# PHYTOPLANKTON – ELEMENT IN ECOLOGICAL STATUS ASSESSMENT FOR LAKES OF THE WEL RIVER CATCHMENT AREA

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**Summary**. Determination of the role of phytoplankton in the ecological status assessment was taken up for ten lakes of the Wel river catchment area. Spring (April) and summer (July) 2009 results of the total biomass and phytoplankton composition were compared. Based on the functional groups structure, the Q index was calculated for three chosen lakes. The greatest phytoplankton biomass (above 20 mg dm<sup>-3</sup>) in spring was recorded in four lakes situated on the Wel river. In July the planctonic algae biomass increased downstream and maximum value (52 mg dm<sup>-3</sup>) was observed in the farthest situated lake in Wel river catchment area. In summer Q index indicated a poor ecological status for Lake Rumian, a moderate state for Lake Lidzbarskie and a good status for Lake Kiełpińskie.

Key words: phytoplankton, lake, ecological status assessment, the Wel river catchment

## INTRODUCTION

Phytoplankton plays a very significant role in lake ecosystems, because of its position at the base of aquatic food-chain, and provides relatively unique information about the environmental condition of the ecosystems [McCormick and Cairns 1994]. Algae biomass and assemblages as important indicators are widely used for routine monitoring or the ecological status assessment [Padisák *et al.* 2008, Nõges *et al.* 2009].

The purpose of this study was to determine the role of phytoplankton in the ecological status assessment for lakes of the Wel river catchment area. These are preliminary results being the effect of a study conducted in the catchment area of the lowland river Wel (Central Poland, 791 km<sup>2</sup>) within the framework of the

Polish-Norwegian project DeWELopment "Development and validation of methods for integrated assessment of ecological status of rivers and lakes to support river basin management plans". The results of this project will find application for the complete and integrated assessment of the freshwaters according to the requirements of the EU Water Framework Directive (WFD) [EC2000/60/WE].

## STUDY AREA, MATERIALS AND METHODS

The ten flow-through lakes with areas from 50.0 to 615.1 ha and maximal depth from 5.2 to 34.7 m, for which the examinations were carried out, are situated in the Wel river catchment (Central Poland). They belong to three different abiotic types of Polish lowland lakes: Dąbrowa Wielka (type 2a), Dąbrowa Mała, Rumian, Grądy, Lidzbarskie, Kiełpińskie (type 3a) and Tarczyńskie, Zarybinek, Hartowieckie, Zwiniarz (type 3b) [Kolada *et al.* 2005]. These lakes are under varied anthropogenic influence, some of them have no indirect or direct pollution sources (e.g. Lake Kiełpińskie or Lake Zarybinek), others have point-sources of pollution (e.g. Lake Lidzbarskie or Lake Hartowieckie).

The quantitative and qualitative studies of algae were conducted in the vegetation period of 2009. In this paper spring (April) and summer (July) results are compared. The integrated water samples were taken from the euphotic zone (spring circulation) and from the epilimnion (summer stagnation) at the deepest places of the lakes. Phytoplankton analysis was carried out according to the Utermöhl method [1958]. Simultaneously, selected physico-chemical measurements of water (Tab. 1) were conducted according to standard methods. The significance of changes in those parameters was determined by the Mann-Whitney U-test [StatSoft 2007].

According the Hungarian method requirements, the phytoplankton composition was expressed in terms of phytoplankton 'functional' assemblages [Padisák *et al.* 2008]. On the basis of the relative shares of functional groups in the total biomass the Q index was calculated for three chosen lakes.

## RESULTS AND DISCUSSION

The examined lakes are situated mainly in a protected area (Wel Landscape Park), but strong anthropogenic effects are observable in the lakes trophy. Physico-chemical parameters, presented in Table 1, indicates moderate or strong eutrophy [Hillbricht-Ilkowska and Wiśniewski 1994]. Seasonal differences of most parameters are statistically significant (Tab. 1). Ratios of N : P > 17 were most frequently noted in the investigated lakes, indicating P to be limiting phytoplankton growth [Lewis and Wurtsbaugh 2008]. Water transparency was rather low (mainly below 2 m) with the exception of Lake Kiełpińskie in the summer (Tab. 1).

Parameter	April	July	Significance level
Temperature, °C	7.3–10.1	19.8-22.2	p = 0.0002*
_	8.5	21.0	
Oxygen, mg dm <sup>-3</sup>	13.8-18.9	4.2-6.0	p = 0.0002*
	15.7	5.1	
TN/N <sub>og</sub> , mg N dm <sup>-3</sup>	1.02-1.64	0.79-1.40	p = 0.005*
	1.34	1.03	
$TP/P_{og}$ , mg P dm <sup>-3</sup>	0.05-0.10	0.04-0.11	p = 0.121
	0.08	0.07	
N/P ratio	13-22	9–34	p = 0.880
	18	18	
TOC/OWO, mg C dm <sup>-3</sup>	4.1-8.2	8.3-10.5	p = 0.002*
	6.2	8.9	
Electrolytic conductivity,	314-372	254-340	p = 0.001*
$\mu S \text{ cm}^{-1}$	351	307	-
Secchi visibility, m	0.9-1.6	0.6-3.8	p = 0.307
	1.2	1.3	-

Table 1. Physico-chemical parameters (range, mean and significance level) of studied lakes in April and July 2009

statistically significant

The total phytoplankton biomass in April ranged from 7 to 28 mg dm<sup>-3</sup> and in July from 2 to 52 mg dm<sup>-3</sup> (Fig. 1). The greatest phytoplankton biomass was recorded in Lake Lidzbarskie, Lake Dąbrowa Mała and Lake Rumian (spring) and in Lake Zwiniarz (summer) which are under the highest anthropopresure (agricultural catchment, inflow of sewage from the holiday centres and cities), whereas the lowest in Lake Kiełpińskie (forest catchment, no sources of pollution). Although the biomass values of lakes Dąbrowa Wielka, Dąbrowa Mała, Rumian, Lidzbarskie and Kiełpińskie were by over twofold or threefold lower than in spring, the average value of all lakes was slightly higher. The values recorded over this period were usually found to be typical of mesotrophic (Lake Kiełpińskie) or moderately and strongly eutrophic waters [Hillbricht-Ilkowska and Wiśniewski 1994] and characteristic mainly of water bloom [Nebeaus 1984].

In April, the phytoplankton assemblages were dominated mainly by diatoms (Fig. 1) which represented up to 84% of total biomass. Representatives of the genera *Cyclotella*, *Stephanodiscus*, *Fragilaria* and *Asterionella* – mainly tolerant or resistant to pollution [Rakowska 2001] – were the dominat taxa. Relatively high biomass was also contributed by chlorophytes from the order *Chlorococcales* which were one of the co-dominant groups in five relatively shallow lakes. Another large contributor to algal biomass were cryptophytes (max. 31% in Lake Lidzbarskie), mostly *Cryptomonas rostrata* and *Rhodomonas lacustris*. Dinoflagellates were less common, with *Gymnodinium uberrimum* which prefers oligotrophic waters [Bucka and Wilk-Woźniak 2002]. *Cyanoprocaryota* biomass in all the lakes never exceeded 6% of total biomass.



■ Cyanoprokaryota III Bacillariophyceae □ Dinophyceae II Cryptophyceae □ Chlorophyta □ Others



■ Cyanoprokaryota 🗉 Bacillariophyceae 🗆 Dinophyceae 🖾 Cryptophyceae 🗔 Chlorophyta 🗆 Others

Fig. 1. The total biomass of phytoplankton and its composition in April and July 2009 in lakes of the Wel river catchment area

A different structure of the phytoplankton assemblages was observed in summer, when they consisted mainly of cyanoprokaryotes (up to 88%) in most of the lakes. These included common and water bloom-forming *Aphanizomenon flos-aquae, Anabaena spiroides* f. *crassa, A. lemmermanii, Aphanocapsa incerta* and *Gloeotrichia echinulata*. In Lake Kiełpińskie the greatest biomass was due to green algae, mostly from the genus *Eutetramorus*, whereas in Lake Lidzbarskie the three co-dominant groups were *Cyanoprokaryota, Bacillariophyceae* and *Chlorophyta*.

There are several methods of ecological status assessment based on phytoplankton parameters, that are still being developed or have already been applied in EU countries [Nõges *et al.* 2009]. In this study, the ecological status evaluation of three chosen lakes was performed applying methods published for Hungarian lowland lakes [Padisák *et al.* 2008]. The value of Q index of all the lakes between April and June was similar and classified them as of the moderate status (Fig. 2).



Fig. 2. Ecological status assessment by the Q index follows Padisák et al. [2006]

Nevertheless, in summer (July), different structure of functional groups in each lake caused different ecological status classification. Lake Rumian, because of the domination of filamentous cyanoprokaryota (group H1), was assessed as poor state. In Lake Lidzbarskie a few functional assemblages was recorded (C, J, K), and this lake remained in the moderate status. In Lake Kiełpińskie, group F reached a relatively high biomass and caused the increase of Q index to the good status value.

#### CONCLUSIONS

The physico-chemical parameters of water indicate moderate or strong eutrophy of examined lakes. The phytoplankton biomass in April and July was typical of mesotrophic (Lake Kiełpińskie) or moderately and strongly eutrophic waters (the rest of lakes). The noted biomass in lakes was most often characteristic of water bloom. The ecological status assessment was done for three of the studied lakes (Lidzbarskie, Rumian, Kiełpińskie) according to the Hungarian method. For Lake Rumian a poor ecological status was established, lakes Lidzbarskie and Kiełpińskie were allocated to the moderate and good states, respectively.

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#### FITOPLANKTON – ELEMENT OCENY STANU EKOLOGICZNEGO JEZIOR ZLEWNI RZEKI WEL

**Streszczenie.** Rolę fitoplanktonu w ocenie stanu ekologicznego określono w 10 jeziorach zlewni rzeki Wel. Porównano wartości biomasy ogólnej i skład fitoplanktonu w kwietniu i lipcu 2009 r. Na podstawie struktury grup funkcjonalnych wyliczono indeks Q dla trzech wybranych jezior. Wiosną największą biomasę ogólną (powyżej 20 mg dm<sup>-3</sup>) odnotowano w czterech jeziorach, przez które przepływa rzeka Wel. W lipcu stwierdzono wzrost biomasy glonów planktonowych w jeziorach wraz z biegiem rzeki, a maksimum (52 mg dm<sup>-3</sup>) zaobserwowano w jeziorze położonym w zlewni najdalej od rzeki Wel. Wartość indeksu Q w okresie letnim wskazywała na słaby stan ekologiczny jeziora Rumian, a umiarkowany i dobry w przypadku jezior Lidzbarskie i Kiełpińskie.

Slowa kluczowe: fitoplankton, jezioro, ocena stanu ekologicznego, zlewnia rzeki Wel