Towards safe waters

Dr Triantafyllos Kaloudis and the **CYANOCOST Steering Committee** describe their efforts to disseminate knowledge, strategies and tactics for mitigating the growing threat posed by toxic cyanobacteria in European water reservoirs, lakes and fresh water bodies

Firstly, could you offer an introduction to Cyanobacteria and Cyanobacterial blooms?

Cyanobacteria are photosynthetic microorganisms that are generally distributed in the biosphere and occur naturally in surface waters. Their name is derived from the Greek word 'κυανός', meaning blue – they are also called blue-green algae.

They are ancient organisms that are thought to have been present on Earth for more than 3 billion years and it is believed that they played an important role in the formation of the Earth's early atmosphere. They account for up to 30 per cent of the photosynthetic activity of our planet. They are very adaptable and can grow in fresh, brackish and saline waters, in a wide range of temperatures and nutrient environments. Under favourable conditions, cyanobacteria can quickly multiply to form blooms and mats.

What are the main dangers posed by algal blooms and cyanotoxins?

A lot of cyanobacteria species and strains are toxigenic (able to produce a diverse range of potent toxins as secondary metabolites). Cyanobacterial toxins – more succinctly termed 'cyanotoxins' – fall into three main groups based on their chemical structure: cyclic peptides, alkaloids and lipopolysaccharides, while new compounds have recently emerged as possible potent toxins, such as the neurotoxic amino acid BMAA. The hepatotoxic microcystins (MCs) are the most widespread cyanotoxins and are often found in lakes and water reservoirs that are used as drinking water sources. MCs are of major concern to public health when water is intended for human consumption. In the last 50-60 years, there have been many reports of human poisoning and livestock deaths caused by drinking water containing cyanotoxins.

Within this context, can you outline the key objectives of CYANOCOST?

The main objective of CYANOCOST is to increase, disseminate and harmonise capabilities across Europe for the risk management of cyanobacteria and cyanotoxins in waters, by establishing strong and synergistic links between academia, authorities, industry and citizens. CYANOCOST will compile and integrate experience, identify research needs and gaps, focus on solutions and disseminate data, results and best management practices to end-users and stakeholders. This knowledge sharing will protect public health, utilities, facilities and enterprises and hence contribute to European science, society and economy.

An important goal of CYANOCOST is to support the mobility of researchers in the field, and especially early-stage researchers, by providing grants for short-term scientific missions to expert labs throughout Europe for up to six months.

How will CYANOCOST influence the European research landscape?

The proposed activities will enable laboratories in European countries to benefit from established research expertise and practical experience in cyanobacterial bloom and toxin risk management. Mutual benefits will emerge for all participants as novel ideas, and approaches, needs and cases will originate in countries that are now only starting to address the subject matter. Awareness-raising, training and technology transfer via networking will disseminate more than 25 years' worth of relevant expertise and experience, currently of limited geographical spread, to the whole of Europe.

Can you expand upon your work to develop a database?

CYANOCOST will develop a Europe-wide rolling database which will act as an extension of UNESCO's 2005 CYANONET. The database will include information about European research in the field (researchers, institutes, expertise, publications, methods, best practices), events (human and animal health incidents, economic and social effects, increased water provision/treatment costs, effects on tourism, national events, etc.), management measures applied or in progress and their evaluation, and national risk management policies in use in Europe and neighbouring states, including guidelines and legislation. CYANOCOST will also disseminate an improved Decision Support Tool for toxic cyanobacteria and cyanotoxins based on the World Health Organization (WHO) Water Safety Plan concept, which was initially developed in a previous EU project.

Finally, could you offer an overview of the next stages in the project? What is the main focus for the near future?

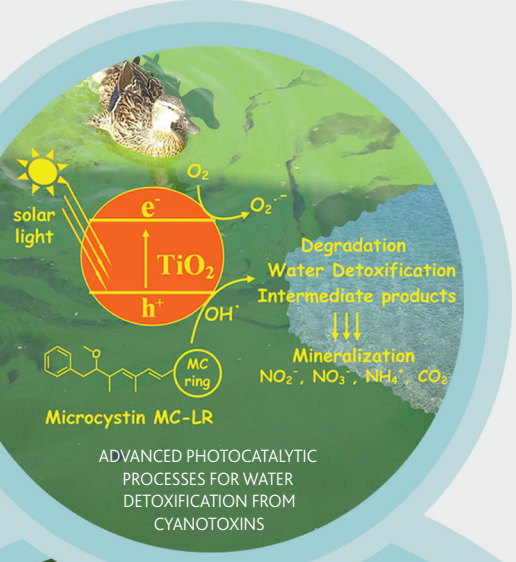
CYANOCOST is currently in its first year. The main goal for the first two years is the development of handbooks with harmonised methods for the analysis of cyanotoxins, the identification of cyanobacteria with molecular techniques, in-lake prevention measures and water treatment technologies. There is real enthusiasm among participants to contribute to their development and editorial meetings are already planned for the development of this material. In parallel, the network is very active in developing the database with information from every participant country. In addition, CYANOCOST seeks to take advantage of its network potential to develop strong consortia for European and international research projects in the subject area.

Aquatic **detox**

The **CYANOCOST** Action (COST ES 1105) is consolidating expertise and knowledge of detection and management approaches towards harmful cyanobacteria and their toxins in water sources to ensure best practices in water safety are consistently achievable across all of Europe

CYANOBACTERIA, ALSO KNOWN as blue-green algae, are common in surface waters and tend to form blooms in lakes and other freshwater bodies under various environmental and nutrient availability conditions. Exposure through drinking or bathing in cyanobacteria-contaminated waters can seriously affect human and animal health: the toxins they produce may damage the liver, kidneys, or central nervous system; or may cause respiratory or gastrointestinal problems.

Instances of water contamination by cyanobacteria have increased over the last decades and climate change, combined with demographic shifts, make an increase in the prevalence of current toxic cyanobacterial populations highly likely. Moreover, there is evidence that new species are also beginning to invade European waters.



ADVANCED PHOTOCATALYTIC PROCESSES FOR WATER DETOXIFICATION FROM CYANOTOXINS

SAMPLE OF A CYANOBACTERIAL BLOOM

WATER QUALITY

The quality of drinking water for human consumption needs to be continuously monitored by government authorities and water companies, but equally other sources and usages of water are under threat from these toxins: cyanobacteria and cyanotoxins can have a major impact on ecosystems, drinking water for livestock, fisheries, agriculture, recreation, tourism and also wildlife and conservation reserves. The costs of an outbreak can also be significant in financial terms: "The development of technologies to monitor and control cyanotoxins in aquaculture and tourism enterprises is a key step to minimise product and revenue losses," declare Dr Triantafyllos Kaloudis and Professor Ludek Blaha, Chair and Vice Chair of the CYANOCOST Action respectively. "Furthermore, occurrences of extreme algal bloom events that cause serious environmental and human health implications are not uncommon," indicates Professor Dion Dionysiou, a CYANOCOST member based in the US.

Of the cyanobacteria that threaten health, microcystins are particularly virulent. They are monocyclic heptapeptides produced by several species of cyanobacteria such as *Microcystis*, *Oscillatoria*, *Anabaena* and *Nostoc* and are found in a large number of variants: "The World Health Organization (WHO) has established a provisional limit of one microgram per litre in drinking water for the most common microcystin, Microcystin-LR, therefore obliging water utilities to apply suitable monitoring plans," Kaloudis explains. While there is a standard international method for determining whether microcystins are present in water samples, there is no established standard for analysing water for other cyanobacteria and cyanotoxins and no harmonised methodology for detecting and dealing with risks to water quality in Europe.

THE CYANOCOST ACTION

As Professor Geoffrey Codd of the Action's Steering Committee elaborates, the knowledge gained from the extensive past and current European research into the nature and management of toxic algal blooms is being pooled for the benefit of all European countries: "We hope to extend and increase recognition and awareness of the occurrence of cyanobacteria and cyanotoxins, and disseminate improved management tools to counteract their production and adverse effects, throughout Europe and beyond".

The objectives of CYANOCOST are primarily to protect public health through the transfer of knowledge and best practices to all end-users (public authorities, water companies, lake and other recreational water body managers, fisheries and agriculture); raise awareness of the health issues pertaining to toxic blooms; and protect enterprises and investments in the recreation, aquaculture, and agriculture sectors.

The work examines the results obtained by European research projects concerned with the question of cyanotoxins in water, and collects and compares the results to evaluate and utilise research from the past 25 years. This effort will not only maximise the benefits of the research already undertaken but also establish a baseline for optimising research resources across Europe in the future, to tackle gaps in knowledge, avoid duplication of effort, and foster excellence and innovation in scientific discovery.

CYANOCOST is therefore developing consistent risk assessment and management strategies and controls; transnational regulations, guidelines and standards; and better, innovative tools that maximise use of the data collected. The project started in April 2012 and is due to be completed in April 2016.

Dr Anastasia Hiskia, Grant Holder of CYANOCOST, is keen to highlight the strength of collaboration at this scale: "Administration of such a large international group can be very demanding, but the enthusiasm and willingness of participants and the excellent support we get from our COST officers makes our task easier".

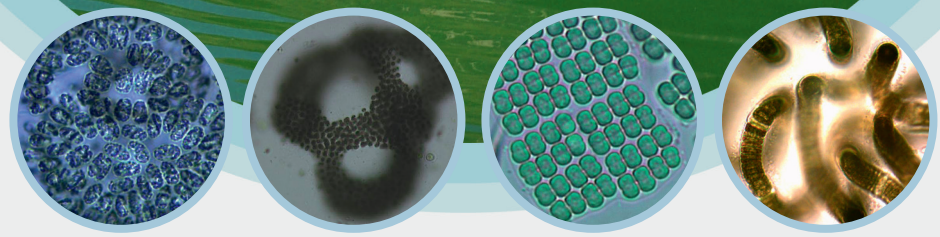
DISSEMINATING BEST PRACTICE AND STATE-OF-THE-ART KNOWLEDGE

Participants are organised into four Working Groups under the direction of the Action's Steering Committee: WG1 – occurrence of cyanobacteria and cyanotoxins, including methods for monitoring and analysis (led by Professor Linda Lawton and Professor Kaarina Sivonen); WG2 – fates, impacts and effects of cyanobacteria and cyanotoxins (led by Professor Geoffrey Codd and Professor Zorica Svircev); WG3 – prevention and control measures (led by Professor Petra Visser and Dr Anastasia Hiskia); and WG4 – end-user and outreach tools, materials and products (led by Luc Brient and Professor Antonio Quesada). The working groups share knowledge to ensure consistency and currency and also actively seek feedback from institutions, end-users and stakeholders.

The project will compare all available methods and practices with the goal of establishing a unified set of best practices for all scales involved. The Action will also address important subject areas such as: (i) proactive and reactive techniques for

CYANOBACTERIAL BLOOM

CYANOCOST MC-WG MEETING, MADRID, NOVEMBER 2012



MICROSCOPIC APPEARANCE OF VARIOUS CYANOBACTERIA

controlling cyanobacterial blooms; (ii) specific characterisation of cyanobacteria and cyanotoxins in all types of water sources to establish appropriate control measures; (iii) novel and rapid analytical and sensing methods to detect and quantify cyanobacteria and cyanotoxins; and (iv) drinking water treatment processes, including adsorption, membrane filtration, ferrate technologies and advanced oxidation processes for the treatment of cyanotoxins in sources of drinking water supply.

Simple methods for rapid detection of cyanotoxins in the field are also being developed in Europe. The partners are reviewing these to establish which may be suitable for widespread issue preferably on-site. This will increase detection capabilities in those European regions that do not have extensive high technology resources.

The consortium is also producing handbooks, journal special issues, and review articles that cover best practices for prevention and control of toxic cyanobacterial blooms; best practices for monitoring and analysis of cyanobacteria; molecular methods based on DNA and RNA for toxic cyanobacteria, cultivation and molecular identification, and detection methods for other potentially toxic cyanobacteria including cylindrospermopsin, anatoxin-a, BMAA and saxitoxin producers.

The Action will also assemble and produce a comprehensive database of research and researchers dealing with cyanotoxin risk and modify and distribute an existing decision support tool for better management of harmful cyanobacterial blooms. Blaha, Codd, Svircev and Quesada are coordinating efforts to design this database and collect data from every participating country. The visibility of all activities, data and knowledge produced and disseminated by CYANOCOST is also a major priority. A first version of CYANOCOST website is already available at www.cyanocost.com and is managed by Luc Brient. The Action additionally offers short-term scientific missions (STSMs) for researchers, as Professor Zorica Svircev, STSMs Manager of CYANOCOST explains: "There is a plan to grant as many as 12 STSM in the first year of the Action and our primary target group is early-stage researchers (ESRs)".

Dionysiou is especially keen to emphasise the international character of this network: "This CYANOCOST Action is instrumental in extending ongoing synergistic efforts as well as developing new collaborative activities between US and European researchers working in the field of harmful algal blooms and their implications. "CYANOCOST creates tremendous and exciting opportunities to help understanding this problem better and finding approaches to minimise it and address its effects," he adds.

Furthermore, in June this year, the American Chemical Society and the CYANOCOST Action are jointly staging a satellite workshop: 'Cyanobacteria and cyanotoxins in aquatic environments', during the EuCheMS International Conference on Chemistry and the Environment (ICCE 2013) in Barcelona. "We aim to open the field up to the scientific community with discussion of the latest information available," conclude Dionysiou, Quesada and Kaloudis, co-conveners of this event.

CYANOCOST (COST ACTION ES1105)

CYANOBACTERIAL BLOOMS AND TOXINS IN WATER RESOURCES: OCCURRENCE, IMPACTS AND MANAGEMENT

OBJECTIVES

To coordinate and network the ongoing efforts and capabilities across Europe for the risk management of cyanobacteria and cyanotoxins in water bodies, by establishing strong collaboration between academia, authorities, industry and citizens.

PARTNERS

Steering and Working Group Leaders:

Dr Triantafyllos Kaloudis (Chair), EYDAP SA, Greece • **Professor Ludek Blaha** (Vice Chair), RECETOX, Czech Republic • **Dr Anastasia Hiskia** (Grant Holder), NCSR Demokritos, Greece • **Professor Zorica Svircev** (STSM Manager), University of Novi Sad, Serbia • **Professor Linda Lawton** (WG1), Robert Gordon University, Greece • **Professor Kaarina Sivonen** (WG1), University of Helsinki, Finland • **Professor Geoffrey Codd** (WG2), University of Stirling, UK • **Professor Zorica Svircev** (WG2), University of Novi Sad, Serbia • **Professor Petra Visser** (WG3), University of Amsterdam, The Netherlands • **Dr Anastasia Hiskia** (WG3), NCSR Demokritos, Greece • **Luc Brient** (WG4), Universite de Rennes 1, France • **Professor Antonio Quesada** (WG4), Universidad Autónoma de Madrid, Spain

A full list of partners can be found here: **www.cost.eu/domains_actions/essem/Actions/ES1105?management**

FUNDING

CYANOCOST is COST Action ES 1105, funded by the European Cooperation in Science and Technology (COST)

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