Analysis of the Viability of Gravel as a Backfill Material for Biostimulation Systems

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Background/Objectives. Biostimulation requires the supply of stimulating agents (NO_3^-, SO_4^{2-}, Fe^{3+} and/or Mn^{4+}) to indigenous microorganisms in order to enhance natural hydrocarbon degradation processes in soils. One of the challenges of biostimulation systems is the proper injection and diffusion of the biostimulatory solution in the soil. Resendes et al. (2021) demonstrated diffusion of a biostimulatory solution mixed with a tracer (NaFl) in two hydrocarbon-contaminated sites after 35 days. It is believed that the implementation of gravel beds in hydrocarbon-contaminated sites have the potential to reduce implementation and operation costs compared with traditional biostimulation injection systems. Two of the main problems associated with backfill materials in saturated environments are the ion adsorption capacity of the material and the possibility of bacterial growth or biofouling. The research assesses ion adsorption capacity and biofouling in pea gravel columns in contact with a biostimulatory solution. We then evaluated the potential of this 'weathered' biostimulatory solution to promote hydrocarbon anaerobic microbial degradation.

Approach/Activities. The laboratory project used vertical flow cylindrical columns of approximately 3.8 cm in diameter and 10 cm in height. Columns (n=6) were packed with pea gravel of approximately 5 mm in diameter to conduct the gravel adsorption and biofouling experiments. A biostimulatory solution and deionized water served as treatments. The biostimulatory solution contained HNO_3, Fe (III) NH_4-citrate, tripolyphosphate and $MgSO_4$. The treatments were continuously pumped through the gravel columns for a month and the effluents collected for further analysis. Ion chromatography analyzed ion concentration in the treatments before and after passing through the pea gravel. Bacterial volumes in the columns were quantified using [^{18}F] $F^-_{(aq)}$ and [^{18}F] F-FDG as radiolabeled tracers in PET imaging. Anaerobic microcosms will be used to conduct the biodegradation experiment. The effluent collected from the first experiment, as well as freshly prepared biostimulatory solution and deionized water, will serve as treatments. Soil samples enriched with the treatments and spiked with benzene will be used to test anaerobic degradation. Gas chromatography will be used to analyze headspace samples in microcosms at several points in time to determine benzene degradation.

Results/Lessons Learned. PET images were obtained to qualitatively demonstrate bacterial growth in different columns across treatments. Total pore volumes, open pore volumes and bacterial volumes in the column were calculated. For the ion adsorption experiment it is intended to create breakthrough curves of each ion and determine equilibrium time in the pea gravel. A low ion adsorption capacity is expected in the pea gravel. For the microcosm experiment it is intended to present the area of benzene peaks in contrast with the standard curve and the correspondent statistical analysis.