Editorial

Advancing Knowledge on Cyanobacterial Blooms in Freshwaters

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Abstract: Cyanobacterial blooms have become a frequent phenomenon in freshwaters worldwide; they are a widely known indicator of eutrophication and water quality deterioration. Information and knowledge contributing towards the evaluation of the ecological status of freshwaters, particularly since many are used for recreation, drinking water, and aquaculture, is valuable. This Special Issue, entitled “Advancing Knowledge on Cyanobacterial Blooms in Freshwaters”, includes 11 research papers that will focus on the use of complementary approaches, from the most recently developed molecular-based methods to more classical approaches and experimental and mathematical modelling regarding the factors (abiotic and/or biotic) that control the diversity of not only the key bloom-forming cyanobacterial species, but also their interactions with other biota, either in freshwater systems or their adjacent habitats, and their role in preventing and/or promoting cyanobacterial growth and toxin production.

Keywords: cyanobacteria; microcystin; water quality; human and animal health; nutrients; climate change; eutrophication; model

1. Introduction

Cyanobacterial blooms constitute a water quality problem that has been widely acknowledged to cause negative effects on the use, safety, and sustainability of drinking and recreational waters supplies and fisheries. Water eutrophication combined with relative high water temperature promote cyanobacterial growth and water bloom formation. The cyanobacterial bloom season may be of extended or even continuous duration throughout the year, especially in freshwaters experiencing external and internal conditions, such as high temperatures and irradiance, thermal stratification, long water replacement times, high phosphorus and nitrogen concentrations, and low zooplankton grazing [1] or low viral attack [2]. Evidence for this can be obtained from lakes in the Mediterranean region [3,4]. In a human and climatically changing world, cyanobacterial blooms seem to have increased in frequency and longevity globally, and are likely to expand and thrive in water resources [1,5,6]. Moreover, the successful dispersal and colonization of new aquatic habitats or newly formed systems by airborne bloom-forming cyanobacteria, such as the cosmopolitan potentially toxic *Microcystis*, seem to facilitate their global expansion and are of immediate ecological, economic, and health-related interest [7,8]. Of most concern are the cyanotoxins along with the mechanisms that induce their release and fate in the aquatic environment. These secondary metabolites pose a potential hazard for human health and agricultural and aquaculture products directed for animal and human consumption, therefore the strict and reliable control of cyanotoxins is crucial for assessing risk [6]. In this direction,
a deeper understanding of the mechanisms that determine cyanobacterial bloom structure and toxin production become a target for managing practices [5,6].

This Special Issue, entitled “Advancing Knowledge on Cyanobacterial Blooms in Freshwaters”, includes 11 research papers [9–19] and aims to bring together the recent research of multi- and interdisciplin ary approaches from the field to the laboratory and back again, driven by working hypotheses based on any aspect from ecological theory to applied research on mitigating cyanobacterial blooms.

2. Contributions

Despite the fact that the interest in cyanobacterial blooms is focused on lakes and reservoirs, where the cyanobacterial bloom presence is most intense, the role of Cyanobacteria in other natural or engineered ecosystems is also attracting scientific interest. One such case is presented by Li et al. [13], who provided a study where potentially toxic cyanobacteria dominate in aquaculture ponds and, thus, might affect the overall aquaculture production.

The issue of deciphering the role of cyanobacterial blooms at the ecosystem level requires investigations both at the organism level (autoecology) and the community level (synecology), which can be approached by field and/or experimental works. Zhang et al. [10] provided an improved modeling approach on the role of turbulence mixing on the growth of Microcystis aeruginosa as a means of affecting differential nutrient transfer between this cyanobacterium and Scenedesmus quadricauda, frequently occurring chlorophyte in eutrophic freshwaters. Another autoecological approach is given by Muhetaer et al. [17]. In this study, the authors conducted experiments in order to evaluate the comparative effects of different light intensities on the growth and stress responses of two bloom-forming cyanobacterial species, Pseudanabaena galeata (strain NIES 512) and Microcystis aeruginosa (strain NIES 111) for a few days.

Apart from the role of Cyanobacteria in previously understudied ecosystems, new ecophysiological roles are gaining momentum in cyanobacteria research, such as the role of cyanobacteria in methane cycling in the oxic waters of lakes [20]. In the current Special Issue, Khatun et al. [16] found that Synechococcus was the most likely methane producer in nine Japanese lakes.

The human, animal, and plant health risks associated with low ecological lake water quality and its subsequent toxic cyanobacterial blooms are showcased by Tokodi et al. [15] in a Serbian lake with 50 years of persistent blooms of toxic cyanobacteria and considerable concentrations of toxins. This renders imperative not only the need for mitigating the existing problems but also the importance of righteous predictive approaches for future cyanobacterial blooms. Towards this direction, an integrated approach for the management of cyanobacterial blooms targeting the impacted ecological functions is presented by Hall et al. [11]. In the fight against toxic cyanobacterial blooms, Herrera et al. [9] proved experimentally the oppressive effect of eight phenyl-acyl compounds in the growth of Microcystis aeruginosa, and also the non-toxic effect of specific caffeic acid concentrations in non-target zooplankton organisms, expanding, thus, the potential use of novel substances in cyanobacterial biomass reduction.

The importance of hydrogeomorphological features in shaping cyanobacterial communities as subcommunities of the phytoplankton community was showcased in two papers of the current Special Issue. Yao et al. [19] investigated a 2-year succession of cyanobacteria and eukaryotic phytoplankton functional groups in a reservoir, while Katsiapi et al. [14] used a system of two recently interconnected ancient lakes to show that this recent mode of water translocation between the two lakes increased the occurrence of potentially toxic and bloom-forming cyanobacteria. Another study with a dataset covering a whole decade between 2004 and 2014 reported that cyanobacteria constituted up to 60% of the primary producer biovolume, with increased dominance after 2010 [18]. The importance of phosphorus management was showcased by Liu et al. [12], not only for cyanobacteria control but also for the “satellite” bacterial communities of a eutrophic lake, which, in total, might affect the biogeochemical functioning of the whole lake.
Cyanobacteria are among these microorganisms that pose major health risks to humanity, but also, at least for some of them, they seem to be favored by our current climatic instability [21]. Predicting the onset and development of cyanobacterial and algal blooms remains a challenging task [1]. Due to the many aspects of the complex ecophysiology of Cyanobacteria which remain either understudied or even unknown and due to the climatic variability which renders the accurate prediction of the environmental settings favorable to Cyanobacteria rather vague, a truly interdisciplinary and not multidisciplinary scientific effort is imperative. This might require us to reset our current working hypotheses or even generate new ones [22]. Future research should include more frequent samplings with standardized protocols [23], following the best established approaches from field to laboratory analysis to data processing and analysis [24], and not only those dictated by managerial directives [25]. Finally, the interconnectivity between experimental and field experiments which combine classic approaches, such as microscopy analysis, with more modern methodologies such as -omics for acquiring more conclusive insights on the biology, ecology, and mitigation of Cyanobacteria and their freshwater blooms seems to be the most inclusive approach for the time being.

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