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Original research paper

Picophytoplankton of a small reservoir under human influence

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Abstract

The abundance and biomass of autotrophic picophytoplankton (APP) were studied in the Cybina River above and below the shallow Antoninek Reservoir (western Poland). APP was studied after restoration of the reservoir, which was carried out in 2002-2003, to compare the results with the period preceding human interference. APP included picochlorophytes (EPP = eukaryotic picoplankton) and picocyanobacteria (PPP = prokaryotic picoplankton), and the eukaryotic component dominated over the prokaryotic component, accounting on average for approx. 80% of the APP abundance and biomass. No significant change in APP size structure was noted between the two sampling stations. In contrast, before the restoration of the reservoir, APP numbers and biomass decreased by 64% between the sampling stations.

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INTRODUCTION

Human influence is the most conspicuous in small water bodies, particularly if they are located in urbanized areas. An example is the small and shallow Antoninek Reservoir in Poznań (western Poland). In 2002-2003 it was subjected to restoration, which consisted of the removal of bottom sediments together with the vegetation that had colonized the reservoir (Gołdyn et al. 2005). As a result, the character of this water body has changed, so presumably its influence on phytoplankton in the Cybina River has also been modified. The Antoninek Reservoir (surface area 7.2 ha, mean depth 0.4 m) is anthropogenic and continuously exposed to human impact. This is the first of a cascade of four reservoirs located in the western part of the city of Poznań, in the lower course of the Cybina (a small lowland river). It was described in detail in many papers (e.g. Gołdyn, Błażejewski 1987; Gołdyn, Grabia 1998; Gołdyn 2000; Gołdyn et al. 2005). Picophytoplankton is recognised as an important component of phytoplankton in many aquatic systems. Because of the small cell size, APP is an important source of food for small zooplankton and a significant primary producer in many water bodies; so it is of considerable importance, although frequently neglected (Stockner 1991). The objective of this study was to analyse the structure of the smallest size fraction of phytoplankton, with particular reference to picochlorophytes, after reservoir restoration, and to estimate changes in APP abundance and biomass in the Cybina River under the influence of the Antoninek Reservoir.

MATERIALS AND METHODS

Water samples were taken biweekly between November 2004 and October 2005 from the Cybina River at the inlet (station 1) and outlet (station 2) of the Antoninek Reservoir (Fig. 1). Autotrophic picoplankton (APP) was analysed on 0.2-μm black membrane filters under an epifluorescence microscope according to protocols described earlier (Szeląg-Wasielewska 2004). APP was divided into eukaryotic picoplankton (EPP) and prokaryotic picoplankton (PPP). Physicochemical parameters were measured according to Polish Standards, and subjected to statistical analyses (correlation coefficients, Wilcoxon matched pairs test) using STATISTICA 5.1 software.

RESULTS AND DISCUSSION

APP abundance (Fig. 2) varies at the inlet from 55 to 2.9×10^5 cells ml^{-1} (mean 6.6×10^4 cells ml^{-1}), and at the outlet from 329 to 2.7×10^5 cells ml^{-1} (mean 6.0×10^4 cells ml^{-1}). The highest values were recorded in March. Similar

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values of abundance were noted at both sampling stations. The mean APP abundance at station 1 was nearly 5 times higher than during a similar study in 1995, when it amounted to 1.4×10^4 cells ml^{-1} (Gołdyn, Szeląg-Wasielewska 2005). The pattern of seasonal variation in APP biomass was similar to the variation in APP abundance. The highest APP biomass was found in samples from March 2005 at both sites, reaching approx. 0.35 mg l^{-1}.

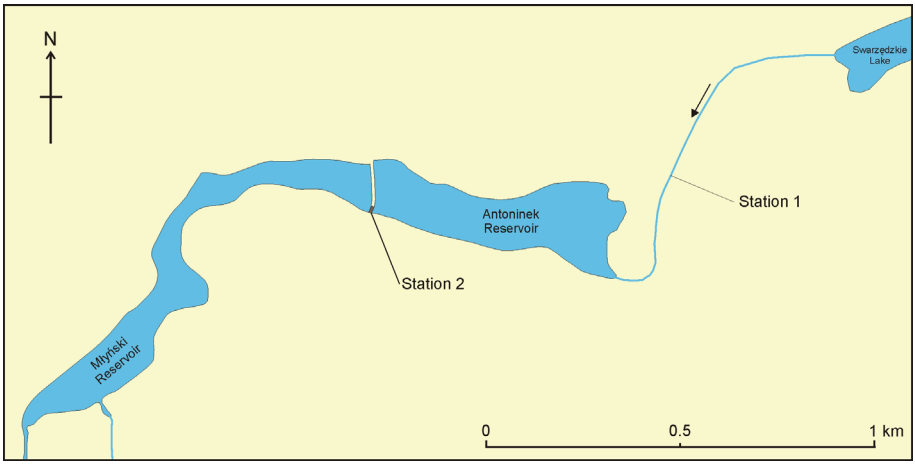

Fig. 1. Lower course of the Cybina River, between the Swarzędzkie Lake and Młyński Reservoir. Stations 1 and 2 = sampling stations.

The quantitative and qualitative structure of the phytoplankton in the Antoninek Reservoir is dependent on the Swarzędzkie Lake, which is located upstream of the reservoir (Gołdyn 2000). Changes in the upper course of the Cybina are probably the cause of the higher mean APP abundance in this study than in the same months in previous years.

APP included picochlorophytes and picocyanobacteria, and the eukaryotic component (EPP) dominated over the prokaryotic component (PPP), as the mean contribution of EPP to total APP abundance and biomass reached 80%. Earlier research on APP at station 1 showed that EPP accounted for a smaller proportion of APP than did PPP, although in winter the EPP amounted to approx. 50% of total APP abundance (Gołdyn, Szeląg-Wasielewska 2005). However, most authors (e.g. Marshall and Affronti (1992), Malinsky-Rushansky and Berman (1991), and Vörös et al. (2000)), found low contributions of EPP to total APP abundance and biomass. In contrast, a dominance of EPP in the cold-water period was described by Weisse (1993),

as well as Hepperle and Krienitz (2001). Ochs and Rhew (1997) reported that in a dam reservoir of 12 000 ha in area, EPP accounted for up to 80% of total APP abundance and 90% of total APP biomass in the cold-water period, while in the warm period its contribution declined to several per cent. This confirms that EPP can thrive in cold waters where the temperature reaches only several ºC above zero.

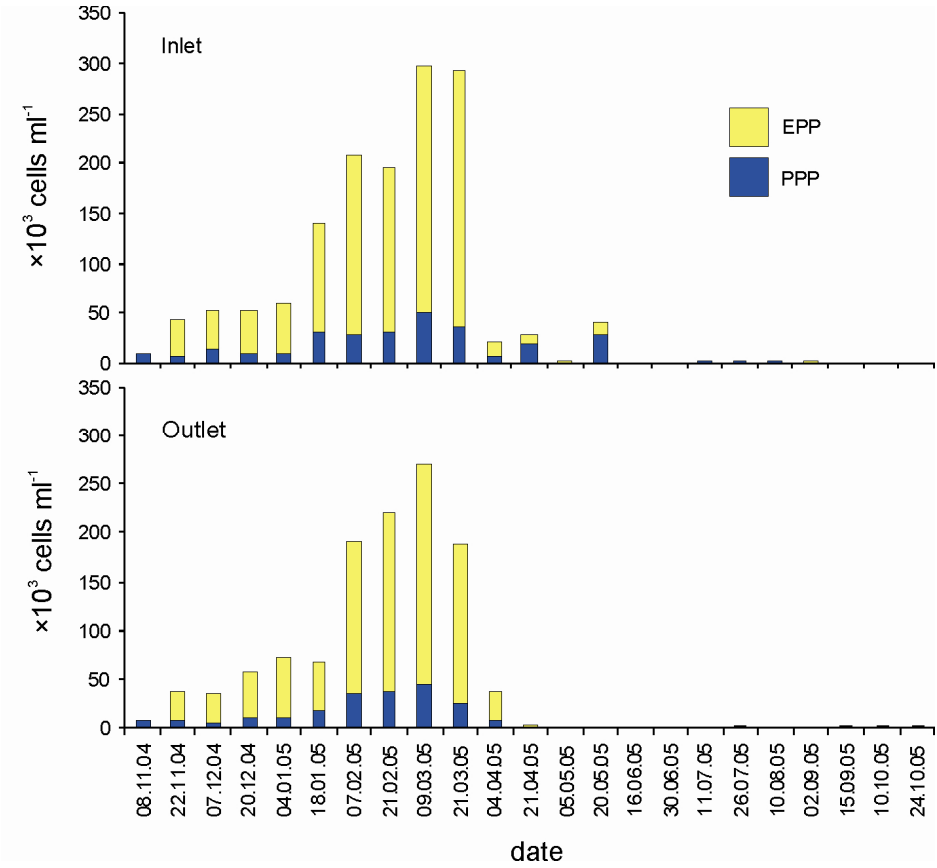

Fig. 2. Abundance of autotrophic picoplankton, divided into eukaryotic picoplankton (EPP) and prokaryotic picoplankton (PPP), at the inlet (station 1) and outlet (station 2) of the Antoninek Reservoir on the Cybina River, between November 2004 and October 2005.

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The rapid decline in APP abundance and biomass (both EPP and PPP) in waters of the Cybina at the inlet of the Antoninek Reservoir in spring is surprising, because this season usually features intensive growth of APP, and of PPP in particular (Gołdyn 2000; Gołdyn, Szeląg-Wasielewska 2005; Hirose et al. 2003). Low densities of APP cells were observed until the end of the study period. According to Weisse (1991), APP is very sensitive to a high trophic level and pollution, especially with heavy metals. The low recorded densities of PPP could result from some of these factors. Low densities of APP cells in the growing season can be also associated with the growth of submerged and emergent vegetation in the Swarzędzkie Lake, and a negative result of macrophyte activity on the growth of phytoplankton (including APP) in the Cybina was described by Gołdyn (2000). Besides this, an important role in regulation of APP abundance could be played by zooplankton, which is considered an important group of consumers in this size fraction (Stockner 1991). Macrophytes could potentially provide shelter to some grazing microorganisms, which according to Stockner (1991) include, cladocerans of the genera *Ceriodaphnia* and *Bosmina.* Vörös et al. (1991) reports on the considerable importance of *Daphnia* grazing on APP in shallow water bodies.

APP abundance was usually higher at station 1 than at station 2. However, the difference in APP abundance between stations 1 and 2 was not significant (p=0.23) in this study, which contrasts with results of earlier research on APP at those sites (Gołdyn 2000, Gołdyn, Szeląg-Wasielewska 2005). APP abundance was then significantly lower at the outlet than at the inlet of the reservoir, the difference being as much as 64%. In the present study, the lack of significant difference is probably due to the fact that the lake restoration involved the removal of a factor (then considered as the most important) that limited the growth of APP in this water body, namely the dense vegetation that colonized it. At the time as samples for the present study where being collected, the major macrophytes found in the reservoir were filamentous algae, which covered its bottom (Dondajewska et al. 2007).

APP abundance and biomass negatively correlated with water temperature at stations 1 and 2. Considering the prevalence of EPP within APP, these correlations also confirm the earlier findings that EPP prefers colder waters (Stockner 1991, Fahnenstiel et al. 1991, Szeląg-Wasielewska et al. 2005). Moreover, a significant and positive correlation was found between water pH and both APP abundance and biomass at station 1. As reported earlier (Stockner, Shortreed 1991), PPP and EPP react differently to changes in water pH: a low pH eliminates PPP but promotes EPP growth. The correlation between APP abundance and water pH is not reported frequently, because the growth peaks of its components (EPP and PPP) are not simultaneous. The significant correlation between total APP abundance and water pH may be due

to the fact that the patterns of seasonal variation of both components of APP were similar in this study. APP abundance and biomass also positively and significantly correlated with the dry weight of seston and chlorophyll *a* concentration at station 1. The most probable explanation for this is that chlorophyll *a* concentration and dry weight of seston depend on the same variables as APP abundance and biomass do.

CONCLUSIONS

The recorded pattern of seasonal changes in APP, i.e. the high abundance and biomass in November–April and low values of both parameters in May–October, may be due to the limiting effect of submerged vegetation. The macrophytes thrive in summer both at the outlet of the Swarzędzkie Lake (located upstream on the Cybina River) and at the inlet of the Antoninek Reservoir. The submerged plants, jointly with their periphyton, compete effectively with phytoplankton (including APP) for light and nutrients, and are a mechanical obstacle for APP. It can be concluded that conditions in the Antoninek Reservoir were unfavourable for APP growth in summer. Also the dense filamentous algae covering the bottom of the reservoir in summer may be additional competitors for APP. The change in character of the reservoir (from macrophyte-dominated to plankton-dominated), caused by human interference, resulted in the reservoir having an insignificant influence on the APP community in the study period.

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