Interpretation of Indirect Geochemical Indicators for In-Situ Bioremediation of Petroleum Hydrocarbons

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Platform Presentation

Enhanced bioremediation is a useful groundwater technology for sites containing residual petroleum hydrocarbons where source removal has occurred. Although enhanced aerobic bioremediation is a slow process, it can reduce site closure schedules from decades for natural attenuation in an anaerobic environment to a few years with the addition of dissolved oxygen. Several passive and semi-passive oxygen delivery systems have been developed over the past decade.

For in-situ enhanced bioremediation of petroleum hydrocarbons, direct contaminant concentrations are useful to monitor the success of the project. However, as water levels rise and fall over the complete hydrologic cycle, other indirect indicators provide confirmatory data for microbial activity and changes in geochemical conditions. Indirect indicators include dissolved oxygen, heterotrophic plate count, specific aerobic degraders, macronutrients ammonia nitrogen and ortho-phosphate, total inorganic carbon, total organic carbon, total dissolved solids, speciated alkalinity, pH, oxygen reduction potential, chemical oxygen demand, biological oxygen demand, ferrous iron, sulfate and nitrate. The iSOC gas infusion system was placed 2-inch diameter wells and has been used on over 400 sites. The gas diffusion system allows oxygen to dissolve slowly at about 15 cc/min or 0.77 cubic feet per day per monitoring well. A gas infusion case study using the iSOC technology from Mapleshade, New Jersey was evaluated for indirect indicators. The indirect geochemical indicators verified that enhanced bioremediation was responsible for the hydrocarbon degradation (benzene > 96%, MTBE = 89% and TBA = 54%) that occurred over a 6-month period. In this case, an average of 221.6% increase in total inorganic carbon (TIC) between pre-treatment and post-treatment samples in 9 wells shows the degradation was related to the iSOC treatment, and not related to seasonal changes in the hydrologic contaminant cycle.

For in-situ enhanced aerobic bioremediation of petroleum hydrocarbons, providing dissolved oxygen in the groundwater is necessary. Nonetheless, measuring dissolved oxygen has always been problematic and a potentially major source of error. A former gasoline underground storage tank case study from northern California had pre-treatment levels of dissolved oxygen ranging from 4.10 mg/l to 5.76 mg/l in the central core of the hydrocarbon plume (8,400 to 23,000 μg/l TPH-g) and 5.61 to 6.84 mg/l DO in the wells without reportable concentrations of TPH-g or BTEX compounds. The evaluation relied on a variety of indirect geochemical indicators in combination to obtain a clear understanding of the subsurface conditions. Based on a combination of indirect indicators, the dissolved oxygen data were questioned and the original interpretation was completely reversed, changing the course of remediation from monitored natural attenuation to enhanced bioremediation. Careful evaluation of the indirect indicators can provide valuable information on in-situ enhanced bioremediation projects.

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