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Meriluoto, Jussi; Tokodi, Nada

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Editorial

Special Issue on Harmful Cyanobacteria and Their Metabolites

Jussi Meriluoto [1,2,*] and Nada Tokodi [2,3]

1 Biochemistry, Faculty of Science and Engineering, Åbo Akademi University, 20520 Turku, Finland
2 Laboratory for Paleoenvironmental Reconstruction-LAPER, Faculty of Sciences, University of Novi Sad, 21000 Novi Sad, Serbia
3 Laboratory of Metabolomics, Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University, Gronostajowa 7, 30387 Krakow, Poland
* Correspondence: jussi.meriluoto@abo.fi

Cyanobacteria, previously called blue-green algae, are photosynthetic microorganisms which thrive especially in aquatic ecosystems suffering from eutrophication. They are also found in waterbodies used for the purposes of drinking water production, irrigation, fishing, and recreation.

Cyanobacterial problems began to attract wider interest in the 1980s. Scientists, water management authorities, and the general public in, e.g., South Africa, Australia, the United States, the United Kingdom, Norway, Finland, Japan, and Brazil were then faced with episodes of harmful cyanobacterial blooms which caused illness and even mortality among humans, wildlife, and domestic animals. Research since the 1980s has identified several hundreds of toxic cyanobacterial metabolites, collectively known as cyanotoxins, which include hepatotoxins, cytotoxins, and neurotoxins. The primary route of exposure to cyanotoxins is through ingestion of contaminated drinking water. There are also concerns and evidence of contamination of fish, shellfish and agri/horticultural products by cyanotoxins. Cyanobacterial hazards and nuisances are, nowadays, experienced in practically all parts of the world.

Much of the cyanotoxin research has benefited from international collaborations which have connected laboratories with specialized expertise in, e.g., hydrobiology, ecology, analytical chemistry, molecular biology, and toxicology. This is also the case with the Special Issue "Harmful Cyanobacteria and Their Metabolites" in Applied Sciences, which contains five research papers that have originated from authors working in eleven countries on three continents. The papers in the Special Issue deal with the occurrence of toxic cyanobacteria and cyanotoxins, physiology and molecular biology related to cyanobacterial adaptation, and analytical methods for cyanotoxins. Further, a management initiative related to cyanobacteria is presented.

Stoyneva-Gärtner et al. reported on the occurrence of the cyanobacterial hepatotoxins microcystins (MCs) and their producers in Bulgarian waterbodies [1]. They used light microscopy to determine species composition and phytoplankton abundance, HPLC methods for the analysis of MCs and marker pigments, and PCR to detect toxigenic cyanobacteria. *Microcystis aeruginosa* and *Microcystis wesenbergii* were identified as the primary planktonic MC producers.

Bustillos-Guzmán et al. studied the occurrence of MCs and paralytic shellfish toxins (PSTs; neurotoxins produced by certain cyanobacteria and dinoflagellates) in a Mexican subtropical crater lake [2]. They used ultra-high performance liquid chromatography coupled to tandem mass spectrometry (UHPLC-MS/MS) for the analysis of MCs, and high performance liquid chromatography with fluorescence detection (HPLC-FLD) for the analysis of PSTs. Seven MC congeners were detected and quantified, but no PSTs were found. This paper is the first to give quantitative data on MC congeners in *M. aeruginosa* present in a Mexican water ecosystem.

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Antosiak et al. described different responses in gene expression in Polish and Australian strains of *Raphidiopsis raciborskii* when they were exposed to chill/light stress [3]. *R. raciborskii* is an invading cyanobacterial species which grows in various climatic regions with different temperature and light conditions, cf. Poland and Australia. The authors compared the growth rate and the expression of certain genes which are thought be relevant in coping with chill/light stress in the two *R. raciborskii* strains. Observed differences and flexibility in the employment of mechanisms involved in the response to chill/light seem to be responsible for the ecological success and expansion of this invasive species.

As there are rapid spatiotemporal variations in the occurrence of toxin-producing cyanobacteria in a waterbody, single measurements of water samples may give misleading results about the condition of the waterbody. **Lepoutre et al.** used freshwater bivalves *Dreissena polymorpha* and *Anodonta anatina* as integrating sampling devices to detect water contamination by MC-producing *Planktothrix agardhii* [4]. Both species were able to accumulate free and bound MC. Free MC in bivalve tissues reflected the environmental MC dynamics more efficiently.

Not all cyanobacteria are harmful, and they perform crucial ecosystem services. **Palanački Malešević et al.** assessed the potential of cyanobacterial inoculation for the restoration of damaged loess surfaces through assisted development of biological loess crusts (BLCs) [5]. A number of cyanobacterial strains were screened for desirable characteristics in the restoration process (lack of toxicity, and high production of biomass and polysaccharides). The authors simulated semi-arid environmental conditions in specially designed chambers, which were used to evaluate the potential of the strains in the assisted development of BLCs and the mechanisms of loess stabilization. It was confirmed that cyanobacteria interact with loess particles, resulting in BLC formation, which immobilizes particles and stabilizes the sediment.

The Guest Editors hope that the five papers published in the Special Issue “Harmful Cyanobacteria and Their Metabolites” are found useful in the management of cyanobacterial issues and that they can inspire future research in the field.

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