Treatment of Mixed Chlorinated Solvents and 1,4-Dioxane in Groundwater: Testing of Two Biodegradation Strategies

Christa Bucior, ***Sophia Dore***, Donald Pope, Ryan Thomas, Alan Weston and Fred Blickle
(GHD, Niagara Falls, New York, USA)

Background/Objectives. 1,4-Dioxane is a stabilizer for storage and transport of chlorinated solvents, in particular 1,1,1-TCA. For this reason, 1,4-dioxane is often found where chlorinated solvents are present in groundwater. Increasing regulatory attention to 1,4-dioxane has prompted the evaluation of 1,4-dioxane at many chlorinated solvents sites around the country.

Chlorinated volatile organic compounds (CVOC) and 1,4-dioxane are present in the soil and groundwater at a site in Southern California. The CVOC are primarily tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), and 1,1-dichloroethane (1,1-DCA) . A laboratory treatability study was performed to determine the best approach for treatment of both CVOC and 1,4-dioxane.

Approach/Activities. A laboratory treatability study was performed to assess the effectiveness of biodegradation for treatment of soil and groundwater from the site under sequential anaerobic/aerobic conditions and under aerobic conditions using a co-metabolic pathway.

Enhanced biodegradation is a passive, low impact treatment strategy that can achieve clean up goals within a relatively short time in a cost-effective manner. Anaerobic biodegradation technology has been demonstrated to be effective for treating PCE and TCE in groundwater at many sites. Under anaerobic conditions reductive dechlorination of chlorinated compounds to ethane and ethene can occur. However, 1,4-dioxane does not degraded under anaerobic conditions, however it can be degraded under aerobic conditions. Chlorinated compounds such as PCE and TCE can be degraded under aerobic conditions via a cometabolic pathway.

Two strategies were tested to treat the mixed chlorinated solvent/1,4-dioxane plume. The first was to to treat chlorinated solvents under anaerobic conditions and once treatment was complete the conditions were made aerobic to treat 1,4-dioxane.

The second stragegy was for 1,4-dioxane and CVOC to be degraded together under aerobic conditions by a co-metabolic pathyway. In order for co-metabolism to occur, a carbon source in addition to the 1,4-dioxane must be present or must be added to the subsurface. In this study, dextrose was tested as a co-substrate. Microogranisms possessing the enzymes to perform this pathway are not present at all sites. The addition of a microbial inoculum may be necessary and was tested.

Results/Lessons Learned. The results of this study showed that CVOC were removed under anaerobic conditions. Some treatment occurred without the addition of a microbial inoculum; however, the data showed that the addition of a microbial inoculum was required in order for complete reductive dechlorination to occur. CVOC were also removed under aerobic, co-metabolic conditions; however, greater treatment was observed under anaerobic conditions.

Up to 26 percent treatment of 1,4-dioxane was observed under aerobic co-metabolic conditions while up to 41 percent treatment of 1,4-dioxane was observed under sequential anaerobic/aerobic conditions. Since greater treatment of both 1,4-dioxane and CVOC were observed with the sequential anaerobic-aerobic treatment, this treatment was recommended for a field implementation, which is scheduled for fall of 2017.