In Situ Reduction of 1,2,3-Trichloropropane in Groundwater: Advancements and Case Studies

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Background/Objectives. 1,2,3-Trichloropropane (TCP) is an emerging groundwater contaminant characterized by high mobility in the subsurface, resistance to natural attenuation and most engineered remedies, and low regulatory levels relative to other volatile organic compounds. For example, the State of California promulgated a Maximum Contaminant Level (MCL) for TCP of 0.005 micrograms per liter (µg/L). TCP has been detected in groundwater near chemical manufacturing facilities and military bases and is present in some agricultural chemicals, including fumigants and pesticides. This use case can result in low-level non-point source TCP contamination in agricultural regions, where large diffuse plumes make it particularly challenging to remediate cost-effectively. Since the mid-2000s, proof-of-concept tests have demonstrated in situ reduction is a promising technology for remediation of TCP at both high and low concentrations. The objectives of this abstract are to present the findings of several case studies exploring site-specific factors that affect TCP chemical and biological reductions and to present recent advancements in both technologies

Approach/Activities. Findings from in situ biological reduction (ISBR) implemented at two agricultural chemical (ag-chem) facilities and in situ chemical reduction (ISCR) implemented at one military base were compared. TCP concentrations in groundwater at the three facilities differed significantly, with up to 10,000 mg/L initially present at Facility 1, up to 70 mg/L initially present at Facility 2, and up to 15 mg/L initially at Facility 3. Groundwater concentrations of 1,2-dichloropropane (DCP), a common TCP co-contaminant at ag-chem facilities ranged from 11,000 mg/L at Facility 1 to a maximum of 730 mg/L at Facility 2 (DCP is not present at Facility 3). At Facility 1, ISBR was implemented in 2004 and included biostimulation within the source area. At Facility 2, ISBR was implemented in 2016 and included a pilot study consisting of biostimulation and bioaugmentation with a microbial culture enriched in *Dehalogenimonas* (*Dhg*) species. Based on the results of the pilot study, a full-scale ISB remedy was implemented at Facility 2 in 2018. At Facility 3, zero-valent zinc (ZVZ) injections to promote ISCR were implemented in 2014 and 2019.

Results/Lessons Learned. At the two ag-chem facilities, post-injection performance monitoring demonstrated reduction of TCP to near analytical method detection limits after an initial lag period of approximately six months. DCP concentrations concurrently decreased to near analytical method detection limits detection limits. At Facility 2, an increase in the *Dhg* population was reported after the initial lag period, concurrent with onset of TCP and DCP degradation. While prior laboratory scale studies demonstrated higher degradation efficiencies and kinetics with higher TCP concentrations, the lag period observed during these case studies appears to be independent of TCP concentrations and potentially influenced by the groundwater composition. This presentation will discuss the elements of groundwater hydrogeology and chemical composition that may affect the efficacy of ISBR as a remedy for TCP remediation. At Facility 3, concentrations of TCP within the ZVZ injection area were reduced by 99%, with observed reductions in downgradient TCP concentrations between 49 and 98%. Efficacy of the

ZVZ injections has been maintained since 2014, with no notable rebound in TCP concentrations within the injection zone.