

Enhanced Anaerobic Dechlorination of TCE via Recirculation and Batch Injection Pilot Systems near São Paulo, Brazil

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Background/Objectives. At an operating manufacturing site in the State of São Paulo, Brazil, groundwater is impacted with trichloroethene (TCE) at concentrations as high as 30,000 micrograms per liter ($\mu\text{g/L}$), with lesser concentrations of other chloroethenes and chloroethanes. The impacted groundwater is present within a diabase saprolite at depths up to 60 feet below ground surface over an approximate 5-acre area, including an off-site manufacturing facility. Bench and pilot testing were implemented in late 2017 and early 2018 to evaluate the effectiveness of enhanced anaerobic dechlorination (EAD) for treatment of TCE and the other chlorinated organics in site groundwater, and to provide design information for full-scale remediation.

Approach/Activities. Maintenance of neutral groundwater pH is an important requirement for EAD systems. Based on the likely presence of acidic soil at the site, bench-scale pH buffer capacity testing was conducted to determine the quantity of alkaline buffer needed to maintain near neutral groundwater pH as part of electron donor injection. In order to retain flexibility with regard to future full-scale electron donor delivery approaches, two EAD pilot tests were conducted. The pilot tests did not include bioaugmentation. One (on-site) pilot test included groundwater recirculation of rapid-release electron donor (sodium lactate) and sodium bicarbonate for pH control through two extraction wells and two upgradient recirculation wells. The other (off-site) pilot test included batch injection of slow-release electron donor (emulsified vegetable oil [EVO]) and sodium bicarbonate through three injection wells. These two electron donors were selected based on their availability in Brazil and also because acid production caused by fermentation of these electron donors is low when compared with other applicable electron donors. For the recirculation pilot test, approximately 5,500 gallons of 4 percent sodium lactate solution was injected over a 5-month period. To reduce the rate of recirculation well biofouling, pulsed injection of sodium lactate over a 4-day timeframe was followed by 3 days of groundwater recirculation on a repeating weekly basis. The batch injection pilot test included application of approximately 2,000 gallons of EVO as a 5 percent solution.

Results/Lessons Learned. The effectiveness of the two EAD pilot tests was evaluated based on geochemical and chlorinated ethene molar concentration data from monitoring wells located within the pilot test treatment zones. TCE concentrations within the recirculation pilot test treatment zone decreased by 83 percent (from 2,375 to 406 $\mu\text{g/L}$) between October 2017 and March 2018, with generation of biodegradation daughter product cis-1,2-dichloroethene (cDCE). TCE concentrations within the batch injection pilot test treatment zone decreased by 97 percent (from 2,354 to 59 $\mu\text{g/L}$) between October 2017 and March 2018, with generation of biodegradation daughter products cDCE and vinyl chloride. The generation of vinyl chloride is consistent with development of *Dehalococcoides* dechlorinating bacteria. The favorable results of the EAD pilot tests were used to design full-scale EAD systems, using groundwater capture zone analyses. The on-site full-scale EAD system will include six extraction wells and ten recirculation wells. The off-site full-scale EAD systems will include ten batch injection wells, five extraction wells, and seven recirculation wells. The rationales for these planned electron donor delivery approaches will be discussed. The full-scale EAD systems will commence operations in late 2018, and available full-scale performance data will be presented.