INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Erosion Mitigation via Bio-Mediated Soil Improvement		
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SHORT ABSTRACT

Existing soil erosion mitigation practices that focus on cement-based hard structures and chemical grouts have limitations in terms of their environmental impact and effectiveness. Recently bio-mediated soil improvement has been proposed by several researchers as a promising eco-friendly solution for mitigating erosion. However, the bio-mediated soil improvement techniques have their own limitations, such as bacteria transportation to the site, non-uniform distribution of bio-precipitates, and generation of ammonia as a by-product.

In the current study, biocementation is employed in soil with the aim of investigating its influence on aeolian erosion, riverbank erosion and coastal erosion using soil microbes isolated from three different local sites. The thesis is comprised of five stages. First, it was revealed via 16S rRNA analysis that the isolated soil Firmicutes prevalently belong to *Sporosarcina* and *Pseudogracilibacillus* genera. The availability of the calcifying microbes in local soil reduces the liability of transporting extraneous microbes to the site.

Second, in a preliminary investigation to check the efficiency of the isolated strain, the desert sand was subjected to biocementation treatment at various concentrations of cementation media (CM), ranging from 250 to 1000 mM. A high unconfined compressive strength (UCS) value of around 900 kPa was observed with a low calcium carbonate content of 1.3%. The wind erosion resistance is observed to be maximum with 1000 mM cementation solution treatment withstanding the maximum wind velocity above 55 km/h.

The third objective was designed to formulate optimal concentration for cementation for improving surficial binding. The microbes liable for bio-augmentation, stimulation, and selective stimulation have been compared for their binding performance via needle penetration test against CM, ranging from 250 to 2000 mM concentration of CM. Maximum needle penetration resistance was observed at 500 mM concentration of CM for all the microbes. The findings revealed that the different microbes respond distinctively to different concentrations of CM. Detailed microstructure analysis of the precipitated $CaCO_3$ crystals suggested that the morphology and quantity are major parameters influencing surficial strength.

Fourth, the Brahmaputra soil isolate (BS3) was employed for a selective stimulation-based treatment for the mitigation of current-induced riverbank erosion. Soil treated with up to four cycles of biocementation treatment (500 mM) has been tested on three different slopes (30°, 45° and 53°) in a flow-controlled hydraulic flume subjected to a critical current profile ranging from 0.06 to 0.62 m/s. Up to a four-fold reduction in the erosion rate was observed with biocementation treatment. However, cementation beyond a threshold (around 7% $CaCO_3$) led to the formation of brittle chunks. Thus, a bio-composite was devised by a pre-treatment of low-viscosity biopolymer along with biocementation. The bio-composite was found to effectively mitigate the current-induced erosion with 36% lower ammonia production. The dual characteristics of the bio-composite were confirmed with the microstructural analysis.

Fifth, the erosion characteristics of soil treated with various levels of biocementation are investigated against waves combined with the hydraulic current, similar to coastal erosion. It was observed that soil erosion declined exponentially with the increase in $CaCO_3$ content against the perpendicular waves. However, the brittle fracture beyond a threshold limits the efficacy of biocementation against the tangential waves. The findings from the current study will be helpful for the transition of bio-mediated treatment toward field-scale applications for erosion control.