Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2013, 10, 243–249

RELATIONSHIP AMONG BIOMASS OF ALGAE AND CONCENTRATION OF CHLOROPHYLL *a*, AGAINST THE TAXONOMIC STRUCTURE OF PHYTOPLANKTON IN THREE LAKES ON LUBLIN POLESIE REGION

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Summary. Relationship among concentration of chlorophyll a, and phytoplankton biomass was studied during two summer seasons in three lakes situated on Lublin Polesie Region. It was affirmed that clear correlation among these two parameters was ($r_S = 0.6$, $p < 0.05$ $n = 96$) however it was different on two analyzed depths. It was observed that content of chlorophyll in biomass of algae decrease with growth of quantity of the phytoplankton measured by the concentration of chlorophyll and biomass.

Key words: phytoplankton biomass, concentration of chlorophyll *a*, phytoplankton composition, photosynthetic active radiation

INTRODUCTION

Concentration of chlorophyll *a* is universally used, simplified method of marking in water quantity of alga, instead of labor-intensive method of biomass calculating. This method is applied in monitoring and ecological investigations often [Ramaraj *et al*. 2012]. In the other hand, some authors claimed, that the concentration of chlorophyll isn't good measure of the biomass of algae, because the relationship among these two parameters is not permanent and strong, it can be caused this, that chlorophyll isn't substratum for production of biomass of algae but only the biocatalyzer in photosynthesis process [Ramaraj *et al*. 2012]. Therefore the mutual relationships among concentration of chlorophyll and biomass of algae are object of many investigations, which analyzed, how mutual proportions of these two parameters change in the lakes with different trophy and with different composition of the phytoplankton as well as under influence of physical and chemical factors [Steemann Nielsen and Jørgensen 1967, Felip and Catalan 2000, Kasprzak *et al*. 2008, Chauhan and Pathak 2010].

The aim of this paper is, how the relationship among biomass of algae and concentration of chlorophyll *a* changed under influence of change in quantity and compositions of phytoplankton and change of intensity of photosynthetic active radiation (PAR) in three lakes of Lublin Polesie Region.

TERRAIN AND METHOD

The investigations were made in three lakes, laid in western part of Lublin Polesie Region: Krasne (N51°25"; E22°57"), Rogóźno (N51°22"; E22°58") and Głębokie Uścimowskie (N51°28"; E22°55") with different trophy and morphometry (Tab. 1).

Table 1. Morphological and ecological features of lakes [Radwan and Kornijów 1998]

Lake	Area, ha	Depth max., m	Trophic status
Krasne	75.9	33.0	mesotrophic
Rogóźno	57.1	25.4	mesotrophic
Głębokie U.	20.5	7.1	eutrophic

The study was carried out during two summer periods in Rogóźno and Głębokie Uścimowskie 2006–2007, Krasne 2005 and 2007, from June to breakthrough of September and October twice a month, altogether 48 terms were.

The intensity of PAR was measured using a Licor Li-250A light meter with a Li-192S probe. Samples for biological analysis were collected at the same depths using a Ruttner sampler with a volume of 1 dm^3, always from two depths: 0.5 m and from the lower boundary of euphotic zone – Z. eup. The concentration of chlorophyll *a*, was estimated follow Nush [1980]. Biomass of phytoplankton was then calculated with method described by Hutorowicz [2005]. In statistical analyses non-linear Spearman's correlation coefficient was used [Sokal and Rohlf 1995].

RESULTS

The quantities of chlorophyll in mesotrophic lakes (Krasne and Rogóźno) changed from 2.6 $\mu g \cdot dm^{-3}$ to 58 $\mu g \cdot dm^{-3}$ and average for lakes and two depths carried out from 8,4 to 13.5 $\mu g \cdot dm^{-3}$, in eutrophic Lake Głębokie Uścimowskie chlorophyll changed from 14 to 63 $\mu g \cdot dm^{-3}$ (average about 30 $\mu g \cdot dm^{-3}$) (Tab. 2). In all three lakes, in whole period of investigations the higher concentration of chlorophyll were on Z.eup., but in mesotrophic lakes these differences were larger (Tab. 2). The similar dependences were observed in distribution of biomass, which values carried out from 1.2 to 119.1 $mm^3 \cdot dm^{-3}$ in mesotrophic lakes (the average about 8, higher only on Z.eup. in Rogóźno Lake – 28 $mm^3 \cdot dm^{-3}$, what caused metalimnetic bloom in 2006 year) and in the eutrophic lake from 2.8 to 147.6 $mm^3 \cdot dm^{-3}$ (average 45–50 $mm^3 \cdot dm^{-3}$).

The taksonomic structure of phytoplankton during time of investigations changed. In Krasne Lake in both seasons of investigations the large part (above 50%) in phytoplankton *Cyanoprokaryota* had, in year 2005 they dominated from July till October and in year 2007 their domination kept in whole period of investigations. On the beginning of investigations (June and July 2005) very numerous colonial *Chlorophyta* also were (Fig. 1).

Table 2. The average values of concentration of chlorophyll *a* (chl *a*) and biomass of phytoplankton during two seasons in studied lakes

Lake	Depth	Chl *a*, μg dm^{-3}			Biomass, mm^3 dm^{-3}		
		mean	max.	min.	mean	max.	min.
Krasne	0.5 m	8.4	11.7	4.7	7.7	28.2	1.2
	Z. eup.	12.3	25.5	6.6	8.7	29.1	1.4
Rogóźno	0.5 m	6.0	10.5	2.6	9.6	34.8	0.7
	Z. eup.	13.5	58.3	4.4	28.7	119.1	4.6
Głębokie U.	0.5 m	28.8	63.0	14.1	44.2	98.4	2.8
	Z. eup.	30.4	63.8	14.6	50.9	147.6	6.7

Phytoplankton in lake Rogóźno was very diversified, on depth 0.5 m in July the most numerous group were *Dinophyceae* in August *Chlorophyta* but since September was observed clear domination of *Cryptophyceae* from genus Cryptomonas Ehrenberg (Fig. 1). More homogeneous were algae on depth Z. eup., since June to half of August dominated blue-green algae *Planktothrix rubescens* (D. C. ex Gomont) Anagnostidis and Komárek and it quantity indicated water bloom. From half of August the most numerous species was *Chlorophyta Closterium acutum* var. *variabile* (Lemmann) W. Kreiger. In year 2007 in this lake, *Bacillariophyceae, Cryptophyceae, Chlorophyta* and *Cyanoprokaryota* were, however clear domination of *Cryptophyceae* and *Bacillariophyceae* was only in June. The most homogeneous composition of phytoplankton was in Głębokie Uścimowskie Lake with clear domination of blue-green algae – about 80% (Fig. 1).

During investigations in all lakes affirmed the clear dependence among the biomass of algae and concentration of the chlorophyll *a*, and correlation between these two parameters were $r_S = 0.6$, $p < 0.05$ $n = 96$, however it was different for different depths, for 0.5 m $r_S = 0.62$, $p < 0.05$ $n = 48$ and for Z. eup. $r_S = 0.54$, $p < 0.05$ $n = 48$. The volumes of biomass and concentration of chlorophyll changed when changed species composition of algae, growth of blue-green algae caused the growth of concentration of chlorophyll ($r_S = 0.55$, $p < 0.05$ $n = 96$) and biomass ($r_S = 0.34$, $p < 0.05$ $n = 96$) just the opposite growth of green algae caused the fall of chlorophyll ($r_S = -0.5$, $p < 0.05$ $n = 96$) and biomass ($r_S = -0,6$, $p < 0.05$ $n = 96$).

The concentration of chlorophyll per unit of biomass changed in different lakes, terms of investigations and with depth. The highest were in Krasne Lake (average 2.1 $\mu g \cdot mm^{-3}$) where the lowest values of chlorophyll and the biomass were, the lowest noted in eutrophic Głębokie Uścimowkie Lake (average 0.9 $\mu g \cdot mm^{-3}$).

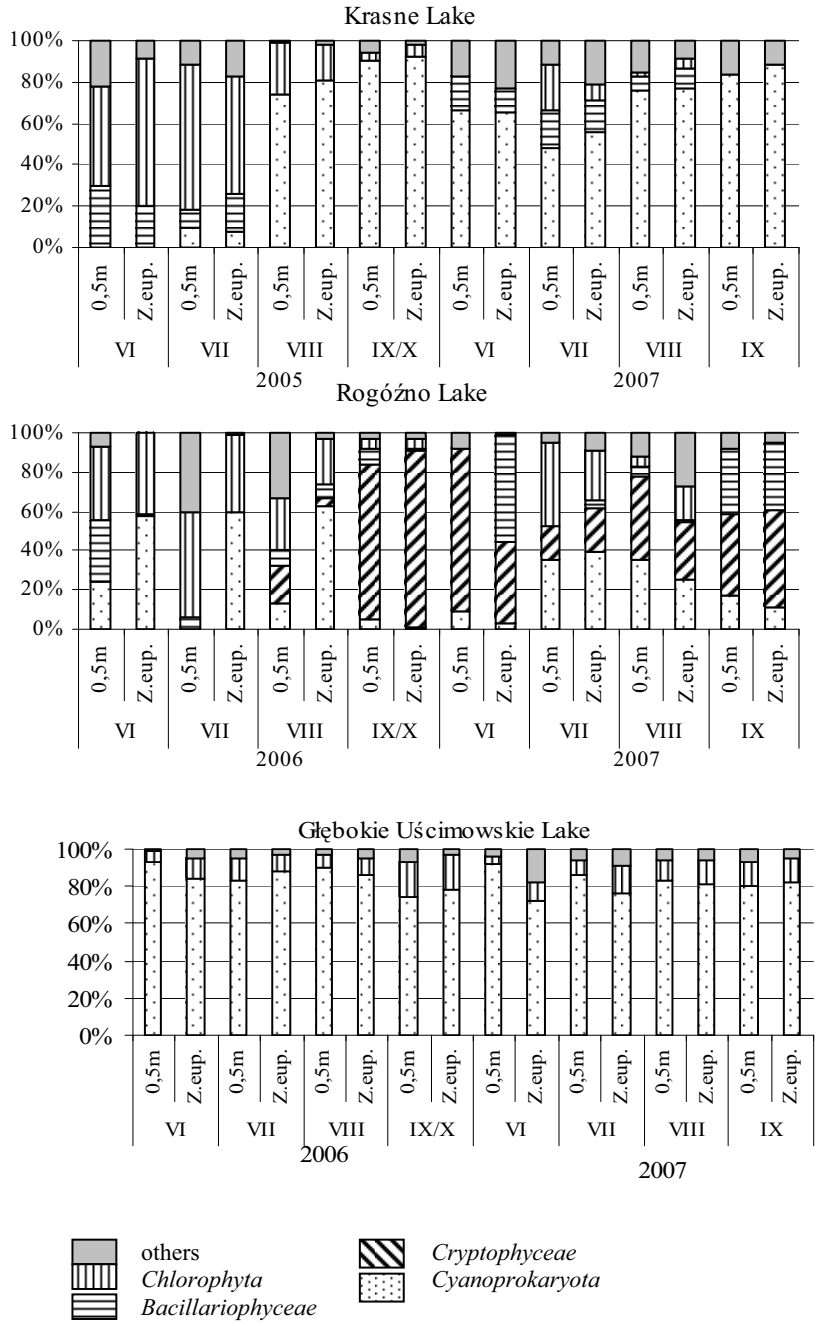

Fig. 1. Percentage share of taxonomic groups in phytoplankton biomass on depth 0.5 m and on the border of euphotic zone – Z. eup, average values for months

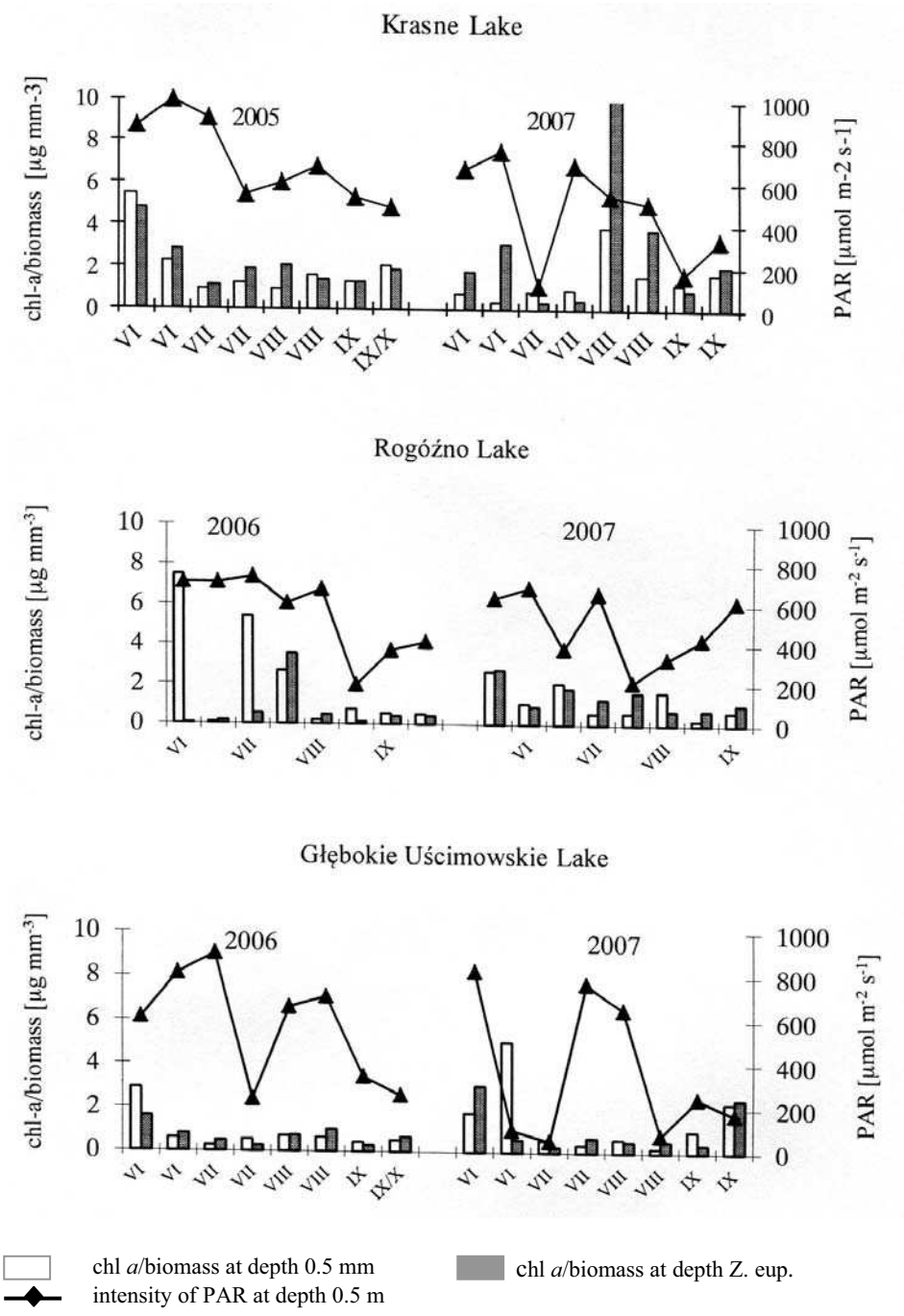

Fig. 2. Content of chlorophyll *a* – chl *a* in the biomass of algae on depth 0.5 m and on the border of euphotic zone – Z. eup. and the values of intensity of photosynthetic active radiation (PAR) on depth 0.5 m in the studied lakes

Statistical influence of growth of quantity of algae on chl *a*/biomass however was small, correlation with concentration of chlorophyll carried out r_S = -0.23, $p < 0.05$ n = 96 and biomass r_S = -0.20, $p < 0.05$ n = 96, but changed with depth, for 0.5m wasn't any correlation but on Z. eup. correlations increase and were r_S = -0,32 with chlorophyll *a* and r_S = -0,30 with biomass ($p < 0.05$ n = 48). The values of quotient chl *a*/biomass changed together with depth also. Especially large differences among 0.5 m and Z. eup. was affirmed in Krasne Lake in June and August 2007 when much higher chl *a*/biomass on Z. eup. were (Fig. 2) and in Rogóźno Lake in June 2006 where was inversely and higher values were observed on depth 0.5 m (Fig. 2). The influence of intensity of PAR on chl *a*/biomass ratio, was observed only in Krasne Lake in year 2005 (Fig. 2), when together with PAR intensity increase, the quantity of chlorophyll grew up in biomass, but wasn't any significant correlation among these parameters.

DISCUSSION

Values of biomass, observed during these investigations are similar to observed by different authors in lakes about similar trophy [Trifonova 1998, Pełechata *et al*. 2009]. Concentrations of chlorophyll, that were determined during this investigations were similarly like values given for studied lakes in earlier articles [Pasztaleniec and Mencfel 2002, Wojciechowska *et al*. 2002, Lenard 2009]. Structure of phytoplankton, in all three lakes wasn't different than earlier publications also [Pasztaleniec and Mencfel 2002, Wojciechowska *et al*. 2002, Lenard 2009].

The clear correlation among the concentration of chlorophyll *a*, and biomass of algae, affirmed in time of investigations was observed by others authors also. It was also affirmed that this dependence is not permanent, but it changes on different depths (and connected with depth intensity of light) or during different species composition of phytoplankton [Felip and Catalan 2000, Kasprzak *et al*. 2008, Chauhan and Pathak 2010]. This can to be caused by mechanism of adaptation to light conditions [Steemann Nielsen and Jørgensen 1967]. The decrease of quantity of chlorophyll in the cells of algae, together with increase of biomass of algae and concentration of chlorophyll in a specific volume of water, was affirmed by different authors also [Felip and Catalan 2000].

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ZALEŻNOŚĆ POMIĘDZY STĘŻENIEM CHLOROFILU *a* I BIOMASĄ GLONÓW NA TLE STRUKTURY TAKSONOMICZNEJ FITOPLANKTONU W TRZECH JEZIORACH POLESIA LUBELSKIEGO

Streszczenie. W trzech jeziorach Polesia Lubelskiego, w okresie lata, w ciągu dwu sezonów badano zależność pomiędzy stężeniem chlorofilu *a* a biomasą fitoplanktonu. Stwierdzono, że występował wyraźny związek pomiędzy tymi dwoma parametrami ($r_S = 0,6$, $p < 0,05$ $n = 96$), jednak był on różny na dwu analizowanych głębokościach. Zaobserwowano również spadek zawartości chlorofilu *a* w jednostce biomasy glonów wraz ze wzrostem ilości fitoplanktonu mierzonej zarówno stężeniem chlorofilu, jak i wielkością biomasy.

Słowa kluczowe: biomasa fitoplanktonu, stężenie chlorofilu *a*, struktura taksonomiczna, światło fotosyntetycznie czynne