Thermally Enhanced Natural Attenuation of VOCs: Two Years after In Situ Thermal Remediation

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Background/Objectives. The Solvents Recovery Service of New England (SRSNE) Superfund Site is in Southington, Connecticut (EPA Region 1). SRSNE processed 60-100 million gallons of solvents between 1955 and 1991. Solvent storage in unlined lagoons and other releases resulted in a non-aqueous phase liquid (NAPL) source zone in overburden and fractured bedrock. The 2005 Record of Decision selected a remedy that included, among other components, in-situ thermal remediation (ISTR) for NAPL in the overburden. ISTR was successfully implemented from May 2014 to February 2015, removing 225,000 kg of volatile organic compounds (VOCs) from 43,400 m^3 of soil, reducing VOC mass in the ISTR zone by >99% in soil and 97% in groundwater. Average total VOC reductions have declined by 97% at downgradient monitoring wells and 98% in untreated influent at a downgradient hydraulic containment system. Post-ISTR groundwater temperature monitoring shows sustained groundwater temperature increases (longer than predicted by pre-ISTR thermal modeling). This study evaluates the possibility that VOC degradation also contributes heat to the system.

Approach/Activities. A baseline microbiological survey was conducted in 2014 (concurrent with initiation of ISTR) using Bio-Trap™ samplers and qPCR "QuantArray-Chlor and/or Petro" analysis, and a post-ISTR survey with the same analyses was completed in 2016. In 2009, In-Situ™ Troll data loggers were installed and recorded temperatures twice daily in five wells (two shallow, one middle, and one deep overburden, and one shallow bedrock) approximately 23 to 28 meters downgradient of the ISTR zone. Pre-ISTR temperatures fluctuated seasonally by up to 15°C. The pre-remediation temperature data were filtered by averaging the measurements recorded on each calendar date at each well using six years of pre-ISTR data, producing a seasonally-adjusted baseline temperature dataset. Baseline temperatures were subtracted from the daily post-ISTR temperature to calculate a net ISTR-related temperature increase. Ten wells downgradient of the ISTR area were sampled for VOCs every other year prior to ISTR, once during ISTR, and three times per year post-ISTR. Pumping system influent was sampled twice monthly.

Results/Lessons Learned. More than two years after shutdown of ISTR, downgradient groundwater temperatures remain approximately 6 to 10°C above baseline. The post-ISTR microbiological survey showed a greater diversity and some higher abundances of reductive dechlorinators and BTEX (benzene, toluene, ethylbenzene and xylene) degraders. Increased temperatures are known to increase biotic and abiotic reactions, and have been documented to increase the degradation rates of aromatic and chlorinated VOCs. As biodegradation reactions are exothermic, it is interpreted that a heat-generating feedback loop was created within the containment area. As seen in landfills and composting, heat is generated due to microbial processes, which further enhances biodegradation, which contributes heat to the groundwater, further enhancing biodegradation. The combination of ISTR and in situ degradation have significantly reduced VOC concentrations in the former NAPL source zone and downgradient area. Even after removing background seasonal temperatures fluctuations, seasonal effects are still observed and decrease with depth below grade. The available data suggest that the total change in temperature is due to thermal treatment and microbial heat production.