Potentially toxic cyanobacteria in Trentino lakes: bloom episodes detected by monitoring data over the last ten years

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ABSTRACT

This short note illustrates some algal blooms caused by potentially toxic cyanobacteria in water bodies in the NE Alps, focusing in particular on the last ten years. The data illustrated come from monitoring activities, bathing health assessments, and analyses carried out on citizen reports. The most important blooms were caused by *Planktothrix rubescens*, *Dolichospermum spp*., and *Microcystis aeruginosa*, and affected Lakes Ledro, Caldonazzo, and Serraia. Experience in the Trentino region has highlighted the importance of effective and timely communication between the monitoring institutions and the users of the lake, to minimize any negative health effects and to increase the knowledge of the population.

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Introduction

Cyanobacteria or blue-green algae are prokaryotic oxygenic phototrophs that colonize all ecosystems. They have a great ability to adapt to changing environmental conditions. Some cyanobacteria prefer cold waters, low light radiation, and low nutrient concentrations. Others need abundant nutrients, high temperatures, and stable stratification of the water column. Cyanobacteria are characterized by great morphological variability, and have unicellular or colonial, globose, or filamentous forms (Komarek and Anagnostidis 2005, 2008; Komarek, 2013).

Some genera of cyanobacteria can develop almost completely monospecific algal populations in their natural environment, with very high numbers of individuals per liter of water (algal blooms). The blooms are often accompanied by foams and superficial streaks or anomalous coloring. Since many species can produce toxins (cyanotoxins) as secondary metabolites, they are considered pathogenic microorganisms to be controlled by public health institutions for bathing waters.

Information relating to the presence of cyanobacteria in water comes from three sources: i) data from monitoring of the lakes that APPA must monitor according to Legislative Decree 152/06 (6 samplings per year), which provide the density (cell/l) and the biovolume (mm^3/m^3) of the algal species living the in the water column corresponding to the euphotic zone (Dlgs 152/2006, 2006; EU 2000); ii) data from bathing samples (5 collected in the May-September swimming period), collected in collaboration with Azienda Provinciale per i Servizi Sanitari (APSS) Trento, which coordinates the sampling and subsequent cyanotoxins analyses; these data provide the density (cells/ml) of cyanobacteria in surface water samples (Dlgs 116/2008, 2008): data obtained from sampling carried out following reports and alarms from citizens.

All data involving algal blooms and monitoring are disseminated through the water protection management plans and through the APPA website (https://www.appa.provincia.tn.it), which reports the most important bloom episodes and the main water coloration and blooms described by citizens.

The main cases of bloom recorded in the province of Trento in the past 15 years are described in the following timeline (Figure 1A).

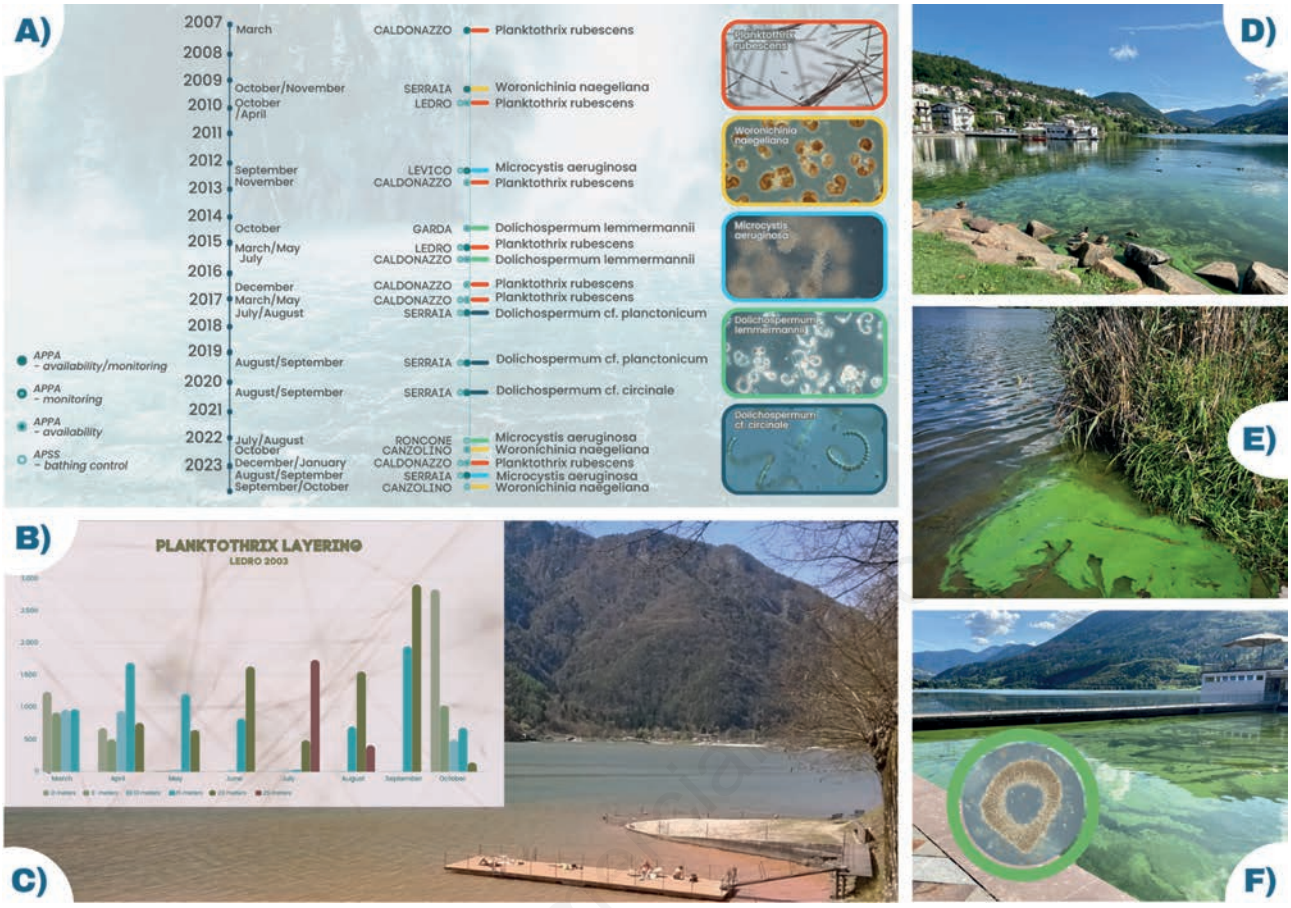

Figure 1. A) Timeline of the most important bloom events occurring from 2007 to 2023 in Trentino lakes. B) Distribution of *Planktothrix rubescens* in different layers of Lake Ledro. C) Surface bloom of *Planktothrix rubescens* in Lake Ledro in May 2015. D) Surface bloom caused by *Microcystis aeruginosa* in Lake Serraia in late summer 2023 and E) Accumulation caused by wind. F) *Microcystis aeruginosa* at 200x magnification (Lake Serraia).

Winter surface blooms in lakes Ledro and Caldonazzo

Lake Ledro and Lake Caldonazzo (Figure 2) have stable populations of *Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis & Komárek that have given rise to winter and spring surface blooms over the years (Figures 1B, C).

The two lakes are similar in many characteristics, but the total phosphorus concentrations during spring mixing are consistently higher in Lake Caldonazzo. Lake Ledro, however, has a significantly higher average annual biovolume of *Planktothrix rubescens*, further confirming that this species is better adapted to oligo-mesotrophic environments rather than in full mesotrophic conditions (Boscaini *et al*., 2017). Both lakes presented winter surface blooms over the years, when *Planktothrix rubescens* tends to be entrained to the surface by mixing processes. In contrast, during the summer months, *Planktothrix rubescens* is located at the depths where it finds the best temperature conditions while simultaneously being able to make the most of nutrient availability. This species positions itself at the lower layer of the thermocline, where most of the nutrient accumulates, and also manages to take advantage of low light irradiance conditions (Walsby *et al*., 2004, 2006; Boscaini *et al*., 2017). This aspect may lead to an underestimation of the risk not so much with regard to bathers but with regard to fish consumption and especially to the possible use of water for drinking (Manganelli *et al*., 2010), a situation not yet current in Trentino, but increasingly likely due to frequent drought episodes related to climate change.

Summer blooms in lakes Levico, Canzolino and Serraia

In September 2012, Lake Levico (Figure 2) showed an intense and anomalous bloom of *Microcystis aeruginosa* (Kützing) Kützing. Lake Levico does not have high phosphorus concentrations at mixing and is classified as having good ecological status. After that year, no more massive blooms occurred.

Lake Canzolino (Figure 2) showed frequent blooms caused by cyanobacteria. It is a small eutrophic basin characterized by excessive external nutrient loading, a large zone of summer hypolimnetic anoxia, and very slow water exchange. In 2022 and 2023, it was affected by conspicuous blooms caused by the

cyanobacterium *Woronichinia naegeliana* (Unger) Elenkin in September and October, with values exceeding the normative limit for bathing water of 100,000 cells/ml.

Lake Serraia (Figure 2) has been the focus of attention of provincial environmental services since the late 1990s, when marked phenomena of algal blooms began to become evident during the summer. These phenomena were the visible manifestation of eutrophication in the lake. The lake is included in the provincial monitoring network and is monitored and classified as required by Legislative Decree 152/06, but over the years, specific studies have been carried out, and sampling frequencies have been intensified. A large amount of data has been collected on this lake.

Focusing only on the events of the last few years, in 2017 we observed a strong bloom of *Dolichospermum* spp. which was often identified in the samples with the coexistence of two (or more) different species, namely *D. circinale* (Rabenhorst ex Bornet & Flahault) Wacklin, Hoffmann & Komárek and *D. planctonicum* (Brunnthaler) Wacklin, L.Hoffmann & Komárek.

In 2019, a new bloom of *Dolichospermum* spp. reached high concentration levels in early September. The scums were very visible, and the coloration of the lake was particularly "unpleasant." During August and September 2020, the lake was again affected by an intense algal bloom, visible to the naked eye by the abnormal coloration of the water and the very apparent formation of yellow-green streaks. However, these bloom episodes, although unpleasant as a visual impact on the enjoyment of the lake, did not lead to the formation of toxins. Finally, in 2023, there was no evidence of *Dolichospermum* sp. throughout the summer season; however, a massive bloom of *Microcystis aeruginosa* developed in the second half of August and continued throughout September, leading to a ban on bathing, fishing, and recreational uses of the lake. Indeed, high levels of microcystins (over 100 µg/L in the superficial accumulation and over 40 µg/L in areas not affected by accumulations) were determined by APSS and Fondazione Edmund Mach (FEM) of S. Michele all'Adige in this circumstance.

Information to the population on cyanobacterial blooms

In the province of Trento there is not yet an established information system in case of toxic algal blooms. It is important that an adequate two-way information flow is built; the correct information must be provided to the users of the lakes through the management institutions and at the same time the flow of information must also work in the opposite direction, through timely reports from citizens who are informed about the type of events.

A better flow of information is therefore needed not only for people who directly use the water (swimmers, sportsmen, fishermen, *etc.*), but also for the authorities responsible for managing the public resource (provincial and municipal governments). Also, because of increased blooms caused by climate change, information is very important so that people learn to recognize the danger. An example of correct information flow is reported on the occasion of the *Planktothrix rubescens* bloom that affected Lake Caldonazzo in winter 2023. The analyses revealed the presence of toxins, and the local municipalities were promptly notified. To support the information to water users, panels with full explanations of the phenomenon and associated dangers were placed at access points to the lake. In this way, people were prevented from getting too close to the algal accumulations, which are also dangerous for animals, for example, for dogs that drink lake water (Fastner *et al*., 2018).

Physical and trophic characteristics of the Trentino lakes considered (Tomasi G.; 2004)

LAKE NAME	GEOGRAPHIC COORDINATES	PHYSICAL PARAMETERS					TROPHIC PARAMETERS
		altitudine mslm	max depth (m)	mean depth (m)	area (ha)	volume (10^3 m^3)	ecological state (Dlgs. 152/2006)
CALDONAZZO	latitude from 46° 00′ 03″ to 46° 02′ 19″ longitude from 1° 11′ 10″ to 1° 13′ 22″	449	49	26.5	563	148,987	MODERATE
CANZOLINO	latitude 46° 05′ 00″ longitude 1° 13′ 35″	540	15	7	7	515	NOT AVAILABLE
LEDRO	latitude from 45° 52′ 12″ to 45° 53′ 10″ longitude from 1° 41′ 10″ to 1° 43′ 13″	655	48	35	218	75,775	MODERATE
LEVICO	latitude from 46° 00′ 25″ to 46° 01′ 42″ longitude from 1° 10′ 00″ to 1° 11′ 15″	440	38	11	116	12,942	GOOD
SERRAIA	latitude from 46° 08′ 01″ to 46° 08′ 29″ longitude from 1° 11′ 25″ to 1° 12′ 12″	974	18	7	44	3,140	MODERATE

Figure 2. Physical and trophic characteristics of the investigated Trentino lakes.

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