A BRIEF REPORT ON DOMINANT SPECIES OF PLANKTONIC BLUE-GREEN ALGAE IN BAVARIAN LAKES AND THEIR CHANGES DURING THE LAKE THERAPY

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(Manuscript received 25 September 1990, revised version accepted 5 October 1990)

Abstract: Blue-green algae in particular of toxin-producing species found in the phytoplankton samples which were irregularly collected from the Bavarian lakes during the past years were microscopically analyzed. It is possible to reduce these cyanophytes quantitatively in lakes by interval destratification of lake waters and phosphorus elimination.

INTRODUCTION

Planktonic blue-green algae, e. g. *Microcystis*, *Aphanizomenon*, *Anabaena*, can produce toxins which in several instances have already poisoned fishes, animals and human beings (Carmichael 1981). The aim of this study is to review the past occurrence of blue-green algae particularly of potentially toxin-producing species in Bavarian lakes and also to show some short-term effects after lake therapy measures on the seasonal appearance of these cyanophytes in the phytoplankton community. As a biological indicator for water eutrophication and civil pollution, blue-green algae which have been regularly found in the Bavarian rivers (Chang and Steinberg 1987, Steinberg *et al.* 1987) play an important role in the water management. The results of this study can be considered as a good basis for further research in order to obtain more information on blue-green algae in Bavarian lakes in relation to controlling or improving the water quality.

MATERIAL AND METHODS

Phytoplankton samples were irregularly (1980–5) collected from different lakes in Bavaria by using a plankton-net and preserved in 2%-formalin or Lugol's solution. Algae in samples were microscopically analysed and counted under a reverse-microscope. The algal identification was according to Geitler (1932), Huber-pestalozzi (1938) and Desikachary (1959).

As a lake therapy, electric compressors were installed at the shore of the lakes and the compressed air was continuously or intervally pumped into the water-body in order to achieve artificial destratification in two lakes (Fischkaltersee, Schliersee) as well as hypolimnetic aeration in Wesslinger See (Steinberg 1983, Steinberg and Arzet 1984, Zimmermann and Steinberg 1986).

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RESULTS AND DISCUSSIONS

Distribution of blue-green algae

Table 1 shows the distribution of blue-green algae in 21 Bavarian lakes. In other lakes, more than 3 species should be existing, since some cyanophytes due to their variability could only be determined to the genus level. In the other hand, the samples were often obtained within a large time interval; consequently the algae with a short-term vegetation period could not be included.

In Bavarian lakes, also well-known species of planktonic blue-green algae did appear (Table 2). The species mostly found is *Microcystis aeruginosa*. This alga is widely distributed in this region as well as elsewhere. It formed water-blooms in September and appeared more or less through the other months. In October

Table 1. The distribution of blue-green algae in Bavarian lakes

Number of Algae (species)	Name of Lake
22	Weßlinger See
19	Langbürgner See
18	Fischkaltersee
17	Obinger See
15	Waginger See
14	Simssee; Starnberger See; Wörthsee
13	Ammersee; Chiemsee
12	Alpsee
9	Schloßsee
8	Tachinger See
6	Schliersee
5	Niedersonthoener See; Bannwaldsee; Hopfensee
4	Ellertshäuser See; Pilsensee; Tegernsee
3	Tahler See

Lakes in which less than 3 blue-greens were recorded, are not listed here.

Table 2. Common species of blue-green algae in Bavarian lakes

Number of Lakes	Species of Cyanophytes
15	Microcytis aeruginosa
12	Aphanocapsa elachista
11	Oscillatoria rubescens*
10	Aphanizomenon flos-aquae; Chroococcus limneticus; C. minutus Coelasphaerium kutzingianum
9	Anabaena flos-aquae; Oscillatoria redekei*
8	Aphanothece clathrata; Coelosphaerium nagelianum
7	Oscillatoria limnetica

Algae distributed in <7 lakes are not listed here.

* Both species are comparable to *O. prolifica* and *Pseudanabaena redekei* (s. Chang & Steinberg 1987). Both are recently changed as *Planktothrix rubescens* and *Limnothrix redekei* (s. Anagnostidis & Komárek 1988).

Table 3. Seasonal appearance of blue-green algae in Bavarian lakes

Cyanophyta	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Oscillatoriales	3	7	9	23	43	15	10	5	14	4	2	8
Nostocales	3	3	0	4	18	13	26	21	22	29	12	6
Hormogonales	6	10	9	27	61	28	36	26	36	33	14	14
Coccales	0	2	1	13	33	18	58	56	79	68	25	19
Sum	6	12	10	40	94	46	94	82	113	101	39	33

The frequency value shown above is a sum of algal amount in samples: no blue-greens (0), few and rare (1, <5% of total algae), some and often (2, <20%), common (3, <30%), very common (4, <50%), in water bloom (5, >50%).

the water blooms of *Aphanizomenon* and *Anabaena* were observed (Table 3). These 3 mentioned species are well-known for being able to produce toxins, but reliable records from Bavarian lakes are still lacking. In cold months the oscillatorian blue-greens are more present. In May, water bloomings of *Oscillatoria orolifica* and *Pseudanabaena redekei* have been recorded (Table 3).

Distribution during Aeration Therapies

Continuous Aeration: A distinct decrease of blue-green algae is shown in the first year after aeration and lake destratification in Wesslinger See (Steinberg and Arzet 1984) and Fischkaltersee, respectively (Steinberg 1983). In Wesslinger See, the amount of cyanophytes has increased in the second year and slightly decreased in following years. This reappearance in Wesslinger See could be explained by the enrichment of nutrients in the phototrophic zone by eddy diffusion through this continuous aeration. In Fischkaltersee, in the third and fourth year of permanent destratification, filamentous blue-green algae particularly *Oscillatoria* species (e. g. *O. redekei*, *O. prolifica*, even the benthic species *O. limosa* and *O. limnetica*), re-invaded heavily (Tille-Backhaus 1984). This is probably due to the ability of long-term adaptation of the oscillatorians to the changed chemical environment. Blue-green algae appear to have a lack of metabolic control by repression of certain enzymes which enable them to respond quickly to changing chemical environments (Fogg *et al.* 1973). Obviously, the period of several years of permanent destratification enables them to adept to the environmental conditions again and to outgrow other planktonic algae, e. g. diatoms and green algae.

Interval destratification: In the potentially meromictic lake, Schliersee, a destratification was installed in order to induce and maintain natural circulation. In this lake, the cyanophytes have decreased in the 2nd year of aeration possibly due to reduced phosphorus concentrations in the water. Oxygen concentration changed only slightly through this aeration. In Fischkaltersee the permanent destratification was changed into a intermittent destratification in the fifth year of lake therapy. This therapy measure reduced blue-green algae again drastically (Zimmermann and Steinberg 1986); two reasons could be assumed: 1) short-term changes of the chemical environment give algae no chance to reach any adaptation and 2) short-term changes of the physical environment (destratification) enable oscillatorian cyanophytes to maintain their gas-vacuoles (Reynolds *et al.* 1983). The biotic (biomass) and abiotic (transparency, nutrient concentrations) changes in Fischkaltersee are so severe that we think the intermittent destratification is an effective tool in controlling algae and cyanophytes.

CONCLUSION

It is evident that planktonic blue-green algae are existing in many Bavarian lakes which are generally known to produce toxins. However, the conditions, which enable blue-greens to produce toxins in these lakes, are still obscure. The filamentous cyanophytes e. g. *Oscillatoria* can form water-blooms in May and the heterocyst-containing species such as *Anabaena*, *Aphanizomenon*, and *Nostoc* do appear in September and October, while the coccal species *Microcystis* were mostly blooming in September particularly on some hot days.

It is possible to improve the water quality (e. g. reduction of blue-green algae) by using different therapy methods. But the treatments we used should go along with a reduction of phosphorus-concentrations, otherwise it is only a temporary therapy to improve the water-quality.

ACKNOWLEDGEMENTS

Thanks to B. Heindel for her assistance and also to K. Arzet, H. Hartmann and R. Tille-Backhaus for providing phyto-plankton data. This has been partially reported in 10th IAC, Athens, Sept. 1986. This study is financially supported through 02-WT465-project from "Ministerium f. Technologie und Forschung".

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德國巴伐利亞湖泊中浮游藍綠藻簡報

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摘 要

本文探討德國巴伐利亞湖泊中浮游藍綠藻，尤其是會產生毒素之品種，在過去幾年間之數量及分佈情形。文中並比較以間歇性破壞溫層及去除水中磷量以達減少藍綠藻數量之效果。