Flocculation of Freshwater Microalgae Using Naturally Derived Biomolecules

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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) have increased in frequency and distribution, impacting communities throughout the US Chemical based treatments for HABs can not only introduce harsh chemicals into the environment, but also prompt the release of toxins from damaged or dying cyanobacteria cells. Thus, alternative treatments using natural materials to bind and precipitate microalgae is of great interest.

Objective

The objectives of this work were to (1) assess the binding efficiency/affinity of naturally derived compounds including chitosan, bio-based cationic compounds, and various types of modified clays (or any combination of chitosan, starches, or clays) to two cyanobacteria species (*Microcystis aeruginosa* and *Anabaena* spp.) typically found in freshwater systems,and (2) determine the stability of algal flocs over time under static and turbulent conditions.

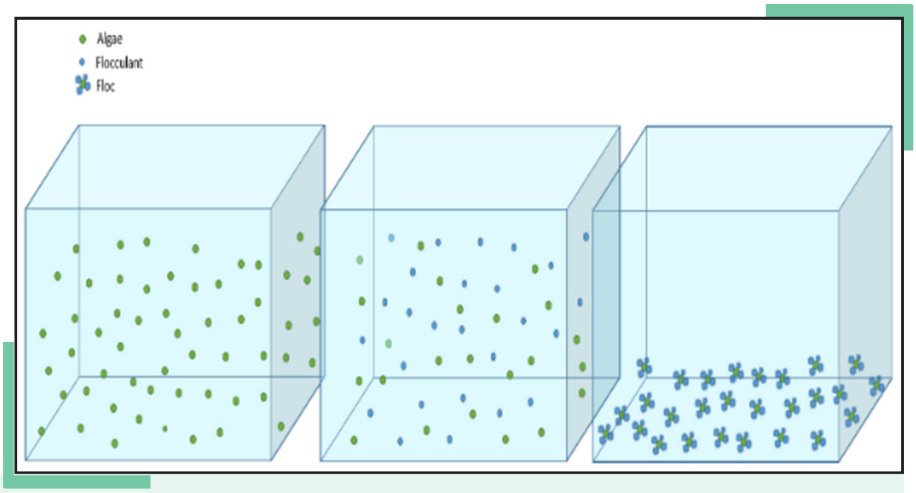

Figure 1. *Schematic illustration of the anticipated behavior.*

Approach

We evaluated the binding affinity of the test amendments to cyanobacteria species and determined optimal dosing amounts using experiments performed under conditions of varying pH and dissolved oxygen (DO) concentrations. Flocculation and precipitation kinetics were also determined under static and mixing conditions. The highest performing amendment and/or application ratios were down-selected for further testing of mixed cyanobacteria cultures in the presence of sediment at mesocosm scale in a wave simulation tank. Commercially available polymers used in experimentation, BioFlow and GeoFlow, were composed of chitosan acetate and a proprietary blend of bentonite, zeolite, and calcium carbonate, respectively. Flocculation and precipitation tests were performed in the presence of total suspended solid (TSS) sediment concentrations up to 220 mg/L, mimicking high turbidity water.

Figure 2. *Precipitated algae flocs formed from (left to right) BioFlow + chitosan flakes; BioFlow + GeoFlow; chitosan powder + modified bentonite clay; and chitosan flakes + modified bentonite clay.*

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Results

Evaluations indicated that two amendment combinations were most effective in binding and precipitating cyanobacteria: (1) BioFlow (a commercially available form of chitosan acetate) + GeoFlow (a proprietary blend of bentonite, zeolite, and calcium carbonate) and (2) Bio-Flow + chitosan flakes (1.6–2.5 mm). Regarding floc stability, flocs formed by the BioFlow + chitosan flake combo were unaffected by fluctuating pH (4–10) and DO concentrations. The BioFlow + GeoFlow combo, however, yielded pH-dependent floc; increasingly acidic conditions (less than pH 5.5) caused the resuspension of flocs back into solution. Flocculation and precipitation tests showed that increasing TSS concentrations improved precipitation rates, likely due to the formation of larger, heavier particles. However, in wave tank simulations, flocculation and precipitation of algae was less effective due to low intensity mixing induced by wave motion. Although the chitosan acetate + chitosan flakes combo demonstrated efficacy to induce sedimentation of algal flocs in the presence of suspended sediment, wave simulations suggest that open water application of the materials is not recommended.

Figure 4. *Algae flocs in wave tank formed by BioFlow + chitosan flakes.*

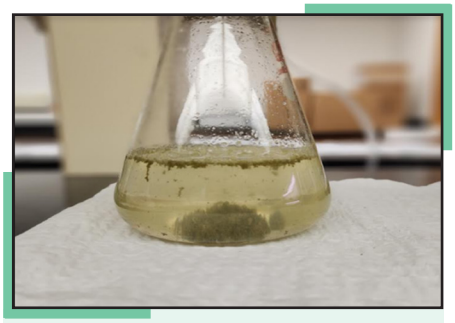

Figure 3. *Algae floc formed by Bio-Flow + chitosan flakes in the presence of suspended sediment at the highest tested TSS concentration (220 mg/L).*

Major Milestones

Deliverable	Description
Publication	**Tech Report.** Thomas et al. In prep. "Flocculation and Precipitation of Freshwater Microalgae using Bio-Based Polymers." ERDC TR.

Partnership/Leveraging Opportunities

This work leveraged that of "Research on Algae Flotation Techniques (RAFT)" (PI: Cender), another USACE Aquatic Nuisance Species Research Program project, in which flocculants were investigated for ability to achieve algae flotation in open water applications.

Value to USACE Mission

Results from our research provide valuable data for practical HAB management solutions involving the application of environmentally benign polymers in low-concentration HAB-impacted waters. Our approach provides a method to disrupt the formation of large algal colonies and thus prevents the spread of algae in a USACE managed lake or reservoir.