

Field-Scale Evaluation of Aerobic Bio-Oxidation to Deplete Groundwater Contaminants from Coal Tar and Creosote

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Background/Objectives. Aerobic bio-oxidation of dissolved-phase petroleum hydrocarbons (including tar and creosote-related compounds) occurs naturally or via engineered applications when suitable microbial populations and geochemical conditions are present in the aquifer. During aerobic biooxidation, microorganisms utilize hydrocarbons as electron donors in the presence of oxygen as the primary electron acceptor. Biosparging is a proven, effective remediation technology to enhance aerobic biooxidation of dissolved hydrocarbons typically observed in groundwater at coal tar and creosote sites. Enhancing biooxidation in the DNAPL tar source area can enhance dissolution of hydrocarbons from the DNAPL and change the composition of the DNAPL. A NAPL dissolution model that includes a Raoult's Law solubility model was developed to evaluate the ability to effectively weather hydrocarbons from DNAPL and meet groundwater criteria using biosparging. The Raoult's Law solubility model is developed from a method that includes laboratory analysis of the NAPL composition and water from NAPL-water equilibrium studies.

Approach/Activities. Engineered applications of biosparging were implemented at a former manufactured gas plant (MGP) site in Florida and a former wood-treating site in Montana. At the Florida site, water-gas tar DNAPL is a source of dissolved-phase VOCs and polycyclic aromatic hydrocarbons (PAHs) to groundwater migrating offsite. Following a 9-month biosparge pilot study at the site boundary to enhance aerobic biooxidation of VOCs and PAHs, the biosparge system was expanded in 2016 to decrease offsite mass flux, and achieve treatment criteria offsite. A portion of the biosparge system that is positioned within the DNAPL tar source area provided data to evaluate DNAPL weathering and use the DNAPL depletion model to estimate the time required effectively weather the groundwater contaminants from the DNAPL.

At the Montana site, creosote DNAPL is primarily a source of dissolved pentachlorophenol (PCP) and PAHs to groundwater. A 10-month biosparge pilot study was completed in 2016 in a portion of the creosote source area to evaluate the ability of biosparging to reduce the mass of PCP and PAHs in soil (DNAPL) and groundwater. The pilot study included baseline and post treatment collection and analysis of soil and groundwater samples to estimate the effective removal of PCP and PAHs from the creosote and mitigate mass discharge of PCP and PAHs to groundwater.

Results/Lessons Learned. At the Florida site, biosparging decreased the mass fraction of isopropylbenzene and naphthalene in the NAPL by 97% and 85%, respectively. To fit the biosparging performance data, the NAPL depletion model estimated half-lives of 0.1 day for isopropylbenzene and 0.4 days for naphthalene. At the Montana site, biosparging decreased the mass fraction of PCP and naphthalene in the NAPL by 66% and 39%, respectively. The modeled aerobic biooxidation half-lives are 0.7 days for PCP and 0.4 days for naphthalene. The results from the pilot studies and NAPL depletion modeling showed that enhanced aerobic biooxidation can be an effective strategy to weather contaminants from DNAPL tars and creosotes. In addition, the NAPL depletion model indicates that the groundwater contaminants can be effectively removed (weathered) from the DNAPL in a reasonable time that ranges from 4 to 6 years.