Cyanophage Treatment Development for Mitigating Freshwater Cyanobacteria HABs

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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) are an environmental problem of increasing concern because they directly affect public health and environmental quality. Viruses that exclusively infect cyanobacteria, cyanophages, are perhaps the most abundant, but also the most underutilized, biological resource on Earth. It is believed that cyanophages hold great promise and can be harnessed to mitigate cyanoHABs in a species-specific fashion, thanks to their host specificity.

Objective

Develop a novel mitigation biotechnology by exploring the lytic life cycle of cyanophages.

Approach

The first step was to isolate, identify, and characterize cyanophages from environmental samples collected from HABs-affected lakes. Methods were developed to infect cyanobacterial cultures with cyanophage, optimize biotic and abiotic conditions for inducing lytic life cycle, and quantify the disruption of cyanobacteria caused by cyanophage infection.

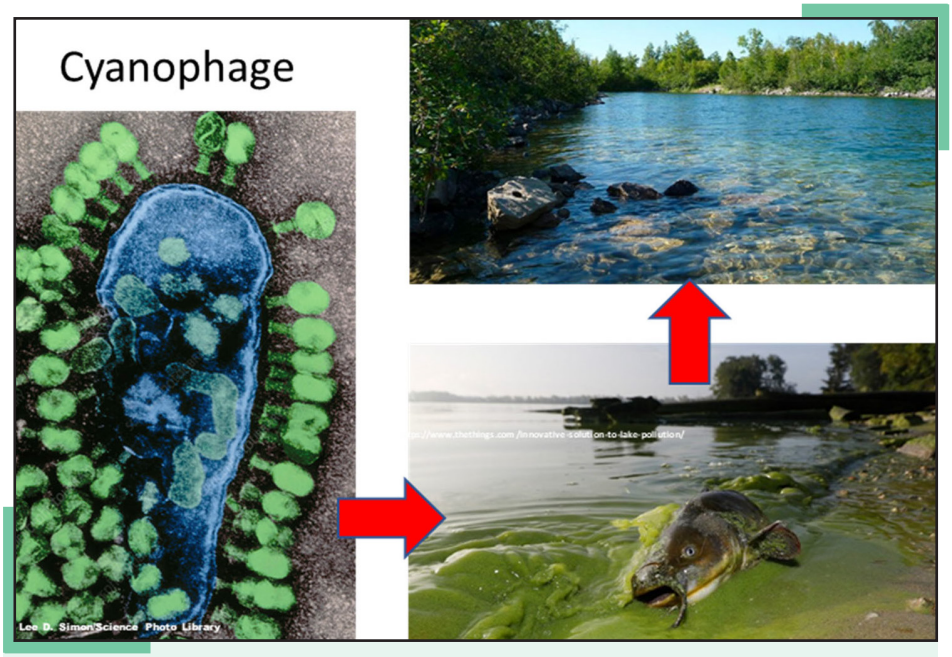

Figure 1. *Cyanophage-based biotechnology (left) to be developed for restoring HAB-impacted lakes and reservoirs (bottom) to balanced, HAB-free state (top).*

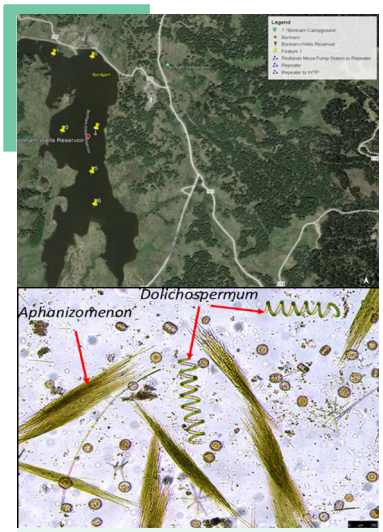

Figure 2. *Sampling sites in Bonham Reservoir, Colorado (top), and microscopic cyanobacteria identification (bottom).*

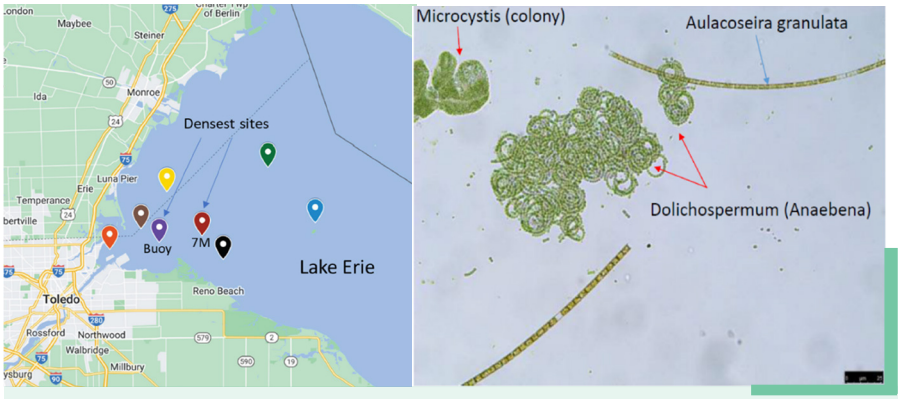

Figure 3. *Sampling sites at Lake Erie near Ohio (left), and microscopic image of isolated cyanobacteria (right).*

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Results

A wide range of multiplicity of infection (MOI) can be considered for cyanophage-based HAB control. When the cyanophage/cyanobacteria ratio is higher than 1:10,000, the HAB may be controlled.

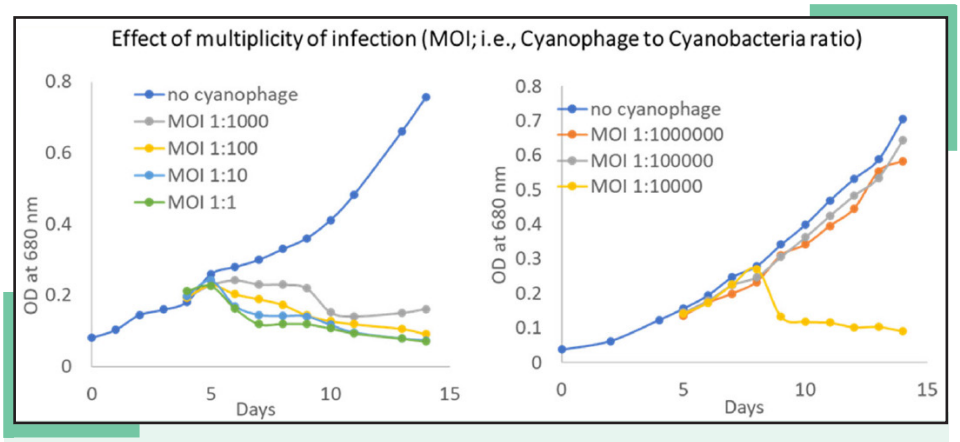

Figure 4. *Determination of multiplicity of infection for lytic phage Ma-LMM01 to its host M. aeruginosa NIES-298.*

Major Milestones

Deliverables	Description
Publications	**Journal Article:** Grasso, et al. 2022. "A Review of Cyanophage-Host Relationships: Highlighting Cyanophages as a Potential Cyanobacteria Control Strategy." *Toxins* 14:385. https://doi.org/10.3390/toxins14060385. **Tech Report:** "Physical/Chemical Induction of Lytic Cyanophage Life Cycle." ERDC TR (in prep).

Partnership/Leveraging Opportunities

This work leverages multiple collaborations and other ERDC work units, including "Small Regulatory Ribonucleic Acids for the Control of Harmful Algal Blooms," "Rapid, Portable, and Multiplexed Detection of Freshwater Harmful Algal Bloom-Forming Genera," and "Development of a Near Real-Time Field Test Kit for the Rapid, Simultaneous Detection, and Quantitation of High Priority Toxic Cyanobacteria."

Value to USACE Mission

This project should result in the development of a novel, cost-effective, species-specific, and environmentally benign technology for HAB treatment in lakes and reservoirs. Such a technology would greatly benefit HAB management at USACE lakes and reservoirs.