USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: The Effect of Biosurfactants on the Fate and Transport of Nonpolar Organic Contaminants in Porous Media

Duration: July 1, 1997 - June 30, 1999

Federal Funds: FY 1997 $69,543

Non-Federal Funds: FY 1997 $220,759

Principal Investigators:

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Congressional District: At Large

Statement of the Critical Regional or State Water Problem(s):

Accidental and intentional release of hazardous wastes threatens environmental sustainability and human health. The Northeast Region has many industrial centers where -accidental or intentional releases of hazardous substances to soils and subsurface environments are common. As a result the region has numerous sites [hat require cleanup of soils and aquifers under various federal and state programs. The contaminated sites include government and industrial facilities (Superfund Program, approximately 50,000 across the U.S.) to leaking underground storage tanks (estimated to be several hundred thousand). Many of the contaminated sites in this region are located in areas that have shallow water tables and course-textured, permeable soils making the grou ndwater more susceptible to contamination. Although the capacity of soils to detoxify waste has been well documented, this capacity is limited however, and natural detoxification processes often require years to restore impacted sites. In the United State s alone, it has been estimated that hazardous waste site resoration costs may approach 1.7 trillion dollars over the next 30 years. These estimates have raised serious concerns regarding the ability to pay for site restoration. Yet in the U.S., 40 million people live within four miles of a superfund site. Therefore, it is likely that support will continue to grow for site clean-up and restoration. Consequently it is imperative that less expensive and more efficient remediation approaches be developed.

Sorption and sequestration of xenobiotic compounds within the soil matrix are critical processes affecting contaminant mobility, toxicity, and persistence. Slow desorption and release from the soil matrix to the aqueous phase represents a long-term con taminant source and hinders remediation efforts. It has been suggested that surfactants may be used to facilitate pump-and-treat and/or bioremediation of contaminated soils and aquifer sediments. Most research has focused on using synthetic surfactants to mobilize contamination for pump-and-treat systems and has shown promise in enhancing biodegradation. Biosurfactants have comparable solubilization properties of synthetic surfactants but have several additional advantages which make them superior candidates in bioremedation schemes. First, biosurfactants are biodegradable and pose no additional pollution threat. Furthermore, most studies indicate that they are non-toxic to microorganisms and therefore are unlikely to inhibit biodegradation of NOC. Biosur factant production is less expensive, can be easily achieved ex situ at the contaminated site, and has the potential of occurring in situ. Petroleum based surfactants, on the other hand, can be toxicants, recalcitrant, and can only be derived from complex synthetic reactions making their production expensive, impossible to achieve on site, and results in the production of toxic waste byproducts. It is reasonable to expect that biosurfactants will have similar effects on sorbed nonpolar organic contaminants (NOC), however, this aspect of biosurfactant chemistry has not been previously investigated.

The results of the proposed research will further our understanding concerning the bioavailability of hydrophobic organic compounds in soil and sedimentary environments. This knowledge will improve our ability to predict the fate of these compounds and lead to the development of more effective remediation strategies for the reclamation of contaminated soils.

Statement of results or benefits:

Reduced contaminant bioavailability due to sorption and/or diffusion through the soil matrix has already been demonstrated. These processes hinder both biologically and physically based remediation systems. Some studies have shown that both synthetic and biologically derived surfactants can enhance dispersion and bacterial uptake of hydrocarbons in surfactant-water systems while many other studies have shown an inhibitory effect. The vast majority of studies involving soil-surfactant-water systems conducted with synthetic surfactants have also shown mixed results. However, very few studies have addressed the effects of biosurfactants on the bioavailability of soil-sorbed substrates. Biosurfactants may influence these systems in several ways. First, soil solution biosurfactant concentrations above the critical micelle concentration (CMC) may enhance the overall rate of NOC degradation by: 1) enhancing the apparent solubility of NOC resulting in higher aqueous phase concentrations and thus higher rates of degradation, 2) altering the distribution of the contaminant between sorbed and solution phases, or 3) enhancing the mass transfer rate of the contaminant from the sorbed to the solution phase. Alternatively, if the micelle-associated contaminant is inaccessible to microorganisms, if the biosurfactant is toxic, or if the biosurfactant is preferentially degraded, then reduced NOC biodegradation maybe observed. Preliminary experiments have shown that treholose micelle-water partition coefficients for toluene, xylene, and trimethyl benzene were higher than those observed for either SDS or soil organic matter. Therefore, it is anticipated that the presence of biosurfactant will enhance the overall rate of NOC biodegradation via enhanced desorption. Once this has been demonstrated at the laboratory scale, the results of this research will provide the basis for developing economically and technically feasible remediation techniques based on flushing the contaminated area with biosurfactant or stimulating biosurfactant production in situ. The proposed experiments are comprehensive and will provide sufficient information to elucidate the mechanisms responsible for surfactant-enhanced NOC biodegradation, ultimately leading to the development of improved bioremed iation strategies. The interdisciplinary nature of the research requires expertise in transport phenomena, surface chemistry, microbiology, organic chemistry, and environmental engineering. The co-principal investigators have experience, expertise and int erdisciplinary backgrounds that overlap to cover all of these areas. This integrated approach will insure the successful completion of the project goals.