Rhamnolipids Compositions for Hydrocarbon-Contaminated Soil Remediation: Part II

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Background/Objective. Rhamnolipid biosurfactants have received much interest for enhancing the bioremediation of hydrocarbons. The main mechanism employed via the addition of rhamnolipids is to increase the apparent solubility of the hydrocarbons and increase their bioavailability to bacteria. When considering the treatment of contaminated soils, most published rhamnolipid research has focused on laboratory studies using well-controlled experimental conditions or field studies with variable parameters (e.g., temperature, soil moisture content, sunlight radiation), but data linking laboratory and field tests are lacking. The purpose of this study is to align both the laboratory and field studies to identify appropriate rhamnolipid and soil nutrient dose concentrations and application frequencies and to explore the potential impact of the rhamnolipid application on the indigenous soil microorganisms.

Approach/Activities. The hydrocarbon-polluted soil used in this study comes from a field site in Ontario, Canada, and contained approximately 20 g/kg of total petroleum hydrocarbons (TPH). For the laboratory experiments, three different rhamnolipid concentrations, 0.1, 0.5, and 1.0 g/kg (mass rhamnolipid per mass soil), are examined for their ability to enhance biodegradation of the hydrocarbon, along with a control. Duplicate reactors containing 0.25 kg of contaminated soil under the four test conditions (eight reactors total) are continuously monitored for biodegradation using pulse-flow respirometry. The soil in the reactors is mixed every two weeks, and ammonium chloride is added at regular intervals as the nitrogen source. Parallel reactors under the same conditions are analyzed for hydrocarbon content, nutrient concentrations, and dominant bacterial species at fixed time intervals.

The field study was done on site in Ontario, Canada. Five one-metric ton piles were created to test various conditions: (1) no amendments (control samples); (2) NH_4Cl addition only; (3) NH_4Cl and 0.5 g/kg rhamnolipid; (4) NH_4Cl and 1.0 g/kg rhamnolipid; and (5) NH_4Cl and a commercial enzyme solution. The soil piles are on cement pads and are covered with a tarp to prevent rain infiltration. The piles are mixed by hand weekly and monitored on-site for soil moisture and pH. Soil samples from each pile are analyzed every three weeks for hydrocarbon content, total organic carbon (TOC), and nutrient concentrations.

Results/Lessons Learned. Lab tests are a critical prerequisite for understanding bioremediation mechanisms for a particular contaminated site and designing an effective field treatment program. To date, the laboratory tests in this study have been continuously running for over 150 days. The laboratory respirometry tests have confirmed that the soil biological activity is dependent on the rhamnolipid dose, with demonstrated oxygen uptake enhancement over the control reactors of 48% and 71% at 0.5 g/kg and 1.0 g/kg of rhamnolipid, respectively, while the 0.1 g/kg rhamnolipid showed no improvement over the control. Knowledge from the lab tests was used to design the field experiments, and the respirometry results were combined with biological stoichiometric calculations to determine the appropriate nutrient loading for the field site. To date, the soil piles have been operational for over 45 days. In this work, we will present the latest results of the laboratory and field studies and provide insight into the combination of laboratory and field studies when applying rhamnolipids for the bioremediation of hydrocarbon-contaminated soils.