

In Situ Vadose Zone Perchlorate Remediation Using Emulsified Vegetable Oil

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Background/Objectives. A field pilot study is being conducted to evaluate the efficacy of emulsified vegetable oil (EVO) injections to stimulate bioremediation of perchlorate present in the approximately 15-foot-thick vadose zone of a southern California site. The field pilot study is ongoing and results presented herein represent the first two years of performance. Perchlorate impacts to vadose zone soil at the site are from historical operations utilizing perchloric acid. The site subsurface is composed of predominately fine-grained sediments with laterally discontinuous interbeds of sand. The fine-grained nature of the site soil made temporary saturation of vadose zone soil using injections of EVO solution practical, allowing establishment of anaerobic conditions suitable for perchlorate degradation.

Approach/Activities. The field pilot study was initiated using closely spaced injection points and an injection solution of 3% commercial EVO product (which was 60% oil by weight) in water. A total of nine injection points spaced approximately 9 feet apart in a grid pattern of three offset rows (each point had a design radius of influence of 5 feet) were used for the study. Injections were performed using direct push equipment in 2-foot vertical intervals from 15 feet below ground surface (bgs) up to 5 feet bgs. Prior to injection, baseline soil samples were collected from nine soil borings within pilot study injection area. Soil samples were collected from 6, 9, 12, and 15 feet bgs from each boring. Initial perchlorate concentrations in these baseline soil samples ranged from 54 micrograms per kilogram ($\mu\text{g}/\text{kg}$) to 19,000 $\mu\text{g}/\text{kg}$ with concentrations generally increasing with depth and exhibiting high lateral heterogeneity. Post-injection samples were collected within approximately 1 foot laterally of baseline locations at approximately 30, 60, 90, 180, 371, and 731 days following injection of EVO solution.

Results/Lessons Learned. Greater than 90% reduction in perchlorate concentrations has been achieved to date using direct injection of EVO solution into the vadose zone. Concentration trends over time indicate that the most reduction was achieved within the first 30 days of treatment and that decline in concentrations continued over the first two years of the study. Perchlorate reduction was most rapid within the uppermost two sampling intervals (6 and 9 feet bgs). The two deeper intervals (12 and 15 feet bgs) showed decreases in concentration that were less rapid initially but that have also continued over the two-year performance monitoring period and overall have been very similar to performance in the shallower depths after two years. The results of the pilot study to date indicate that injection of EVO has been effective at creating conditions suitable for perchlorate reduction in the fine-grained vadose zone. Continued reductions in perchlorate concentrations in samples collected between 30 days and 731 days post-injection indicate that perchlorate reduction has continued over a sustained period of time. Injection of EVO solution into the unsaturated zone represents an efficient means of achieving perchlorate reductions in situ.