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BIODIVERSITY OF PHYTOPLANKTON IN HYDROCHEMICALLY DIFFERENT TYPES OF HUMIC LAKES IN THE DRAWIEŃSKI NATIONAL PARK* **

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A b s t r a c t. This work presents the taxonomical composition and number of phytoplankton of three hydrochemically different, mid-forest humic lakes. The largest species abundance of phytoplankton was noted in the oligohumic lake (76 taxa), and decidedly smaller in the mesohumic (42 taxa) and polyhumic (37 taxa) lakes characterized by higher content of humic substance. The value of index of species difference in the mesohumic lake was much lower than in other lakes.

K e y w o r d s: humic lake, phytoplankton, biodiversity, humic substances

INTRODUCTION

The specific feature of humic lakes is the presence of dissolved, mainly humic organic matter. This causes a series of changes of hydrochemical features of water: acidification, brown water colour, low transparency and poor oxygen conditions [2]. Biochemical activity of dissolved humic substances (DHS) leads to a state of extreme impoverishment of the water habitat in biometals (Ca, Fe), as well as phosphate, nitrate and ammonium ions [7,9]. Increase in the content of dissolved humic substances leads to a lowering of pH and, in consequence, to the appearance of active ions of aluminium, toxic for a majority of organisms. The results follow the changes in the structure of organism assemblages among phytoplankton.

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The aim of the investigation was to estimate the biodiversity of phytoflora in hydrochemically different types of humic lakes.

MATERIAL AND METHODS

The subject of the investigation were three small, postglacial mid-forest lakes differing in content of humic substances (Tab. 1), owing to which it was possible to observe a clear gradient – from the oligohumic Piaseczno Małe Lake (PML), to the mesohumic Głodne Lake IV (GL IV) after the polyhumic Głodne Lake III (GL III). In the surroundings of the Głodne Lakes an ombrotrophic peat bog can be found, with predominant *Sphagnum magellanicum* and *Sph. rubellum*. Only PML possesses a transitory minerotrophic peat bog that occupies a small section of the northern bank [7].

The qualitative and quantitative composition of the phytoplankton was investigated from May 1999 to July 2002, at 3-month intervals. Samples were taken (with the use of 10l water sampler) without condensation, from every thermal layer in the deepest place from pelagial, directly, then conserved with Lugol liquid. *In situ* measurements included: water transparency, temperature, pH, oxygen content and conductivity in the whole water column at 1m intervals; the measurements were taken with the use of the YSI 600R multi-parameter probe. In the laboratory: phosphorus, nitrogen, alkalinity, Ca, Fe, DOC and colour were analysed [5]. The value of the coefficient of absorbance at 530 and 630 nm [2], concentration of dissolved humic substances DHS [3], and chlorophyll *a* and bacteriochlorophyll *d+e* were also determined.

RESULTS

The functioning of the lakes depended on their qualitative composition and on the concentration of organic carbon connected with organic humic substances. The value of physicochemical parameters of water: colour, transparency, value of absorbance ratio A_{530}/A_{630}, indicated the greatest process of humification advance in GL III, and considerably smaller in the two other lakes. Despite the high content N and P the lakes represented a state of low abundance in biological assimilable nutrients, especially dissolved reactive phosphorus (Tab. 1).

The zone of well oxygenated epilimnion in the polyhumic lake was on average 1 m thick; in the mesohumic and oligohumic lake – 3 and 4 m, respectively. The location of the lakes in a deep natural hollow in the surrounding forest was the reason for the formation in early spring and continuance for the greater part of the year of sharp stratification in the thermal and oxygen conditions. During the summer in the hypolimnion and sometimes in the metalimnion deficits of oxygen were found. These conditions may be improved by anaerobic sulphur bacteria, for which the maximum concentrations of bacterial pigments and chlorophyll *a* were observed (Tab. 1).

Table 1. Mean annual values of physicochemical properties of water (DRP – dissolved reactive phosphorus)

Parameters	Głodne III	Głodne IV	Piaseczno Małe
Conductivity (µS cm^{-1})	29	24	69
Calcium (mg dm^{-3})	2.2	1.2	7
Alkalinity (mval dm^{-3})	0.08	0.06	0.28
Iron (mg dm^{-3})	0.4	0.3	0.2
Total phosphorus (µg P dm^{-3})	75	78	77
DRP (µg P dm^{-3})	8	10	4
Total nitrogen (µg N dm^{-3})	1510	1470	1940
DOC (mg C dm^{-3})	17.6	9	15.8
DHS (mg C dm^{-3})	14.6	5.7	8.5
*Chlorophyll (µg dm^{-3})	176.7	117.2	260.5
*Bacteriochlorophyll (µg dm^{-3})	212.0	151.8	371.1

*maximum

The lake phytoflora comprised 10 groups from which a great number was represented by *Chlorophyceae* (Fig. 1). The largest number of taxa – 76 – was detected in phytoplankton of the oligohumic PML (H"=1.34), a lesser number in the mesohumic GL IV – 42 (H"=0.5), and the least in the polyhumic GL III – 37. The highest value of coefficient of biodiversity was observed there also – H"=2.32. With regard to the number of phytoplankton, the lakes Głodne III and Piaseczno Małe were similar – mean 4287 ind. cm^{-3} and 4010 ind. cm^{-3}, however in the mesohumic lake over 20 times more algae were affirmed – 87725 ind. cm^{-3}. The investigation of chlorophyll *a* showed an accumulation of biomass of phytoplankton in summer in the vicinity of the euphotic zone border, in waters with considerable decreases of oxygen. However, the water column showed only a weak connection between the concentration of chlorophyll *a* and the number of algae.

A considerable proportion of phytoplankton was made up of organisms with locomotive organelle, belonging mainly to *Chlorophyceae*, *Xanthophyceae*, *Chrysophyceae* and *Raphidophyceae* (Fig. 1). In the polyhumic GL III they were characterized by weak qualitative differentiation (14 taxa), but the largest part in the total number (average 82% of phytoplankton). In the meso- and oligohumic lakes their diversity was larger (22 and 28 taxa, respectively), but their share in the total number was smaller (1 and 33% of algae). The low percentage of flagellata in the phytoplankton of GL IV resulted from extremely numerous (from spring to autumn) *Chlorophyceae* – nanoplanktonic *Choricystis minor* (average 99% of phytoflora). Only in the winter did the percentage content of flagellata grow to over 90% thanks to the mass occurrence of *Scourfieldia cordiformis*.

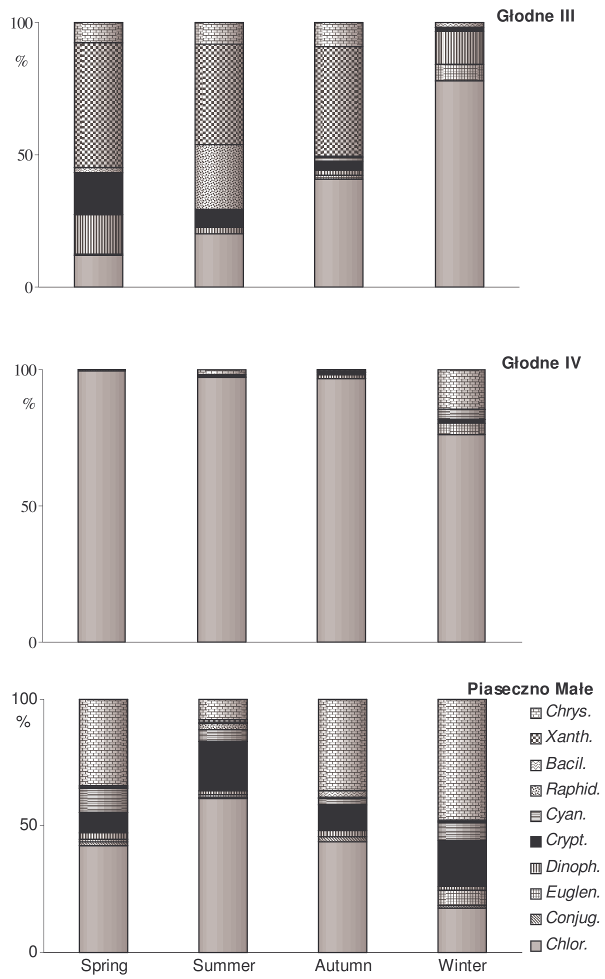

Fig. 1. Seasonal changes percentage of phytoplankton composition (average annual values)

DISCUSSION

The humic lake is a habitat that provides the inhabiting organisms with difficult life conditions. This is mainly due to DHS which, thanks to its chemical features, modifies the abiotic environment and the structure and metabolic processes of organisms [4]. The consequence of the physical-chemical transformations in the water environment is a decrease in the diversity and density of phytoplankton communities [7]. Along with the increasing gradient of DHS concentrations the autotrophic algae disappear, and their place is taken over by species with features of facultative heterotrophs and flagellated phytoplankton that are able to move in the water column [6]. It has been proved that in humic lakes characterised by constant increase of DHS concentration, the flagellata migrate between the well illuminated epilimnion and nourishment-rich deeper layers, gaining both quality and quantity preponderance over permanently fixed forms of algae. This, however, does not mean that the species diversity index should be lower in a lake of higher concentration of DHS compared to lakes with lower amounts of DHS.

The very low value of diversity index obtained from GL IV resulted from the dominance of 1 species – nanoplanktonic green algae *Choricystis minor* from the order *Chlorococcales*. This species is characteristic of lakes which are poor in nutrients, where due to unfavourable ratio of the body surface to the body volume the larger phytoplankton are unable to compete effectively for food resources with bacteria [8]. *Chlorococcales* reveal a tendency towards heterotrophy, using dissolved organic compounds, which helps them to live in humic lakes with high concentrations of organic substances [4].

The low relationship between maximal concentrations of chlorophyll *a* and the phytoplankton abundance recorded for the lakes may be a result of the presence of green, phototrophic sulphuric bacteria (that besides bacteria pigments also contain chlorophyll *a*) and the so called chromatic adaptation of algae cells in conditions of restricted light availability [1].

CONCLUSION

The transformations of abiotic features of water environment under the influence of increased concentrations of DHS lead to qualitative changes in the conditions of aquatic phytoflora. However, the value of the variety diversity index does not decrease directly in proportion to the growing content of DHS. In the phytoplankton, the percentage of facultative heterotrophs and phytoflagellates which can migrate in the water column increases, and that of some of the autotrophic organisms diminishes. The common phenomenon is domination of one or subdomination of two species.

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RÓŻNORODNOŚĆ GATUNKOWA FYKOFLORY W ZRÓŻNICOWANYCH HYDROCHEMICZNIE TYPACH JEZIOR HUMUSOWYCH DRAWIEŃSKIEGO PARKU NARODOWEGO

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S t r e s z c z e n i e. Przedstawiono skład taksonomiczny i liczebność fitoplanktonu trzech różnych pod względem hydrochemicznym, śródleśnych jezior humusowych. Największe bogactwo gatunków odnotowano w jeziorze oligohumusowym (76 taksonów), a zdecydowanie mniejsze w cechującym się większą zawartością substancji humusowych mezohumusowym (42) i polihumusowym (37). Wartość indeksu różnorodności gatunkowej w jeziorze mezohumusowym była zdecydowanie niższa, niż w pozostałych.

S ł o w a k l u c z o w e: jeziora humusowe, fitoplankton, bioróżnorodność, substancje humusowe