Contribution ID: **42** Type: **Poster**

Bio-Mediated Soil Stabilization for Enhanced Infrastructure Resilience

Tuesday, May 14, 2024 3:45 PM (35 minutes)

In the United States, addressing the detrimental effects of freeze-thaw phenomena on highway infrastructure alone costs approximately $2 billion annually. Frost-heave and thaw-weakening pose significant challenges to civil infrastructure in cold regions. Psychrophiles have evolved a range of adaptations to cope with the stresses imposed by freeze-thaw cycles. This research project presents the application of extracellular polymeric substances (EPS) secreted by a psychrophilic bacterium to stabilize frost-susceptible (FS) soil. EPS has been acknowledged in literature to display antifreeze properties, including water retention, nutrient and ion sequestration, and osmoregulation, thus enabling bacteria to prevent ice crystal formation in soils. Therefore, we propose that these properties of EPS could also stop frost-susceptible soil from freezing if enough EPS is present to regulate the soil's moisture. For this purpose, EPS was extracted from a psychrophilic bacterium, grown at different temperatures and growth media for 30 days. The extracted EPS is combined with FS Soil to examine it for antifreeze properties under a microscope. The thermal properties like freezing, thawing, and thermal hysteresis of the control and treated soils are evaluated using a thermoelectric cooling system. Indeed, by employing EPS for soil stabilization in the Sanford Underground Research Facility (SURF), we can mitigate frost-heave and thaw-weakening risks underground, ensuring the integrity of underground structures for research.
Keywords: Bio-mediated soil stabilization; Extracellular polymeric substances (EPS); Psychrophilic bacteria

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Session Classification: Poster Session

Track Classification: Biology