Explosives Conjugation Products in Remediation Matrices

Cleanup
CU-715

RESEARCH CATEGORY: 6.1 Basic Research

LEAD AGENCY: U.S. Army

LAB: Waterways Experiment Station - Vicksburg, MS

PRINCIPAL INVESTIGATOR: Dr. Judith Pennington, (601) 634-2802

FY 1998 COMPLETED PROJECT

OBJECTIVE: During investigations of potential treatment technologies for explosives-contaminated soils, specifically during bioslurry treatability studies and composting, TNT has been observed to interact with some components of the treatment matrix in such a way as to preclude extraction with organic solvents. Similar interactions have been observed in explosives-amended soils: mass balance determinations using radio-labeled TNT reveal that the radioactivity is still present in the matrix in some unknown form. As much as 80 percent of the radioactivity added to tests is accounted for in the unextractable matrix. Therefore, the parent compound has not been completely destroyed, but has changed to a more complex form. The long-term stability and environmental safety of these uncharacterized conjugates are unknown. Objectives of this basic research include characterization of these explosives conjugates, development of an analytical methods for identifying them in treatment systems and in soils, and determining the long-term stability and environmental safety of the conjugates. Accomplishment of these objectives will ensure the development of effective remediation technologies that ameliorate environmental health effects and lead to a more complete characterization of the end products of new treatment technologies. Research was initiated to determine the basic mechanisms of interactions between TNT and humus, soil enzymes and clays under SERDP in FY93. This proposed research intends to expand upon that effort.

BENEFIT: The Department of Defense (DoD) places a high priority on development of truly effective remediation technologies for explosives-contaminated soils and groundwater. Nevertheless, most current technologies fail to demonstrate complete destruction of explosives. Rather, explosives are transformed to related conjugation products that are recalcitrant to further characterization. Although these products are suspected of being relatively unavailable for transport or toxicity in the short term (weeks to months), their ultimate fate in the long term (years) is unknown. This lack of understanding of the ultimate fate of explosives severely limits the credibility of certain remediation technologies. This study will improve existing and future remediation technologies by identifying the types of chemical bonding and potential environmental impacts of explosives conjugates in remediation matrices.

ACCOMPLISHMENTS: In FY98 spike-recovery studies using compost, sand and digester sludge were completed. Results of all the testing to date on solvent extractable and hydrolyzable explosives and their transformation products in compost and digester sludges are being compiled into a U.S. Army Cold Region Research and Engineering Laboratory (CRREL) Special Report. Additional analytical tests were under development to measure the capacity of a bioremediation matrix for binding of TNT transformation products. For the nuclear magnetic resonance (NMR) spectra, time-series incubations of amino and diamino transformation products with whole peat is still continuing. Solution phase analyses have been conducted by CRREL while the incubations and NMR spectra were conducted by the U.S. Geological Survey (USGS). In addition, results from the microbial degradation studies indicated incorporation of as

much as 5% of the radiolabel from TNT (added to soil prior to composting) into bacterial glycolipids. This confirms a limited amount of bacterial uptake and processing of the contaminant during composting. An alkaline-unwinding assay for DNA single strand breakage was also adapted for application to earthworms. The assay measures genotoxicity quantitatively and is an indication of a direct impact of chemicals on genetic material. Results obtained with earthworms exposed to uncomposted TNT were negative which is consistent with our previous studies showing a low order of mutagenicity of TNT. Tests with composted material are in progress.

TRANSITION: This project will transition widely to DoD sites contaminated with explosives. Acceptance of remediation technologies will be enhanced with regulatory agencies and other users concerned with the ultimate safety and environmental effects of explosives. Furthermore, an understanding of the nature and properties of conjugation products will lead to new and improved approaches to remediation.