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Management and Treatment of Contaminants in Low Permeability Zones with Colloidal Activated Carbon

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Background/Objectives. A primary concern in subsurface contaminant hydrology is what can be done to address contaminant storage and release from low permeability (k) layers in plumes, also known as back diffusion. Previous studies that examined various in situ treatment options for back diffusion demonstrated an initial decrease in groundwater concentrations, followed by a rebound once the amendment dissipated. These results indicate a necessity for longer-term treatment options in order to effectively treat the persistent contamination associated with back diffusion. Laboratory studies were performed to evaluate the efficacy of Plumestop® (PS), a distributable form of colloidal activated carbon, for removing and degrading common volatile organic compounds (VOCs) in groundwater compared to controls.

Approach/Activities. Four identical 0.5 m x 1.0 m x 0.0254 m laboratory tanks with nine alternating layers of transmissive and low k field soils were employed as a means for simulating TCE back diffusion from low permeability zones. This experimental setup allowed for a comparative analysis of various remediation approaches, including the PS technology and enhanced reductive dechlorination (ERD), for treating contaminants in low k zones. The experiments involved flushing with a saturated aqueous solution of TCE to saturate the soils, flushing with cleanwater, implementing the treatment, and post-treatment flushing with cleanwater. Throughout the experiment, the effluent concentrations of contaminants were monitored. The four treatments were: 1) no-action control, 2) PS -only, 3) *Dehalococcoides* microbial inoculum and lactate (DHC-L), and 4) PS with *Dehalococcoides* microbial inoculum and lactate (PS-DHC-L). At the conclusion of the study, microbial populations and PS on soils were analyzed.

Results/Lessons Learned. After injecting a TCE-saturated aqueous solution for 36 days, a 67-day water-only flush was able to reduce effluent TCE concentrations by approximately 2.5 orders of magnitude from solubility (~1,200 mg/L) to below 10 mg/L in each of the tanks. During and after the treatments, the TCE eluting from the control was sustained around 1 mg/L and can be expected to take years to achieve effluent TCE levels nearing the MCL. Following injection of the PS, effluent concentrations of TCE quickly fell over three orders of magnitude (i.e., 99.9%) in the two PS treatments, indicating sorption was the initial mechanism of removal of TCE from the aqueous phase. Degradation daughter products (i.e., cis-DCE and VC) were observed in the months following the PS treatments, indicating biological VOC dechlorination following the initial sorption. The DHC-L treatment also saw an increase in effluent daughter products and a reduction in effluent TCE. Total effluent VOCs eventually rebounded to within an order of magnitude of the control in all three treatments, but to a lesser degree with the PS and PS-DHC-L. After approximately 20 days post-delivery, the PS had migrated throughout the transmissive and low k soil layers within the two PS treatments. Findings of this work include: 1) consequential contaminant storage and release timeframes associated with low k zones, 2) sorption is the primary initial removal mechanism when the PS is initially applied, 3) a solution of DHC and lactate will provide reductions in effluent VOC concentrations, but will eventually rebound once the electron donor is exhausted, 4) sorption leading to degradation are the removal mechanisms when PS is applied, 5) treatment by PS-DHC-L increased DHC populations approximately two orders of magnitude in both the silts and sands compared to the DHC-L treatment, and 6) the migration of the PS throughout the low k soils of the two PS

treatment tanks indicates a substantial increase in sweep efficiency compared to a water-only flush, which has far-reaching implications for long-term treatment options.