Research Project Summary

Project Details

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Title: Urease Efficacy in Enzyme Induced Carbonate Precipitation (EICP) in Selected Soil Samples and Experimental Conditions
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Background and Rationale

Erosion and dust formation are natural or man-made phenomena that have significant economic, environmental, and health-related consequences. Strategies for dust control based on naturally occurring or induced chemical or biological processes represent a more sustainable alternative to traditional dust control methods, especially those that rely and use large volumes of water (1). This project attempts to analyze the efficacy of Enzyme Induced Carbonate Precipitation (EICP), a bio-mediated dust and erosion control method, in selected experimental conditions and soil samples used in current geotechnical engineering research.

Research Objectives

- To test the efficacy of EICP in selected Ottawa 20/30 B-2.5 and B-1.5 soil samples
- To quantify the efficacy of EICP in Ottawa 20/30 B-2.5 and B-1.5 soil samples by performing Unconfined Compression Strength (UCS) testing
- To examine Ottawa 20/30 B-2.5 and B-1.5 soil samples by scanning electron microscopy (SEM)
- To test the efficacy of different EICP solution concentrations in soil samples from Minnesota iron mine tailings
- To quantify the efficacy of different EICP solution concentrations in soil samples from Minnesota iron mine tailings by conducting penetrometer testing and carbonate measurements on pan crust
- To determine the feasibility of conducting EICP experimentation on column treatment or on pan treatment in a Biology for Majors (BIO 181) undergraduate lab course.

Methods and Materials

Ottawa 20/30 B-2.5 and B-1.5 soil sample columns (three for each soil type) were built. EICP solution was added to each column, which were let sit at room temperature for 72 hours. To quantify the efficacy of EICP in Ottawa 20/30 B-2.5 and B-1.5 soil samples Unconfined Compression Strength (UCS) testing was performed and Scanning Electron Microscopy (SEM) samples were prepared for later visualization. To test the efficacy of EICP solution concentrations in Minnesota iron mine tailings, three pans were prepared: Pan 1 (control) was untreated; Pan 2 was treated with a 1M urea, 0.67M $CaCl_2$ EICP solution; Pan 3 was treated with a 1.5M urea, 1M $CaCl_2$ EICP solution. Samples were let dry for 72h. Carbonate and penetrometer measurements were performed on each soil sample pan.

Experimental Results

Ottawa 20/30 B-2.5 and B-1.5 treated soil sample columns showed significantly different stress responses as measured by UCS testing. Ottawa 20/30 B-2.5 (EICP milk B-2.5) samples supported less stress (x= 253.67 kpa) than Ottawa 20/30 B-1 (EICP milk B-1.5) samples (x= 462.12 kpa). Examination of Ottawa 20/30 B-1.5 (EICP milk B-1.5) SEM prepared samples revealed carbonate precipitate crystals (Fig. 1), which were not visible in untreated samples. Pan crust soil sample penetration test results showed that EICP treatment is three to four times stronger in treated Minnesota iron mine tailing soils (Fig.2). Untreated soil (Pan 1) supported the least stress (20 kpa); EICP 1.5M urea, 1M $CaCl_2$ EICP treated soil (Pan 3) supported less stress (80 kpa) than EICP 1M urea, 0.67M $CaCl_2$ treated soil (Pan 2) (105 kpa). Untreated soil showed the least displacement (0.01 cm) when compared to treated soils (0.2 cm).

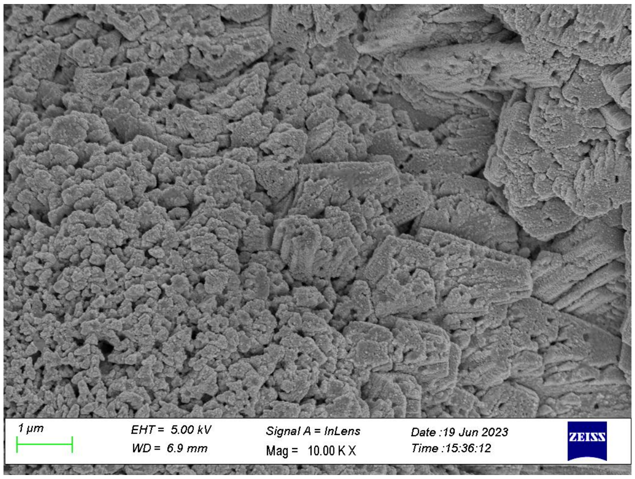

Figure 1: SE micrograph of carbonate precipitate crystals in treated Ottawa 20/30 EICP-milk B-1.5 soil samples

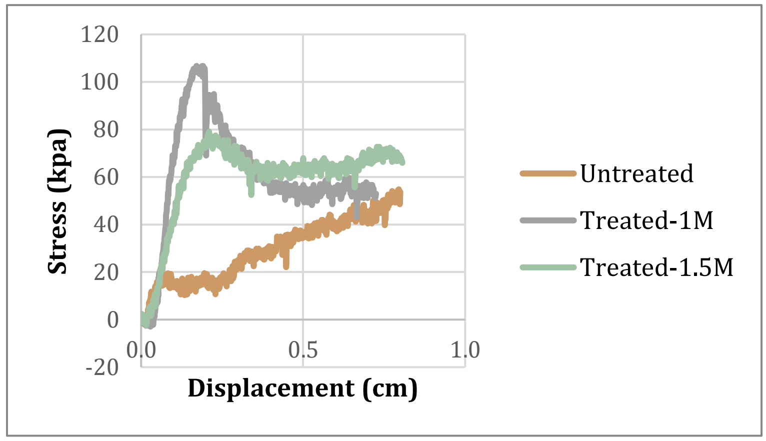

Figure 2: Stress values (kpa) for untreated and treated Minnesota iron mine tailings soils

Research Conclusions

Ottawa 20/30 B-1.5 EICP treated soil sample columns exhibited a much higher stress response (x= 462.12 kpa) to unconfined compression than Ottawa 20/30 B-25 EICP treated samples (x= 253.67 kpa). Minnesota iron mine tailings soil pan crust untreated samples were three to four times less strong than EICP treated samples. 1M urea, 0.67M $CaCl_2$ EICP solution soil samples exhibited the highest stress response (105 kpa), as determined by penetrometer testing.

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References

(1) Kavazanjian Jr. E & Iglesias E (2009). Biopolymer soil stabilization for wind erosion control. *Proceedings, 17th International Conf. Soil Mechanics and Geotechnical Engineering*, Alexandria, IOS Press - Mill Press, Vol. 2: 881-884