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DIVERSITY OF PHYTOPLANKTON COMMUNITY IN BORUSA AND GRUNDELA PONDS

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Summary. Variation in the composition and biomass of phytoplankton assemblages was investigated on two urban ponds (Poznań) subjected to restoration. During one year 274 taxa of algae belonging to 97 genera were recorded for both ponds. This richness of species was related to the chlorophytes and diatoms variety. Phytoplankton dominant species observed in each season diversified the examined ponds. Results obtained show that cyanobacteria and green algae were the main dominants of the phytoplankton in Pond Borusa while green algae with large amount of cryptomonads, diatoms and euglenoids domination was observed in Pond Grundela.

Key words: urban pond, species richness, diversity, phytoplankton, green algae

INTRODUCTION

For some taxonomic groups, especially algae, species numbers are correlated with habitat heterogeneity. Similarly, ponds have many ecological niches, alike to shallow lakes and, as a consequence, a higher structural diversity which is reflected in the number of species [Reynolds 1984, Wetzel 2001, Duelli and Obrist 2003]. A related complication is that species diversity within a community or habitat is defined in terms of a wide range of environmental factors including soil erosion, changes of the water level, nutrient concentrations, or herbivores density [Wetzel 2001]. Many of these factors are complex and it is likely that the abundance of algae species in a community can attempt to create variability in population size within particular species. In addition, ponds are shallow and continuously mixing, which permits the algae cells to remain in suspension and exposes them to light, very often promoting their growth. This is a particularly important factor in the case of ponds located in forests or parks overshadowed with trees [Messyasz and Jurgońska 2003, Messyasz *et al*. 2005].

The ecological territory „Dębina" is situated in Poznań, in an area on the left bank of River Warta, in the south part of the city. A considerable part of the area of the ecological territory „Dębina" is occupied by waters, mainly four ponds: Grundela, Borusa, Dębowy and Słoneczny [Kaniecki 1993, Danielewicz *et al*. 2001]. In the nineteen nineties, on account of the bad sanitary condition of ponds, a decision about their restoration was taken [Chojnacki 2006]. As part of these plans, the ponds were cleaned of scums, deepened from 20 up to 100 cm, their bottoms were formed for stocking with fish, and their shorelines were shaped. At the same time, avenues for pedestrians and access roads were reconstructed. All the time a stage of fish restocking in the ponds is being realized [Danielewicz *et al*. 2001].

Before the restoration the ponds were characterised by great phytoplankton species richness in all seasons of the year, which was conditioned by their high fertility [Reiter and Burchardt 2005]. The reconstruction of Pond Borusa was finished in 2000. In 2004 the restoration process of Pond Grundela was undertaken. The purpose of this research was to compare the changes within the diversity of phytoplankton communities (number of taxa and biomass) among two shallow ponds, differentiated in the time of their restoration treatment.

STUDY AREA, MATERIAL AND METHODS

The ecological territory „Dębina" is a part of a forest Dębina complex which covers the area of 260 ha. There is a zone (181.4 ha) of taking drinking water for Poznań located here, and this part of the space is the protective zone. The ponds are fed with water through ground permeating when the River Warta has a high level of water. On account of permeable ground, water from the river to the ponds is also supplied by a waterworks pipe throughout the year [Chojnacki 2006]. All the ponds are integrated with one another by means of culverts and bolts. Every three years the ponds are limed with chlorinated lime [Danielewicz *et al*. 2001].

Pond Borusa is one of four ponds located in the park. Its surface amounts to 2.44 ha (with islands), maximum depth is 2.48 m. Around the pond there is a road for strollers. Twelve years ago this pond almost completely was drained. After reconstruction in 2000, the pond is exploited for fishing.

Pond Grundela (3.23 ha with island) is a narrow and elongated water body with maximum depth of 4.57 m (average – 1.65 m). In 2004 bottom deposits were removed by refullering method, which consists in pipe sucking out the sediment from under water, without drying the pond [Chojnacki 2006]. Water from the removed deposits was returned gravitationally back to the pond. Dried sediment from the pond was used as filling material for local holes of the land.

In each case the sampling station was located in the central part of pond. Water samples for phytoplankton and chlorophyll *a* analyses were taken every month from 16.07.2004 to 12.07.2005 (with the exception of January and April). The Secchi disk visibility, water temperature, pH, oxygen and nutrient concentrations were also measured. Chlorophyll *a* concentration (corrected for pheopigments) was determined fluorimetrically according to the procedures described by Strickland and Parsons [1972].

Phytoplankton cell biovolumes were calculated according to standard geometrical figures [Rott 1981]. The dominating phytoplankton species were defined as those which exceeded 10% of the total biomass. The diversity index calculations (Shannon-Weaver index, evenness index) were based on the phytoplankton biomass concentrations.

RESULTS AND DISCUSSION

The small ponds Borusa and Grundela are permanent reservoirs, containing water at all times of the year. In the period of conducted examinations both ponds were rich in inorganic nitrogen (nitrates: 0.1-1.4 mg l^{-1}; ammonium form: 0.16-1.46 mg l^{-1}) and dissolved phosphorus (0.02-1.25 mg l^{-1}), with clearly lower concentrations in Pond Grundela. Water pH fluctuated between 6.94 and 8.46 in Pond Borusa and 6.88-7.98 in Pond Grundela. In 2004/2005 chlorophyll *a* concentrations were from 7.65 μg l^{-1} (12.08.2004) to 34.86 μg l^{-1} (8.10.2004) in Pond Borusa, and 2.61 μg l^{-1} (17.06.2005) – 40.63 μg l^{-1} (16.07.2004) in Pond Grundela. Chlorophyll average values as well as nutrients level were characteristics of eutrophic water environments [Kawecka and Eloranta, 1994].

Shallow water bodies are usually characterized by an abundance of algae. There is a considerably diversity of phycoflora in the Dębina ponds, with a total of 274 species found during one year examination. Most species were represented by the Chlorophyta (122), Bacillariophyceae (63) and Cyanoprokaryota (37). The other algal groups included Euglenophyta (14) and Cryptophyceae (8). The number of taxa in particular ponds was different and amounted to from 208 taxa (92 chlorophytes, 46 diatoms, 32 cyanobacteria) in the total number of algae in Pond Borusa to 217 taxa (103, 46, 25 respectively) in Pond Grundela. There was no clear difference in the relative proportion of the number of species between Borusa and Grundela ponds noted in particular seasons and algae groups.

Chlorophytes, represented mainly by chlorococcales, were the richest algae species group in both ponds. The major genera were *Crucigenia* (4), *Desmodesmus*/*Scenedesmus* (30), *Kirchneriella* (4), *Lagerheimia* (4), *Pediastrum* (7), *Monoraphidium* (9), *Tetraëdron* (3). Among diatoms, the important genera – *Cyclotella*, *Cymbella*, *Gomphonema*, *Fragilaria*, *Navicula* and *Nitzschia* – were the most abundant during spring and autumn. Cyanobacteria were dominated by the genera *Anabaena, Aphanizomenon, Jaaginema, Limnotrix, Microcystis, Oscillatoria* and *Planktothrix*. Jaccard's coefficient of similarity between the phytoplankton community structure of both ponds was 0.79. A decreasing tendency in similarity of phytoplankton communities from autumn 2004 to summer 2005 was observed, and the lowest values were recorded in the spring and summer (0.24-0.46).

These results, together with observations by other authors [Reynolds 1984, Alam *et al.* 2001, Burchardt and Pawlik-Skowrońska 2005, Messyasz 2006], indicate that it is not only the dominant species that vary among ponds, but also the density of the component species (Tab. 1).

Table 1. Seasonal changes in the phytoplankton dominants structure (biomass in mg l^{-1}) of the examined ponds
Tabela 1. Sezonowe zmiany struktury dominantów (biomasa w mg·l^{-1}) w fitoplanktonie badanych stawów

Season – Sezon	Pond Borusa – Staw Borusa	Pond Grundela – Staw Grundela
Summer	*P. boryanum* v. *long.* (13.79)	*Cryptomonas ovata* (5.46)
Lato 2004	*Aph. flos-aquae* (6.89)	*P. boryanum* v. *long.* (3.49)
	P. biradiatum v. *longe.* (6.26)	*P. biradiatum* v. *longe.* (3.53)
Autumn	*Aph. flos-aquae* (22.97)	*Planktothrix agardhii* (8.57)
Jesień 2004	*Planktothrix agardhii* (14.13)	*Cryptomonas erosa* (7.34)
	Planktolyn. limnetica (11.77)	*Aph. flos-aquae* (4.22)
Winter	*Rhodomonas minuta* (6.71)	*Peridinium cinctum* (0.24)
Zima 2004	*Chlamydomonas globosa* (3.22)	*Cryptomonas erosa* (0.23)
	Pediastrum boryanum (0.82)	*Trachelomonas volvocina* (0.22)
Spring	*P. boryanum* v. *long.* (3.29)	*Cryptomonas erosa* (0.11)
Wiosna 2005	*Limnothrix redekei* (3.15)	*P. boryanum* v. *long.* (0.08)
	P. biradiatum v. *longe.* (2.47)	*Rhodomonas minuta* (0.06)
Summer	*Aph. flos-aquae* (6.18)	*Cocconeis placentula* (2.15)
Lato 2005	*Pediastrum boryanum* (5.99)	*Oocystis lacustris* (0.72)
	Planktothrix agardhii (5.08)	*P. boryanum* v. *long.* (0.71)

P. – *Pediastrum*; Aph. – *Aphanizomenon*; Planktolyn. – *Planktolyngbya*; long. – *longicorne*; longe – *longecornutum*)

In summer and autumn, the phytoplankton biomass had a high concentration in both ponds (Fig. 1), and the predominant species were cyanobacteria *Aphanizomenon flos-aquae* and *Planktothrix agardhii* (Tab. 1). These cyanobacteria species, forming dense bloom in Pond Borusa, were found to be poorer in subjected to restoration Pond Grundela. The results clearly suggest that the environmental factor that seems to control the growth of phytoplankton in Pond Grundela was small nutrient concentration. The biomass of phytoplankton significantly decreased when sediment was removed from Pond Grundela.

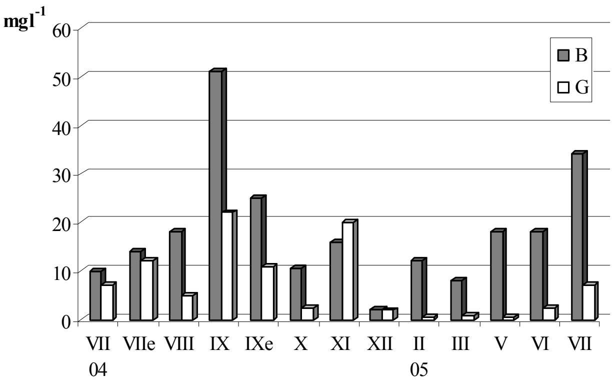

Fig. 1. Changes in phytoplankton biomass in Borusa (B) and Grundela (G) ponds in particular seasons (e – the end of month)
Rys. 1. Zmiany biomasy całkowitej fitoplanktonu w stawach Borusa (B) i Grundela (G) w poszczególnych sezonach (e – koniec miesiąca)

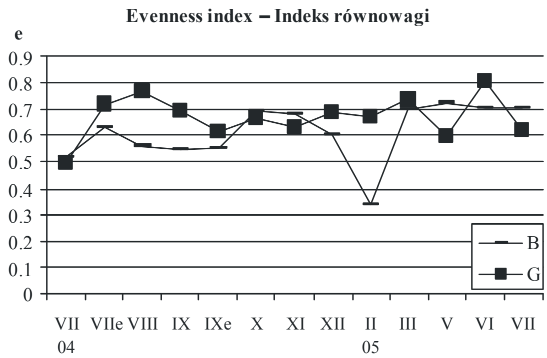

Fig. 2. Changes in phytoplankton biodiversity in Borusa (B) and Grundela (G) ponds in different seasons (e – the end of month)
Rys. 2. Zmiany bioróżnorodności fitoplanktonu w stawach Borusa (B) i Grundela (G) w różnych sezonach (e – koniec miesiąca)

In both ponds, chlorococcales green algae dominated the phytoplankton communities during summer. Other chlorophytes genera, not mentioned as dominants, were less frequent but in some samples they reached densities higher than 10^6 cells l^{-1}. It is also commonly assumed that in shallow ecosystems, high availability of nutrients can be a good nutritional base for intensive chlorococcales development [Reynolds 1984, Kawecka and Eloranta 1994, Bucka and Wilk-Woźniak 2002, Messyasz 2006]. In addition, observed cryptomonads preference for Pond Grundela appeared to be connected with unsteady environment. Their survival appeared to be related to such features as fast reproduction, short lifespan, and mixotrophic kind of feed [Reynolds 1995, 1996, Bucka and Wilk-Woźniak 2002]. In a similar context, the restoration process raised the water turbulence in this pond, which contributed to increased diatom participation in the phytoplankton community.

The value of the Shannon-Weaver index amounted from 4.75 (12.07.05) to 1.79 (27.02.05) in Pond Borusa. Evenness index value for this pond ranged from 0.34 to 0.72 (Fig. 2). In the case of Pond Grundela the diversity varied from 2.95 (16.07.04) to 4.78 (12.08.04) and for the evenness the range of variability was 0.50-0.81. In almost all cases, diversity index values were in accordance with positively valued expectations in the habitat restoration of Pond Grundela. Nevertheless, high diversity during cyanobacteria blooms (e.g. beginning of September in Pond Borusa) was observed.

CONCLUSION

This study identified the diversity in the phytoplankton community structure in two urban ponds. Algal species richness and abundance showed seasonal variation with an increase during the summer months and a decrease in the winter. Relatively larger phytoplankton biomass in Borusa than Grundela ponds was reflected in relatively higher nutrient concentration. Furthermore, the biomass of phytoplankton was drastically reduced after removing bottom sediment in Grundela Pond in 2005. In both ponds big green algae species diversity and the quantitative differences in the phytoplankton biomass were noted. The analysis of the evenness index revealed very high values in both ponds, independently from the time of restoration and intensity of water bloom.

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RÓŻNORODNOŚĆ ZBIOROWISKA FITOPLANKTONU W STAWACH BORUSA I GRUNDELA

Streszczenie. Badania dotyczące zmian w strukturze i biomasie zbiorowisk fitoplanktonu prowadzono w dwóch stawach miejskich, poddanych rekultywacji (Poznań). W ciągu roku badań stwierdzono występowanie 274 taksonów glonów, reprezentujących 97 rodzajów. Bogactwo gatunkowe wynikało z dużej różnorodności zielenic i okrzemek. Gatunki dominujące w fitoplanktonie różnicowały badane stawy w poszczególnych sezonach. Wyróżnione dla każdej pory roku dominanty różnicują badane stawy, wskazując na wyraźny charakter sinicowo-zielenicowy fitoplanktonu w stawie Borusa i zielenicowy z dużym udziałem kryptofitów, okrzemek i euglenin w stawie Grundela.

Słowa kluczowe: staw miejski, bogactwo gatunkowe, różnorodność, fitoplankton, zielenice