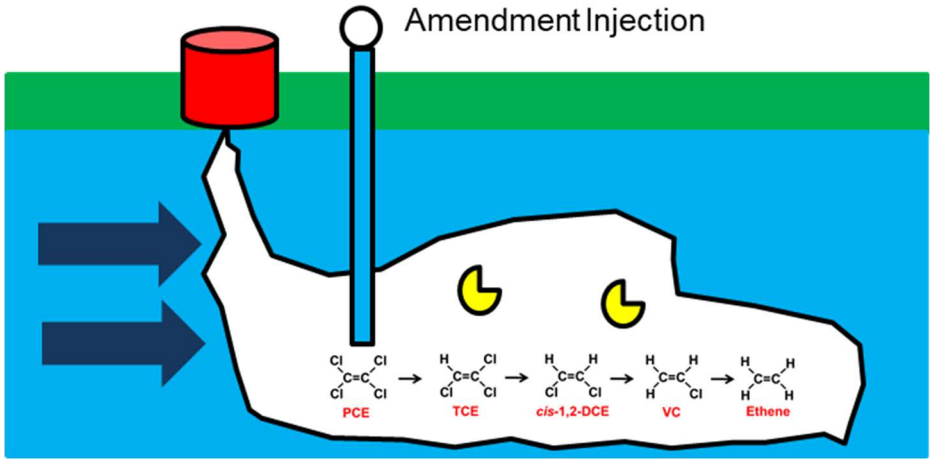
PROJECT ID:
626

Evaluation of the Mechanisms Driving Persistence of Low Concentrations of Chlorinated Ethenes and Ethanes at Legacy Bioremediation Sites



Graphic of impacted groundwater site with transformation pathway of CVOCs using bioaugmentation (amendment injection of dechlorinating bacteria).
(Image credit: Tony Danko)

OBJECTIVE

This project will expand our understanding of the mechanisms responsible for cis-dichloroethane (cis-DCE) and vinyl chloride (VC), and chloroethane persistence at impacted sites, specifically looking at the role of sulfur minerology in hindering the bioremediation processes of chlorinated volatile organic compounds (CVOCs). The goal is to develop a decision matrix for Navy remedial project managers (RPMs) to evaluate the potential for continued bioremediation or the need for alternative remedies at these sites.

PROBLEM STATEMENT

In situ bioremediation of CVOCs in groundwater at Navy sites uses bioaugmentation and biostimulation amendments to break down harmful chemicals like perchloroethylene (PCE) and trichloroethylene (TCE) ultimately into harmless byproducts such as ethene and ethane. However, the process often stalls, especially with intermediate chemicals like cis-dichloroethane (cis-DCE) and vinyl chloride (VC), causing contaminants to persist, resulting in these sites not achieving closure.

DESCRIPTION

This project hypothesizes that sulfate and sulfur minerals (e.g., calcium sulfate, iron sulfide) influence sulfate concentrations in groundwater and inhibit cis-DCE and VC dechlorination. These differences may vary not only between sites but also within the same site. While lower sulfate concentrations generally correlate with improved remediation, this is not always consistent, highlighting the need to better understand sulfur's role in the persistence of cis-DCE and VC.

The first task involves analyzing historical data from selected demonstration sites, including bioremediation outcomes and trends in cis-DCE, VC, and sulfur-related concentrations.

The second task involves collecting soil cores and groundwater samples for analysis of CVOCs, dissolved gases, major ions, total organic carbon, volatile fatty acids, hydrogen,

field parameters, and a detailed suite of microbial biomarkers. These metrics will be integrated into the historical data to identify statistical relationships between key parameters, if present.

The outcome will be a decision matrix for Navy RPMs, guiding bioremediation efforts based on site-specific concentrations of CVOCs and other parameters relative to the sulfur-related characterization and recommending further analysis if necessary. If successful, the matrix will provide RPMs with a key line of evidence for continued bioremediation efforts or rationale for considering an alternate approached at the site.

RETURN ON INVESTMENT

For large treatment zones, fermentable carbon substrates, such as emulsified oil injections, are typically use and can cost hundreds of thousands to millions of dollars. In practice, these remediation injections can be cost-effective at first, resulting in substantial conversion of PCE or TCE to daughter products cis-DCE and VC (i.e., low $/mass of TCE degraded). However, subsequent injections often fail to achieve the same level of conversion of cis-DCE and VC to ethene, resulting in persistent concentrations of these compounds and greater unit costs (i.e., high $/mass of VC degraded). More frequent monitoring and sampling of wells typically follow these reinjection events, which further increases the overall costs.

This project aims to provide cost savings through: 1) the refinement of the proposed injection strategy (i.e., re-inject at specific wells rather than site-wide); 2) less frequent re-injection events; and 3) ceasing further injections in favor of an alternative remedy/strategy.

NAVY BENEFITS

Navy RPMs need a decision tool to assist in the determination of proper paths to follow regarding legacy bioremediation sites. This project will provide guidance to answer critical questions at remediation sites including:

- Was bioremediation the appropriate strategy for the site based on the performance results to-date (including sulfur parameters)?
- Do we expect subsequent rounds of emulsified oil injections to result in a successful outcome or should an alternative remedy be considered?

TRANSITION DESCRIPTION

An accessible and field-relevant guidance document for evaluating the performance of bioremediation sites with a focus on the nexus of sulfur minerals and dissolved sulfates will be developed. This guidance will be developed with RPMs in mind to aid in future decision making for bioremediation remedy optimization. Additionally, outreach of this project may include tutorials and webinars for the implementation of these guidelines.

CONTACT

For more specific information about this project, contact the Principal Investigator, at anthony.s.danko.civ@us.navy.mil

ABOUT THE NESDI PROGRAM

The Navy Environmental Sustainability Development to Integration (NESDI) program is the Navy's environmental research and development demonstration and validation program, sponsored by Office of the Chief of Naval Operations (OPNAV) Compliance and Mission Readiness Division (N4I1) and managed by the Naval Facilities Engineering Systems Command (NAVFAC) from the Engineering and Expeditionary Warfare Center (EXWC) in Port Hueneme, CA.

The mission of the program is to provide solutions by demonstrating, validating and integrating innovative technologies, processes and materials; and by filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring fleet readiness.

For more information, visit the program's web site at www.navfac.navy.mil/nesdi
or contact the NESDI Program Managers at NESDI.fct@navy.mil