Biosorption Treatment of Plasticizers and Solvents

Cleanup
CU-711

LEAD AGENCY: US Army

LAB: USAE Waterways Experiment Station (WES)

PRINCIPAL INVESTIGATOR: Ms. Cynthia L. Teeter (601) 634-4260

PROBLEM STATEMENT: The Department of Defense (DoD) and Department of Energy (DOE) have many sites that contain groundwaters contaminated with low levels of plasticizers (acetone) and chlorinated solvents (trichloroethylene [TCE]). Current or traditional treatment technologies available for use in TCE treatment are granular activated carbon (GAC) and air stripping; however, neither technology results in the direct destruction of the organic contaminant. An innovative technology, ultraviolet (UV) chemical oxidation, will be available for use in the near future for chlorinated solvent oxidation. Remediation costs for all of these technologies generally falls within the $1.00 to $5.00 per 1,000 gallons range. In the case of GAC, treatment of groundwaters containing low levels of chlorinated solvents is not economically feasible.

Acetone poses a very unique challenge to both traditional and innovative technologies. Acetone does not adsorb onto GAC due to its high water solubility, it does not strip in air strippers due to its low Henry's Law constant, and it does not oxidize in chemical oxidation systems due to its stable chemical structure. Acetone is degraded biologically, but biotreatment is unsuitable for treatment of low level contaminated groundwaters because an active biomass cannot be sustained due to low substrate loadings. Unfortunately, most groundwaters contain acetone at relatively low levels; therefore, expensive cometabolite addition is almost always required.

TCE can also be treated using biological degradation. TCE is somewhat more difficult to biodegrade then acetone, but recent advances in cometabolic pathways (methanotrophic) indicate that biotreatment of TCE is feasible. One problem associated with TCE degradation is the tapering off of microbial activity, over time, in continuous and semi-continuous biological systems. Biosorption is almost always associated with GAC. Primarily, GAC is used as a means of extending the service life of a GAC bed by regeneration of the spent carbon within the bed. Recent work on phenolic compounds has resulted in the development of an innovative technology known as biofilters. This technology utilizes GAC as a means of structurally supporting an active biomass.

Organophilic clays (OPCs), have been successfully used to remove low levels of wood preserving waste from contaminated groundwater. Results of this evaluation are encouraging, but disposal of the spent OPC is a problem. OPCs are innovative adsorbents that have received limited evaluation and application for the removal of TCE.

The USAE Waterways Experiment Station (WES) has conceptualized a treatment system for low level contaminated groundwaters based on biosorption and bioslurry systems. In this treatment scheme, the contaminants are adsorbed onto the OPC until all adsorption sites of the OPC are spent. The spent OPCs are removed from the reactors and then an on-site reactor is used to biologically degrade the adsorbed contaminants. This converts OPC adsorption from a simple phase-change technology into an on-site destruction technology.

This proposed treatment approach is an applied research and technology field pilot application (6.2). This research is an enhancement to an existing FY 93 SERDP proposal.

Specific identified user requirements to be addressed through performance of this work unit include:

- Technology for removal of energetics/other organics contamination.
- Treatment system for water contaminated with organic contaminants.
- Treatment system for water contaminated with chlorinated and defense hydrocarbons.
- Treatment of Navy revellent contaminants in salt/brackish/groundwater matrices.
- Isolation and treatment technology for contaminated surface water impoundments.
- Treatment system for water contaminated with mixtures of chlorinated solvents.
- Contamination under buildings and roads.
- Remedial treatment technology for soils contaminated with chlorinated and nonchlorinated organics.
- Improved marine sediment remediation technologies for metals, organics, and PCBs.
- Enzyme and bacterial treatment technology.

PROJECT DESCRIPTION: The USAE Waterways Experiment Station (WES) under the Environmental Quality and Technology Program (EQT) is developing a means of biologically regenerating spent GAC. WES also plans to evaluate the use of OPCs for treatment of explosives contaminated groundwater. It is believed that OPC biosorption can be utilized for the treatment of low level explosive contaminated groundwater.

The USAF Tyndall AFB has been active in development of microbial consortia capable of effectively degrading TCE from contaminated groundwaters. This technology can be tailored to interact with the conceptualized OPC biosorption schemes. Tyndall AFB is currently developing a bioreactor for treatment of contaminated groundwater with higher levels of TCE. The consortia developed in these efforts will be useful in the development of the OPC biosorption concept. Tyndall has also developed a surfactant which may further enhance the sorptive capacity of the OPCs. An increase in sorptive capacity will result in improved costs benefits. There has been little or no direct development of OPC biosorption. Past efforts on bioregeneration of spent GAC containing phenolic compounds indicates promise for the use of microorganisms to degrade adsorbed compounds.

A recent evaluation of OPCs for wood preserving waste treatment indicates the utility of OPCs for groundwater remediation. Unfortunately, there are few options for disposal of spent OPCs (and GAC). Under US Environmental Protection Agency funding, WES has demonstrated the feasibility of using bioslurry systems for treatment of soils contaminated with plasticizers and wood preserving wastes. The contaminated soils used in these studies did contain significant clay fractions.

The overall objective of this study is to develop an OPC based biosorption process. Development of this technology will provide environmental engineers with a practical means of treating acetone. With respect to TCE, this technology may eliminate the problem of TCE activity loss over time.

The development of OCP biosorption into a fieldable technology for site remediation will be approached through a series of tasks detailed below:

a. Task I. The adsorption capacity of various OPCs and other sorbents will be preliminarily evaluated by contacting the sorbent with spiked solutions containing TCE. Three to four sorbents will be selected for further testing in adsorption isotherms. Activated carbon performance will be compared to the performance of the sorbents. One or two of the most effective sorbents will be selected for small column studies.

b. Task II. Evaluation of microbial activity toward adsorbed TCE. Toxicity effects of TCE concentrations on microbial consortia will be evaluated using a respirometer study. The ability of a microbial consortia to desorb and subsequently biodegrade the adsorbed acetone and TCE from the OPC will be evaluated using laboratory batch systems.

c. Task III. Bench Scale Bioslurry Studies. Bench scale studies will be performed to determine process feasibility, verify reaction kinetics and pathways, and set pilot studies test matrices.

d. Task IV. Pilot Scale Studies. Pilot scale studies will be performed using pilot OPC absorbers. The complete pilot system will be designed for complete mobility to other candidate sites. If required, a process gas management system may be used if off-gassing of TCE and the selected cometabolite is deemed problematic. These pilot scale studies will be performed in the field at CRREL. Once completed, the pilot system will be available for field pilot application at other installations.

e. Task V. Draft Report. A report detailing the following will be drafted:

1. Describe techniques on how to perform bench scale treatability studies used for process evaluation during Feasibility Studies (FS).
2. Discuss process feasibility and potential limitations.
3. Present the results from the bench and field pilot studies.
4. Summarize available full scale equipment availability.

The report will be design and applications orientated. The report will serve as a handbook for implementation of OPC biosorption at other field sites.

The information obtained from the performance of this study will assist in meeting several DoD/DOE environmental remediation objectives. This work effort will result in the development of a contaminant-destruction technology applicable toward chlorinated solvent compounds.

Technical issues to overcome as identified to date are to determine if OPCs have appreciable adsorption capacities for TCE; if OPCs can be treated to levels that render them environmentally safe and regulatory acceptable; and if process gas recirculation will be required for TCE biodegradation of the ground OPCs. This project falls under the 1.H and 1.I requirement thrust areas under the Tri-Service Environmental R&D Strategy Plan.

EXPECTED PAYOFFS: Potential users include all groups, both private and governmental, that are involved in remediation of groundwaters contaminated with organic and explosives compounds. OPC biosorption may eliminate problems associated with reduce TCE bioactivity over time. The actual economic benefit is difficult to ascertain due to the innovative nature of the concept. A conservative estimate is that the technology could be implemented at a cost range of $1.00 - $3.00 per 1,000 gallons treated.

TRANSITION PLAN: This technology development will generally follow the typical transitional path detailed under DoD's EQT Program. Within three years, the technology will be transitioned from a bench concept to an implementable technology. Technical assistance will be available to technology users during design and implementation of OPC biosorption. Collaboration with private organizations for improving process development through CRADAs will be proposed. The technology will be transitioned to the user community through technical papers, presentations, briefings by the performers of this proposal.