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Water blooms and their toxicity in public swimming areas of lakes in the Poznań district

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Abstract

Eight lakes in the district of Poznań were examined in 2004 and 2005 for cyanobacteria and microcysin content. In only 8 of 24 water samples were species of cyanobacteria not the dominants. Toxin samples were analyzed with HPLC in the first year and HPLC with MS detector in the second. Microcystins were detected in the water of all the investigated lakes in 71% of the samples. The concentration of microcystins ranged from 0.000 to 1.6 μg l^{-1}. The highest concentration of microcystins was detected in Lake Kierskie in Poznań.

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INTRODUCTION

The eutrophication of lakes and reservoirs contributes to the more frequent occurrence of water blooms. Most blooms caused by cyanobacteria species, e.g. *Aphanizomenon flos-aquae, Microcystis* spp., *Anabaena* spp., *Planktothrix* spp., pose serious problems when these water bodies are used for water supply and recreation. The production of toxic compounds by these species may pose a danger to both animals and human beings. The problem of cyanobacterial water blooms and diseases caused by cyanotoxins is the subject of intense study the world over (e.g., Frazier 1998, Chorus and Bertram 1999, Falconer 1999, Szyper and Gołdyn 2000, Mazur-Marzec 2005). Research, documentation, and statistical analyses of these events have also been conducted in Poland in recent years (e.g., Tarczyńska et al. 2001; Kobos et al. 2005; Mankiewicz-Boczek et al. 2006a, 2006b). The study of the toxicity of intensive water blooms in lakes in and near Poznań began in the summer of 2004 (Zagajewski and Gołdyn 2005). This research was continued into the summer of 2005 to compare the stability of water blooms and their toxicity.

The main goal of the study was to describe the problem of cyanobacteria occurrence in lakes used for recreational purposes, especially the abundance and species composition of cyanobacteria as well as microcystin levels.

MATERIALS AND METHODS

The occurrence of toxic cyanobacteria water blooms was studied in 8 popular recreational lakes in and near Poznań during the summers of 2004 and 2005. The lakes chosen for this study were natural bodies of glacial origin (Table 1). Cyanobacterial water blooms commonly occur in half of these lakes during summertime.

Table 1

Characteristics of the studied lakes (Choiński 1992, Gołdyn et al. 1996)

Lakes	Lake area (ha)	Lake volume (10^3 m^3)	Average depth (m)	Maximum depth (m)
Biezdruchowo	48.8	2815.5	5.7	17.7
Bnińskie	225.9	9525.6	4.2	8.5
Dymaczewo	119.6	6221.0	5.3	12.0
Kierskie	310.0	34100.0	11.0	34.1
Lipno	9.0	495.0	5.5	9.5
Lusowskie	121.9	10479.0	8.6	19.5
Niepruszewskie	242.3	7578.3	3.1	5.2
Strykowskie	305.3	13637.4	4.5	7.7

Water samples were collected from the surface water layer within the swimming areas. Samples measuring 200 ml were collected for phytoplankton analyses and fixed with Lugol's solution according to Utermöhl. Qualitative analyses and the number of cells (identified to the species or genus level in the case of cyanobacteria and total number of other algae) was done using the Sedgwick-Rafter cell (0.65 ml in volume).

Water samples measuring 5 l without any added preservatives were transported to the laboratory and filtered through Whatman GF/C filters in order to analyze cyanobacterial toxins. The concentrated material and filtered water samples were frozen prior to solid phase extraction. The preparation of samples for toxin analyses was performed according to WHO par ISO 20179 (2005).

Samples used to determine toxin content were analyzed using Agilent 1100 High Performance Liquid Chromatography. In 2005, a Mass Spectrometry Detector was used. The calibration curve was determined using MC-LR Calbiochem Lot#B60096 and MC-RR Calbiochem Lot#B63953 as standards.

RESULTS AND DISCUSSION

Strong water blooms caused mainly by cyanobacteria were noted in half of the monitored lakes. Among the cyanobacterial species noted, the following potentially toxic taxa dominated: *Planktothrix agardhi*, *Aphanizomenon* sp., *Lyngbya limnetica*, *Limnothrix redekei*, *Pseudanabaena limnetica.* The co-occurrence of other cyanobacterial species from the following genera was also noted: *Anabaena*, *Anabenopsis*, *Chroococcus*, *Cylindrospermopsis*, *Merismopedia*, *Microcystis*, *Planktothrix*, *Raphidiopsis*, *Spirulina*, *Woronichinia*. *Aphanizomenon* sp. was the most frequent cyanobacteria (25.8%), followed by *Limnothrix redekei* (22.9%) and *Pseudanabaena limnetica* (17.1%). The share of cyanobacteria in total phytoplankton abundance was as high as 97.8% in Lake Bnińskie, but in some lakes (Lipno, Lusowskie) cyanobacterial water blooms were not noted (Table 2). It is worth emphasizing that some of the species found in the studied lakes are considered to be invasive cyanobacteria that have increased their range in recent years. These include *Cylindrospermopsis raciborskii*, *Raphidiopsis mediterranea*, and *Anabaenopsis cunningtonii*, which were identified in Lake Dymaczewskie, and *C. raciborskii* that was noted in Lake Bnińskie. The latter species had already been confirmed in Lake Bnińskie in 2002 by Stefaniak and Kokociński (2005). The occurrence of *A. cunningtonii* had not yet been reported in Poland. This is a pantropic species, principally noted in Africa (Taylor 1932, Brook and Rzoska 1954, Abu Gideiri 1968, El-Otify 2002). In recent years it has also been confirmed in Greece (Vardaka 2005), Hungary (Padisak and Reynolds 1998), and Germany

Table 2

Phytoplankton abundance in the studied lakes (cells ml^{-1})

Lakes	Date	Sum of Cyanobacteria	Sum of other phytoplankton taxa	Total number of phytoplankton	Percentage of Cyanobacteria
Biezdruchowo	08.2004.	1839	19516	21355	8.6
	07.2005.	3128	10080	13208	23.7
	08.2005.	565	15901	16466	3.4
Bnińskie	08.2004.	140923	3128	144051	97.8
	07.2005.	17349	43615	60964	28.5
	08.2005.	7560	25032	32592	23.2
Dymaczewo	08.2004.	29063	5644	34707	83.7
	07.2005.	8916	32954	41870	21.3
	08.2005.	9304	20289	29593	31.4
Kierskie	08.2004.	2746	26197	28943	9.5
	07.2005.	4523	9640	13893	32.6
	08.2005.	10583	17833	28416	37.2
Lipno	08.2004.	483	12995	13478	3.6
	07.2005.	0	7365	7365	0.0
	08.2005.	0	6397	6397	0.0
Lusowskie	08.2004.	253	10695	10942	2.3
	07.2005.	3088	1874	4962	62.2
	08.2005.	129	3619	3748	3.4
Niepruszewskie	08.2004.	74936	7480	82416	90.9
	07.2005.	34253	6591	40844	83.9
	08.2005.	42078	5678	47756	88.1
Strykowskie	08.2004.	72039	13872	85911	83.8
	07.2005.	27137	8879	36016	75.3
	08.2005.	32256	2199	34455	93.6

(Mischke 2001). Its occurrence in Lake Dymaczewskie confirms its invasive character and its spread in the northern hemisphere.

HPLC analyses produced positive results in 71% of all the water samples. The concentration of microcystins, measured as the sum of microcystin-LR (MC-LR) and microcystin-RR (MC-RR), ranged from 0.0 µg l^{-1} to 1.6 µg l^{-1}. The highest concentration of microcystins was detected in Lake Kierskie in August 2004 (Table 3). Both microcystins were detected in small amounts, which was probably the result of the low percentage of toxin-producing cyanobacteria occurring in the investigated lakes. This is especially true of *Microcystis aeruginosa* (0.1% of all cyanobacteria) and *Planktothrix* sp. (12%) (Codd 2000, Wolf and Frank 2002).

The amount of microcystin-LR detected in all the samples from the studied lakes was below the standard set by the WHO (5 µg l^{-1}) for swimming areas. According to the limit proposed by Falconer et al. (1999) for cyanobacterial water blooms, seven of the water samples qualified for first degree alert (20,000-100,000 cyanobacterial cells ml^{-1}). However, the reported microcystin

Table 3

Microcystins in the studied lakes (μg l^{-1})

Lakes	Year	Month	MC-LR	MC-RR	Sum of MC
Biezdruchowo	2004	August	0.0	0.0	0.0
	2005	July	0.938	0.010	0.948
		August	0.000	0.003	0.003
Bnińskie	2004	August	0.7	0.0	0.7
	2005	July	0.000	0.006	0.006
		August	0.000	0.000	0.000
Dymaczewo	2004	August	0.6	0.8	1.4
	2005	July	0.000	0.008	0.008
		August	0.000	0.015	0.015
Kierskie	2004	August	0.6	1.0	1.6
	2005	July	0.000	0.000	0.000
		August	0.000	0.008	0.008
Lipno	2004	August	0.5	0.0	0.5
	2005	July	0.000	0.000	0.000
		August	0.000	0.000	0.000
Lusowskie	2004	August	0.5	0.0	0.5
	2005	July	0.000	0.011	0.011
		August	0.000	0.000	0.000
Niepruszewskie	2004	August	0.5	0.0	0.5
	2005	July	0.242	0.126	0.368
		August	0.276	0.179	0.445
Strykowskie	2004	August	0.0	0.8	0.8
	2005	July	0.000	0.003	0.003
		August	0.000	0.000	0.000

level was not as high as the guideline limits (2-4 μg l^{-1}) proposed by other authors. This was probably due to the occurrence in the studied lakes of non-toxic species and non-toxic strains of potentially toxic cyanobacteria. Samples from Lake Bnińskie (August 2004) qualified for second degree alert (over 100,000 cyanobacterial cells ml^{-1}). The microcystin level in this sample was also below the range of the guideline limits (20-50 μg l^{-1}) despite the domination of the potentially toxic species *Pseudanabaena limnetica* and *Planktothrix agardhii*.

CONCLUSIONS

- This study confirmed the presence of cyanobacterial toxins in the water of all the monitored lakes used for recreation in the vicinity of Poznań. It also suggests that this may become a sociological problem if the content of microcystin exceeds the limit proposed by WHO.

- Simultaneously extremely dangerous and very interesting was the appearance of the rare, invasive cyanobacteria species *Cylindrospermopsis raciborskii*, *Raphidiopsis mediterranea*, and *Anabaenopsis cunningtonii* in Lake Dymaczewskie and *C. raciborskii* in Lake Bnińskie. Nevertheless, they have yet to become dominants.

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