A Case Study of In Situ Bioremediation of Low Permeability Soils Using Specialized Waterjet Technology

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Background/Objectives. Bioremediation in low-permeability soil presents unique remedial challenges, such as back diffusion, substrate transport, and contaminant rebound. Often contaminated sites characterized with low-permeability soils are approached with long-term, expensive methods or left untreated. Soil mixing is a common approach used to bring remedial amendments into close contact with contaminants. However, this method has disadvantages, most notably the loss of soil strength required to support buildings or other structures. Chemical Grout Co. Ltd (CGC) along with EOS Remediation, LLC (EOS Remediation) have engineered an in situ technology for effectively addressing sites impacted by chlorinated solvents (cVOCs) under low permeability conditions. This technology, BioJet™, is based on hydrogen diffusion that determines the spacing of horizontal slices cut into the low permeability soil while delivering a proprietary slow-release electron donor for enhanced reductive dechlorination. This technology was used at a site located in Tokyo, Japan in 2020, meeting site cleanup goals within six-months post-injection.

Approach/Activities. At the site of a precision parts manufacturing factory targeted for remediation, the low water permeability soil layers were contaminated with trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE) and chloroethylene (VC). The total site area was 9,300 m^2, and about 2,000 m^2 was the target area for BioJet™, resulting in 10,000 m^3 of soil to be remediated. The objectives of the BioJet™ were to: (1) increase immediate contact between contaminants, EOS® engineered electron donor, and indigenous microbes to accelerate biodegradation in low permeability soil matrices and (2) decrease the distance that hydrogen generated by fermentation must diffuse through the saturated soil, thereby stimulating reductive dechlorination, decreasing the remedial time frame and cleanup costs. The vertical interval between horizontal slices was set to 25 cm based on theoretical calculations derived by the diffusion rate of hydrogen molecules. The slit diameter of Φ2.2~3.0 m was created with jetting pressure of the water jet set to 35 MPa with the flow rate of 150 L/min. The total number of BioJet™ column was 335 columns.

Results/Lessons Learned. BioJet™ technology effectively delivered engineered electron donors into low permeability zones resulting in enhanced reductive dechlorination of targeted cVOCs. The Japan EPA cleanup goals are targeted toward soil leachate concentrations and groundwater concentrations, with 0.03 mg/L for TCE, 0.04 mg/L for cis-1,2-DCE and 0.002 mg/L for VC. The starting soil leachate concentrations for this site were 0.13 mg/L for TCE, 0.20 mg/L for cis-1,2-DCE, 0.12 mg/L for VC. After injection, the remediating target value was met in about six months. Also, the loss of soil strength did not occur. Based on these results, it is possible to remedy cVOC contamination in low permeability soil by injecting EOS® engineered electron donor into horizontal slices using water jet technology, and that the contamination can be remediated to the standard value in about half a year depending on the contamination concentration and other influential conditions.