Full-Scale Application in Italy of a Combined ISCR and ERD Technology for the Treatment of an Aerobic Aquifer Impacted with Tetrachloromethane and Chloroform

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Background/Objectives. The site is in a highly industrialized area of northern Italy, where groundwater is contaminated with tetrachloromethane (>10 ppb), chloroform (>10 ppb), hexavalent chromium and, to a lesser extent, PCE and TCE (<1 ppb). The EHC® Liquid technology deploys in situ chemical reduction (ISCR) mechanisms for treatment of impacted groundwater. It is comprised of two ingredients which are easily combined and diluted for injection: i) ELS™ Microemulsion: a controlled-release food-grade carbon in the form of lecithin, and ii) EHC® Liquid Reagent Mix: an organo-iron compound. The addition of organic carbon in a saturated zone is widely known to promote conventional enzymatic reductive dechlorination reactions. As bacteria ferment the ELS Microemulsion component, they release a variety of volatile fatty acids (VFAs) such as lactic, propionic and butyric, which diffuse from the site of fermentation into the groundwater plume, and serve as electron donors for other bacteria, including dehalogenators. Lecithin itself is primarily composed of phospholipids, with both hydrophilic and hydrophobic properties in the molecular structure. Further, phospholipids support remediation by providing essential nutrients (carbon, nitrogen, phosphorus) to bacteria. Synergistically, the soluble organo-iron component is comprised of a ferrous iron (Fe^{2+}) that can form a variety of iron minerals (e.g., magnetite, pyrite) capable of reducing contaminants as they oxidize further to the ferric (Fe^{3+}) state via one electron transfer. The ferric ion can then be "recycled" back to ferrous, as long as other electrons from supplied carbon and indigenous carbon are available.

Approach/Activities. In the intervention area and its downstream sector, 10 standard pump and treat wells were located, designed to accelerate the removal of various contaminants. However, the presence of active pumps inside, or in the immediate vicinity, of the EHC Liquid injection zones could have compromised their effectiveness. This is a function of the increase in groundwater speed and potential removal of the injected emulsion. For this reason, a strategy has been planned to remodel the onsite well flow rates by reducing them to below threshold values, thus protecting effectiveness of the ERD treatment. Through use of mathematical modelling, optimal flow rates were defined to keep natural seepage velocity <300 m/year in the ERD treatment area, while still allowing P&T of groundwater in a wide downstream area, and effectively capturing flow from the injections area. Application of the remedial reagents was performed via direct injection through 28 fixed Manchette tubes distributed in the source area. The injection campaign required 306 kg of ELS Concentrate per point, plus 70 kg of organo-iron powder, for a total injection volume of 96 m^3 of EHC Liquid emulsion, in 10% solution.

Results/Lessons Learned. Fifteen months after injection of EHC Liquid into the main source area, concentrations of CT and CF contaminants were rapidly reduced up to 95% compared to pre-treatment levels. Requisite remedial target values were reached in all main monitoring piezometers in the area. Main field parameters in the ISCR and ERD treatment areas included: i) increase of Mn and Fe(II) in solution as anaerobic cometabolites, ii) decrease of DO (mg/L) and sulfate (mg/L) – competing electron acceptors pH stable in the neutral range, and iii) negative redox around -150 mV.