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Changes in the biomass and structure of phytoplankton in the Dobczyce Reservoir (southern Poland)

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Abstract – In the period 1990–1994 the average biomass of phytoplankton increased from 2.9 to 9.9 mg dm^{-3}. In 1990 Cryptophyceae dominated (29% of total biomass), in 1991–1993 Bacillariophyceae (20.5–35%), and in 1994 Cyanophyta (39%). On the turn of winter and the beginning of spring a mass development of the diatoms *Asterionella formosa* Hass., *Cyclotella* sp., and *Stephanodiscus hantzschii* Grun. occurred every year. The diatom density was over 4000 ind. cm^{-3}. On the turn of summer and the beginning of autumn cyanobacterial blooms were observed of *Woronichinia naegeliana* (Unger) Elenkin and *Microcystis aeruginosa* Kütz. with a density of 950 colonies cm^{-3}.

Key words: dam reservoir, phytoplankton, biomass, blooms.

Zmiany w biomasie i strukturze fitoplanktonu Zbiornika Dobczyckiego (południowa Polska). W latach 1990–1994 średnia biomasa fitoplanktonu wzrosła z 2.9 do 9.9 mg dm^{-3}. W 1990 roku w biomasie dominowały Cryptophyceae (29%), w latach 1991–1993 Bacillariophyceae (20.5–35%), a w 1994 roku Cyanophyta (39%). Rokrocznie na przełomie zimy i wiosny masowo rozwijały się *Asterionella formosa* Hass., *Cyclotella* sp. i *Stephanodiscus hantzschii* Grun. osiągając zagęszczenie powyżej 4000 ind. cm^{-3}. Na przełomie lata i jesieni masowo rozwijały się sinice *Woronichinia naegeliana* (Unger) Elenkin i *Microcystis aeruginosa* Kütz. osiągając liczebność 950 kolonii cm^{-3}.

1. Introduction

Phytoplankton is a very important component of the bioceonosis of a dam reservoir and its development within the annual cycle can be an indicator of water quality (Sommer 1986). As an increase in biomass of algae can have a negative effect on drinking water (Vrba 1993). The Dobczyce Reservoir has been monitored systematically ever since its filling in. In the initial period (1986–1987) amount of phytoplankton ranged considerably — average density from 920 to 11,200 ind. cm^{-3} and biomass from 0.4 to 7.8 mg dm^{-3} (G. Pająk unpubl.). These changes were connected with the succession of algal community. Then, in the years 1988–1990 the reservoir ecosystem stabilized. The density and biomass of phytoplankton decreased, amounting to 720–7500 ind. cm^{-3} and 0.34–3.69 mg dm^{-3}, respectively (J. Różowska unpubl.).

The aim of the investigations, which were carried out from 1990 was to analyze subsequent changes in the phytoplankton structure as one of the criteria used to determine the trophic state of the water ecosystem (Kajak 1979).

2. Study area

The Dobczyce Reservoir (49°52' N, 20°02' E) is situated on the 60th km of the River Raba in the Pogórze Wielickie Hills (western part of Polish Carpathians), at an altitude of 270 m, about 25 km south of Cracow. The reservoir is the main source of drinking water for that city. The filling of the reservoir was started in February 1986 and lasted until December 1987. Its maximum area is about 1120 ha and average depth about 11 m (Pasternak 1980).

3. Material and methods

Samples were taken from the epilimnion of the Dobczyce Reservoir at one station (fig. 1), at two-week intervals, from January 1990 to December 1994. At the same time, water transparency by Secchi disc and water temperature were measured. The phytoplankton samples were preserved with Lugol iodine solution and concentrated by sedimentation over 48 h. The algae were counted using a Kolkwitz chamber and the average size of the individuals was measured. The phytoplankton biomass (biovolume) was calculated by comparing the algae to geometrical shapes (Rott 1981). For taxonomic analyses of diatoms the following keys were used: Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) and Siemińska (1964), and for other algal groups Starmach (1966, 1989).

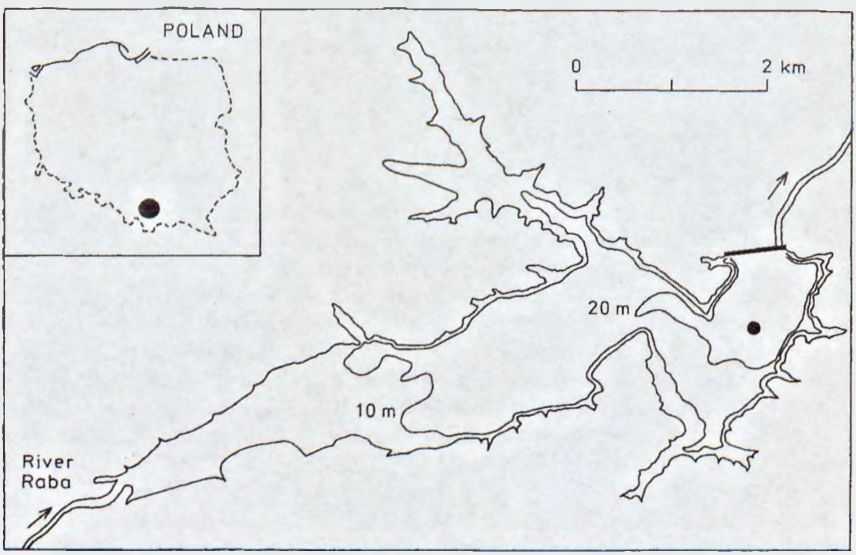

Fig. 1. Location of the sampling station on the Dobczyce Reservoir.

4. Results

During the period 1990–1994, 118 taxa of algae were identified: 12 of Cyanophyta, 6 of Chrysophyceae, 29 of Bacillariophyceae, 3 of Dinophyceae, 6 of Cryptophyceae, 5 of Euglenophyta, 52 of Chlorophyceae, and 5 of Conjugatophyceae. The number of taxa changed in the following years. In 1990, 49 taxa were determined, in 1991 — 47, in 1992 — 71, in 1993 — 68, and in 1994 — 71. The biomass in particular samples varied from 0.27 to 72.37 mg dm^{-3}. The average annual biomass in the subsequent years was 3.5, 2.9, 4.8, 9.8, and 9.9 mg dm^{-3}, respectively.

Phytoplankton of the investigated period was represented mainly by the taxa: *Woronichinia naegeliana* (Unger) Elenkin, *Microcystis* sp. (Cyanophyta), *Asterionella formosa* Hass., *Cyclotella* sp., *Cymbella* sp., *Diatoma* sp., *Fragilaria* sp., *Gomphonema* sp., *Navicula* sp., *Nitzschia* sp. (Bacillariophyceae), *Coelastrum* sp., *Crucigenia* sp., *Elakatothrix* sp., *Monoraphidium* sp., *Pediastrum* spp., *Scenedesmus quadricauda* (Turp.) Bréb. sensu Chodat., *Scenedesmus* sp. and *Tetraedron minimum* (A. Br.) Hansg. (Chlorophyceae).

At the beginning of the study in 1990 Cryptophyceae were the group with the greatest percentage share (29%) in the total biomass of algae (fig. 2). In the

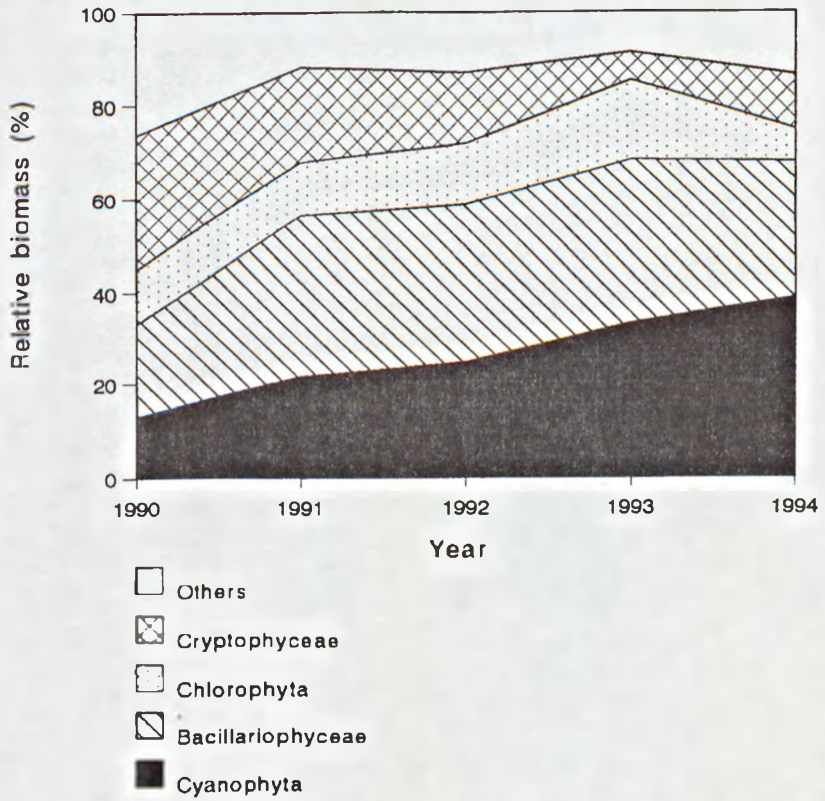

Fig. 2. Share of dominant algal groups in the total biomass of phytoplankton of the Dobczyce Reservoir. Others — Chrysophyceae, Dinophyceae, Euglenophyta, and Conjugatophyceae.

following years a decrease in the share of this group occurred, falling to 6% in 1993. At the same time the share of Bacillariophyceae increased from 20.5% to 35%. During the three following years (1991–1993) this group was dominant. The share of Cyanophyta become three times as great as in the beginning — rising from 13% in 1990 to 39% in 1994. No significant changes in the abundance of Chlorophyceae were observed in the first three years of the investigations (11.5, 12, and 13.6% respectively). Then the share of this group increased to 16.5% in the fourth year of the study but in the following one it dropped to 7%. The algae of others groups (Chrysophyceae, Dinophyceae, Euglenophyta, and Conjugatophyceae) were not so numerous, with regard to their share in the total biomass. The cumulative share of these groups decreased during the period 1990–1993, with a simultaneous rise in the share of green algae. In 1994 total share of Chrysophyceae, Dinophyceae, Euglenophyta, and Conjugatophyceae increased while at the same time that of green algae decreased.

Different groups dominated in particular seasons of the year (fig. 3). In the winter of 1990 (from January to the end of March) Cryptophyceae (*Cryptomonas* sp.) was the dominant group in the phytoplankton biomass, in the spring (from April to the end of June) Bacillariophyceae (*A. formosa*, *Cyclotella* sp.), in summer (from July to the end of September) Cyanophyta (*Microcystis* sp.), and in autumn (from October to the end of December) again Bacillariophyceae. The following year the changes in the annual cycle of domination were different: Bacillariophyceae (*Cyclotella* sp.) dominated in the winter, Cyanophyta (*Microcystis* sp.) in spring,

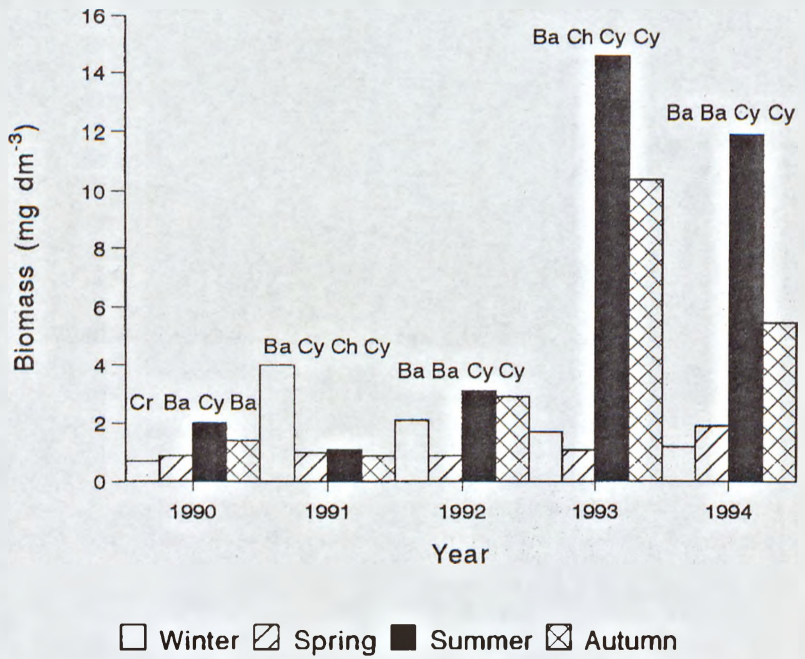

Fig. 3. Mean phytoplankton biomass and algal groups dominating in particular seasons of the year in the Dobczyce Reservoir: Ba — Bacillariophyceae, Ch — Chlorophyceae, Cr — Cryptophyceae, Cy — Cyanophyta.

Chlorophyceae in summer, and Cyanophyta (*Microcystis* sp.) again in autumn. In spring 1992 and 1994 Bacillariophyceae prevailed while in 1993 Chlorophyceae (*Scenedesmus* sp., *Sphaerocystis* sp.) dominated. In winter 1992, 1993, and 1994 Bacillariophyceae (*A. formosa*, *Cyclotella comta* (Ehr.) Kütz., *C. meneghiniana* Kütz., *Stephanodiscus hantzschii* Grun.) were the most abundant while in summer and autumn Cyanophyta (*W. naegeliana*, *Microcystis aeruginosa* Kütz.) were the most numerous group.

In the period 1990–1994 blooms were observed each year, at the turn of winter (March and April) and that of summer/autumn (September and October). In spring blooms diatoms appeared abundantly, *A. formosa* or *Cyclotella* sp. or *S. hantzschii* then being the dominants. During spring blooms the water temperature ranged from 3.3 to 12.0 °C, its transparency from 0.8 to 1.7 m, and phytoplankton density from 1170 to 4460 ind. cm^{-3}. The autumn phytoplankton was dominated by the blue-green algae *W. naegeliana* and *Microcystis* sp. During autumn blooms the water temperature was in range 14.0–17.7 °C, transparency 2.3–4.5 m, and density of algae 130–950 col. cm^{-3}.

5. Discussion

The eutrophication of waters is not a new problem but it is a very interesting one, especially in dam reservoirs, which supply drinking water. Important indicators of eutrophication are the phytoplankton biomass, its structure, and seasonal succession (Trifonova 1989). During five years of systematic monitoring significant changes in the phytoplankton structure were observed. The biomass of blue-green algae increased rapidly and reached the greatest percentage shares in the total biomass of algae. The second dominant group were diatoms. Phytoplankton composition corresponded with that of eutrophic or mesotrophic reservoirs, e.g. the eutrophic reservoirs Goczałkowice (Pająk 1986) and Římov (Vrba et al.1995), or the mesotrophic Vir Reservoir (Žaková et al 1993).

Spring blooms of diatoms (March, April) observed in the Dobczyce Reservoir are typical of many other reservoirs (Bucka 1985, Welch et al. 1992, Puchalski 1994, Soyupak and Gökçaj 1994, Puchalski et al. 1995, Vrba et al. 1995). Spring blooms in the Dobczyce Reservoir were formed by *A. formosa* or Centricae diatoms. *A. formosa* is qualified as a common species, occurring in the plankton of lakes and ponds, both in pure and polluted waters, stagnant and flowing. It often grows abundantly in eutrophic waters (Bucka 1989, Rast et al. 1989). Centricae developing in large quantities in the Dobczyce Reservoir are also classed as indicators of eutrophic waters (Rast et al. 1989, Hofmann 1994).

A mass appearance of the blue-green algae *W. naegeliana* and *M. aeruginosa* was observed in September or October. In other reservoirs blue-green algae blooms were recorded in summer, e.g. in June (Welch et al. 1992), in July (Soyupak and Gökçay 1994), or in August (Bucka 1985). A mass growth of *M. aeruginosa* as a eutrophication trend indicator was described in the Goczałkowice (Kasza et al. 1987), Vir (Žaková et al. 1993), and Keban (Soyupak and Gökçay 1994) reservoirs. At the beginning of the study *Microcystis* sp. with accompanying *W. naegeliana* dominated in autumn blooms. In 1995 in autumn blooms *W. naegeliana* was the dominating species. Green algae, especially those of the genera *Pediastrum*, *Scenedesmus*, and *Tetraedron* found in great quantities in the summer phytoplankton in the Dobczyce Reservoir also indicate an increase in its fertility. These algae are defined as indicators of the 1st degree of eutrophication (Kawecka and Eloranta 1994).

Changes in the phytoplankton composition and seasonal domination of particular groups, the presence of species typical of polluted waters and the increasing biomass of algae, show that the Dobczyce Reservoir is becoming a eutrophic water body.

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