Performance of a New Activated Carbon Amendment for Bioremediating Petroleum-Impacted Sites

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Background. The treatment of petroleum contamination using injectable activated carbon amendments is increasing in popularity, in part due to the rate with which drops in contaminant concentrations are usually seen after application. Rapid removal of contamination from groundwater by adsorption is attractive, yet in situ biodegradation is often also needed to properly manage higher contamination levels frequently seen in petroleum sites. Here we present a new activated carbon-based amendment that combines micron-sized activated carbon with nitrate (NO_3^-) and sulfate (SO_4^{2-}) salts serving as electron acceptors. As a part of development, the new formulation, PetroFix® Remediation Fluid, was field-tested on a contaminated area downgradient of a former bulk petroleum storage facility in South Bend, Indiana. Historical remedial efforts included LNAPL recovery and air sparging/soil vapor extraction (AS/SVE), however relatively high concentrations of petroleum hydrocarbons remained in the groundwater, restricting site closure.

Activities/Results. PetroFix was injected by low-pressure direct-push methods in an area surrounding a single monitoring well with over 50 ppm total petroleum hydrocarbons in the diesel and gasoline range combined. Groundwater samples were monitored at baseline and at regular intervals post-application for standard chemical and geochemical parameters, as well as by QuantArray® Petro (Microbial Insights) for quantification of the bacterial communities. Baseline microbial analysis indicated a moderate presence of both aerobic and anaerobic petroleum degraders. At both one- and three-months post-injection, contaminant concentrations had fallen by over 90%. At three months, RNA analysis showed Methylibium petroleiphilum (PM1), a known BTEX degrader, replicating robustly. Another line of evidence for biodegradation was the rapid reduction of NO_3^- followed by a more gradual loss of SO_4^{2-}. Dissolved methane initially dipped, before climbing to over twice the pre-application concentration. This is consistent with increased hydrocarbon biodegradation, despite the dramatic removal of contamination from the dissolved phase.

Lessons Learned. The removal of petroleum from the groundwater by adsorption onto the activated carbon does not appear to have a negative effect on biodegradation. Additionally, the conditions in the treatment area appear to be favorable for long-term biodegradation of the remaining hydrocarbons, as indicated by the increasing methane concentrations when compared to the pre-injection level. The results thus far indicate that PetroFix is a powerful amendment capable of treating sites contaminated with moderate amounts of petroleum hydrocarbons. The placement of activated carbon with electron acceptors under low pressure conditions ensures good amendment coverage in the high flux zones where contaminants migrate and promotes biodegradation by the microbial community in place.