Application of Engineered Natural Materials for Phosphorus Removal to Control Algae Blooms in Eutrophic Water with Insight into Chemical Mechanisms and Large-Scale Feasibility Analysis

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Eutrophication is a significant environmental issue caused by excess nutrients, primarily phosphorus, that lead to algae growth, fish kills and ocean dead zones. The objective of this project was to develop an in-situ deployable product to remove phosphorus (P) for algae bloom control in eutrophic water. Our previous year's screening, based on Fourier transform infrared-spectrum (FTIR) and isotherm data, identified two potential candidates: a precipitation-based cockle shell and sorption-based zeolite. Bench-scale studies showed promise of using these naturally abundant shells and zeolites as raw materials for the removal of P (30.4% for cockle shell; 99.5% for zeolites, as measured by inductively coupled plasma-optical emission-spectrometry, or ICP-OES), and effectiveness increased as the size of engineered cockle shells decreased. This promising result prompted us to conduct further pilot- and field-scale tests since 2018 for their commercial applications as a cost-effective and eco-friendly phosphorus removal technique and their technical feasibility in natural water. A pilot-scale experimentation using phosphorus contaminated river water (40 L) removed 75.4 % P after 48 hrs following the treatment with zeolites at the concentration of 1.0 g/L, and a field-scale test (250 L) at a reduced dose (0.1 g/L) confirmed its efficiency to achieve water quality standard. Engineering feasibility analysis applied to two water bodies confirmed the cost-effectiveness, safety, and deployment potential of these natural products in open surface water, based on dosage, settling velocity using Stokes's law, and cost comparisons with the conventional method of sediment dredging ($168 k vs. $1,075 million in the case of Lake Houston).