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Enhanced In Situ Bioremediation of Cadmium- and Lead- Impacted Groundwater

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Background/Objectives. The project site is a former lead smelting plant and battery recycling facility located in the southern US. Previous investigations identified the occurrence and extent of cadmium, lead and sulfate impacts in groundwater associated with a former septic system leach field. The impacted saturated zone, ranging in thickness from 5 to 15 feet, comprises clean, silty and clayey sands overlying a dense, plastic clay that serves as a regionally extensive aquitard that inhibits downward vertical groundwater flow. The associated groundwater plume discharges to a creek located adjacent to the site where concentrations of cadmium and lead have been detected in excess of surface water quality criteria. Remediation of cadmium and lead impacts in groundwater, and subsequently surface water, is being achieved by utilizing existing microorganisms in the subsurface and adding an additional carbon source to the system to stimulate biological reduction of sulfate, subsequently generating solid-phase cadmium and lead sulfide mineral phases (cadmium and lead immobilization).

Approach/Activities. Cadmium/lead/iron sulfides are stable mineral phases provided that the system geochemistry (pH and oxidation reduction potential) remains relatively constant through time. The introduction of an organic carbon amendment (e.g., lactate) into the subsurface provided an energy source to indigenous sulfate-reducing microorganisms to convert existing sulfate in groundwater to sulfide. A pilot-scale study was conducted to evaluate the feasibility and effectiveness of subsurface lactate injections performed on a quarterly basis for one year. Performance monitoring data collected during the study and 18 months following the final lactate injection indicated that biological reduction of sulfate was stimulated and resulted in sequestration of cadmium and lead from groundwater as insoluble cadmium and lead sulfide minerals. Based upon the favorable pilot test results, the enhanced bioremediation approach was subsequently expanded, including quarterly injection of lactate in 10 injection wells in the known source area and along two primary downgradient groundwater flow paths. The lactate injectate dosage is customized for each injection in response to monitoring data to sustain target total organic carbon concentrations in the injection wells and across the performance monitoring area.

Results/Lessons Learned. A comprehensive understanding of site conditions and intrinsic biogeochemical processes resulted in successful application of an organic carbon amendment to mitigate cadmium and lead impacts in groundwater. Performance monitoring data indicated cadmium and lead groundwater concentrations were reduced below the regulatory requirement for each constituent in all injection wells within three months of the first injection. Geochemical monitoring data demonstrated sulfate depletion in the injection wells, which further supports the enhanced sulfate reducing conditions developed by the addition of an organic amendment sequestered cadmium and lead from groundwater. Twelve months following the initial injections, increased total organic carbon levels and the onset of sulfate reducing conditions in downgradient monitoring wells result in decreased cadmium and lead groundwater concentrations some 300 feet downgradient of the injection area.