GENERAL NUMBER AND PERCENTAGE SHARE OF DIFFERENT SYSTEMATIC GROUPS OF PHYTOPLANKTON IN THE LITTORAL AND PELAGIAL ZONE OF LAKE PIASECZNO IN ESTIMATION OF ITS TROPHY STATE IN THE YEARS AND SEASONS OF 2001–2003

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Summary. The mesotrophic Lake Piaseczno in the Łęczna-Włodawa Lake District comes under constant pressure of agricultural and recreational nature, and as an effect of that there are severe disturbances of its biotope and biocenosis connected with eutrophication. The goal of this paper was an examination of changes in percentage composition and specific domination in phytoplankton in the littoral and pelagial zones of the lake in seasons of 2001-2003. In the research period the general number of phytoplankton for all research sites, in annual and seasonal aspects, showed diversified values varying from 79.8 to 828.6 thousand ind. dm⁻³, but no "water bloom" was recorded. At each research site, both in annual and seasonal periods, the lowest percentage share with minimal exceptions was constantly noted for taxons of Chrysophyceae and Xanthophyceae. The highest percentage share of the general number of phytoplankton, that exceeded, sometimes by a large margin, the level of 30%, was indicated in the examined years and seasons for monotaxonomic Cryptophyceae with nano-planktonic Rhodomonas pusilla - species of high diagnostic and phytosociological value, and for diversified taxons of Chlorophyceae and Cyanophyceae. The rest of the systematic groups of phytoplankton, throughout the whole period of research, had very low and non-diversified levels, which was the main cause of their low percentage share (below 20%) of the general number of phytoplankton. The comparatively balanced shares of systematic groups and their specific composition did not testify to intensification of eutrophication, and that, in comparison with other trophication indicators of visible amplitudes, is a proof of temporal instability of trophy in the water of the reservoir.

Key words: algae, phytoplankton, lake, eutrophication

INTRODUCTION

Piaseczno is the deepest mesotrophic lake of Łęczna-Włodawa Lake District (38.8 m), situated in the area of the 'Łęczna Lake District' Landscape Park. Until recently, it was also one of the cleanest and most valuable, in the natural area, lakes in the region and country. Intensification of agricultural activities and development of recreational infrastructure had a tremendous influence on the biotope and biocenosis of the lake from the early 1970's. The biggest changes concerned the eutrophication of the lake, of which effects were, among others, fluctuations in the specific composition of phytoplankton [Krupa and Czernaś 2003].

MATERIAL AND METHODS

Samples for quality and quantity analysis were taken from two littoral sites: peat-bog littoral adjacent to degraded transitional peat-bog in the NW part of the drainage area, and agricultural-recreational littoral adjacent to area of dense individual recreational building with a small quantity of cultivation fields in the E part of the drainage area, and also from pelagic zone (epi- and metalimnion) in the deepest part of the lake (Fig. 1). Samples were taken on 11 different research





dates during spring–summer–autumn seasons of years 2001–2003, around midday. The method used was dragging of a plankton net made of mill gauze (net mesh diameter approx. 60 μ m) – in the littoral research sites it was dragged horizontally under the water surface, and in the pelagic zone it was dragged vertically to the surface, from the lowest ranges of epi- and metalimnion, which were each time individually defined on the basis of thermal profile.

Samples from the littoral sites were taken by taking water into a container of approx. 0.25 dm^3 in capacity, and from the pelagic site water was taken with a scoop from the successive depths, then 1 dm^3 of water from each stratum of

epilimnion were mixed together into one sample, and from that, without any condensation, the final sample of capacity of approx. 0.25 dm³ was taken. Each sample was afterwards quickly fixated with Lugol's fluid and the next day it was preserved in formalin.

The phytoplankton number and taxonomic identification were made courtesy of Danuta Krupa, PhD, with use of a reverse microscope. Further analyses included the general number of phytoplankton, percentage share of different systematic groups, and dominating species [according to Hindák and Marhold 1998] in the annual and seasonal aspect.

RESULTS

In the years 2001–2003 the general number of phytoplankton for all the research sites in annual and seasonal aspects showed diversified values, varying from 79.8 to 828.6 thousand ind. dm⁻³. In general, the lowest average number was



Fig. 2. Annual average and extreme numbers of phytoplankton in peat-bog littoral, agricultural-recreational littoral and pelagial zone of Lake Piaseczno in the years 2001–2003

noted for the year 2001 and the autumn season, and the highest – for the year 2003 and the summer season (Fig. 2, 3). At all research sites 68 different species of phytoplankton were determined, belonging to 9 systematic classes: *Cyanophyceae, Euglenophyceae, Dinophyceae, Cryptophyceae, Chrysophyceae, Xanthophyceae, Bacillariophyceae, Chlorophyceae* and *Conjugatophyceae*.

For the peat-bog littoral, in annual aspect of the research, the lowest percentage share in phytoplankton ($\leq 0.01\%$) was noted for *Chrysophyceae* represented by *Chrysamoeba radians*, sporadically for *Euglenophyceae* with *Trachelomonas volvocinopsis* (2003), and in summer and autumn seasons additionally for *Dinophyceae* with *Peridinium bipes* and *Ceratium hirudinella*, and *Bacillariophyceae* with *Tabellaria flocculosa* and *Asterionella formosa*. The presence of *Xanthophyceae* taxons was not noted at all. High percentage share (> 23%) was usually noted for *Cryptophyceae* with the sole species of *Rhodomonas pusilla*, with the highest share noted in 2001 (39.6%) and in the autumn season (38%), and for *Chlorophyceae* with domination of *Elakatothrix lacustris*, *Coenococcus planctonicus*, *Oocystis lacustris*, *Crucigenia apiculata* and *Chlorella vulgaris*, for which the highest (> 30%) share was noted in 2003 and in the spring and summer seasons. In 2002 and in the autumn season a high rate of presence (> 25%) was noted for *Cyanophyceae* with temporal subdomination of *Anabaena circinalis*, *Woronichinia naegeliana* and *Snowella lacustris* (Fig. 4, 5).

In the agricultural-recreational littoral the lowest share in phytoplankton was noted for *Chrysophyceae* with *Mallomonas* sp., *Xanthophyceae* with *Isthomochloron lobulatum* and *Euglenophyceae* with *Trachelomonas volvocinopsis*. In the annual aspect, the distribution of the lowest values was similar to the peat-bog littoral, with slightly higher share of *Euglenophyceae* with *Trachelomonas volvocinopsis* and *Euglena* sp. The highest share in the years 2001–2003 was noted for *Chlorophyceae*, with quantity and quality composition similar to the



Fig. 3. Seasonal average and extreme numbers of phytoplankton in peat-bog littoral, agricultural-recreational littoral and pelagial zone of Lake Piaseczno in the years 2001–2003

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Fig. 4. Average annual percentage share of systematic groups in general number of phytoplankton in peat-bog littoral of Lake Piaseczno in the years 2001–2003



Fig. 5. Average seasonal share of systematic groups in general number of phytoplankton in peat-bog littoral of Lake Piaseczno in the years 2001–2003

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Fig. 6. Average annual percentage share of systematic groups in general number of phytoplankton in agricultural-recreational littoral of Lake Piaseczno in the years 2001–2003



Fig. 7. Average seasonal percentage share of systematic groups in general number of phytoplankton in agricultural-recreational littoral of Lake Piaseczno in the years 2001–2003



Fig. 8. Average annual percentage share of systematic groups in general number of phytoplankton in epilimnion of Lake Piaseczno in the years 2001-2003



Fig. 9. Average annual percentage share of systematic groups in general number of phytoplankton in metalimnion of Lake Piaseczno in the years 2001-2003

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Fig. 10. Average seasonal percentage share of systematic groups in general number of phytoplankton in epilimnion of Lake Piaseczno in the years 2001–2003



Fig. 11. Average seasonal percentage share of systematic groups in general number of phytoplankton in metalimnion of Lake Piaseczno in the years 2001–2003

peat-bog eulittoral – max. 44.1% in 2003 (Fig. 6, 7). The highest average share, with high rate of presence of *Chlorophyceae*, was noted for *Cryptophyceae* with monotaxonomic *Rhodomonas pusilla* (35.6%), and in the summer and autumn seasons, with high share of *Cyanophyceae* – for *Chlorophyceae* (46.6% for summer and 33.1% for autumn) with dominating *Coenococcus planctonicus* and *Chlorella vulgaris*. In spring and summer seasons a relatively high share (> 16%) was noted for *Conjugatophyceae* represented in the highest number by *Cosmarium* sp., *Staurastrum* sp. and *Closterium* sp. (Fig. 7).

In the pelagic zone the distribution of the lowest values of percentage shares of systematic groups was similar to the littoral research sites and had similar specific composition. In the seasonal aspect, for both zones of the pelagial the lowest share, rarely exceeding 1%, was noted for *Xanthophyceae* with *Isthomochloron lobulatum* and *Euglenophyceae* with *Trachelomonas volvocinopsis* and, in the case of the autumn season, additionally for *Dinophyceae* with *Peridinum bipes* and *Ceratium hirudinella*.

In the epilimnion the highest share was noted for Cryptophyceae with Rhodomonas pusilla (2001), and in subsequent years of the research, for Chlorophyceae with domination of Elakatothrix lacustris, Coenococcus planctonicus and Crucigenioa apiculata with highest share (47.3%) in 2003 (Fig. 8), and in the metalimnion, with quite a high share of Chlorophyceae, monotaxonomic Cryptophyceae (Fig. 9). The seasonal shares were similar. In the epilimnion, during the spring season, monotaxonomic Cryptophyceae predominated, and during the summer and autumn seasons, with predomination of Coenococcus planctonicus, Chlorella vulgaris and Elakatothrix lacustris – Chlorophyceae were in superiority (Fig. 10). High share in phytoplankton in all seasons was also noted for Cyanophyceae with domination of Aphanothece clathrata and Snowella lacustris, of which the highest seasonal mean (24.8%) was noted in autumn (Fig. 10). In the metalimnion, for each season of research, the highest share in the general number of phytoplankton was noted for Cyanophyceae with Rhodomonas pusilla. Participation of Chlorophyceae was a bit lower, reaching its maximum mean value, with specific composition similar to the littoral, in the summer season (33.4%). Much lower share (approx. 11.5%) in the spring and autumn seasons was also noted for Cyanophyceae with predomination of Aphanotece clathrata, Snowella lacustris and, periodically, Anabaena circinalis (Fig. 11).

DISCUSSION

In the years 1972–1976 nanoplanktonic, monotaxonomic *Cryptophyceae* (*Rhodomonas pusilla*) were dominants in phytoplankton, and various species of *Cyanophyceae* represented 27% of the general number of phytoplankton. In late 1980's the share of *Cryptophyceae* decreased to 26%, the share of *Chlorophyceae* increased to 39%, and in specific composition of *Cyanophyceae* the fili-

form species began to predominate, i.e. *Planktothrix rubescens*, causing seasonal water blooming, which is a proof of visible eutrophication of water reservoir. Also visible was an increase of the number of *Chlorophyceae*, i.e. *Coenococcus* sp. or *Crucigenia tetrapedia*, which were, until recently, regarded as typical indicating species for more fertile waters, eutrophic and polluted [Turoboyski 1970].

According to other researches, in 1972 in phytoplankton of the summer season, beside the dominating *Rhodomonas pusilla* and *Chlorophyceae*, an over 30% share belonged to *Cyanophyceae*, the share of which has been constantly increasing from the late 1980's and maintains on the level of over 50%, with visible domination of *Planktothrix rubescens* and *Anabaena circinalis*. That had an impact on decreasing of specific diversity and it has been confirmed by indexes of Shannon-Weaver and similarity, especially in the summer season in 2002 during which, apart from significant domination of *Cyanophyceae* reaching over 80% of the general share in phytoplankton, the visibility of Secchi disk decreased from 6.5 m in the 1970's to 1.7 m in the summer of 2002 [Wojciechowska *et al.* 2002].

During the research period (2001–2003), as in the mid 1980's [Krupa et al. 1991], a big share in the composition of phytoplankton had the nanoplanktonic Cryptophyceae with monotaxonomic Rhodomonas pusilla, high share of which may indicate a low-trophy character of the reservoir [Kajak 1994]. This species dominated mainly in the epi- and metalimnion, and in the peat-bog littoral, in which high share of Cyanophyceae [Rogalska-Kupiec and Bochnia 1988], potentially dangerous to the health of animals and people, was noted, with Anabaena circinalis, Woronichinia naegeliana and Snowella lacustris. In agricultural-recreational littoral the highest share in phytoplankton was noted for Chlorophyceae with Elakatothrix lacustris and Coenococcus planctonicus, but none of those species, on any of the research dates, indicated in the means of quantity for water blooming of the Piaseczno Lake. In 2002 domination of Cvanophyceae was not confirmed, at least for epi- and metalimnion, for which dominating groups were, respectively, Chlorophyceae and Cryptophyceae, and the average visibility of Secchi disk was much higher (4.53 m). Therefore the abovementioned differences might be caused by different methodology of sample taking, dissimilarities in subjective evaluation of visibility of Secchi disk, and especially by different research dates in the summer season, in which notification of at least short-term monotaxonomic water blooming usually determinates limitation of biodiversity of phytoplankton and low average visibility.

In lakes of similar trophy the specific composition of phytoplankton may differ greatly [Wojciechowska *et al.* 2002], therefore any comparisons with other water reservoirs are pointless, and specific composition itself cannot be a unequivocal index of trophy. Proof of this may be the analysis of phytoplankton in lakes of the Kashubian Lake District, which are in majority Lobelia-type, thus similar to Piaseczno in their typology [Wojciechowski *et al.* 1995, Wojciechowski 1999], in which high share of general phytoplankton number was noted for *Bacillariophyceae* with *Astrionella formosa* and Tabellaria flocculosa [Oleksowicz

1989]; those species in Piaseczno Lake in the years 1980–1990–2000 reached only a few percent of general share in phytoplankton.

Changes of specific composition of the phytoplankton in the Piaseczno Lake are not permanent, and they rather indicate trophic instability of the reservoir, which is also confirmed by high amplitudes of values of biological indicators of trophy: gross primary production, concentration of a-chlorophyll and the value of the assimilation number for the research period [Serafin and Czernaś 2003, Serafin 2004].

CONCLUSIONS

1. In the seasons of 2001–2003, during which the research took place, the number of subsequent systematic groups and particular species in phytoplankton of Piaseczno Lake did not indicate water blooming.

2. The composition of phytoplankton in eulittoral, epi- and metalimnion was relatively balanced, and it indicated domination of nanoplanktonic *Cryptophyceae*, sometimes *Chlorophyceae*, rarely *Cyanophyceae*.

3. The species of the greatest diagnostic and phytosociological value belonged to *Cryptophyceae – Rhodomonas pusilla*, high share of which may indicate a low-trophy character of the reservoir.

4. Systematic groups represented the least numerously were *Chrysophyceae* and *Xanthophyceae*, the share of which rarely exceeded 1%.

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LICZEBNOŚC OGÓLNA I PROCENTOWY UDZIAŁ GRUP SYSTEMATYCZNYCH FITOPLANKTONU W STREFIE LITORALU I PELAGIALU JEZIORA PIASECZNO W OCENIE JEGO STANU TROFII W SEZONACH 2001–2003

Streszczenie. Mezotroficzne jezioro Piaseczno na Pojezierzu Łęczyńsko-Włodawskim podlega nieustannej presji rolniczo-rekreacyjnej, czego skutkiem są zaburzenia w jego biotopie i biocenozie związane z eutrofizacją. Celem pracy było zbadanie zmian liczebności w składzie procentowym fitoplanktonu strefy litoralnej i pelagialnej jeziora w sezonach i latach 2001-2003. W okresie badań liczebność ogólna fitoplanktonu na wszystkich stanowiskach wykazywała w aspektach rocznym i sezonowym zróżnicowane wartości w zakresie 79,8-828,6 tys. os. · dm⁻³, ale nie zdeterminowała "zakwitu wód". We wszystkich stanowiskach badań w aspekcie rocznym i sezonowym najmniejszy udział procentowy (z niewielkimi wyjątkami) notowano dla taksonów Chrysophyceae i Xanthophyceae. Największy udział procentowy w ogólnej liczebności fitoplanktonu wykazywały w różnych latach badań i różnych sezonach monotaksonomiczne Cryptophyceae z nanoplanktonowym Rhodomonas pusilla o dużym walorze diagnostyczno-fitosocjologicznym oraz zróżnicowane taksony Chlorophyceae i Cyanophyceae, przekraczając (niekiedy znacznie) wartość 30%. Pozostałe grupy systematyczne fitoplanktonu przez cały okres badań miały niską i mało zróżnicowaną liczebność, co zdecydowało o niskim udziale procentowym (> 20%) w ogólnej liczebności fitoplanktonu. Względnie zrównoważony udział grup systematycznych i ich skład gatunkowy nie świadczył o nasileniu eutrofizacji, co wobec innych wskaźników trofii o wyraźnie znacznych amplitudach wartości dowodzi czasowej niestabilności trofii tego zbiornika.

Słowa kluczowe: glony, fitoplankton, jezioro, eutrofizacja