Sustainable In Situ Remediation Approach for Arsenic-Impacted Groundwater at a Superfund Site in New Jersey

Tricia North (Tricia.M.North@usace.army.mil) and
Lily Sehayek (Lily.Sehayek@usace.army.mil)
(U.S. Army Corps of Engineers, Philadelphia, PA, USA)
Rick Wilkin (Wilkin.Rick@epa.gov) (U.S. EPA ORD, Ada, OK, USA)
Hunter Young (Young.Hunter@epa.gov) (U.S. EPA Region II, New York, NY, USA)
Diana Cutt (Cutt.Diana@epa.gov) (U.S. EPA ORD, New York, NY, USA)

Background/Objectives. The Vineland Chemical Company operated from 1949 to 1994 producing arsenical herbicides and fungicides. A Record of Decision (ROD) signed in 1989 addressed remedial action at the site which included a pump and treat (P&T) system to remediate arsenic (As) in groundwater. An optimization study conducted in 2010, ten years after the onset of the P&T system, found that the current P&T system is unlikely to restore the aquifer within a reasonable time period as specified by the ROD. Because the annual cost for the P&T system is very high, the study listed several recommendations designed to optimize or replace the P&T system including in-situ remediation for As immobilization. The objective of this work was to find a sustainable in situ approach to remediate As and identify the key processes that account for the success of the remedial action.

Approach/Activities. Arsenic in iron (Fe) rich groundwater was immobilized successfully using a large scale pilot air sparge system. Key processes and parameters controlling As immobilization were determined through a novel approach that combined bench scale tests, geochemical modeling, and groundwater and soil characterization. Results from these tests will be used to optimize the design and operation of the full scale system, and provide guidance for design of air sparge systems at other sites with As impacted iron rich groundwater at variable redox conditions.

Results/Lessons Learned.
Field data from the large scale air sparge system show that As and Fe were reduced from levels ~ 1 and 15 ppm to levels as low as 10 ppb and 1 ppm, respectively. Key processes that account for As immobilization in groundwater include:

- Oxidation and precipitation of Fe to amorphous hydrous ferric oxide (Hfo) – This process was modeled as a function of dissolved oxygen and pH using a non-equilibrium kinetic rate equation. Fe precipitation does not occur instantaneously at the pH range of 5.5 to 6.5 encountered at this site. Precipitation of Hfo occurred downgradient of the air sparge wells prior to reaching compliance points, reducing the need for well maintenance due to clogging.
- Sorption of As to amorphous Hfo and Fe in soil - This process was modeled using the surface complexation model available in Phreeqc. The majority of As was immobilized by the freshly oxidized Fe with a small fraction of As immobilized by Fe in soil. Soil and groundwater characterization demonstrated that oxidation of As was not required for As immobilization since the reduced form of As was found to be the dominant species in both the aqueous and solid (immobilized) phases.
- Degassing of CO_2 - The pH of groundwater is controlled by oxidation of iron, which decreases pH and degassing of CO_2, which increases pH.

The pilot air sparge system at the Vineland site was operational for over a year without the need for pH adjustment or other significant maintenance of the air sparge wells. Identifying the processes responsible for As immobilization was an important factor in the sustainable operation of the air sparge system.