Application of Enhanced Reductive Dechlorination: The Value of Assessing Site Conditions Prior to Decision Making

John Bastrup (jub@geo.dkl) and ***Hamdi Ashur*** (hma@geo.dk) (Geo, Lyngby, Denmark)

Background/Objectives. Chlorinated solvents have been widely used on electrical substations in Denmark as a degreasing agent to clean transformers. The excessive use has led to soil and groundwater contamination threatening the groundwater resource. Geo has remediated the groundwater contaminated with chlorinated solvents on several substations with very different site conditions like Site 1 and Site 2 showed in this presentation. The substations are located in the northern part of Zealand in Denmark. Prior to the remediation with enhanced reductive dechlorination (ERD) the surface near contaminant source zone was excavated. Full degradation of the mother compound occurred at Site 1 but only partial degradation was observed at Site 2. We will present the results, differences between the two sites, and discuss the lack of full degradation at Site 2.

Approach/Activities. For the ERD for Site 1 a total of 4.000 kg molasses was injected in 22 injections well with a dilution factor of 1:4 in September 2014. The treatment zone had approximately a volume of 20.000-26.000 m^3. At site 2, 450 kg molasses were injected in 29 wells with a dilution factor of 1:5 in June 2012. The treatment zone had approximately a volume of 190 m^3. At Site 1, the geology is characterized by quaternary deposits consisting of alternating layers of moraine clay and regional glacial sand. According to the water level measurements a general south-southeast groundwater flow were observed in the sandy aquifer. The geology at Site 2 is more complex. Southeast of the site, the geology consists of a marsh area with thick layers of peat. There is no clear flow direction in the secondary groundwater aquifer due to inconsistency in the measured hydraulic water levels. Quantitative analysis of the bacteria *Dehalococcoides 16S with the gene bvcA* was done on groundwater samples from both sites. At Site 1 the bvcA gene were present in concentrations up to 10E7 gene copies per l groundwater. While at Site 2, the maximum concentration was 10E4 gene copies per l groundwater. To obtain significant full dechlorination the concentration of *Dehalococcoides* 16S with the gene vcrA or bvcA must be above 10E5–10E6 gen copies per l. Furthermore, the redox conditions were measured after the addition of substrate and both sites showed increased reductive conditions optimal for reductive dechlorination. In order to distribute the substrate in the groundwater aquifer the ERD design at Site 1 included a closed-loop of groundwater recirculation. At Site 2 a recirculation system were not included in the ERD design due to the geological conditions. After a year the concentration of the chlorinated solvents were reduced by up to 91% at Site 1 compared to the baseline, and further reduction where observed at the second injection of substrate up to 100%. There is not observed a clear trend related to the reduction of chlorinated solvents due to the recirculation. At site 2 a significant increase of chlorinated solvents up to 990% compared to the baseline were observed after the injection of the substrate. The decrease in mother compounds and increase in degradation products indicate a partial degradation of PCE/TCE.

Results/Lessons Learned. ERD was used as remediation technique for two sites contaminated with chlorinated solvents. The sites had same usage and cause of contamination, but due to complicated geology resulting in poor contact to the contaminants and lack of bacteria with a specific gene only a partial degradation were observed at Site 2. Full degradation were observed for Site 1. The results from the two sites highlights the significance of site conditions. An assessment of preconditions (redox, available bacteria and geology) of a site will not only reduce remediation cost but also reduce the duration of the remediation time.