

## **Substrate Injection Treatment for a Chlorinated Solvent Groundwater Source Area**

William Smith, P.G., *Kevin A. Morris*, (kmorris@envalliance.com)  
(Environmental Alliance, Inc., Wilmington, Delaware, U.S.A.)

An industrial facility has been operating under a RCRA consent order since the early 1990's with documented contamination from chlorinated solvents in surface, shallow and deep groundwater systems. In situ anaerobic bioremediation pilot tests were implemented in August 2002 to address both the residual chlorinated solvents and perchlorate in soil and shallow groundwater simultaneously at a primary source area of the facility. The pilot test in the primary chlorinated solvent source area (tetrachloroethene) includes the injection of substrate into the shallow groundwater to stimulate the indigenous bacteria to both reduce PCE to ethene and ethane and completely reduce perchlorate.

The source area injection pilot study system operation was initiated in October 2002 and consists of three injection points. The injection pilot study system is monitored by a single downgradient shallow monitoring well which is located in a shallow bedrock bowl. PCE concentrations have historically been as high as 90 mg/L at this monitoring point with perchlorate concentrations of approximately 1.5 mg/L.

Substrate injections are conducted with a substrate solution mixed with purge water from either onsite deep groundwater or shallow groundwater wells. For each injection event, approximately equal amounts of substrate solution were injected into each injection point. After the substrate injections are complete, an approximately equal amount of flush water is injected into each point to both disperse the substrate and to prevent biofouling at each point. The primary lines of evidence for evaluation of the success of the pilot system to induce an anaerobic reducing environment is the reduction of perchlorate, competing electron acceptors (Dissolved oxygen, iron, nitrate and sulfate) and PCE and its daughter products (TCE, cis-1, 2-DCE and VC, ethene and ethane). Groundwater monitoring also includes pH, oxidation-reduction potential, dissolved organic carbon (DOC) and microbial analysis.

The laboratory analytical data indicates an anaerobic subsurface environment has been established via the subsurface substrate injections based on field data and both perchlorate and VOC reductions. Perchlorate concentrations have been reduced from 1.5 mg/L in September 2002 to 0.86 mg/L in November 2005. PCE has been reduced from approximately 60 mg/L to 3 mg/L, TCE has been reduced from 0.24 mg/L to 0.01 mg/L, Cis-1, 2-DCE has been reduced from 1.5 mg/L to 0.5 mg/L, and VC has been reduced from 0.03 mg/L to 0.01 mg/L. These positive results of the shallow groundwater bioremediation pilot test indicate that this type of system may be feasible for full-scale implementation at the facility for the in situ bioremediation of both chlorinated solvents and perchlorate in soil and groundwater to risk-based levels that are protective of human health and the environment.