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Effects of Soil Texture on Soil Bioelectrochemical Remediation and Associated Geophysical Monitoring

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Background/Objectives. Bioelectrochemical system (BES) has demonstrated high efficiencies in enhanced remediation of hydrocarbon-contaminated soils with low cost and easy monitoring by using electrical signals. However, it is unknown whether BES will be able to perform in different soil conditions as previous studies have only tried saturated sandy soil. Previous researches showed that the diffusion of hydrocarbon towards electrode was highly affected by soil porosity and conductivity due to the hydrophobic feature of hydrocarbon, so this study expands the scope to understand how soil texture affects the BES performance. In addition, data collection still rely on traditional intrusive and time-consuming chemical methods, so we also present a new nonintrusive geophysical approach to obtain the TPH spatial distribution in real time, especially for convenient field applications.

Approach/Activities. Two rectangle tanks (5 L volume) were filled with diesel contaminated sandy (57.14% sand, 28.93% silt and 13.93% clay in dry weight) and clayey (33.12% sand, 35.46% silt, and 31.42% clay in dry weight) soil, respectively. Soils were saturated with artificial groundwater (conductivity = 500 µS/cm at 22 °C, pH = 8.2), which led to soil conductivities of 558 µS/cm (sandy) and 1109 µS/cm (clayey), respectively. The initial TPH values for sandy and clayey soil were 6960 mg/kg and 6495 mg/kg, respectively. Tubular BES with outer diameter of 4.5 cm and length of 25 cm was inserted into the soil on the left side of each tank. A total of 32 stainless steel electrodes were fixed to the side wall of the tank to monitor geophysical signal. For each geophysical survey, 480 resistance measurements were inverted together with the active time constraint (ATC) technique.

Results/Lessons Learned. After 60 days of operation, the TPH removals for sandy soil were 41% and 35% at 1 cm and 35 cm far from electrode, respectively, while clayey soil removed 23% and 17% TPH at same location. All removals in active BESs were high than 25% (sandy) and 15% (clayey) in controls with natural attenuation. At the end of the experiments (230 days), TPH removals in sandy soil were 41% (1 cm) and 39% (35 cm), which were higher than 35% (1 cm) and 25% (35 cm) in clayey soil. As expected, the TPH removals in control were only 34% (sandy) and 25% (clayey). BES has a better performance for sandy soil remediation than clayey soil due to improved hydrocarbon transfer in sandy soil texture. Geophysical monitoring showed that an increase of soil conductivity corresponds to a decrease of TPH content in sandy soil at the early period of the remediation, but not for clayey soil due to the high surface conductivity. The leakage of the fluid through the perforated BES reactors acts as a driving force for the movement of ions and diesel contaminant toward the electrodes. Results demonstrated the promising prospect of usage of geophysical survey for contamination remediation monitoring.