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 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.

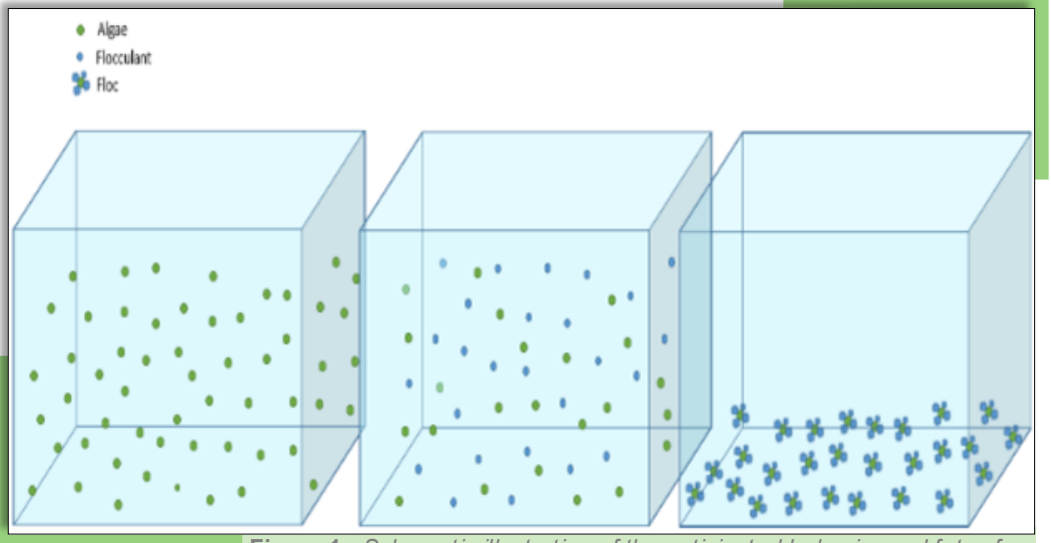

Figure 1: *Schematic illustration of the anticipated behavior and fate of chitosan during the flocculation process in open water.*

Objective The objectives of this work are 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 2 cyanobacteria species (*Microcystis aeruginosa* and *Anabaena* spp.) typically found in freshwater systems, 2) determine the stability of algal flocs over time under static and turbulent conditions.

Approach Evaluate the binding affinity of the test amendments to cyanobacteria species and determine optimal dosing amounts. Experiments are to be performed under conditions of varying pH and dissolved oxygen (DO) concentrations. Flocculation and precipitation kinetics will also be determined under static and mixing conditions. Down-select highest performing amendment and/or application ratios for further testing of mixed cyanobacteria cultures in the presence of sediment at mesocosm scale in a wave simulation tank.

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

USACE District Liaison: Jim Riley, Jacksonville District

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Results

After the evaluation of several amendments and amendment combinations, two amendment combinations were most effective in binding and precipitating cyanobacterial. These amendment combinations included the following: 1) BioFlow (a commercially available form of chitosan acetate) and GeoFlow (a proprietary blend of bentonite, zeolite, and calcium carbonate), and 2) BioFlow and chitosan flakes (1.6 -2.5 mm). Regarding floc stability, flocs formed by BioFlow and Chitosan flakes were unaffected by fluctuating pH (4-10) and DO concentrations. BioFlow and GeoFlow, however, yielded floc that were shown to be pH dependent as increasingly acidic conditions (less than pH 5.5) caused the resuspension of flocs into solution. Flocculation and precipitation tests performed in the presence of sediment at range of total suspended solid (TSS) concentrations up to 220 mg/L, mimicking high turbidity water. Results showed that increasing TSS concentrations improved precipitation rates, likely due to the larger, heavier particles formed. Wave tank simulations performed to evaluate algae flocculation and precipitation are ongoing and have shown thus far vast differences in both flocculation and precipitation kinetics. Flocculation and precipitation occur at a considerably slower rate relative to that observed under rapid mixing conditions. More experimentation under simulated wave conditions is underway.

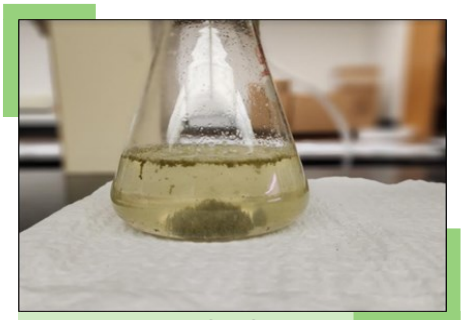

Figure 3: *Algae floc formed by BioFlow and chitosan flakes in the presence of suspended sediment at the highest tested TSS concentration (220 mg/L).*

Figure 4: *Suspended algae flocs in wave tank formed by BioFlow and chitosan flakes. The wave motion within the tank yielded slower flocculation and precipitation rates compared to vortex mixing.*

Major Milestones

Date	Milestone
FY21, Q1-Q3	Testing of flocculants on single and mixed cyanobacteria cultures
FY21, Q3	Evaluation of floc stability under mixing conditions
FY21, Q4	Flocculation testing under various pH and DO conditions
FY21-Q4	Go-No Go point based on success of flocculation stability under varying environmental conditions over time
FY22, Q2-4	Evaluation of flocculants under simulated lake conditions (mesoscale)
FY22, Q2-4	Technical Report final report
Costs	**FY21:**$168K **FY22:**$100k **TOTAL:**$268K

Partnership/Leveraging Opportunities

This work leverages work from an ongoing ERDC-CERL Aquatic Nuisance Species Research Program project, "Research on Algae Flotation Techniques (RAFT)" (PI-Clinton Cender) in which flocculants are investigated for algae flotation in open water applications.

Value to USACE Mission

This research will develop a practical option for HAB management through the application of naturally derived flocculants to areas of low HAB concentrations to disrupt the formation of larger colonies before spreading throughout a USACE managed lake or reservoir. Further, this work would benefit USACE as it is cost effective, with no harmful compounds being introduced or generated in the environment.