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The effect of water blooms caused by blue-green algae on the bottom macrofauna in the Goczałkowice Reservoir (southern Poland) in 1992

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Abstract - In 1992, there took place in the Goczałkowice Reservoir intensive water blooms caused by blue-green algae with the domination of *Aphanizomenon flos-aquae*. They led to the dying out of the bottom macrofauna (Chironomidae, Oligochaeta, Ceratopogonidae larvae) and other animals connected with the bottom (Decapoda, Bivalvia). It is assumed that this event was due to the toxic effect of the metabolites of the blue-green algae.

Key words: dam reservoirs, water bloom, dying out of the bottom macrofauna.

1. Introduction

A consequence of the increasing eutrophication of waters are the water blooms induced by algae, which often have a detrimental effect on the organisms inhabiting these environments. Toxic algae are occasionally encountered in all aquatic environments and they are regarded as being responsible for the poisoning and death of crustaceans, fish, amphibians, birds, and mammals. Acute skin irritation, caused by the algal excretions, was observed in people bathing during the period of water blooms caused by the blue-green algae, to which toxic properties are most frequently attributed (Moore 1977, Sivonen et al. 1990, Reynolds 1991).

In the Goczałkowice Reservoir, in the summer of 1992 there occurred an unusually intensive water bloom with the participation of the blue-green algae, in the course of which the dying-out of animals inhabiting the bottom was observed.

The aim of the present work was to describe the effect of water blooms induced by the blue-green algae (including the qualitative and quantitative characteristics) on the animal communities of the bottom, i.e. their taxonomic composition, density, and biomass.

2. Study area, material, and methods

The investigations were carried out at a single selected station (Station I, fig. 1) situated in the north-eastern part of the Goczałkowice Reservoir. Hydrobiological investigations of this reservoir have been carried out since its construction, i.e. since 1955 (Krzyżanek et al. 1986, Krzyżanek, Kownacki 1986), including those on the bottom macrofauna (Krzyżanek 1986, 1991).

Samples were collected at weekly intervals during the period 29 April-8 December 1992, at the time of water blooms, i.e. for 2 weeks the frequency of sampling being increased to 2-4 days. Samples of phytoplankton and of the bottom fauna were collected and examined using the methods which have been applied for this reservoir since the beginning of its existence. A detailed description of these methods can be found in the studies by Pająk 1986 and by Krzyżanek 1986. Chlorophyll was determined by the SCOR-UNESCO method (Ausgewählte Methoden der Wasseruntersuchung 1970), and oxygen by that of Winkler.

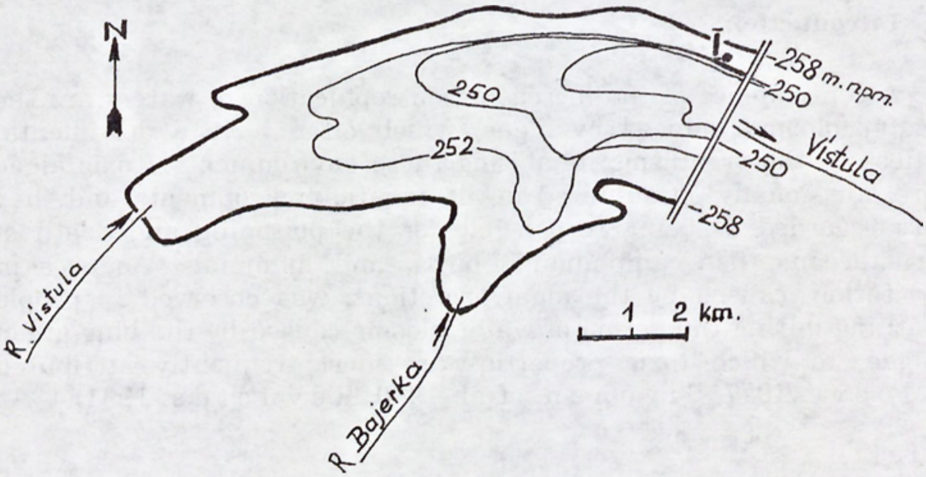

Fig. 1. Map of the Goczałkowice Reservoir. I - sampling station

3. Results

In spring, in the Goczałkowice Reservoir, a very intensive development of phytoplankton was observed with the dominance of Bacillariophyceae (*Synedra acus*, K ü t z., *Asterionella formosa*, H a s s., and *Melosira granulata*, E h r. (R a l f s). On 29 April the density of this group reached 37 980 indiv. cm^{-3} with a biomass of 51 mg dm^{-3}. In the second decade of May the number of taxons of the nannoplanktonic Chlorophyceae increased. In June a decrease in the development of the algae was observed (500-1200 indiv. cm^{-3}, 0.67-1.73 mg dm^{-3}). By 10 of June the Cyanophyceae became more and more frequent, in the last days of July reaching 88-99% of the population and biomass. The main representative of this group was *Aphanizomenon flos-aquae* (L.) R a l f s (70-80%), beside *Anabaena flos-aquae* (L y n g b.) B r é b., *Microcystis aeruginosa* K ü t z., *Gomphosphaeria naegeliane* (U n r e r) L e m m., and *G. compacta* (L e m m.) S t r o m. *Aphanizomenon flos-aquae* developed and decayed in the upper parts of the water. During the first days of August its density reached the record values of 49 300 trichomes cm^{-3}, with a biomass of 78.49 mg dm^{-3} (figs 2, 3). In the second half of August

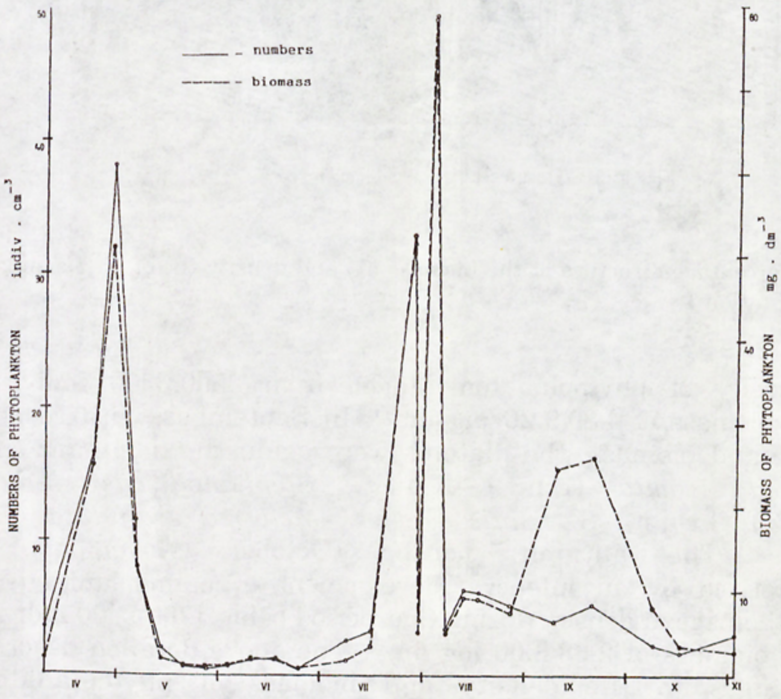

Fig. 2. Changes in the biomass and density of phytoplankton at Station I in the period May-December 1992

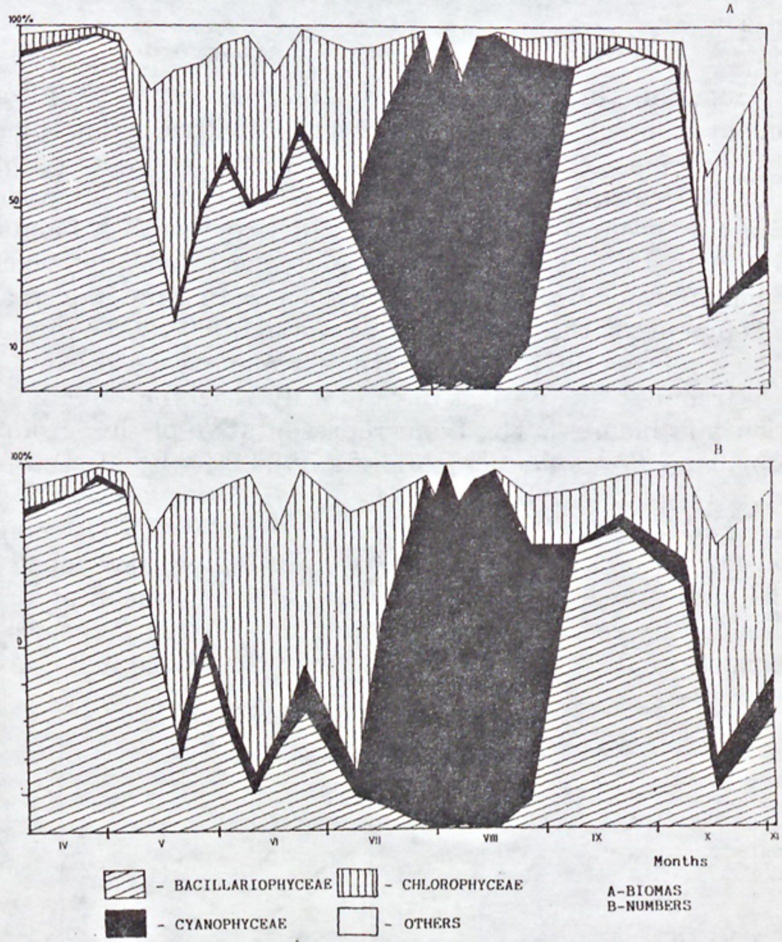

Fig. 3. Percentage structure of the biomass (A) and density (B) of phytoplankton at Station I

the density of phytoplankton ranged from 3500-6300 indiv. cm^{-3}, with a biomass of 4.89-9.26 mg dm^{-3}. In September, with respect to density and biomass, the diatoms were again the dominant species (*Cyclotella comta* (Ehr.) Kütz., *Stephanodiscus minutulus* (Kütz.) Grun., *S. tenuis* Hust., *Melosira granulata* (Ehr.) Ralfs. The autumn months (October, November) were characterized by an intensive development of nannoplankton green algae, their mean density during that period being 1700-2900 indiv. cm^{-3} with a biomass of 2.68-8.00 mg dm^{-3}. The above detailed description of changes in the density and biomass of phytoplankton is complemented and confirmed by the content of chlorophyll *a* (fig. 4).

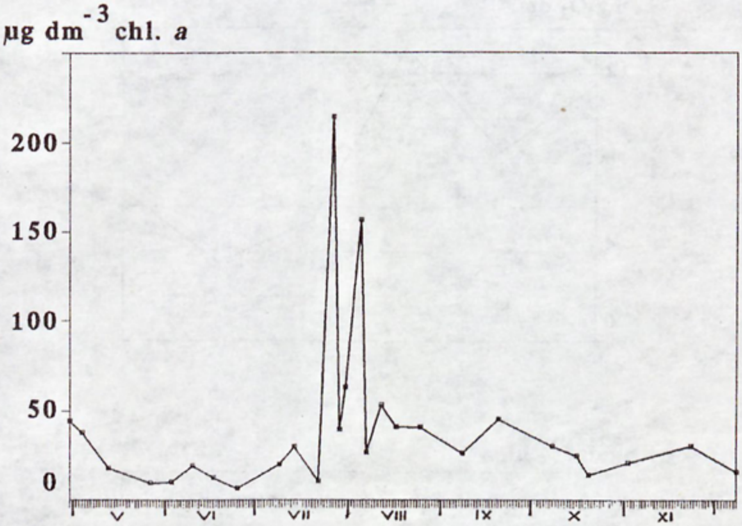

Fig. 4. Changes in the content of chlorophyll *a* at Station I in the period May-December 1992

Ivestigations of chlorophyll stratification carried out at the time when the water bloom was at its most intense revealed a certain differentiation between its concentration in the surface and in the near-bottom layer of the water. At both examined levels the amounts of chlorophyll were very high. On 3 August 1992, i.e. 2 days before the observed sudden changes in the bottom fauna, the concentration of chlorophyll *a* near the water surface was 234 µg dm^{-3}, and at the bottom 71 µg dm^{-3}.Simultaneous investigations of the stratification of oxygen concentration revealed small amounts of it, especially noticeable in the near-bottom layer, i.e. from 2.2 to 4.3 mg O_2 dm^{-3}, between 31 July and 7 August 1992; however, no oxygen deficiency was observed (fig. 5).

At the studied station the bottom macrofauna was rich quantitatively, but qualitatively very little differentiated. The dominant larvae were Chironomidae, especially large forms of the taxon *Chironomus* sp. I (? *Chironomus plumosus* L.). A particularly large biomass was attained by this taxon in the middle of May. Only specimens over 20 mm long, were encountered in the samples, as well as chrysalides. In the second half of May the flight of imagines of this taxon took place. During this period, besides the taxon *Chironomus* sp. I, the predatory larvae of the taxon *Procladius* spp. appeared occasionally in great numbers, as well as *Cryptochironomus defectus* K. and *Microchironomus* sp. (? *M. tener* K.). Oligochaeta occurred in small numbers and also Ceratopogonidae.

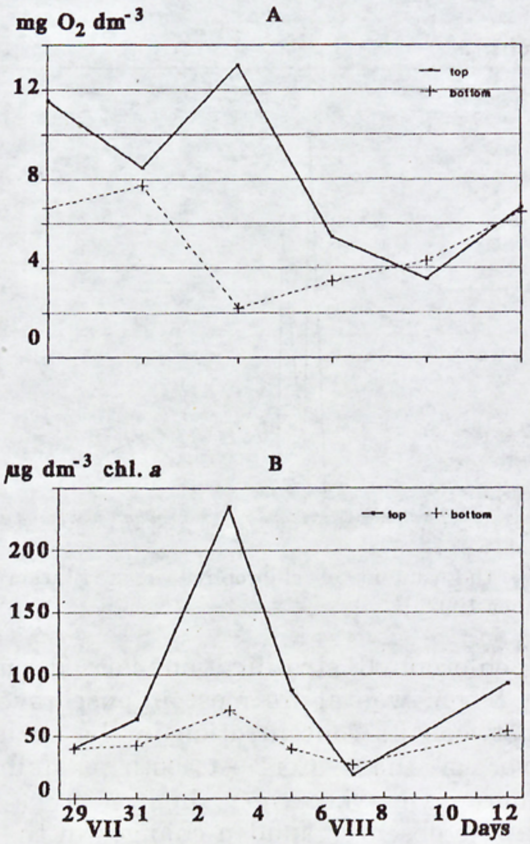

Fig. 5. Content of oxygen (A) and of chlorophyll *a* (B) in the surface and in the near-bottom layers in the period from 29 July to 12 August at Station I

On 5 August, immediately after the water bloom (figs 6, 7), only a few specimens of *Chironomus* sp. I and Oligochaeta were found in a sample. At the same time, a dense mass formed of bottom animals was observed on the shore, among which Chironomidae larvae (Table I) in various age groups prevailed. Tossed to the shore by the waves, they formed there a strip about 1 m wide, along a distance of 860 m. The colour of this mass was dark red, which after a week turned brownish-brick-red.

Small amounts of the bottom macrofauna were observed in the samples for 3 weeks. The density of the bottom macrofauna did not increase until the end of August, but consisted almost exclusively of the larvae of *Chironomus* sp. I. The group composition of the fauna as observed in the first half of the year was not regained until the end of the year.

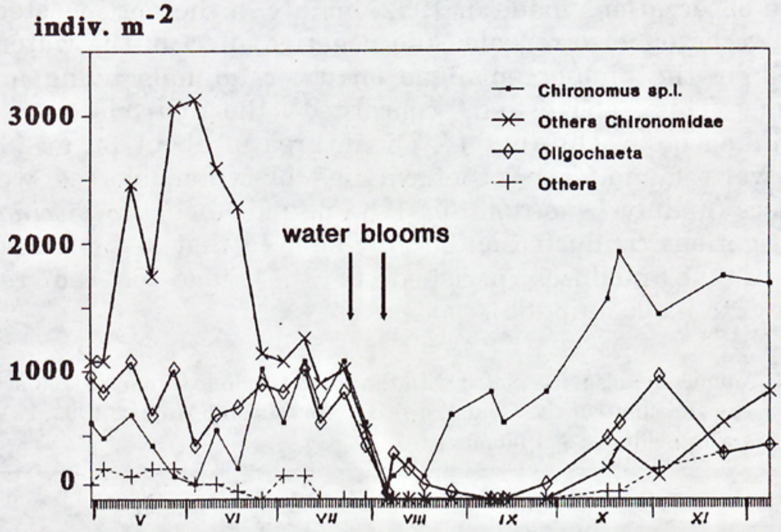

Fig. 6. Changes in the density of bottom macrofauna at Station I in the period from May to December 1992

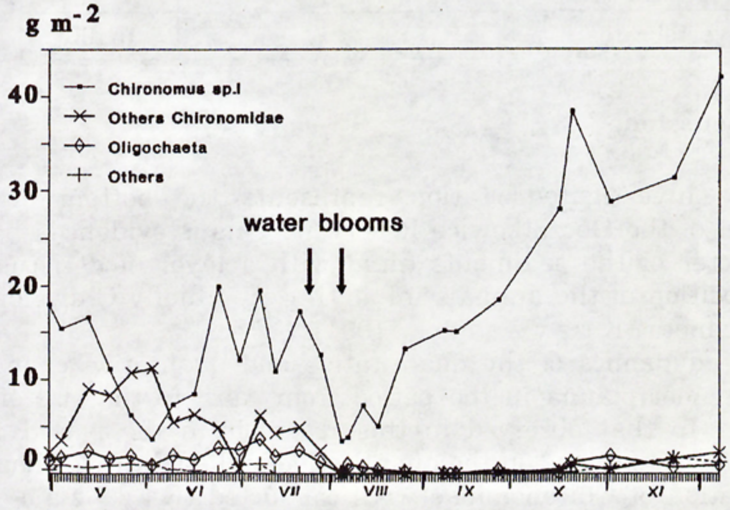

Fig. 7. Changes in the biomass of bottom macrofauna at Station I in the period from May to December 1992

The observations made in 1992, mainly in the north-eastern zone of the reservoir also revealed the negative effect of the water bloom caused by the blue-green algae on other animals living near the bottom. This above all concerned the *Orconectes limosus* Rafinesque. On July 14, on an area of about 30 m 285 dead ones were found. The other victims of water blooms were the molluscs (mainly *Unio tumidus* Phlp. and *Anodonta piscinalis* L.). Investigations conducted on 29 July showed that at that time about 60% of the molluscs perished in this zone of the reservoir (Krzyżanek unpubl.).

Table I. Animal organism associated with the bottom, collected from an area of 100 cm^{-2} on the shore of the Goczałkowice Reservoir on 5 August 1992. N - number of individuals; B - biomass (g)

Taxa	N	B
Cryptochironomus defectus K	5800	69.6
Procladius spp.	3600	18.0
Chironomus sp. (? *Ch. plumosus* L.)	2100	55.8
Microchironomus sp. (? *M. tener* K.)	2000	8.0
Chironomidae - other	1000	6.2
Oligochaeta	600	1.8
All invertebrates	15100	159.4

4. Discussion

The investigated station represents the bottom environment typical of the Goczałkowice Reservoir. This is evidenced both by the character of the sediments (mud with a layer of detritus) and the composition of the animals inhabiting it - chiefly Chironomidae and Oligochaeta (Krzyżanek 1991).

The dynamics of the quantitative and qualitative changes in the bottom macrofauna in the period from April to the end of July was similar to that observed in this reservoir in the period 1961-1963, when investigations on the quantitative and qualitative changes in the population of Chironomidae were conducted (Krzyżanek 1966), as well as to the dynamics in other reservoirs (Shilova 1960). In the investigations carried out from 1961-1963 the reproduction of the communities of Chironomidae from the beginning of August was very rapid. In 1992 it was found that, starting from August, the dynamics of the changes in the bottom macrofauna was affected by an additional factor, which was responsible for a considerable loss of animals for a longer period of time. According to the authors' observations, this factor might be the toxic effect of the metabolites of the algae during water blooms caused by the blue-green algae. It should be mentioned here that the species of blue-green algae occurring when this phenomenon was observed, were not examined with respect to their toxicity.

Most of the Chironomidae larvae reported from the examined station live under condition of oxygen deficiency. In spite of this, the breathing efficiency of these larvae is high, which is to be attributed to the presence of haemoglobin, which facilitates the uptake and storage of oxygen (C z e c z u g a 1960). The oxygen content in the near-bottom layer at the studied station, established in the investigations, could not, in the authors' opinion, have been the cause of the death of the bottom animals.

5. Polish summary

Wpływ zakwitów sinicowych na makrofaunę denną w zbiorniku Goczałkowickim (Polska południowa) w 1992 r.

W 1992 r. miały miejsce w zbiorniku Goczałkowickim intensywne zakwity sinicowe z dominacją *Aphanizomenon flos-aquae* (L.) R a l f s . W pierwszych dniach sierpnia na stanowisku I (ryc. 1) jego liczebność osiągnęła rekordowe wartości 49 300 trychomów cm^{-3} (ryc. 2, 3). Wysokie wartości osiągnął także w tym okresie chlorofil (ryc. 4). Równocześnie badania stężeń tlenu ujawniły jego niewielkie ilości, szczególnie w warstwie przydennej (ryc. 5).

Zakwity sinicowe wywarły ujemny wpływ na zwierzęta denne. Zmiany ilościowe i jakościowe w makrofaunie dennej (wymarcie w sierpniu prawie wszystkich larw Chironomidae oraz Oligochaeta (ryc. 6, 7, tabela I), a także innych zwierząt dennych głównie z rodziny Bivalvia (*Unio tumidus* P h l p. i *Anodonta piscinalis* L.) i Decapoda (*Orconectes limosus* R a f i n e s q u e), mogły być spowodowane toksycznym działaniem metabolitów glonów sinicowych.

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