Temperature effects explain continental scale distribution of cyanobacterial toxins

Article by Evanthia Mantzouki and Bas Ibelings, Univ. of Geneva

The first product of the European Multi Lake Survey (EMLS) is published in *Toxins*. This paper would not have been possible without the EMLS, the grassroots initiative that brought together around 200 scientists from 26 European countries to sample their lakes and answer questions of ecological importance. Understanding global scale phenomena, such as climate warming, requires information of high spatial resolution to investigate if lakes of similar characteristics (e.g. morphometry, trophic status) would respond in a consistent manner to similar environmental forcing. Cyanobacterial occurrence as a typical consequence of environmental perturbation in aquatic systems worldwide, was the centre of attention in the EMLS. Starting from a common goal to produce adequate evidence and eventually push for stricter regulation towards improved freshwater quality, the EMLS consortium designed straightforward sampling protocols to accommodate the capacity in funding, time, personnel and equipment of all participants, without compromising quality. Cyanotoxins, phytoplankton pigments and environmental parameters were sampled and analysed in a fully standardised way to ensure scientific validity.

As a result of this effort, the first peer-reviewed EMLS article casts light on cyanotoxins and toxin quota distribution across the European continent. In an unexpected - but welcoming for our research purpose! - hot summer in 2015, temperature effects, both directly through boosting physiological processes of cyanobacterial growth and, indirectly through enhancing water stability that facilitate buoyant cyanobacterial cells, determined the spatial distribution of hepatotoxins (microcystins), neurotoxins (anatoxin-a) and cytotoxins cylindrospermopsin). The Northern European lakes were struck by a prolonged heat wave, more than the Mediterranean ones, during the sampling period that pinpointed the reality of climate warming. In such an event, toxin diversity increased along the latitudinal gradient, showing that cyanobacterial toxin production is enhanced not necessarily when it is hot (Mediterranean) but when it gets warmer than usual (heat event in North). Increases in toxin diversity (increase in toxin numbers but also representation of each toxin), entailed an increased presence of cylindrospermopsin, anatoxin and less studied microcystin variants, with a simultaneous decrease in the famous MC-LR. While global warming continues, the direct and indirect effects of increased lake temperatures will drive changes in the distribution of cyanobacterial toxins in Europe, potentially promoting selection of a few highly toxic species or strains.

Reference (Open access):

EMLS was supported by COST Actions [NETLAKE](https://netlake.cordis.europa.eu/) and [CYANOCOST](https://cyano-cost.eu/).
The persistence of cyanotoxins and cyanotoxin genes in natural and controlled environments has received some attention, although this has focussed mainly on aquatic systems. For example, microcystins are intrinsically robust molecules, able to withstand extremes of temperature and pH (Codd and Bell, 1996). An acceleration of their degradation and detoxification typically requires the addition of an oxidative or photocatalytic treatment (e.g. Sharma et al., 2012; Pestana et al., 2015). Such studies on the persistence of cyanotoxins in dried matrices, whether short-term (hours, days), or long-term (months, years, decades), e.g. in biocrusts of terrestrial cyanobacteria, in dried scums of planktonic species, or in dried mats of benthic cyanobacteria, are lacking.

The determination, e.g. as half-lives, of cyanotoxin persistence in air-dried environmental materials, would aid in the interpretation of emerging observations on the presence of cyanotoxins in exsiccatae (dried herbarium specimens) of cyanobacteria of historic interest. A feasibility study of the presence of microcystins in 30 exsiccatae of aquatic and terrestrial cyanobacteria collected between 1839 and 1950, and stored in the Natural History Museum (NHM) in London, revealed some promising results (Metcalf et al., 2012). Of the 30 samples, 27 were positive for microcystins according to high performance liquid chromatography with photodiode array detection and/or immunoassay. Of 24 of these samples amplified for the microcystin synthetase gene mcyD, 4 were positive (Metcalf et al., 2012). Such samples of dried material merit further examination for cyanotoxin genes. Indeed, other samples of dried cyanobacteria, stored for up to 120 years, have yielded robust 16S rRNA sequences permitting the determination of phylogenetic relationships within the dried coccoid and filamentous cyanobacterial groups examined (Palinska et al., 2006).

A further finding of cyanotoxins in cyanobacterial material, also held in the UK’s NHM, has recently been reported (Jungblut et al. 2018). The dried cyanobacterial mat samples had been collected in Antarctica during the 1901-1904 “Discovery” National Antarctic Expedition, led by Captain Scott. Up to 5 microcystin variants and the neurotoxin β-N-methylamino-L-alanine (BMAA) plus its isomers 2,4-diaminobutyric acid (2,4-DAB) and N-(2-aminoethyl) glycine (AEG) were identified. These are the oldest cyanobacterial samples to have been examined from Antarctica, providing a snapshot of freshwater cyanobacterial mat cyanotoxins before the influence of human activity and of climate change. The findings provide further encouragement to consider cyanobacterial exsiccate in the national museums and major herbaria throughout Europe and beyond as potential sources of research material of historical and ecotoxicological importance.

References
CYANOjobs

PhD Position - Acclimation of photosynthetic organisms to solar and extrasolar radiation. Université Grenoble Alpes, France.

Doctoral scholarship, Ecosystem management, University of Antwerp, Belgium.

2 Postdoc Positions (24-36 months) and 1 PhD position (36 months) in the field of Metabolic Engineering of Microalgae (Chlamydomonas reinhardtii), Bielefeld University, Germany.

Researcher positions for PhotoWING Project, Univ. of Florence, Italy.

Two Postdoctoral positions in Algal Biochemistry/Physiology and in Algal Molecular Biology, STU-UNIVPM Joint Algal Researcher Center, Italy.

CYANOevents


Summer course “Integrating ‘Omics’ Technologies into Aquatic Ecology, 25-29 June 2018, S. Michele all’Adige, Italy

3rd Early Career Researcher Symposium on Cyanobacteria, 12-14 September 2018, Univ. of Freiburg, Germany.

BCCM training on preservation of micro-organisms: a practical approach, 18-21 September 2018, Belgium.


18th International Conference on Harmful Algae (ICHA18), 21-26 October 2018, Nantes, France.

11th International Conference on Toxic Cyanobacteria (ICTC11), 5-10 May 2019, Krakow, Poland.

The Steering Group (SG) of CYANOCOST has submitted comments to the European Commission about the inclusion of MC-LR in the proposed revision of the Drinking Water Directive (DWD).

You can read the CYANOCOST comments in the EC webpage (download the file with comments).

Subscribe to the US EPA—Freshwater HABs Newsletter, edited by Dr. Lesley V. D’Anglada for more info on upcoming events in USA and beyond.
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CYANOresearch

Dionysios (Dion) Dionysiou and a research team of University of Cincinnati have been awarded an NSF grant to develop sensors for Microcystins.

Dr. Dionysios (Dion) Dionysiou of the University of Cincinnati (UC), member of CYANOCOST, together with co-PIs Dr. William R. Heineman and Dr. Vesselin Shanov have been granted a National Science Foundation (NSF) award to develop sensors for hepatotoxic Microcystins. The news is shared from the UC webpage:

“The grant is funded by the CBET Division of Chemical Bioengineering Environmental and Transport Systems of NSF. The ultimate outcome will be to develop highly-selective and fast-responding sensors for the detection and quantification of toxins in drinking water and sources of drinking water supplies.

The presence of high concentrations of cyano-toxins in several freshwaters, some of which serve as sources of drinking water supplies, seriously threatens human and environmental health. In 2014, for example, the cyanobacterial harmful algal bloom (HAB) in Lake Erie affected the drinking water for more than 500,000 people in Toledo, OH alone.

The project, entitled “Nanosensor for the Point-of-Use Detection of Hepatotoxic Microcystins in Water” will specifically develop and test a novel sensor designed to detect and quantify algal toxins frequently found in freshwaters.

“We are honored to receive support from NSF. The award will allow us to continue our research activities and directly advance the knowledge and understanding while also promoting teaching, training and learning at UC. Through this research effort, we look forward to creating vital solutions in the realm of water quality and we hope to get closer to presenting a point-of-care sensor for environmental applications to UC and the scientific community,” said Dr. Dionysios D. Dionysiou, leader and principal investigator of this grant.

This project aims to create nanostructured biosensors for selective identification and quantification of toxins in water. Two outcomes are targeted: 1) demonstrate nanostructured sensors for point-of-use determination of toxic compounds, and 2) validate sensor performance with real-world water samples. The fabricated device will be evaluated for its ability to detect and quantify toxins in natural surface water obtained from various freshwater aquatic systems, that experience severe occurrence of cyanobacterial harmful algal blooms.”

CYANOpapers

This column features papers that acknowledge CYANOCOST and other papers. A list of all publications can be downloaded from www.cyanocost.net (publications page).


