PROJECT FACT SHEET

CONTRACT TITLE: Environmentally Acceptable Endpoints: The Influence of Soils characteristics and Molecular Hydrocarbon Properties on Bioavailability and Toxicity in Aged Soils

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CONTRACT PERFORMANCE PERIOD:
05/15/1997 to 05/14/1998

PROGRAM: Environmental-Oil
RESEARCH AREA: Environmental

FUNDING ($1000'S)	DOE	CONTRACTOR	TOTAL
PRIOR FISCAL YRS	106	0	106
FISCAL YR 1998	0	0	0
FUTURE FUNDS	0	0	0
TOTAL EST'D FUNDS	106	0	106

OBJECTIVE: Determine the influence of soil characteristics and molecular properties of selected petroleum hydrocarbons on their respective bioavailability and toxicity in aged soils.

PROJECT DESCRIPTION:

Work to be performed: Nine model solids/soils and a non-biodegradable NAPL have been selected and spiked with crude oil to initiate a 12 to 18 months aging process. The aged soil solids will be subjected to bioremediation treatment in a well-mixed, aerated slurry bioreactor. Slurry treatment will be initiated by inoculating each reactor with a bacterial culture enriched with crude oil degraders. Aged and bioremediated soil samples will be subjected to column leaching tests. Representative soil slurry samples will be periodically taken from the bioreactors and will be analyzed for straight-chain and branched aliphatic hydrocarbons as well as parent and alkylated polynuclear aromatics. Using an innovative biomarker analysis method, the changes in concentration of 50 to 100 individual hydrocarbon compounds will be accurately measured during bioremediation treatment. The resulting experimental data will be sued to determine how soil characteristics and hydrocarbon molecular properties affect both the rate and extend of biodegradation in aged soils. Correlations between these bioavailability parameters and the respective soil and molecular properties will be obtained using statistical and mathematical data analysis methods. The reduction of soil toxicity during bioremediation treatment will be measured using the Microtox assay. In addition, the bioavailability of hydrocarbons in contaminated soils to earth=dwelling organisms will be estimated by measuring the bioaccumulation potential with semipermeable membrane devises (SPMDs) consisting of polyethylene film. Small polyethylene strips will be exposed to the soil slurry in each reactor at the beginning and end of the bioremediation treatment.

PROJECT DESCRIPTION (Continued)

Background: It is currently believed that low rates of desorption or dissolution of hydrocarbons from porous soil aggregates or NAPLs limit the bioavailability, and consequently, the biodegradability of these molecules.

PROJECT STATUS:

Current Work: Since the startup of all 12 bioreactors on December 17, 1997 (see below), we are currently measuring the concentrations of parent and alkylated PAHs, n-alkanes, and recalcitrant biomarkers as a function of time in all soil slurries to obtain kinetic information related to bioavailability mechanisms. We are also monitoring the pH, dissolved oxygen, and the concentrations of both total heterotrophs and hydrocarbon degraders in all reactors. We initiated 12 column leaching experiments and are currently monitoring benzene, toluene, ethyl-benzene, xylene, naphthalene, and selected alkyl-naphthalenes in the leachate. In addition, we initiated our SPMD (semi-permeable membrane device) exposure experiments to assess the bioaccumulation potential in all 12 initial slurries. We are also currently measuring the changes in toxicity (via MicrotoxTM) in all 12 bioreactors as a function of time. Finally, we just recently initiated the XAD desorption experiments to evaluate whether the bioremediation process in mass-transfer or reaction-rate limited.

Scheduled Milestones:

Accomplishments: We completed the following important method development tasks prior to our milestone on December 1, 1997:

a) Bioreactor design and setup,
b) Development and testing of the MicrotoxTM protocol,
c) Development and testing of the SPMD bioaccumulation procedure,
d) Design and setup of column leaching experiments,
e) Performance of preliminary solvent extractions and XAD desorption experiments,
f) Performance of enrichment culturing for hydrocarbon degraders,
g) Soil characterization (particle size distribution, pore size distribution, BET, TOC, moisture),
h) Method development for the analysis of BTEX (SPME/GC) and PAHs (HPLC) in aqueous leachates,
I) Method development for the analysis of petroleum biomarkers (Hopane, etc.) using GC/MS.

As a result of these successfully completed method development tasks, we could start the 12 bioreactors (via inoculation with an active hydrocarbon degrader culture) and all associated tests on December 17, 1997.

Based on the results from our preliminary solvent extraction tests, we decided that none of the solvents were suitable for "mimicking" bioavailability. Consequently, we decided (instead) to perform abiotic desorption experiments using XAD resin for at least 8 soil slurries. These experiments will show whether the slurry biodegradation process is mass-transfer limited (i.e., by desorption) or reaction-rate limited (i.e., by microbial metabolism) .The development of a method for fluorescence detection of hydrocarbons on particle surfaces or within particles is still ongoing. Recently, the Co-PI - Dr. Donald Friedrich at the EMSL at PNNL - made a significant breakthrough in a related research project when he was able to measure phenanthrene concentration profiles inside silica particles using a two-photon excitation profiling system. We are planning to adapt this methodology for the profiling of hydrocarbon mixtures in transparent quartz sand particles taken from active slurry bioreactors.