

Comparison of Aerobic and Anaerobic Biotreatments of Low-Level Vinyl Chloride

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Abstract: A field comparison study of aerobic and anaerobic enhanced bioremediation was conducted on two low-level vinyl chloride (VC) plumes in groundwater in the surficial (Columbia) aquifer of Solid Waste Management Unit (SWMU) 2C at Naval Air Station (NAS) Oceana in Virginia Beach, VA. ORC[®] (Regenesys, San Clemente, CA) was used in the approximately 80,000 square foot north groundwater plume area as a time-release oxygen source to facilitate aerobic biodegradation of VC in groundwater. NewmanZone emulsified vegetable oil (RNAS, Inc., Brooklyn Center, MN) was used in the approximately 84,000 square foot south groundwater plume area as an electron donor to promote reductive dechlorination (RD) of VC. At SWMU 2C, the surficial aquifer consists mostly of fine to medium grained sands with occasional thin, discontinuous layers of silt. Groundwater velocity is estimated at 10 ft/year. Depth to groundwater is usually between four and nine feet. The Yorktown Confining Unit is generally encountered between 16' and 20' bgs. The estimated average hydraulic gradient across SWMU 2C is 0.036 ft/ft.

In the north plume area, 5,130 lbs of ORC[®] were injected at a rate of 3 lbs/ft into the surficial aquifer through a grid of 171 direct push injection points completed from 6' to 16' bgs. The total cost of this effort was approximately \$95,000. In the south plume area, 69,700 gallons of diluted emulsified oil (1% oil) were applied through a grid of 208 temporary application wells screened from 8.5' to 18.5' bgs. The total cost of the oil application effort was approximately \$110,000. Based on the sizes of the treatment areas, these costs are considered to be comparable. Overall, injection of ORC[®] through direct push rods was completed with more ease than was the application of emulsified oil. The oil was applied using a manifold system, which required that ten wells be installed before treatment could begin. This proved to be difficult in roadways and other high traffic areas typical of this site.

Groundwater monitoring of VOCs and geochemical parameters was performed prior to injection of ORC[®] and emulsified oil (Baseline event) and in four post-injection monitoring events at approximately 2, 4, 8, and 12 months after injection (Events 1 through 4). Average VC concentrations in the north plume ORC[®] study area show an overall reduction of 67% (from 77.7 µg/L to 25 µg/L). Geochemical parameters do not indicate aerobic conditions expected with the ORC[®] treatment approach. However, comparisons of ORC[®] treatment area analytical data to upgradient well and historical data indicate that the ORC[®] injections have increased the rate and efficiency of VC degradation. Average VC results for the south plume emulsified vegetable oil study area indicate an overall 69% reduction (from 15.6 µg/L to 4.72 µg/L). Comparison of Baseline and Event 1 values for geochemical parameters (such as DO, ORP, and sulfide) did not indicate that initial reductions in contaminant concentrations were a result of the RD. However, Event 3 and 4 data show low DO, negative ORP, production of methane, and increases in volatile fatty acids, consistent with the anaerobic treatment approach. The results suggest a lag time for the geochemistry changes and RD of VC after vegetable oil application and potentially a greater longevity of the vegetable oil treatment.