An Updated Site Conceptual Model for Oleophilic Biobarriers

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Background/Objectives. Oleophilic Biobarriers (OBBs) involve 1) an oleophilic (oil-loving) plastic geocomposite to intercept and retain hydrocarbon contamination from the groundwater and 2) the exchange of surface water and/or air to deliver oxygen and nutrients to support biological treatment of the oil. Recent deconstruction and sampling of an OBB site in the northeast U.S. (deployed for four years) has led to an updated site conceptual model for OBBs.

Approach/Activities. A 12.5 ft by 30.5 ft demonstration OBB was installed in November 2013. The barrier addressed sheens leading to the installation of a 12.5 ft by 190 ft full-scale OBB in October 2017. This construction event allowed destructive sampling of an OBB after four years of deployment. After removing the armoring layer, geotextile, and sand fill, the top of the geocomposite was scanned with ultraviolet light to determine whether any detectable hydrocarbon had seeped through. Samples of the geocomposite, sediment from 0-4 in below the geocomposite, and sediment from 4-8 in below the geocomposite were collected at 14 locations. All samples were shipped on dry ice and stored at -80 °C until analysis to preserve the samples including RNA. Samples were visually inspected for fouling and analyzed for hydrocarbons and microbial community.

Results/Lessons Learned. No non-aqueous phase liquid (NAPL) was observed on the geocomposite. The interior of the geocomposite samples were open, free of sediment, precipitates, and biofouling. An interval of red precipitates (presumed to be ferric iron hydroxides) was observed above and below the geocomposite. Ferric iron hydroxides/oxides are attributed to ferrous iron from the hydrocarbon plume reacting with oxygen delivered by the OBB. No NAPL was observed in the geocomposite and underlying soil (0-4 in. with ferric iron hydroxides). Diesel range organic (DRO) compounds in these layers were below method quantification limits (2 mg/kg). Immediately below (4-8 in.), black soils were encountered, containing visible NAPL and DRO concentrations in the low 1,000s of mg/kg.

This evidence suggests hydrocarbon degradation processes are occurring below and in the OBB. The two to three order-of-magnitude reduction occurs over a sharp red-black interface, suggesting that the ferric iron acts as a bank of solid phase electron acceptors in the upper sediment. Analysis of the polar / nonpolar distribution of the hydrocarbon constituents shows that in the lower sediments the majority of the compounds are polar, providing a line of evidence that hydrocarbons have been oxygenated. Microbial data show that the number of bacterial 16s transcripts in the geocomposite are larger than in the sediment layers, confirming that the geocomposite is a suitable substrate for microbes to inoculate. Microbial community analysis suggests a larger anaerobic community in the lower sediment than in the upper layers, supporting the model of different redox conditions above and below the red-black interface.