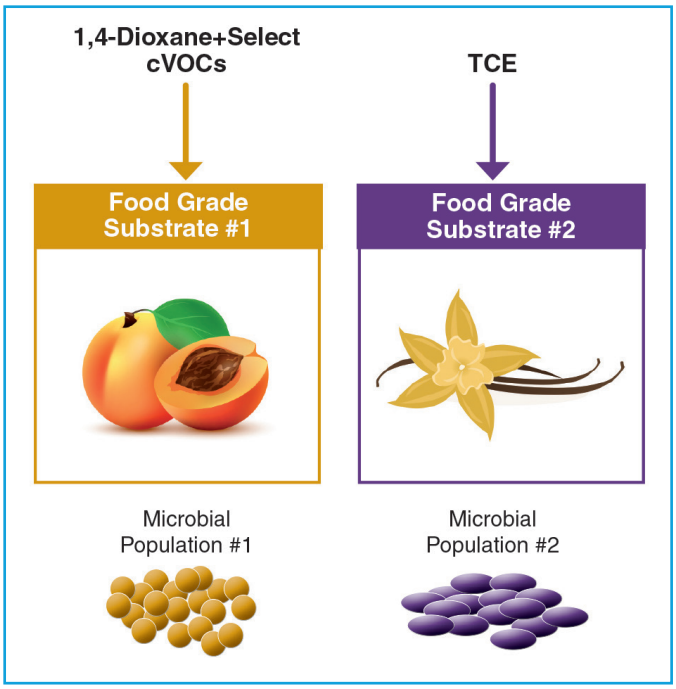
PROJECT ID:
579

In situ Biodegradation of 1,4-Dioxane and Chlorinated Solvent Mixtures in Dilute Plumes



OBJECTIVE:

The objective of this effort is to demonstrate that soluble, food grade substrates, including specific organic acids or alcohols, can be used to promote the in situ cometabolic treatment of 1,4-dioxane and chlorinated volatile organic compounds. Field evaluations using single-well-push-pull tests will be performed at a selected Navy site where the aquifer contains both substances.

PROBLEM STATEMENT:

1,4-Dioxane is a chemical found at many federal facilities because of its widespread use as a stabilizer in certain chlorinated solvents, paint strippers, greases and waxes. It is classified by the U.S. Environmental Protection Agency (EPA) as a likely human carcinogen. Chlorinated volatile organic compounds (CVOC) are an associated class of compounds widely used as solvents and degreasing agents. CVOCs may contain 1,4-dioxane, along with other chemicals, such as trichloroethylene (TCE).

Together, these compounds have been found at over 100 DoD installations.

Although EPA does not have a maximum contaminant level (MCL) in drinking water for 1,4-dioxane, the regional screening level may be as low as 0.46 micrograms per liter (μg/L). MCLs for CVOCs can be as low as 2 μg/L, as is the case with vinyl chloride. 1,4-Dioxane and CVOCs have differing physical and chemical properties, and both are expensive to treat. Ex situ pump and treat methods are somewhat effective, but Navy policy is to limit the installation of these systems since they are a significant long-term cost and difficult to shut down once started.

DESCRIPTION:

The project team will first select an appropriate Navy site and will install wells, if needed, to obtain samples. Samples of sediment and groundwater will be collected and a microcosm study conducted. Samples will be placed in serum bottles and subjected to various biostimulation and bioaugmentation procedures with an end goal of producing the food grade substrates benzyl alcohol and 2-butanol.

The investigators for this project discovered the use of food grade substrates to promote aerobic cometabolism of 1,4-dioxane and CVOCs in a current Strategic Environmental Research and Development Program (SERDP) project *Evaluation of Branched Hydrocarbons as Stimulants for In Situ Cometabolic Biodegradation of 1,4-Dioxane and Its Associated Co-Contaminants* (no. ER-2303). Using the pure culture *Rhodococcusrhodochrous 21198*, they found that 2-butanol was effective in inducing the short chain monooxygenase that transforms 1,4-dioxane and a broad range of CVOCs.

At the end of the microcosm study, pending a "go" decision, the next task will be a series of single-well push-pull tests.

Using protocols developed in an earlier Environmental Security Technology Certification Program (ESTCP) project, along with that project's lead investigator, the most promising growth substrate and culture will be pushed into the in situ well. Prior to injection, a conservative tracer (bromide) will be added with the cometabolic growth substrate and reactive surrogate. Dissolved oxygen or hydrogen peroxide as a source of oxygen will also be added.

Since the cometabolic process transformation is driven by a growth substrate, 1,4-dioxane and CVOCs can be treated to levels below those needed to meet regulatory requirements.

The test solution will be permitted to reside in the aquifer so that utilization of the growth substrate is achieved under natural gradient conditions. The tests will include a series of steps that will demonstrate the ability to stimulate native or bioaugmented microorganisms, plus their ability to promote the cometabolism of 1,4-dioxane and CVOCs of concern.

During the extraction phase, flow is reversed and concentrations of tracer, reactive solutes and possible reaction products are measured as a function of time at the same well. Tracer concentrations are used to adjust concentrations of test solution components for dilution. Mass balances are computed by integrating dilution-adjusted concentrations during the extraction phase.

The main goal is to determine the ability of native microorganisms to transform the 1,4-dioxane and the CVOCs when grown on these substrates and potentially additional substrates discovered through the team's current SERDP project. Investigators will also determine if the bioaugmentation of *Rhodococcus rhodochrous 21198* or *Pseudomonas mendocina KR1* results in more effective in situ remediation. The ability to use food grade organic acids and alcohols as growth substrates is novel and would result in much wider implementation of this technology. In addition, since the cometabolic process transformation is driven by a growth substrate, 1,4-dioxane and CVOCs can be treated to levels below those needed to meet regulatory requirements.

TRANSITION DESCRIPTION:

Technology transfer activities include publication of peer-reviewed papers, presentations at national meetings and participation in technology transfer organizations such as the Interstate Technology and Regulatory Council (ITRC). Additional efforts facilitated by the Naval Facilities Engineering and Expeditionary Warfare Center could include a presentation at the Remediation Innovative Technology Seminars (RITS) and the environmental restoration training event, Open Environmental Restoration Resource (OER2) webinar and briefings in various Navy workgroups including the Risk Assessment Workgroup (RAW) and the Alternative Restoration Technology Team (ARTT).

CONTACT:

For more specific information about this project, contact the Principal Investigator at 805-982-4805. Contact the NESDI Program Manager at 805-982-4893 for more general information about the program.

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 the Chief of Naval Operations Energy and Environmental Readiness Division and managed by the Naval Facilities Engineering Systems Command from the Engineering and Expeditionary Warfare Center 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 Navy readiness and lethality.

Visit the program's public website at https://www.navfac.navy.mil/NESDI for more information.