United States
Environmental Protection
Agency

EPA/540/MR-95/529
August 1995

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Demonstration Bulletin

Ex-Situ Anaerobic Bioremediation Technology - TNT

J. R. Simplot Company

Technology Description: The J. R. Simplot Ex-Situ Anaerobic Bioremediation System, also known as the J.R. Simplot Anaerobic Biological Remediaton Process (the SABRE™ Process), is a technology designed to destroy nitroaromatic and energetic compounds. The process does not evolve any known toxic intermediates at the completion of treatment. The nitroaromatic analyte of interest during this demonstration was 2,4,6-trinitrotoluene (TNT), an explosive compound used in ordnance operations. [NOTE: A separate Demonstration of this technology was previously undertaken with dinoseb (2-*sec*-butyl-4,6-dinitrophenol) as the contaminant of interest. The results of this Demonstration are reported independently.] The theory of operation behind the J. R. Simplot bioremediation process is that TNT-contaminated soils (or liquids) can be treated using an anaerobic consortium of soil microorganisms. Under aerobic conditions, degradation of TNT forms polymerization products that are potentially toxic. Anaerobic degradation of TNT takes place without the presence of these toxic polymerization products at the completion of treatment. The J.R. Simplot technology mixes a carbon source with contaminated soil and then adds water and phosphate buffers to create a slurry adjusted to the required pH. This prompts aerobic microorganisms to consume the carbon source and thus the oxygen. This lowers the redox potential (E_h) of the slurry and creates anaerobic conditions. Anaerobic microorganisms are then stimulated to consume toxins present in the slurry. The J.R. Simplot Company proposes to mix the carbon source with the slurry water prior to contaminated soil addition in the future.

Figure 1 presents a schematic flow diagram of the J. R. Simplot Ex-Situ Anaerobic Bioremediation System that was used during the Demonstration Test. Initially, excavated soil was sent through a vibrating screen to remove large rocks and other debris. The oversize rocks and debris can be treated by a separate technology onsite or transported offsite and disposed of at a licensed waste disposal facility. When the oversize rocks and debris comprise a large fraction of the contaminated soil, they may be passed through a rock/soil washing system with the water being added to the bioreactor or, alternately, crushed to an appropriate diameter and then added to the bioreactor for treatment. Enough water was added to the bioreactor to provide one liter of water for each kilogram of soil to be treated. Phosphate buffers were added to the system to control the pH. Batches of soil and a J.R. Simplot potato-processing starch byproduct (2% by weight) were mixed together by hand and added to the bioreactor until loading was completed. After filling the bioreactor, 0.02 m^3 (a 5-gal pail) of soil previously treated by the J.R. Simplot process was added

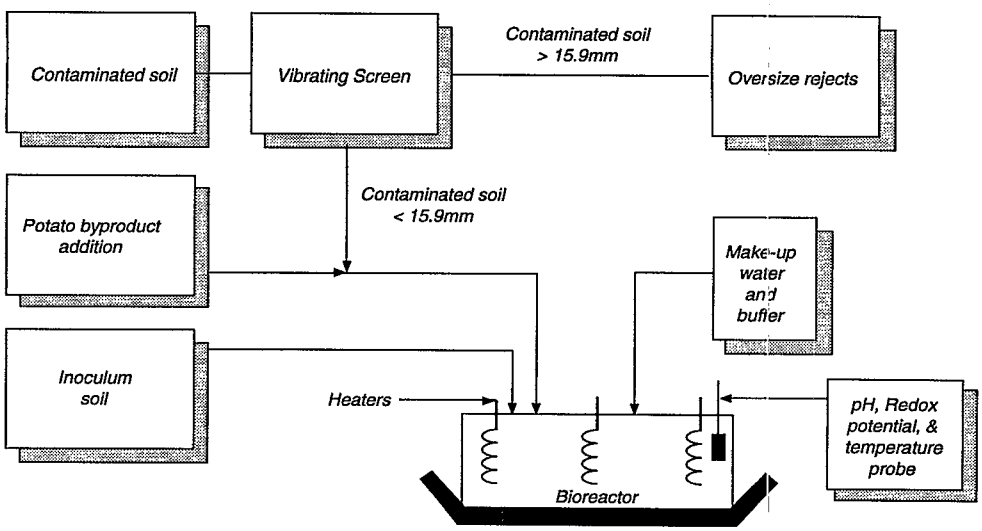

Figure 1. *J.R. simplot process flow diagram for the TNT SITE demonstration test.*

to the bioreactor. This previously treated soil contained the naturally selected microorganisms necessary for the degradation of TNT using the anaerobic process. The entire contents of the bioreactor were mixed together (lanced) on a biweekly basis. Based on laboratory studies, the preferred operating conditions for the degradation of the nitroaromatics are between 35 and 37°C and a pH below 8 (ideally between 6.0 and 7.0 for TNT degradation and between 7.5 and 8.0 for dinoseb degradation).

Waste Applicability: This technology is suitable for soils and liquids contaminated with nitroaromatic and energetic compounds. However, the media to be treated must not contain total hydrocarbons >1,000 mg/kg as measured by EPA Method 418.1 (TRPH). This technology is a sulfate reducing process, therefore, toxic metals will be reduced to their sulfide form, making the metals less toxic to the microorganisms.

Demonstration Results: Two evaluations of the J. R. Simplot Ex-Situ Anaerobic Bioremediation System have been performed under the Superfund Innovative Technology Evaluation (SITE) Program. The first Demonstration occurred in June/July 1993 at Bowers Field, a municipal airport in the Ellensburg, WA. This site was contaminated with dinoseb, an agricultural herbicide. The source of the contamination at this site is suspected to be from crop dusting activities in Central Washington during the agricultural season. The results of this successful Demonstration are reported in a separate Demonstration Bulletin. The second Demonstration Test is the subject of this Bulletin. This Demonstration was initiated at the Weldon Spring Ordnance Works (WSOW) site in September 1993 and concluded in late June 1994. The WSOW was a U. S. Army World War II Ordnance Works for the manufacture of TNT that ceased production in 1945. The present day soil contamination is the result of previous Ordnance Works operations.

During the second Demonstration, approximately 23 m^3 (30 yd^3) of soil contaminated with TNT at an average concentration of 1,500 mg/kg (on a dry basis) based on 41 samples using an HPLC procedure was placed in the portable bioreactor onsite. If a larger volume of soil had been used for the Demonstration, then one or more in-ground, lined pits would have been more appropriate for use as bioreactors than the small, portable bioreactor. The Demonstration was anticipated to last approximately six weeks, however, daily sampling (using a field test kit) showed that TNT was still present at low levels in the slurry up to approximately 9 mon later when post-treatment sampling was initiated. The extended length of treatment time may be due, in part, to the cold temperatures encountered over the harsh winter of 1993 that prompted the installation of heaters to maintain a suitable bioreactor temperature.

United States
Environmental Protection Agency
National Risk Management Research Laboratory (G-72)
Cincinnati, OH 45268

Official Business
Penalty for Private Use
$300

EPA/540/MR-95/529

Demonstration testing of the J. R. Simplot Ex-Situ Anaerobic Bioremediation Technology for TNT gave the following results:

- The process can reduce the levels of TNT in the feed soil. Based on an average pre-treatment slurry concentration of 1,500 mg/kg (on a dry basis) and a final post-treatment slurry concentration of 8.7 mg/kg (on a dry basis) of 40 samples analyzed by an HPLC procedure, a 99.4% reduction of TNT was achieved. The 95% Confidence Interval for this Removal Efficiency is 98.3% to 99.9%.
- A 95% Removal Efficiency, the critical objective of this Demonstration, was achieved in approximately 5 mo of remediation.
- Intermediate byproducts from the biological degradation of TNT were found to increase during the course of treatment and then decrease to below the analytical detection limit at the completion of the Demonstration.
- Relative toxicity studies (early seedling growth, root elongation, and earthworm reproduction) from the commencement of the treatment process to the 95% Reduction Efficiency point showed that the technology successfully reduced the toxicity of the contaminated soil.
- The soil type remediated was clayey gravel with sand. This provided good adhesion properties for the TNT and made degradation more difficult.

The ITER describing the complete demonstration and other pertinent information will be available in the Fall of 1995.

For Further Information:
EPA Project Manager
Wendy Davis-Hoover
U. S. EPA National Risk Management Research Laboratory
5995 Center Hill Avenue
Cincinnati, OH 45224-1701
(513) 569-7206

Technology Developer Contact:
Russ Kaake
J. R. Simplot Company
P. O. Box 912
Pocatello, ID 83201
(208) 234-5367

Tom Yergouich
J.R. Simplot Company
P.O. Box 912
Pocatello, ID 83201
(208) 238-2850 • (800) 635-9444

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35