentrations) the dissolved fractions of biogenic essential influence had, high values of coefficient of correlation proved this.

The authors also showed that the main factors maintaining dominance of cyanobacteria representing *Limnothrix* sp. and *Planktolyngbya* sp. genera were water turbidity (low Z_{SD}) and PAR intensity in water depths.

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WPLYW PARAMETRÓW ŚRODOWISKOWYCH NA ILOŚĆ I STRUKTURĘ GATUNKOWĄ
FITOPLANKTONU W EUTROFICZNYM JEZIORZE GŁĘBOKIE UŚCIMOWSKIE

Streszczenie. W płytkim, eutroficznym jeziorze Głębokie Uścimowskie badano: warunki świetlne, stężenie biogenów oraz liczebność i skład gatunkowy fitoplanktonu. W czasie dwu sezonów w latach 2006 i 2007 w okresie od czerwca do września stwierdzono wyraźną (około 80%) dominację sinic: gatunku *Planktolyngbya limnetica* i rodzaju *Limnothrix* spp. Analizy statystyczne wykazały, że na ilość i skład taksonomiczny fitoplanktonu wpływały: temperatura wody, naświetlenie toni wodnej i ilość rozpuszczonych frakcji biogenów (P-PO₄, NO₃⁻, NH₄⁺). O strukturze zbiorowiska glonów w szczególności decydowało duże pochłanianie światła w mętnych, często mieszanych wodach i niedobory rozpuszczonego fosforu.

Słowa kluczowe: fitoplankton, dominacja sinic, światło, biogeny