Determining Environmental Triggers of HAB and Toxin Production for the Purpose of HAB Prediction, Detection, and Management (HAB-PDM) in Flowing Waters

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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.

Problem

Harmful algal blooms (HABs) in riverine ecosystems are increasing in severity and frequency. Understanding what has caused this increase is complicated due to the complex hydrogeology, water quality, and biology associated with riverine ecosystems. The additional variability associated with managed river ecosystems further complicates our knowledge of algal community dynamics in such systems. While the general conditions that support bloom formation (i.e. low flow, high temperatures, and nutrient abundance) are understood, the interaction of these factors with the complex hydrology of managed riverine ecosystems and the algal community dynamics in these systems have not been well characterized, leading to data gaps for bloom prediction and management. Specific predictions of bloom timing and location and an ability to thwart bloom development, predict the extent of toxin production, reduce bloom duration, or effectively remediate blooms are all dependent on understanding biotic and abiotic conditions in these complex and poorly described ecosystems.

Objective

There is a definitive need to understand algal community dynamics and HAB development in managed river ecosystems. This research addresses data gaps identified in understanding of hydrology and ecology in these systems with application of the knowledge for bloom prediction and management. Specific objectives of the research are as follows: (1) detect: identify HAB sources, ecological triggers, and regulators of cell growth/toxin production; (2) predict: develop hydrodynamic, hydrologic, and machine learning models to simulate the role of hydrology, nutrients, and light attenuation on HAB growth; and (3) Manage: Investigate how riverine management affects HAB formation.

Approach

Our collaboration takes a broad approach to the diverse objectives aiming to fill data gaps by identifying HAB sources, identifying HAB triggers and cell growth/toxin production mediators, investigating the role of managed river hydrology in bloom formation, and preparing for the scalability and transferability of methods and tools developed. Field efforts in tributaries and the mainstem of the Ohio River investigate algal sources and community dynamics in the managed river ecosystem. Simultaneous laboratory efforts investigate cell growth and HAB triggers to support the field investigations and inform predictive models. Congruent hydrologic and hydrodynamic modeling efforts, along with statistical evaluations and machine learning efforts, test multiple approaches to bloom prediction and management. Project outcomes will include protocols/guidance for data collection for HAB monitoring and predictions, and a predictive tool for HABs in a managed river ecosystem.

Figure 1. *The Ohio River.*

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Major Milestones

Date	Milestone
FY24, Q1	Contribution of landscape/basin scale hydrologic and water quality loadings to HABs in the Greenup Pool of the Ohio River. Technical report and/or white paper, input to hydrodynamic model.
FY24, Q2	Use of machine learning models to determine critical ecological parameters contributing to HAB formation. Technical report and/or white paper, input to hydrodynamic model.
FY24, Q4	Field study and analysis informing the contribution of tributaries to mainstem HAB formation, as well as filling data gaps on managed river ecosystem algal community dynamics and providing input for hydrodynamic, hydrologic, and machine learning models. Technical report and/or white paper.
FY24, Q4	Laboratory determination of environmental triggers/thresholds for algal growth and toxin production. Technical report and/or white paper.
FY24, Q4	Summary of tributary influences on mainstem HAB conditions to support mainstem modeling efforts. Technical report and/or white paper, input to hydrodynamic model.
FY25, Q3	Hydrodynamic model and scenario analysis for predicting/managing HABs in the Greenup Pool of the Ohio River. Technical report and/or white paper.
FY25, Q3	**Technical Report:** Guidance for data collection for optimal HAB detection.
FY25, Q3	**Technical Report:** Guidance for data collection to inform HAB predictive tool development.

Partnership/Leveraging Opportunities

This work will leverage multiple collaborations and other work units. Additionally, this effort utilizes the cross disciplinary expertise of the collaborators, representing biological, toxicological, and engineering disciplines from five universities. Our modeling and machine learning efforts will leverage available data from academic, public, and private sector sources to maximize the use of available data.

Value to USACE Mission

This research will alleviate disruption of aquatic uses due to adverse impacts from HABs, which are notable at USACE projects authorized for transportation, aquatic recreation, and water supply. Our efforts will increase the knowledge of HAB formation requirements and improve risk assessment and management of HABs in ecosystems with USACE management and oversight by providing methods for the monitoring, prediction, and management of HAB development, as well as a framework scalable and transferable to other managed river ecosystems.