Enhanced In-Situ Bioremediation Using Emulsified Edible Soybean Oil

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ABSTRACT

Sulfae oil water at an industrial site in Mountain View, California has been affected by spills of distillate and amines, an odoriferous organic compound (VOC) source. The contamination plume is characterized by total VOC concentrations (TCA) ranging from 2,200 to 7,000 μg/L in the A-zone and in the adjacent B-zone, respectively. Two in-situ remediation phases were implemented in August 2005: Phase I Emulsified Oil Injection and Phase II Bioaugment. Phase I included 35,000 gallons of 2% oil emulsion, with a total of 1,000 gallons of anaerobic chase water. Phase II included 91,000 gallons of 2% oil emulsion and 200,000 gallons of 3% emulsion, with a total of 4,000 gallons of anaerobic chase water. The project's overall goal was to reduce VOC concentrations below the California reporting limit of 10 ppb. To achieve this goal, the project included in-situ emulsified oil injections, anaerobic chase water, and bioaugmentation with Dehalococcoides KB-1 culture. The project utilized in-situ bioremediation to degrade total VOC concentrations to less than 10 ppb.

OBJECTIVES

The primary objectives for this enhanced in-situ bioremediation project were to:

1. Test the project's ability to reduce VOC concentrations using a modified field approach (Phase I Injection).
2. Test the project's ability to reduce VOC concentrations in the subsurface using a modified field approach (Phase II Injection).
3. Test the project's ability to reduce VOC concentrations in the subsurface using a modified field approach (Bioaugmentation).

SITe GEOLOGY & HYDROGEOLOGY

A detailed hydrogeologic section of the aquifers was prepared for the project, with an emphasis on the characterization of the aquifers and the understanding of the subsurface flow regime.

SITE HISTORY

VOCs first detected in 1984 (Lot 3).

VOCs of concern (VOCs) are ethene (1,2-DCE, TCE, cis-DCE), toluene, benzene, and chlorinated solvents, located off the site in a commercial area.

The majority of VOCs present is toluene (30%), followed by benzene (20%) and ethene (10%).

Groundwater recharge is 90% surface runoff and 10% precipitation, with a mean annual recharge of 386 ft.

Phases I and II were implemented in August 2005.

EMULSIFIED OIL SUBSTRATE

A commercial vegetable oil (7% sunflower, 11% vegetable, 2% fish, 2% soybean, and 2% canola) was injected at a concentration of 2% oil emulsion.

REMEDIAL DESIGN PHASE I

Phase I Emulsified Oil Injections (August - September 2005)

Selection and design of injection points was based on the Site Geology & Hydrogeology section. Injection points were selected to maximize contact with the subsurface and to minimize the risk of plume migration.

MAXIMUM TCE, DCE, VC CONCENTRATION VARIOUS a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z

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<th>TCE (μg/L)</th>
<th>DCE (μg/L)</th>
<th>VC (μg/L)</th>
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<td>210</td>
<td>28</td>
<td>6.3</td>
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Comparison of the VOC distribution in the A-water-bearing zone

REMEDIAL DESIGN PHASE II

Phase II Emulsified Oil Injections (July 2006)

Max. TCE conc. (prior to pilot test) - 43 μg/L

Max. TCE conc. (after Phase II) - 1.1 μg/L

Bioaugmentation with Dehalococcoides KB-1 culture to reduce VOC concentrations below the California reporting limit of 10 ppb.

Next Steps:

- Additional injections and bioaugmentation may be considered (Phase I – September 2005).
- Enhanced in-situ bioremediation appears to have reduced the VOC concentrations in the subsurface.

RESULTS AND CONCLUSIONS

- Enhanced in-situ bioremediation was used to reduce VOC concentrations below the California reporting limit of 10 ppb.

Detailed cross-sectional views of the site from the southeast corner of the contaminated area at 1 ft (0.3 m) intervals, showing the injection points and the emulsified oil injections.

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