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Original research paper

The dynamics of a *Planktothrix agardhii* population in a shallow dimictic lake

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Abstract

Planktothrix agardhii is one of the most common species of cyanobacteria, known to form water blooms and to produce toxins. This paper aims to examine the dynamics of the *P. agardhii* population in the shallow though dimictic Uzarzewskie Lake and to answer the questions related to microcystin content within the population and its release. *P. agardhii* was found in all the seasons of the year 2006, and it was the dominant taxa in the phytoplankton of the lake from August, when it outcompeted Nostocales, until October. Microcystin-YR was detected in only one of the samples, while microcystins-RR and LR were not found in any sample.

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INTRODUCTION

Among bloom-forming cyanobacteria, *Planktothrix agardhii* (Gom.) Anagn. et Kom. is one of the most common species. Abundant populations of the species develop in lakes and reservoirs worldwide (Rücker et al. 1997, Padisák & Reynolds 1998, Komárek et al. 2002, Willame et al. 2005), and have been observed many times in Poland (e.g. Gołdyn et al. 1997, Stefaniak et al. 2005, Pełechata et al. 2006). The cyanobacterium is often the most abundant species in the phytoplankton, responsible for its low diversity. In a temperate climate it forms large populations usually in late summer and in autumn (Rücker et al. 1997). *P. agardhii* is well-known as producing several kinds of bioactive peptides, among which the best-known are hepatotoxic cyclic heptapeptides - microcystins (Sivonen 1990, 1996; Rohrlack & Utkilen 2007).

The dynamics of a *P. agardhii* population in the shallow, but dimictic Uzarzewskie Lake has been examined, as well as microcystin content in the biomass and in the water.

STUDY SITE

Uzarzewskie Lake is a postglacial, kettle-shaped lake, situated in the vicinity of the city of Poznań (western Poland). Through the lake flows the Cybina River, a right-bank tributary of the Warta River. The lake covers an area of 10.6 ha, has a maximum depth of 7.3 m and a mean depth of 4.3 m (Jańczak 1996). The lake is dimictic but due to its kettle-shape and shading from wind by surrounding forests it is characterized by a short mixing time, with the mixing not reaching the bottom every year. In the past the lake received a large amount of domestic and industrial sewage in the water of the Cybina River (Gołdyn, Grabia 1998). Blooms of *Planktothrix agardhii* were noted in the lake in the late summer and autumn of 2005 (A. Budzyńska, unpublished data).

MATERIALS AND METHODS

Samples for the phytoplankton analysis were taken from the deepest part of the lake, from each meter of the water column. The phytoplankton samples were taken once in winter and then at least once a month from April to October. They were preserved with Lugol's solution and analysed with an inverted microscope after sedimentation in cylindrical chambers. The abundance of phytoplankton was expressed as the number of cells. The biomass was estimated from the cell volume, counted with the use of geometric models.

Samples for the toxin analysis were taken from the water column on four selected dates (12.07, 16.08, 14.09 and 26.09). The samples were taken to the laboratory and filtered through Whatman GF/C filters. The concentrated material and water samples were frozen before solid phase extraction. The preparation of samples for toxin analyses was performed according to WHO par ISO 20179 (2005). All toxin samples were analysed with the use of Agilent 1100 High Performance Liquid Chromatography with mass spectrometry (HPLC/MS). The calibration curve was determined using MC-LR Calbiochem Lot#B60096 and MC-RR Calbiochem Lot#B63953 as the standards.

RESULTS

Planktothrix agardhii was present in Uzarzewskie Lake in all the seasons of 2006. In February, April, May and June it did not exceed the level of 8×10^3 cells ml^{-1}. The spring plankton was dominated by diatoms and *Limnothrix redeckei* (van Goor) Meffert in April and by *Limnotrix redeckei* and *Pseudanabaena acicularis* (Nyg.) Anagn. et Kom. in May and June. The *P. agardhii* population increased in July, when the cyanobacterium co-dominated with *Aphanizomenon klebahnii* (Elenk.) Pechar et Kalina. The two species were accompanied by *Anabaena* spp., *Limnothrix redeckei*, *Pseudanabaena limnetica* Lemm., *Cuspidothrix issatschenkoi* (Usačev) Rajaniemi et al. and less abundant eukaryotic algae. From August till October *P. agardhii* dominated in the phytoplankton of the lake, constituting between 73% and 86% of the phytoplankton (Fig. 1) and reaching the maximum level of 565×10^3 cells ml^{-1} on 25 August in the surface water layer.

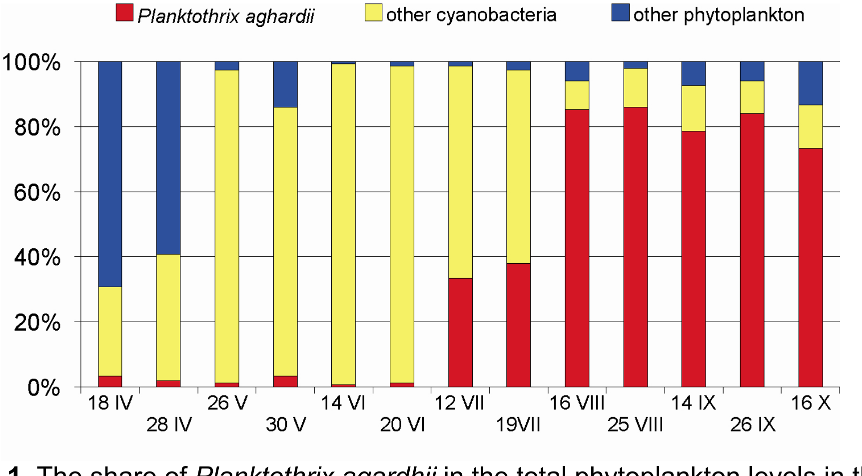

Fig. 1. The share of *Planktothrix agardhii* in the total phytoplankton levels in the surface water layer of Uzarzewskie Lake.

The biomass of *P. agardhii* did not exceed 23 µg ml^{-1}. It was always much higher in the epilimnion, which is quite shallow in the lake (no more than 2-3 m depth), than in the meta- and hypolimnion (Fig. 2).

No LR, RR, YR–microcystins were detected on 12/07, 16/08 or 14/09. On 26/09, 21.79 µg g^{-1}DW of MC-YR was present in the biomass of the surface water layer. From 1 m under the surface to the bottom, no microcystins were found either in the biomass or in the water.

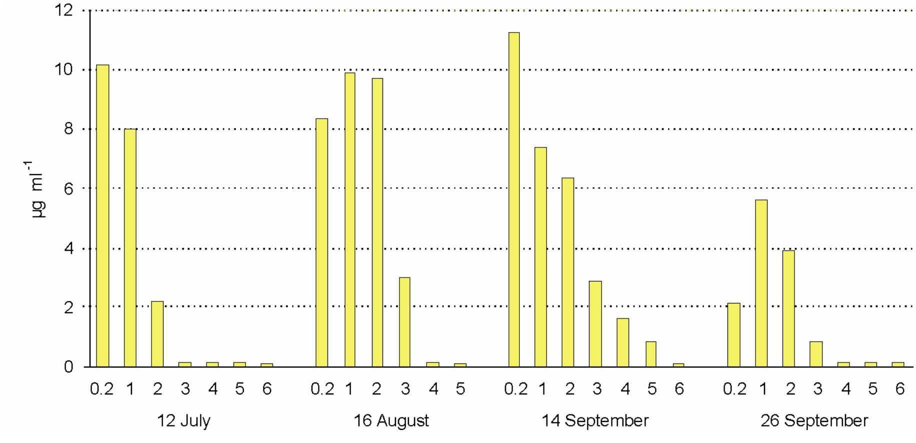

Fig. 2. The biomass of *Planktothrix agardhii* in the water column of Uzarzewskie Lake on specific dates.

DISCUSSION

Planktothrix agardhii is a species developing abundantly, usually in turbulent water (Dokulil & Teubner 2000). Due to its high shade tolerance and ability to survive with frequent fluctuations in light it is typically found in shallow polymictic lakes (Reynolds 1994). Uzarzewskie Lake, therefore, seems a somewhat unusual habitat for this species. However, the mass development of *P. agardhii* in the lake occurred in the epilimnion only. The upper water layer offers similar conditions for the phytoplankton as a polymictic lake. Frequent mixing in the epilimnion favours Oscillatoriales, as Nostocales cannot survive with frequent fluctuations in light (Nixdorf et al. 2003). *Aphanizomenon klebahnii* and several species of *Anabaena*, dwelling in the lake in July, were outcompeted by *P. agardhii* later in summer. As stated by Mischke (2003), such a succession is partly due to self-shading of cyanobacteria.

The problem of toxicity of the *P. agardhii* population in Uzarzewskie Lake remains unresolved. As microcystins were detected in one sample only it may be speculated that other potentially toxic cyanobacteria developing in the lake (*Anabaena* sp. div., *Pseudanabaena limnetica*, *Limnothrix redeckei*) produced the toxin. However, these other species were present in relatively low numbers on 14/09, so the presence of microcystins in the biomass should be attributed to *P. agardhii*. The toxin production might have been induced by the addition of a phosphorus coagulant. In 2006 the prototype for a mobile pulverising aerator was tested in the lake with the intention of aerating the lake, and released a phosphorus-binding compound based on iron sulphate into the water. The restoration was found to remove SRP from the water for a short time only. After a few days the SRP level in water was high once more (R. Gołdyn, unpublished data). On one hand, the addition of an iron sulphate-based coagulant supplies cyanobacteria with a certain amount of the iron which they need to grow. Luka & Aegerter (1993) stated that the colonial cyanobacterium *Microcystis aeruginosa* grew more slowly at low Fe concentrations, but produced more toxins. According to Kortmann (2003), cyanobacteria have a high cellular iron requirement. Thus, an iron sulphate addition should stimulate cyanobacterial growth, but prevent toxin production. On the other hand, however, stress conditions are believed to stimulate cyanobacteria to produce toxins. The coagulant added to Uzarzewskie Lake caused a rapid decrease in SRP concentrations, thus creating stress conditions for cyanobacteria. As the problem remains unresolved, we intend to continue its analysis in later studies.

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REFERENCES

Dokulil M.T., Teubner K., 2000, *Cyanobacterial dominance in lakes*. Hydrobiologia, 438: 1-12

Gołdyn R., Kozak A. Romanowicz W., 1997, *Food-web manipulation in the Maltański Reservoir*, Hydrobiologia, 342/43: 327-33

Gołdyn R., Grabia J., 1998, *The protection programme of Cybina River waters.* Wydział Ochrony Środowiska Urzędu Miasta Poznania, pp. 101 (in Polish)

ISO 2005, *Water quality – Determination of microcystins – Method using solid phase extraction (SPE) and high performance liquid chromatography (HPLC) with ultraviolet (UV) detection.* ISO 20179, pp.17

Jańczak J. (ed.), 1996, *The atlas of lakes in Poland*. Sc. Publ. Bogucki, Poznań, pp. 268 (in Polish)

Komárek J., Komárkova-Legnerová J., Sant'Anna C.L., Azevedo T.P., Senna P.A.C., 2002, *Two common Microcystis species (Chroococcales, Cyanobacteria) from tropical America, including M. panniformis sp. nov*. Cryptogamie Algologie, 23:159-77

Kortmann R.W., 2003, *In-lake methods you have never heard about* [in:] *Integrating Science and Technology into Successful Lake Management.* Proceedings of the 12th Annual North American Society of Southeastern Lake Management Conference, Harper H.H., Darling S.H. (eds.), Orlando, Florida, pp. 157-58

Luka M., Aegerter R., 1993, *Influence of trace metals on growth and toxin production of Microcystis aeruginosa*. Toxicon, 31(3): 293-305

Mischke U., 2003, *Cyanobacteria associations in shallow polytrophic lakes: influence of environmental factors*. Acta Oecologica, 24: S11-23

Nixdorf B., Mischke U., Rücker J., 2003, *Phytoplankton assemblages and steady state in deep and shallow eutrophic lakes – an approach to differentiate the habitat properties of Oscillatoriales.* Hydrobiologia, 502: 111-21

Padisák J., Reynolds C.S., 1998, *Selection of phytoplankton associations in Lake Balaton, Hungary, in response to eutrophication and restoration measures, with special reference to the cyanoprocaryotes*. Hydrobiologia, 384: 41-53

Pełechata A., Pełechaty M., Pukacz A., 2006, *Cyanoprokaryota of shallow lakes of Lubuskie Lakeland (mid-western Poland).* Oceanological and Hydrobiological Studies, 35(1): 3-14

Reynolds C.S., 1994, *The long, the short and the stalled: on the attributes of phytoplankton selected by physical mixing in lakes and rivers*. Hydrobiologia, 289: 9-21

Rohrlack T., Utkilen H., 2007, *Effects of nutrient and light availability on production of bioactive anabaenopeptins and microviridin by the cyanobacterium Planktothrix agardhii.* Hydrobiologia, 583: 231-40

Rücker J., Wiedner C., Zippel P., 1997, *Factors controlling the dominance of Planktothrix agardhii and Limnothrix redeckei in eutrophic shallow lakes.* Hydrobiologia, 342/43: 107-15

Sivonen K., 1990, *Effects of light, temperature, nitrate, orthophosphate, and bacteria on growth of and hepatotoxin production by Oscillatoria agardhii strains.* Applied and Environmental Microbiology, 56(9): 2658-66

Sivonen K., 1996, *Cyanobacterial toxins and toxin production.* Phycologia, 35: 12-24

Stefaniak K., Kokociński M., Messyasz B., 2005, *Dynamics of Planktothrix agardhii (Gom.) Anagn. et Kom. blooms in polymictic Lake Laskownickie and Grylewskie (Wielkopolska region) Poland*. Oceanological and Hydrobiological Studies, 34(3): 125-36

Willame R., Jurczak T., Iffly J.F., Kull T., Meriluoto J., Hoffmann L., 2005, *Distribution of hepatotoxic cyanobacterial blooms in Belgium and Luxemburg.* Hydrobiologia, 551: 99-117