U.S. Environmental Protection Agency, Office of Research and Development

SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM

RAC Meeting

SSWR 404.2 – Management of HABs in the Built and Natural Environment

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Harmful Algal Blooms (HABs) Overview

HABs have the potential to pose human and environmental health risks

HABs have the potential to generate adverse economic impacts

Partners have identified HABs research needs in toxicology, epidemiology, watershed management, economic analysis, treatment, and monitoring/prediction

ORD HABs Research

Research is organized into 3 areas:

Health Effects and Toxicity

Managing HABs in the Built and Natural Environment

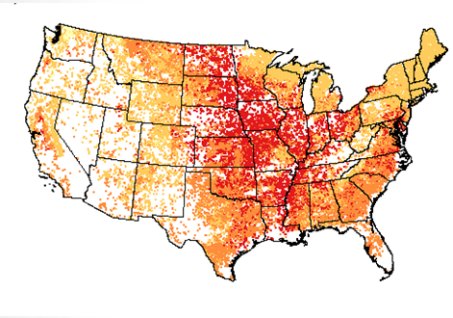
Science of Harmful Cyanobacteria Bloom Forecasting

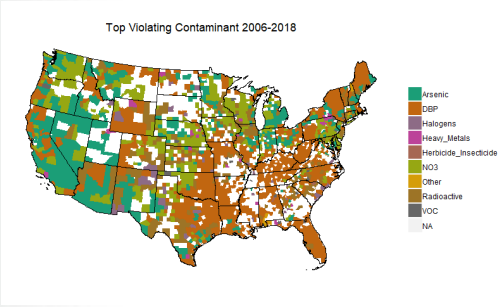
Managing HABs in the Built and Natural Environment (Output 404.2)

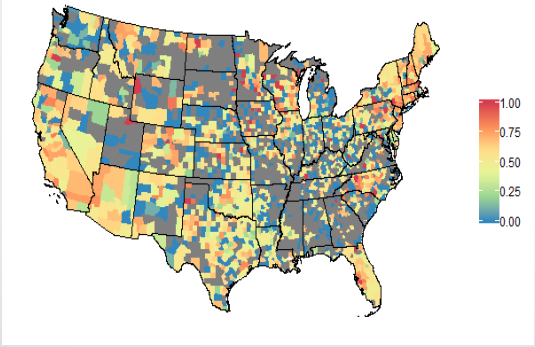
Developing a rigorous framework for identifying water sources and drinking water systems vulnerable to HABs, evaluating the efficacy and impacts of chemical and physical HABs interventions applied to source waters, and evaluating the efficacy and impacts of interventions applied to remove cyanobacterial biomass and metabolites from drinking water.

- Vulnerability assessment for risk of harmful algal blooms (HABs) on U.S. public drinking water supplies
- Surface water interventions for HABs management
- Drinking water interventions for HABs management

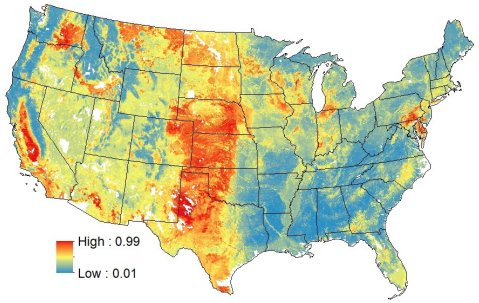
Public water system vulnerability to HABs

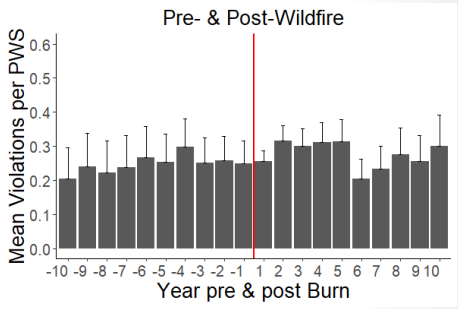






Spatial and Temporal Information on Drinking Water Violations that may be affected by HABs





Overall estimate of public water system vulnerability

Contact: Michael Pennino
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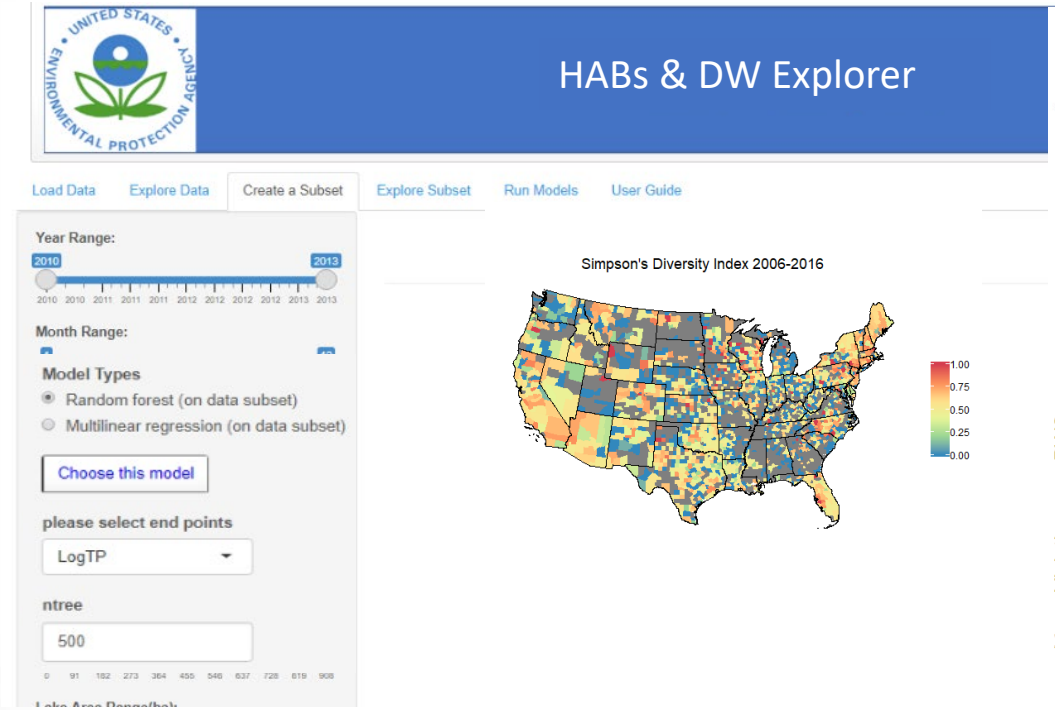
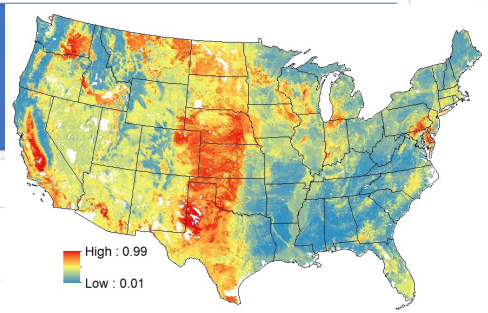
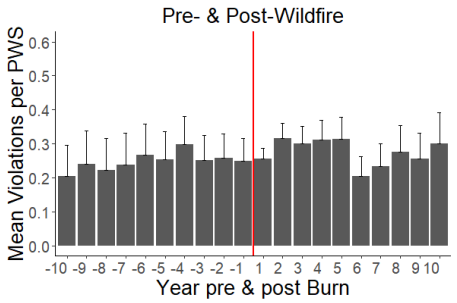
Water system vulnerability accomplishments to date

- Title: Vulnerability Assessment for Risk of Harmful Algal Blooms (HABs) on U.S. Public Drinking Water Supplies
  - Link: https://rapid.epa.gov/rapid/product/1271/summary
- HABs Risk Modeling – Prediction Maps for Chl-a concentrations (a proxy for HABs) across CONUS, generated by Meredith Brehob
- Obtained maps on drinking water source locations from Office of Water.
- R code generated for processing time series of drinking water data from SDWIS and for summarizing drinking water violations data at NHD catchment scale, in order to match with HABs locations.
- Task Order SOW submitted into EAS to have contractor obtain information about drinking water system operational capabilities (treatment, managerial, financial, etc.), during FY24.

Public water system vulnerability to HABs







Control of cyanobacteria (HABS) for the entire summer by the addition of glucose

Challenge: Controlling HABS without Toxic Chemicals (sub-product SSWR 404.2.2.6)

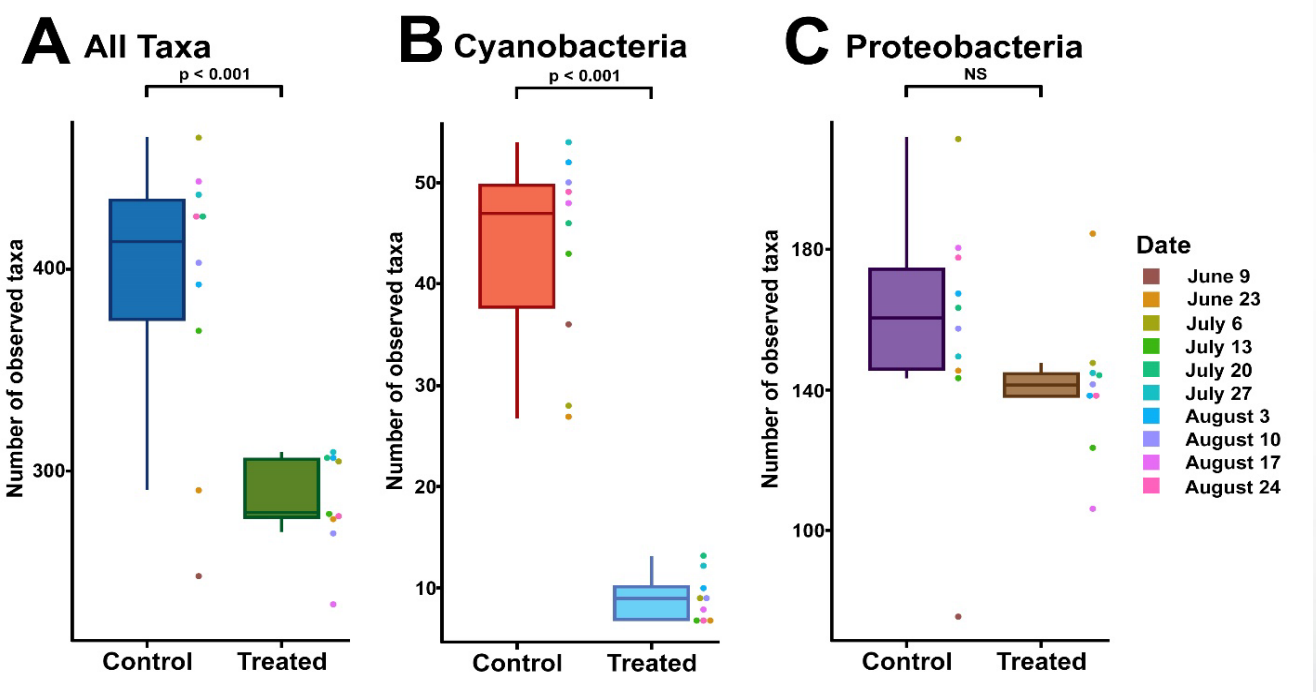
Approach: Additions of Harsha Lake water were made each week of the summer to either a Control or Glucose-treated mesocosm. High-throughput sequencing of DNA extracts from weekly samples from each mesocosm were used to establish any changes in the bacterial community. The amplicons generated from each sample extract were processed using the software suite QIIME 2 2021.4.0.

Results: Cyanobacteria were nearly eliminated from the Glucose-treated mesocosm compared to the Control mesocosm (see B below) [also, reflected in the overall taxa diversity (A)]. However, the diversity of the Proteobacteria were unaffected by the glucose (C).

Impact: Glucose may be a non-toxic method of controlling HABS. The next step is to determine a practical method of implementation.

Number of observed taxa in Control versus Glucose-treated mesocosms.

(A) All bacterial taxa
(B) Cyanobacteria
(C) Proteobacteria



Contact: Ian Struewing; struewing.ian@epa.gov

Using fluorescence to measure the impacts of treatment and stress

Problem: Need a method to evalute the growth and health and effect of algicides of cyanobacteria that can be applied to lakes, ponds, and reservoirs with the aim of monitoring mitigation.

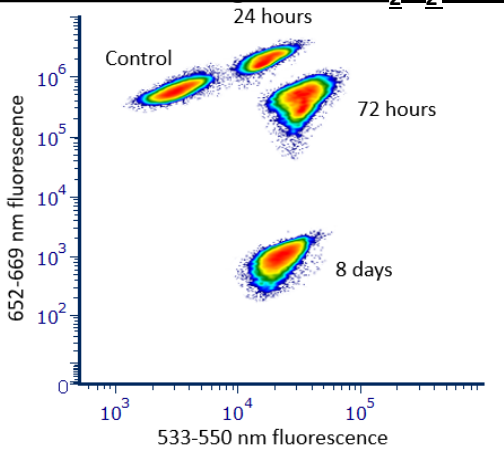
Action: The use of flow cytometry to measure fluorescence emission from cyanobacteria to evaluate the effect of different algicides and nutrient deficiency.

Results:

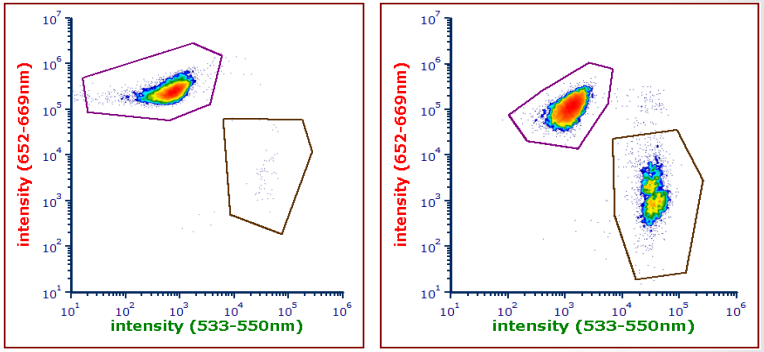
- Initial increase of red fluorescence from Hydrogen peroxide followed by a decrease as the cell becomes stressed.
- Increase in green fluorescence in response to chemicals and nutrient deficiency.
- Publication: PLOS Water: Analysis of Microcystis aeruginosa physiology by spectral flow cytometry: Impact of H_2O_2 and light exposure

Impacts: Useful method to monitor the effect of algicides and nutrient deficiency which can be applied for mitigation application of blooms and water systems

Fluorescence changes after H_2O_2 treatment



Nutrition deficiency of cells in aging media



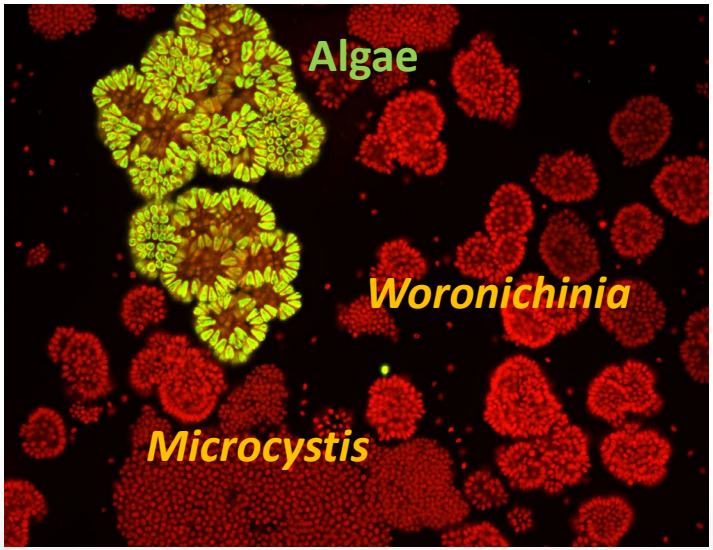
Contact: Robert Zucker
zucker.robert@epa.gov

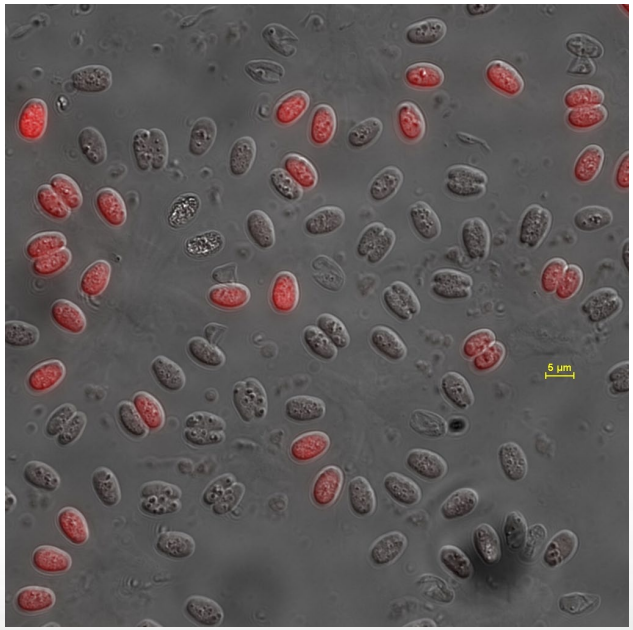
Monitoring for improved HAB assessment and characterization

Problem: Detect, monitor and predict the emergence of HABs in several freshwater systems in the U.S.

Action: Fluorescence microscopic techniques are used to characterize algae and cyanobacteria based on their specific absorption of different wavelengths of light and their subsequent emission.

Impact: Provides an easy technique to detect organisms in a water body with better accuracy than conventional microscopy techniques.





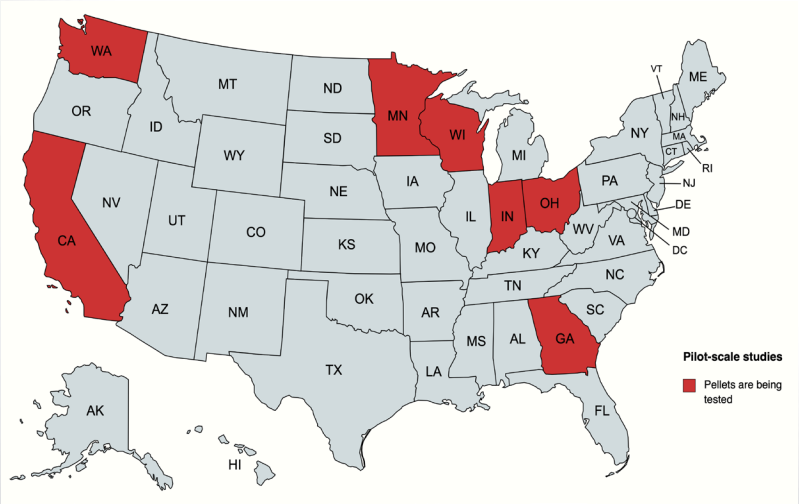
Contact: Robert Zucker *zucker.robert@epa.gov*

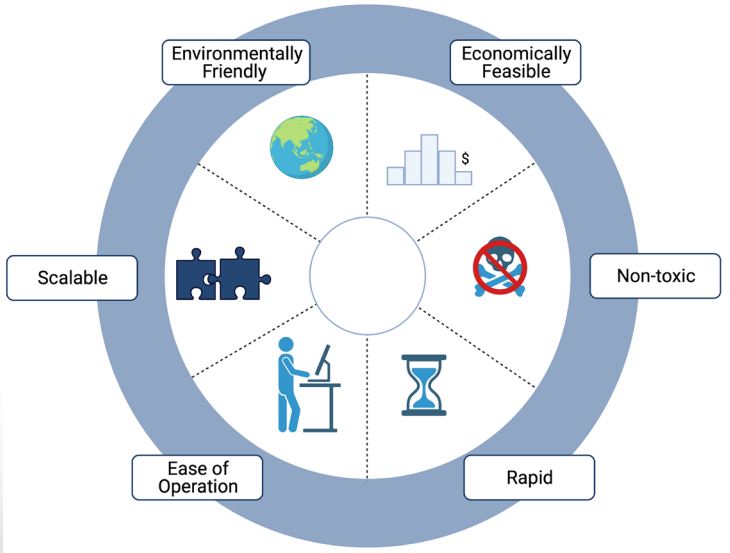
Biocompatible nutrient adsorbents

- Synthesized magnesium carbonate pellets have been thoroughly **characterized** in terms of size, bulk density, strength, and adsorption capacity.
  - Adsorption capacity: 81 mg/g
  - Bulk density: 38.6 lb/ft^3
  - Pellet size: 2.3-6.3 mm

Contact: Mallik Nadagouda
nadagouda.mallikarjouna@epa.gov

- To **enhance phosphate selectivity and decrease cost**, a range of mechanically stable pellets were prepared by blending different ratios of magnesium carbonate and alumina to optimize the pellet design and generate a more **cost-effective** sorbent.
  - Magnesium carbonate blended with alumina (i.e., blended sample) exhibited **higher stability** ($105 \pm 59\ N$ compared to $53.4 \pm 17.4\ N$) consistent with thermal analysis.
  - Unblended magnesium carbonate demonstrated **higher adsorption capacity** than the blended material (81 mg/g compared to 72 mg/g).





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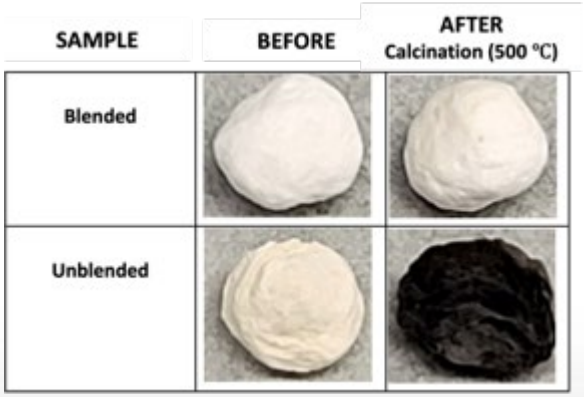


Food web effects of HABs

Challenge: To interpret and forecast how HABs affect aquatic ecological communities (and vice versa).

Approach: Building infrastructure for lab experiments, eDNA sampling, in-silico investigations, and HABs monitoring and risk communication.

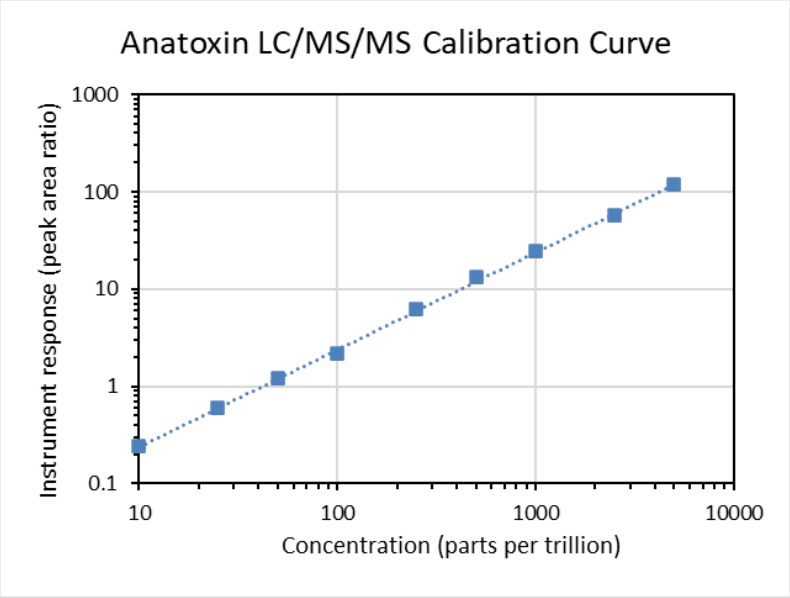
Results:

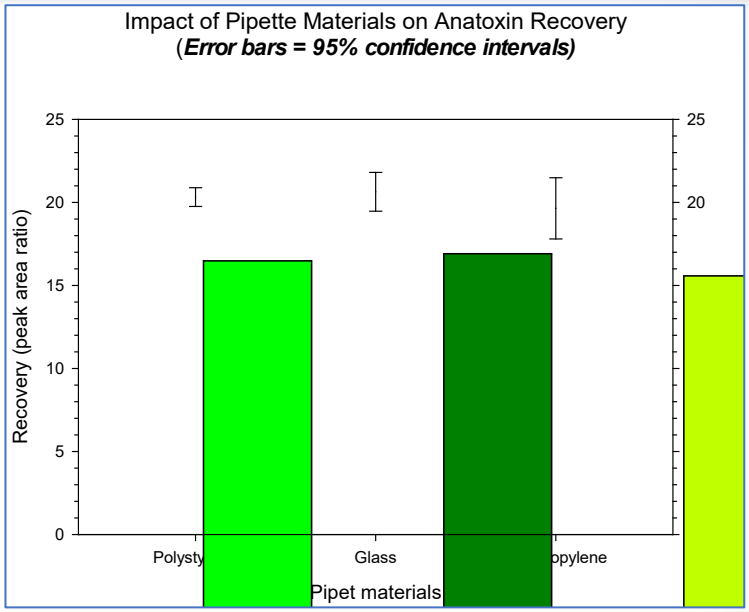
- Establishment of a GLTED toxic cyanobacteria culture facility.
- Collection of >100 eDNA samples from various sites, organisms, and times in L. Superior and L. Ontario.
- Expansion of the ECOTOXicology Knowledgebase to include nearly 100 different cyanotoxins.
- Creation of the Lake Superior Bloom Bulletin.

Impact: Ability to: (1) study causes and consequences of HABs and non-target effects of algaecides used to control HABs; (2) cross-validate and refine eDNA- and fluorescence-based methods; and (3) inform and liaise with partners.

Contact: Aabir Banerji; banerji.aabir@epa.gov

Removal of anatoxin by powdered activated carbon (PAC)





Challenge: To evaluate the impact of changing background water qualities on the removal of anatoxin by PAC.

Approach: Bench-scale trials varying PAC type and background organic matter; also examine the impact of floc entrainment. Analysis by LC/MS/MS. First step is preliminary experiments to evaluate potential for anatoxin loss onto common lab materials.

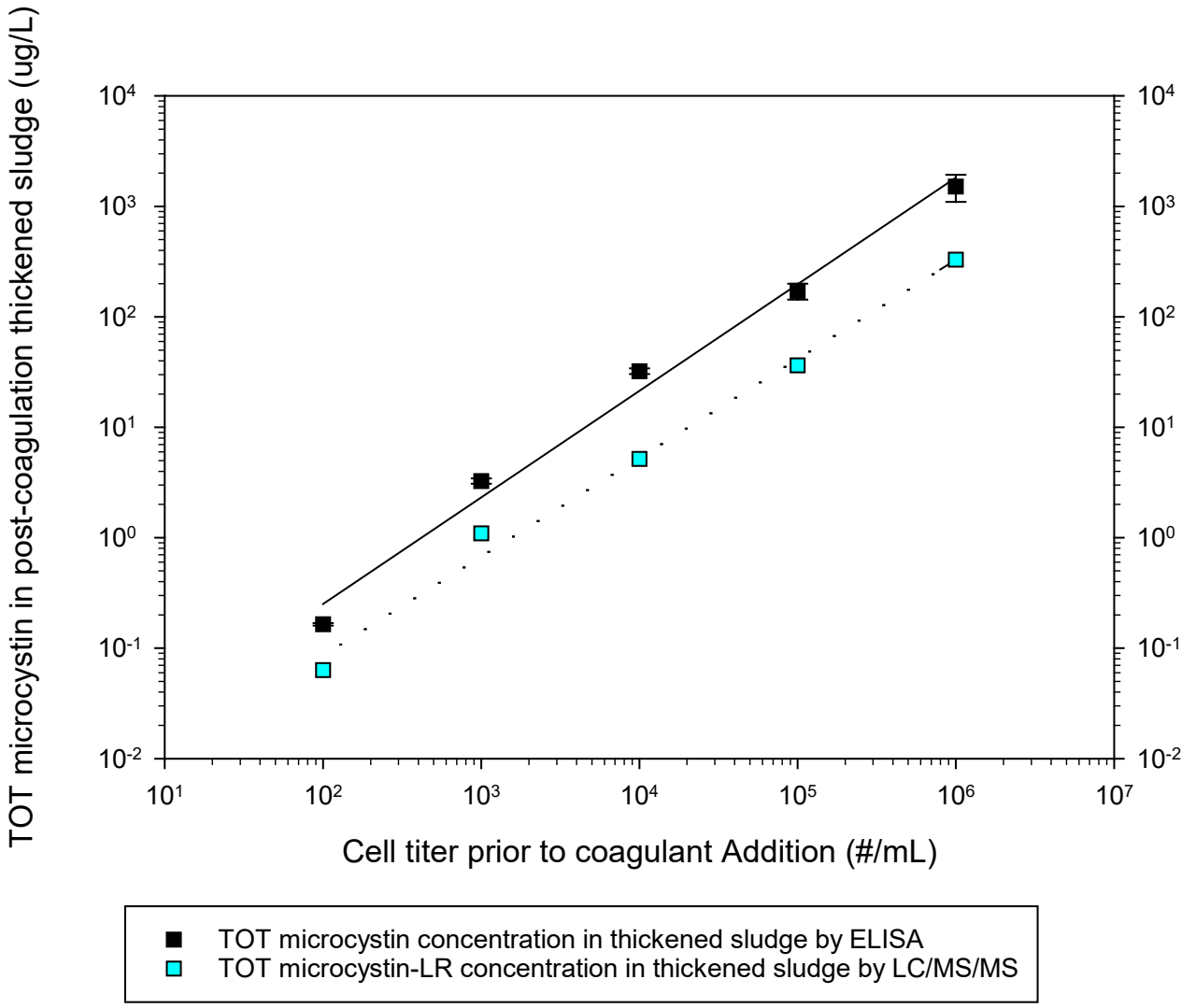
Results: Analytical method up and running. Experiments to evaluate potential sources of anatoxin loss due to complete by end of FY23.

Impact: Treatment guidance for drinking water utilities

Contact: Nicholas Dugan; dugan.nicholas@epa.gov

Recovery of cyanobacteria and toxins from water treatment sludges

- Predictable relationship between pre-coagulation cell counts and toxin concentrations in sludge
- Toxins can be measured in sludges when pre-coagulation concentrations too low for measurement
- Good agreement between ELISA and LC/MS/MS
- Analysis work with real-world Ohio river water
- Sludge analysis procedure is technically accessible



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