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SPECIES BIODIVERSITY OF NET PHYTOPLANKTON AS AN INDICATOR OF TROPHIC CHANGES IN THE URBAN LAKE JEZIORAK MAŁY

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Summary. The studies were carried out on net phytoplankton in the urban Lake Jeziorak Mały in the years 1996-1999. An increase in phytoplankton biodiversity, a decrease in the total phytoplankton numbers, a decrease in the number and percentage of blue-greens, and an increase in diatoms were observed. The results obtained may indicate changes in the trophic conditions of the lake and its transformation from polytrophy to eutrophy, which could be caused by lake restoration works.

Key words: lake, phytoplankton, biodiversity

INTRODUCTION

Domestic sewage, industrial effluents, agricultural runoff, and storm waters from urban agglomerations produce certain ecological effects in lakes, often referred to as eutrophication [Vollenweider 1968, Kajak 1979, Lampert and Sommer 1996]. Eutrophication causes changes in the biocenotic structures of phytoplankton. Due to a short vegetation season, phytoplankton may respond quickly to these changes, which manifests itself in biodiversity reduction, increased numbers of particular taxonomic groups or alterations in their structure, often resulting in blue-green algal blooms [Kawecka and Eloranta 1994]. An indicator of trophic changes taking place in lakes may be species biodiversity, i.e. relative abundance of particular species [Kawecka and Eloranta 1994]. The differences in biocenotic diversity are determined on the basis of the Thienemann's Principles [Remmert 1985, Lampert and Sommer 1996]:

1. The greater the diversity of conditions in a locality, and the closer they are to normal optima, the larger the number of species that make up the community.

2. The more the conditions deviate from normal, hence from the normal optima of most species (even temporarily only), the smaller is the number of species which occur there, and the greater the dominance of some species.

The first situation is typical of oligo- and eutrophic lakes, whereas the other – of polytrophic ones, often dominated by blue-green algae [Reynolds 1984].

The objective of the present study was to determine the species biodiversity of net phytoplankton as an indicator of trophic changes in the urban lake Jeziorak Mały in the years 1996-1999.

RESEARCH AREA, MATERIAL AND METHODS

The urban lake Jeziorak Mały covers an area of 26 ha; its maximum depth is 6.4 m, mean depth – 3.4 m. For many decades this lake received municipal sewage from the town of Ilawa. Since 1991 the effluents have been treated at a local wastewater treatment plant, and since 1997 restoration works have been carried out in the lake, including the installation of separators for pretreatment of storm water influents, and a fountain-based water aeration system.

Samples of net phytoplankton were taken once a month, from May to September, in the years 1996, 1997, 1998 and 1999. The material was collected in the pelagial, every meter from the water surface to a depth of 4 m. The samples were taken with a 5-liter plankton scoop TOŃ 2 (10 liters of water at each depth level). The scoop contents was poured through a plankton net no 30, and then preserved with a Lugol's solution and, separately, with a 4% formaldehyde solution. 80 water samples were taken altogether. The following physicochemical water parameters were determined: Secchi disc transparency (m), water temperature (°C), oxygen concentration ($mgO_2\ dm^{-3}$) and % oxygen saturation – with the HI 9143 dissolved oxygen meter.

The quantitative and qualitative determinations of phytoplankton samples were performed under an optical microscope Alphaphot YS2 NIKON. The specimens were counted in a 1 ml plankton chamber, and expressed per dm^3. Arithmetic means were determined for phytoplankton numbers and physicochemical parameters of water. The data on the abundance and number of phytoplankton species provided the basis for calculating the following biodiversity indices: Margalef, Menhinick, Shannon and Weaver.

RESULTS

An increasing number of species observed in Lake Jeziorak Mały in successive years was accompanied by an increase in phytoplankton diversity indices. Growing values of these indices were recorded in the years 1996-1998, followed by a slight decrease in 1999. The Margalef index varied from 3.92 in 1996 to 9.82 in 1998, the Menihnick index ranged from 0.12 to 0.51, and the Shannon-Weaver index – from 0.82 to 3.17. The number of species in these years was 48 to 101 (Tab. 1). Heinonen [1980]

Table 1. Indices of phytoplankton biodiversity in Lake Jeziorak Mały in the yearis 1996-1999
Tabela. Wskaźniki różnorodności fitoplanktonu w jeziorze Jeziorak Mały w latach 1996-1999

Years – Lata Indices of biodiversity – Wskaźniki różnorodności	1996	1997	1998	1999
Margalef	3.92	7.13	9.82	8.53
Menihnick	0.12	0.5	0.51	0.29
Shannon and Weaver (bit/species)	0.82	2.88	3.17	3.12
Number of species	48	66	101	89

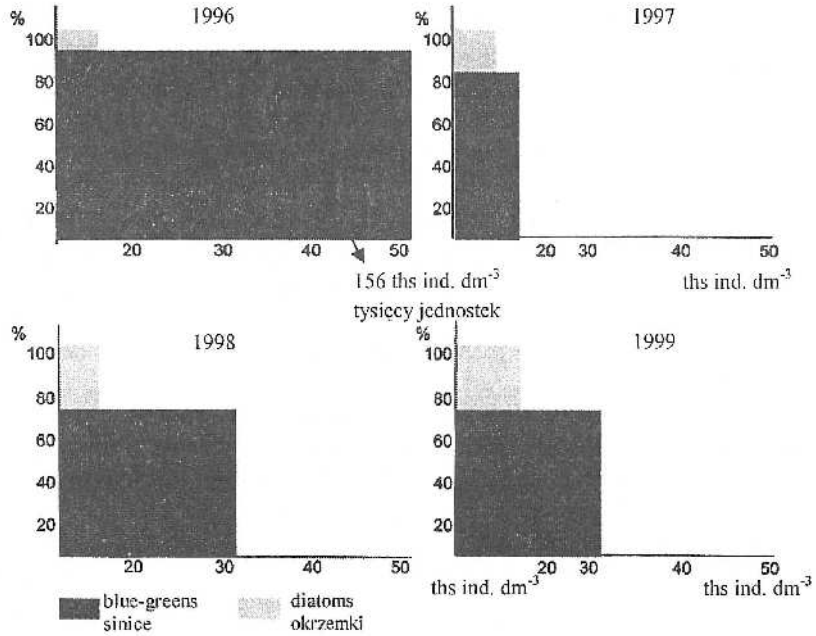

Fig. 1. The numbers and structure of phytoplankton in the Lake Jeziorak Mały in years 1996-1999

Rys. 1. Liczba i struktura fitoplanktonu w jeziorze Jeziorak Mały w latach 1996-1999

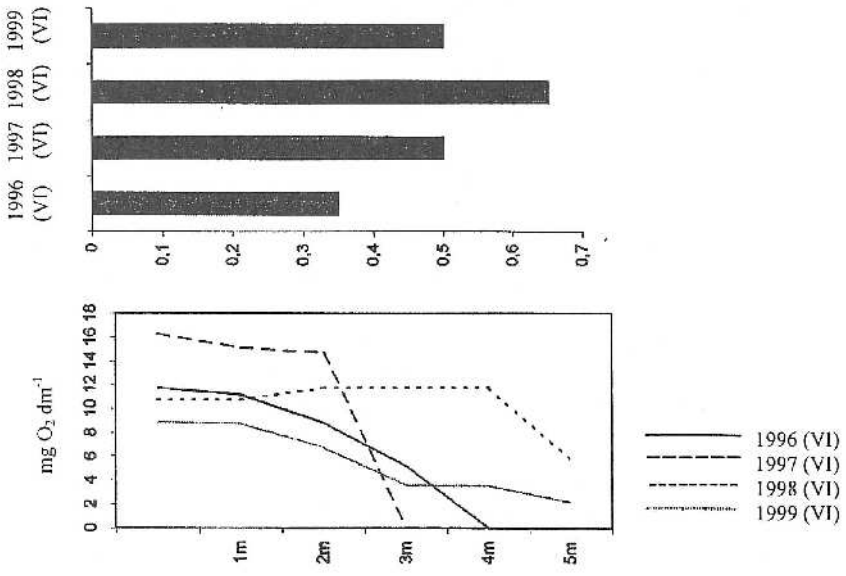

Fig. 2. Oxygen concentration and Secchi disc transparency (m) in Lake Jeziorak Mały in the years 1996-1999

Rys. 2. Stężenie tlenu i widzialność krążka Secchi'ego (m) w jeziorze Jeziorak Mały w latach 1996-1999

Table 2. Physicochemical parameters of water in Lake Jeziorak Mały in the years 1996-1999
Tabela 2. Fizykochemiczne parametry wody w jeziorze Jeziorak Mały w latach 1996-1999

Years – Lata / Water parameters – Parametry wody	1996	1997	1998	1999
Temperature (°C) – Temperatura	17,4	17,9	19,6	19,1
Oxygen concentration (mg dm^{-3}) – Stężenie tlenu	3,71	6,23	7,70	7,93
Oxygen saturation (%O_2) – Natlenienie	38,8	76,0	93,6	86,6
Secchi disc transparency (m) – Widzialność krążka Secchi'ego	0,65	0,85	0,85	0,86

reported similar values of biodiversity indices, i.e. the Margalef index – 7.15 to 7.56, and the Shannon-Weaver index – 3.46 to 3.60 for 94 taxa in eutrophic lakes, and 6.81 and 3.03, respectively, for 92 taxa in hypertrophic lakes. In the studies conducted by Eloranta in eutrophic lakes [1986], the Shannon index was 2.76.

Changes in the numbers and structure of dominant taxonomic groups of phytoplankton (blue-green algae and diatoms) were also observed in Lake Jeziorak Mały. A significant decrease in total phytoplankton numbers was recorded in the years 1996-1999. The highest number and proportion of blue-green algae in total phytoplankton numbers was noted in 1996 (15 6187 specimens/dm^{-3} – 96.47%). In successive years their number was decreasing, giving place to diatoms, although the blue-greens were still the dominant species (Fig. 1). Similar tendencies, i.e. a decrease in the numbers of blue-green algae accompanied by an increase in the numbers of diatoms, were also reported by other authors [Chudyba 1992, Visser *et al.* 1996] in the case of lakes subjected to artificial aeration, and eutrophic polymictic ones [Dokulil and Padisak 1994, Nixdorf 1994, Gervais *et al.* 1999].

The physicochemical parameters of water in the examined lake also changed over the experimental period. In the years 1996 and 1997 oxygen deficit was observed at the bottom (at a depth of 4 m and 3 m, respectively), followed by an increase in its concentration, preventing further deficits in the near-bottom layers in consecutive years. Sechci disc transparency in June increased as well, from 0.35 m in 1996 to 0.65 m in 1998. In the years 1996-1999 water temperature rose from 17.4 to 19.6°C (Tab. 2, Fig. 2). Similar changes in the physicochemical parameters of water, resulting from lake restoration, were described by Visser *et al.* [1996], Gervais *et al.* [1999].

DISCUSSION

Phytoplankton is a good indicator of environmental changes taking place in water bodies. For instance, it responds with an increase in species abundance and a decrease in biodiversity to intensified inflow of biogene elements [Kawecka and Eloranta 1994]. According to Reynolds [1984], in waters characterized by very high nutrient concentrations both the number of species and their diversity are lower than in less eutrophicated ones. This means that the number of species increases along with an increase in eutrophy, before it starts to reduce, which can be observed in hypertrophic lakes.

An increase in the number of phytoplankton species and biodiversity, and an over fivefold decrease in total phytoplankton numbers, were observed in Lake Jeziorak Mały

in the analyzed period. As regards the dominant taxonomic groups of phytoplankton, the number and percentage of blue-green algae reduced in the years 1996-1999, giving place to diatoms. The above changes may indicate lake transformation from polytrophy to eutrophy. It seems that they could have been caused by ecological stress connected with restoration works. According to Burchardt *et al.* [1994], ecological stress may evoke a series of harmonious trophic changes, leading to quantitative and qualitative changes in the floristic composition of phytoplankton, until the process of lake trophy transformation is completed. The change in environmental conditions that took place in Lake Jeziorak Mały in 1996 manifested itself in increased oxygen supply and Secchi disc transparency, observed despite a rise in mean water temperature recorded in successive years.

CONCLUSIONS

The studies on net phytoplankton conducted in Lake Jeziorak Mały in the years 1996-1999 showed:

1. An increase in the number of species and their biodiversity, calculated employing the following indices: Margalef's, Menihnick's and Shannon-Weaver's.
2. A decrease in total phytoplankton numbers and a considerable reduction in the number and percentage of blue-green algae, accompanied by an increase in the number and percentage of diatoms.
3. An increase in oxygen concentration, no oxygen deficits at the bottom in summer, and increased Secchi disc transparency, leading to higher thickness of the light-penetrated layer.
4. The above quantitative and qualitative changes in phytoplankton communities allow to classify Lake Jeziorak Mały as a polytrophic water body undergoing transformation towards eutrophy. This process could be caused by restoration works, which changed environmental conditions.

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RÓŻNORODNOŚĆ GATUNKOWA FITOPLANKTONU SIECIOWEGO JAKO WSKAŹNIK ZMIAN TROFII ŚRÓDMIEJSKIEGO JEZIORA JEZIORAK MAŁY

Streszczenie. Badania fitoplanktonu prowadzono w śródmiejskim jeziorze Jeziorak Mały w latach 1996-1999. Na podstawie uzyskanych badań stwierdzono wzrost bioróżnorodności gatunkowej fitoplanktonu, spadek ogólnej liczebności fitoplanktonu oraz spadek liczebności i udziału sinic a wzrost okrzemek, co może wskazywać na zmianę warunków troficznych i przechodzenie z politrofii w kierunku eutrofii. Zmiany te mogły być spowodowane wprowadzeniem zabiegów ochronno-rekultywacyjnych w jeziorze, w wyniku których wzrosło natlenienie i widzialność krążka Secchiego.

Słowa kluczowe: jezioro, fitoplankton, bioróżnorodność gatunkowa