MTBE Case Study
In Situ Bioremediation at Brownfield Site, Chattanooga, Tennessee

Site Name: Brownfield Site (actual site name confidential)

Site Location: Chattanooga, TN

Contaminants: MTBE, BTEX, TPH

Media: Groundwater

Technology: In Situ Bioremediation

Technology Scale: Full

Type of Cleanup: RCRA UST (Tennessee LUST Program)

Period of Operation: January 1999 to present (data available through December 1999)

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Site History [1, 2, 3]:

As a result of leaking underground storage tanks (USTs), gasoline, diesel fuel, and waste oil releases occurred at an abandoned gasoline service station located in a mixed-use area in Chattanooga Tennessee. The service station has no remaining on-site structures or facilities. The releases resulted in contamination of soil and groundwater at the site with MTBE, BTEX, and petroleum constituents. Concentrations of contaminants measured in groundwater at the site were as high as MTBE at 5,000 ug/L, benzene at 8,000 ug/L, and total petroleum hydrocarbons at 300,000 ug/L. The vendor estimated that 1,500 cubic yards of soil at the site were impacted by the contamination. In the mid-1990s, the USTs were removed and decommissioned. Figure 1 shows a site plan.
Figure 1. Site Plan - Tennessee Brownfield Site [3]
The contaminated groundwater extends off-site and the vendor reported that it has migration pathways to the north, southwest, and east. The groundwater plume containing MTBE and benzene covers approximately 16,000 square feet (1/3 acre) and the plume containing TPH covers approximately 66,000 square feet (1.5 acres). Groundwater beneath the site is located within a tight clay soil horizon at 5-7 feet below ground surface (bgs). Off-site groundwater is located in bedrock consisting of limestone and shale beds at depths of greater than 10 feet.

**Technology Description [1, 2, 3, 5]:**

Beginning in January 1999, *in situ* bioremediation using the Enzyme-Catalyzed In Situ Dissolved Oxygen Treatment (DO-IT) process was used to treat groundwater at the site. This process uses a combination of proprietary multi-enzyme complexes and a consortium of total petroleum hydrocarbon (TPH) degrading bacteria, with supplemental oxygen, to biodegrade MTBE, BTEX, and TPH contaminants. According to the vendor, the enzymes are complex proteins that are extracted from living TPH-degrading bacterial cultures. The enzymes catalyze the conversion of aromatic and aliphatic hydrocarbons to fatty acids, and the bacterial consortium then provides mineralization of the remaining hydrocarbons and fatty acid complexes to carbon dioxide and water. The pure oxygen mixing process generates a concentration of dissolved oxygen in water of approximately 40 mg/L.

The DO-IT process was applied at this site by installing three horizontal injection wells, two vertical injection wells, and three extraction/recovery wells into the area of the contaminated plume, as shown on Figure 1. The injection wells were installed using trenching, hollow-stem auger drilling, and horizontal drilling techniques, as the contamination was located beneath a roadway.

Groundwater was extracted from down-gradient locations, amended by adding oxygenated water, nutrients, and the enzyme/bacterial consortium mixture, and then re-injected using the horizontal and vertical injection wells. Oxygenated water and pure oxygen were injected automatically into each of the horizontal and vertical wells. The combination of extraction and injection wells created a closed-loop treatment system and cycled groundwater within the contaminated area, providing for both treatment and hydraulic control of the contaminated groundwater.

The initial inoculation of the enzyme/bacterial consortium mixture was performed in January 1999, and consisted of approximately 75 gallons of enzymes and 150 gallons of bacteria. Each month, 5 gallons of enzymes and 10 gallons of bacteria have been added to the oxygenated water to maintain the microbial population. Water samples are collected monthly to monitor the nutrient concentrations and the bacterial plate count population within the aquifer. Additional nutrients, including nitrogen, phosphorus, and potassium, were added, as needed. Based on the results, active recirculation and amendment of contaminated groundwater was ongoing as of December 1999, and the vendor indicated that completion of the remediation is anticipated by mid-2000.

**Technology Performance [1, 2, 3, 5]:**

The groundwater at this site was classified by the state as a non-drinking water aquifer, and the cleanup criteria specified for this site were benzene - 100 mg/kg in soil and 70 ug/L in groundwater, and TPH - 1,000 mg/kg in soil and 1,000 ug/L in groundwater. No cleanup levels were specified for MTBE, however MTBE was identified as a contaminant of concern for the site.
Monitoring wells within the contaminated area were used to monitor performance of in situ bioremediation, as shown on Figure 1. Monitoring was performed quarterly for most monitoring points. Figures 2, 3, and 4 show the concentrations of MTBE, benzene, and TPH in selected wells at the site, respectively, during the first 360 days of treatment using in situ bioremediation (these figures are based on a treatment start date of July 1998 - the most recent round of sampling data that existed prior to system start-up). As shown on Figure 2, the concentration of MTBE in well MW-2 (the well with the highest concentrations of contaminants) was reduced from approximately 5,000 ug/L to approximately 200 ug/L (a 96% reduction). The vendor reported that the average reduction for MTBE concentrations was 82% during this time period.

While information was not available about the concentrations of benzene or TPH in soil after treatment had begun, data on their concentrations in groundwater showed reductions, but levels in some wells that were higher than their cleanup goals. In particular, well MW-2, located in the main portion of the plume, had benzene and TPH concentrations higher than their cleanup goals after 360 days of treatment. Overall at the site, benzene concentrations were reduced from as high as 8,000 ug/L (in MW-2) to less than approximately 1,000 ug/L, as shown in Figure 3, (a 88% reduction). The vendor reported that the average reduction for benzene concentrations was 95% during this time period.

TPH concentrations were reduced from as high as 300,000 ug/L (in MW-2) to less than approximately 50,000 ug/L, as shown in Figure 3, (a 83% reduction). The vendor reported that the average reduction for TPH concentrations was 73% during this time period.

Figure 2. Concentrations of MTBE at Tennessee Brownfield Site - 360 Days of Operation [3]
Figure 3. Concentrations of Benzene at Tennessee Brownfield Site - 360 Days of Operation [3]

Figure 4. Concentrations of TPH at Tennessee Brownfield Site - 360 Days of Operation [3]

Technology Cost [5]:

Start-up costs for this site, including the initial inoculation, were approximately $30,000. Monthly maintenance costs are approximately $4,000. A total cost to date is not available.
Observations and Lessons Learned [5]:

The concentrations of MTBE, BTEX, and TPH were reduced by more than 70% during the first 360 days of treatment using in situ bioremediation, however cleanup goals were not reached for benzene or TPH in the groundwater during this time, and treatment is ongoing.

The technology vendor reported that this application was aided by the design of injection galleries that were specific to the low permeability of the soil formation and the intended injection approach.

References:


