

Testing Technology for Toxic Cyanobacterial Algal Blooms in Fresh or Salty Water



CONTENTS

- Toxic cyanobacterial blooms are a worldwide problem
- Cyanotoxin monitoring is required by various actors and segments
- Unique 2nd generation immunoassay testing technology
- Advances and examples



Turun yliopisto
University of Turku



Blue-Green Algae is a worsening global problem

- Cyanobacteria, also known as blue-green algae, form yearly mass occurrences in both fresh and salty surface waters worldwide



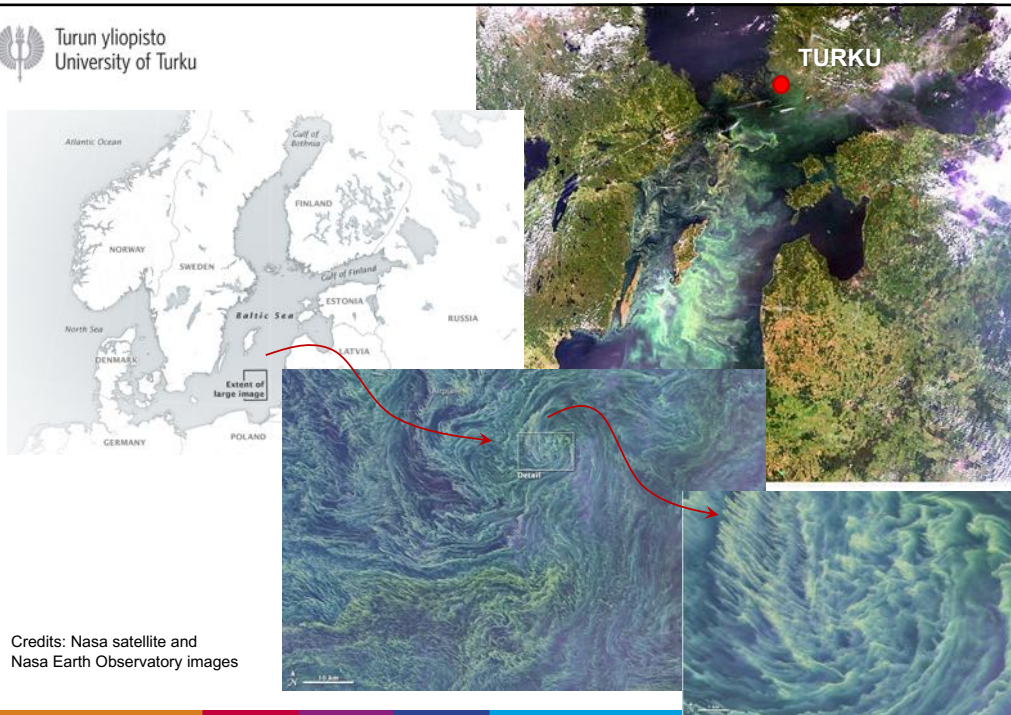
FIGURE 1. Map of the world showing where microcystins have been detected in freshwaters.

Zurawell, 2005

3



Turun yliopisto
University of Turku



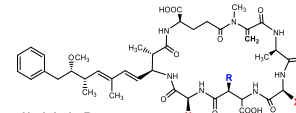
Credits: Nasa satellite and
Nasa Earth Observatory images

Microcystins and nodularins – most common cyanotoxins

- > 50 % of cyanobacterial blooms produce toxins (cyanotoxins)
 - The majority of these are microcystins and nodularins
- The cyanotoxins are hepatotoxic and cause various symptoms in people exposed to contaminated water (rashes, headaches, fever, diarrhea, abdominal pain, nausea, vomiting)

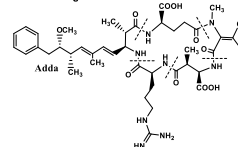
Microcystin Variants

Mw=823 g/mol + X+Y+R



Nodularin-R

Mw=825 g/mol



A polluted river in Shanghai

Photo: Reuters

<http://www.straitstimes.com/asia/east-asia/chinese-cities-cant-hide-water-pollution>

5

- Most significant health hazards and acute poisonings arise from the use of contaminated surface water (lakes, rivers, ponds) for preparation of drinking water
 - Microcystins have been associated with increased frequency of liver cancer in China and have caused deaths in Brazil
 - The toxins are not removed by boiling, chlorination, UV or sieving
 - There are no means to visually differentiate toxic and non-toxic strains
 - Blooming cyanobacteria can produce cyanotoxins in concentrations that kill livestock and wild animals drinking the water



Lake Taihu in China

Photo: Hans Paerl

<http://cen.acs.org/articles/94/i12/Scientists-debate-best-way-tame.html>

In Chinese:

<http://cen.acs.org/articles/94/i12/Scientists-debate-best-way-tame-cn.html>

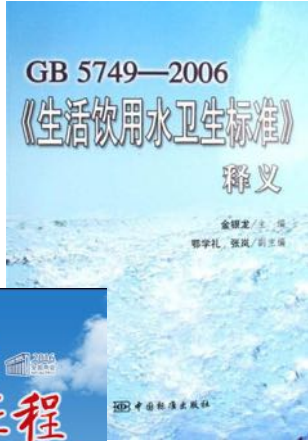

6

Turun yliopisto
University of Turku

VTT

Need for monitoring is recently recognized by authorities

- Maximum allowed level of microcystin regulated by WHO and areally/nationally in EU, Australia and Asia
 - typically 1 µg/L in drinking water
 - 20 µg/L in recreational water
- In China, GB 5749-2006 "National standards for drinking water quality" also sets the maximum limit at 1 µg/L
- Cities across China are urged to meet this national standard
- The monitoring of algal risk for urban water plants is noticed as a specific concern the 13th 5 year plan in China

7


Turun yliopisto
University of Turku

VTT


Tools to detect cyanotoxins

- Immunoassays (antibody-based assays)
 - Easy-to-use tools for toxin detection
 - Robust – not prone to technical problems
 - Adaptable for both low and high sample numbers
 - Multiple applications, can be used:
 - At sampling site or in laboratories
 - By specialist or even by consumers
- HPLC or MS^{*)}
 - Detailed information on the toxin composition of the sample
 - Laborious & limited to laboratory use, require:
 - Specialized personnel
 - Sophisticated and costly instruments
 - More suitable for further analysis of + samples


Example:
Toxin testing by authorities



First-line screening by immunoassay



Analysis of positive samples, when needed, by HPLC/MS



Detailed characterization

^{*)} HPLC = High Performance Liquid Chromatography
MS = Mass Spectrometry

8

Who needs monitoring of cyanotoxins?

Authorities (China)

- The 13th Five-Year Plan states that >70% of China's surface water must reach Grade III (scale I-V) by 2020
- In 2015, 66% reached Grade III
- Pollution control programs in use
- Monitoring is mandatory

Researchers

- Toxin occurrences of algal blooms: where and when?
- Epidemiologic studies; efficiency of water purification strategies to cut down health problems

Aquafarmers

- Cyanotoxins accumulate to fish and shellfish
- For example see Peng et al: *Health risks associated with consumption of microcystin-contaminated fish and shellfish in three Chinese lakes: significance for freshwater aquacultures.* *Ecotoxicol Environ Saf* 2010;73(7):1804-11

Farmers

- Microcystins can be lethal to livestock
- The toxins also inhibit the growth of crops

Citizens

- Safety for recreational use and watering
- In many rural areas pond and lake water is also directly (or after minor purification) used as drinking water



Turun yliopisto
University of Turku



Innovation by the University of Turku, Finland: 2nd generation immunoassay technology for testing of cyanotoxins in water samples


- Broad-spectrum high-performance immunoassays based on validated components (antibodies)
- The patented 2nd generation assay brings significant advances compared to competitors immunoassays
 - Highly increased practicability and performance of the toxin assays compared to the 1st generation assays on the market
- The technology and components fit to different scales and assay formats and can be adapted to existing testing platforms
- Opportunity to Chinese test developers and manufacturers to fulfill the extensive and diverse needs of the various customer segments

Turun yliopisto
University of Turku


VTT

Demonstrated assay formats

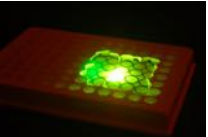
- At the university, the technology has been successfully fitted in various assay formats
 - Studied tests are not commercially available
 - Technique and antibodies are available for licensing
- The assay can be easily adapted to any immunoassay testing platform selected, e.g.
 - Single-use quick tests
 - High-scale monitoring tests (various automated formats)




Quick test (similar to pregnancy test)



Quick test (incorporated in test card)
https://www.youtube.com/watch?v=WhgwaOS_-ek



High-performance test format (fluorescent label)
Akter et al Anal Chem 2016



Simple screening test (coloured label; needs no sophisticated instrumentation)
Akter et al AIOL 2017

11

Turun yliopisto
University of Turku

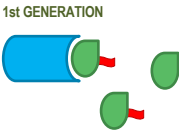
VTT

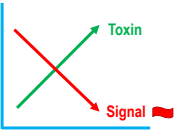
Generic assay – Single test detects all the major cyanotoxins in one reaction


- Unique 2nd generation assay concept:
Direct toxin detection:
More toxin means more signal, resulting in an assay which is:
 - More sensitive
 - More reliable
 - More robust
 - Rapid
 - Easy to interpret
 - Easy to manufacture!

... compared to competitors indirect 1st gen assays (where signal is inversely proportional to toxin concentration)

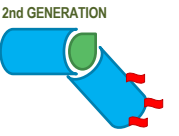
1st GENERATION

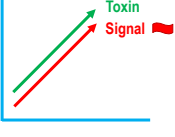







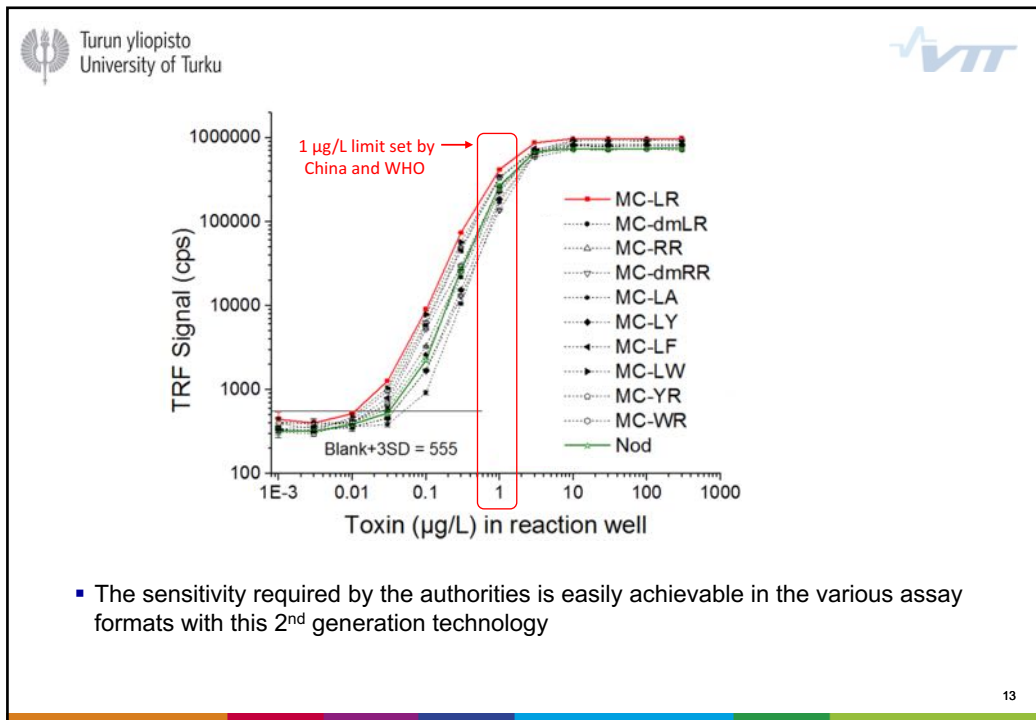
2nd GENERATION







12



For further information, please contact:

Piia von Lode
Innovation Manager, PhD

piia.vonlode@utu.fi

Development Services / Innovations
University of Turku
FINLAND

www.utu.fi/tto



Turun yliopisto
University of Turku