Active Early Detection and Diagnosis of HABs with Scalable Biological Treatment Strategies

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USACE Harmful Algal Bloom Research & Development Initiative

Delivering scalable freshwater HAB prevention, detection and management technologies through collaboration, partnership and cutting-edge science

The main objective of the project is to develop multi-dimensional technologies for the early detection and management (mitigation and treatment) of harmful algal blooms (HABs). By the completion of the 3-year research project, the team aims to develop and validate cutting-edge HAB diagnostics to improve the timeliness of decision making for source-water treatment and will find optimum algaecides and biological treatment methods on HAB-impacted reservoirs; thus, developing a robust dataset and recommendations linking novel HAB diagnostics with treatment performance. Novel sensors can detect catastrophic HAB cell lysis and toxin release events in source water on a scale of minutes to hours, in time for managers to respond appropriately. Meanwhile, the molecular techniques will be able to characterize the microbial community, including both the cyanobacteria and the viruses (cyanophages) that target the cyanobacteria, in the days and weeks leading up to a lysis event – providing a longer-term picture of HAB risk. Together, the approaches in this study may be able to provide real-time and longer-term assessments of bloom health in large water bodies as well as guiding the application of biological and chemical treatment methods for optimum performance in HAB-impacted reservoirs.

During the second year of the project, several tasks were completed under each objective:

OBJECTIVE 1: Two algal fluorometers (PhycoSens and PhycoLA) were successfully tested. The summer 3-month deployment of the PhycoSens at the Toledo WTP characterized the types and amounts of algae entering the plant. PhycoSens also detected and reported unbound phycocyanin (uPC) in real time corresponding with increases in extracellular/cell-bound toxin ratios (determined later) in Lake Erie. In lab experiments PhycoSens and PhycoLA provided high- resolution data on the appearance of uPC following treatment of Microcystis lab cultures with cyanophages and algicides, again corresponding with release of toxins from cells. PhycoLA successfully characterized algal samples from lake monitoring samples throughout summer 2022 and detected uPC in several late-summer samples.

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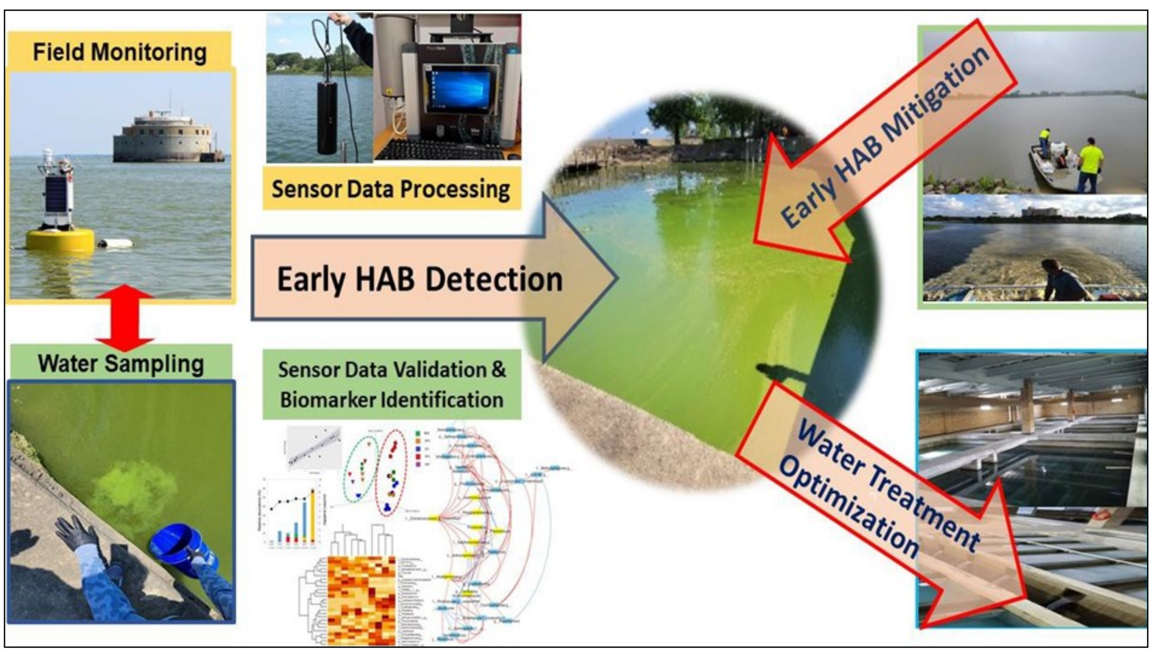

Figure 1: *A schematic diagram for the project goal*

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OBJECTIVE 2: Biweekly samples were continuously collected in both Lake Erie and Grand Lake St. Marys. Multiple additional sampling locations were newly included in Lake Erie to better capture microbial activity before, during and after cyanoHABs. Physicochemical and pigments parameters were monitored to understand cyanoHABs, and toxin levels were also measured by using LCMS/MS. Microbial dynamics of cyanobacterial species and their neighboring community were investigated via amplicon sequencing (16S, 18S, and fungal ITS), and their functional roles on cyanoHABs were investigated by using metagenomic sequencing (bacterial and viral DNA). Multi-omic data were further aligned with QPCR (targeting cyanobacterial 16S, mcyE, and mlrA genes) and water parameter data to validate the candidate biomarkers for early warning of cyanoHABs. Data driven machine learning approach (de novo approach by combining sequencing data) is also additionally considered to efficiently integrate rich multi-omic and physicochemical data to find early warning biomarkers.

OBJECTIVE 3: Both lab and field tests (mesocosm tests at Lake Erie and full-scale field tests at a reservoir in Bowling Green Ohio) were conducted for selected commercial algaecides. The influence of commercial algaecide treatment on cyanobacteria inactivation and the release of algal organic matter and toxins, as well as on microbial community responses were monitored. Additionally, the team also explored new methods of controlling cyanobacteria by targeting carbon dioxide fixation and evaluating the efficacy of cyanophage treatment. They found that a combination of cyanophages and low-dose algaecide treatment was effective in controlling cyanobacteria blooms and that the lytic activity of cyanophages was enhanced with low-dose peroxide treatment. The team also constructed and tested lab-scale biofilters using cyanotoxin-degrading bacteria for removing microcystin-LR, which were found to be effective in removing microcystin-LR with reduced lag phage time for toxin Biodegradation.

Research findings of the project have been disseminated through peer-reviewed journal articles and presentations at national and international conferences. From the results of the first two years of the project, the team has published two peer-reviewed journal articles and presented research findings at thirteen conferences. Additionally, five manuscripts are currently in preparation for submission.

Figure 2: *Tested mesocosm setup at the western basin of Lake Erie*