Cost and Performance Summary Report
Bioremediation at the Stauffer Management Company Superfund Site, Tampa, Florida

Summary Information [1, 2, 3, 4, 5, 7]

The Stauffer Management Company (SMC) Superfund Site is an inactive pesticide manufacturer/distribution facility encompassing approximately 40 acres of land in an industrialized area of Tampa, Florida. From 1951 to 1986, the site was used to formulate agricultural chemical products (organochlorine and organophosphorus pesticides). Agricultural pesticides, such as herbicides and insecticides, were combined with raw materials such as kerosene, xylene, clay, solvents, and diatomaceous earth to form pesticide dusts, granules, and liquids that were packaged for distribution.

From 1953 to 1973, waste materials from the facility were disposed of on site. Containerized wastes, packaging materials and other pesticides were buried on site, leading to pesticide contamination in soil, surface water and sediment in onsite ponds, and in groundwater underlying the site. Typical pesticide concentrations measured in the soil were chlordane - 47.5 mg/kg; DDD - 162.5 mg/kg; DDE - 11.3 mg/kg; DDT - 88.4 mg/kg; dieldrin - 3.1 mg/kg; molinate - 10.2 mg/kg; and toxaphene - 469 mg/kg.

Buried drums and debris and 3,450 cubic yards of highly contaminated soils were removed from the site in 1993. EPA issued a Record of Decision for the site in December 1995, which identified bioremediation as the selected remedy for pesticide-contaminated surface soils and sediments at the site. SMC is performing the cleanup under an Administrative Order on Consent. The Remedial Design began in May of 1996, with the Remedial Action for contaminated soils expected to be complete by 2002.

SMC is an affiliate of AstraZeneca Group PLC and has developed a composting processes called Xenorem™ for remediating soils contaminated with chlorinated pesticides and other persistent organics at SMC sites. Xenorem™ is covered by a number of patents and uses anaerobic and aerobic cycles to bioremediate pesticides, with indigenous bacteria and addition of amendments.

A field demonstration of the Xenorem™ process was conducted in an enclosed warehouse at the SMC Tampa site, using soil taken from "hot spots" at the site. A compost pile was constructed in June of 1997 and operated until September of 1998. Solid amendments, including organic wastes and by-products, were added to soils to maintain desired conditions of temperature, oxygen, pH and nutrient availability. The process used an initial aerobic environment with high levels of nutrients, followed by an anaerobic cycle, when the pile was covered with a tarp. The field demonstration included hot and cold weather variations (conducted during hot and cold weather periods) to assess amendment quality effects and use various mixing equipment.

This report addresses the results of the laboratory studies and field demonstration of Xenorem™ technology to treat soil and sediments. Based on the results of the demonstration, the Xenorem™ technology is being used in a full-scale cleanup of the SMC Tampa site, to treat approximately 16,000 yd^3 of soil.

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Timeline [1, 2, 3, 4, 5]

1993	Source removal activities performed - removal of buried drums and debris and 3,450 yd^3 of highly-contaminated soils
12/95	ROD issued
1/94 – 12/96	Bioremediation treatability studies conducted
6/97 – 9/98	Bioremediation pilot-scale studies conducted
5/00 - ongoing	Bioremediation of SMC Tampa Site treating 4,000 yd^3 per batch

Factors That Affected Cost or Performance of Treatment

Listed below are the key soil characteristics for this technology. Although quantitative information on these parameters was not provided, the vendor indicated that these parameters had no impact on the cost or performance of the technology application at this site.

Matrix Characteristics

Parameter	Value
Soil Classification:	Information not provided
Clay Content and/or Particle Size Distribution:	Information not provided
Moisture Content:	Information not provided
pH:	Information not provided

Treatment Technology Description

Laboratory Research/Early Field Trials [1, 7]

From 1994 – 1996, SMC conducted laboratory research on bioremediation of pesticides in soil, and found that indigenous microflora associated with contaminated soil can degrade pesticides. Testing was conducted in 14 yd^3 boxes and showed that DDT could be 100% biodegraded without the buildup of DDD and DDE. Further, the research showed that DDT was transformed to polar non-chlorinated compounds, which are biodegradable under aerobic conditions.

A follow-up field trial was conducted with 100 yd^3 of soil, using a windrow design. This trial showed that an anaerobic/aerobic technology was more effective in degrading the DD(X) pesticides than other technologies. (DD(X) refers to DDT and its major metabolites, DDD and DDE). The composting technology reduced concentrations of DDT in contaminated soil from approximately 88 mg/kg to 1.2 mg/kg (98% reduction), and was found to be effective on higher initial DDT concentrations as well.

Field Demonstration [1, 7]

For the field demonstration, soil was excavated by track hoe from two areas at the site which had relatively high concentrations of pesticides - Area A and Area B. Site preparation work included clearing material used during previous testing; installation of an odor abatement system; soil excavation and staging; and ambient air monitoring. The pile was constructed in a warehouse at the site.

Excavated soil was screened through a 2” screen prior to treatment to remove items such as concrete, stones, and pipes. After screening, soil was mixed on the warehouse floor using a mining protocol, where soil was initially quartered. Each pile was mixed with another pile and then split to create two new piles. The mixing and splitting procedure was carried out 32 times over five days using a front end loader. The purpose of this activity was to assure uniform initial soil concentrations and reduce analytical variability.

The initial pile constructed for the demonstration was 905 yd^3 (500 yds^3 of soil and 405 yds^3 of amendments) and located in the center of the warehouse. The pile was trapezoidal with a base dimension of approximately 40 ft wide by 80 ft long by 10 ft high. The height was restricted due to the 13 ft ceiling rafters in the warehouse. Several pieces of mixing equipment were evaluated in the demonstration, including a loader, a roto-tiller, and two turners (Fecon and SCAT).

Although a wide range of agricultural wastes were identified by the vendor as acceptable amendments, cow manure and straw were selected for the demonstration, as they were readily available in the local area. Amendments were added at weeks 0, 14, 22, 33, and 48, to create a total volume of 1,193 yd^3 after week 48. Information about the specific composition of amendments and the amounts added at specific times during the demonstration was not provided.

Anaerobic conditions were achieved by covering the pile with a 40 mil, 30x60 ft woven one-piece tarp. Aerobic conditions were created by either mechanically mixing and turning the windrow, or by injecting compressed air into the pile. Injectors were spaced 15 ft apart along the length of the pile. Aerobic and anaerobic operating cycles were varied to maximize contaminant destruction rates.

Listed below are the key operating parameters for this technology and the values measured for each during the demonstration.

Operating Parameters [1]

Operating Parameter	Value
Air Flow Rate	Information not provided
Mixing Rate/Frequency	Information not provided
PH	5 to 9
Residence Time	< 6 months
System Throughput	500 yds3
Temperature	up to 60ºC
Oxygen Uptake Rate	Information not provided
Nutrients and Other Soil Amendments	Cow manure and straw
Moisture Content	30 to 90% soil water holding capacity

Performance Information [1]

The ROD identified cleanup levels for the following seven constituents in surface (0 to 2 ft bgs) soil at the site: chlordane; DDD; DDE; DDT; dieldrin; toxaphene; and molinate. Objectives of the field demonstration included determining if the technology could meet the ROD cleanup levels, or achieve 90% reduction in contaminant concentration; evaluating the effect of pile geometry; examining the technology’s performance for pesticides other than DD(X); and evaluating the equipment that would be used in a full-scale operation.

Soil samples were collected weekly from four locations within the pile using a stainless steel auger. Samples were analyzed for pesticides (using Methods SW846-8080/8081A and WRC89-45), BOD_5, COD, inorganic composition, microbial enumeration, moisture and dry matter, organic matter, pH, surface tension, thiocarbamates, and water holding capacity. Analysis for pesticides was performed by PCI Laboratory.

Table 1 shows the cleanup levels specified in the ROD, the concentrations of chlorinated pesticides and thiocarbamate and organo-phosphate pesticides at the beginning (T_0) and end (T_{64}) of the field demonstration, and the percent reduction in concentration over that period.

Table 1. Concentrations Measured at Start and End of Demonstration [1]

Parameter	ROD Cleanup Level (mg/kg)	T_0 Concentration (mg/kg)	T_{64} Concentration (mg/kg)	% Reduction in Concentration
Contaminants with ROD Cleanup Levels				
Chlordane	2.3	47.5	5.2	89
DDD	12.6	242 *	23.1	90.5
DDE	8.91	11.3	6.8	40
DDT	8.91	88.4	1.2	98
Dieldrin	0.19	3.1	<MDL	NA
Toxaphene	2.75	469	29	94
Molinate	0.74	10.2	<MDL	NA
Other Chlorinated Pesticides				
Aldrin	NONE	1.5	<MDL	NA
Alpha-BHC	NONE	1.6	<MDL	NA
Beta-BHC	NONE	<2.0	<MDL	NA
Delta-BHC	NONE	<1.0	<MDL	NA
Gamma-BHC	NONE	<1.0	<MDL	NA
Endosulfan I	NONE	<1.0	<MDL	NA
Endosulfan II	NONE	8.9	<MDL	NA
Endosulfan Sulfate	NONE	<1.0	<MDL	NA
Endrin	NONE	28	<MDL	NA
Endrin aldehyde	NONE	4.0	<MDL	NA
Heptachlor	NONE	1.2	<MDL	NA
Heptachlor epoxide	NONE	<1.0	<MDL	NA
Methoxychlor	NONE	14.7	<MDL	NA
Toxaphene by-products	NONE	779	68	91
Thiocarbamate and Organo-Phosphate Compounds				
Atrazine	NONE	<MDL	<MDL	NA
Carbophenothion	NONE	5.1	1.5	71
Fonofos	NONE	3.4	4.7	-38
Ethylparathion	NONE	<MDL	<MDL	NA
Butylate	NONE	8.3	<MDL	NA
Cycloate	NONE	21.0	1.2	94
EPTC	NONE	2.0	<MDL	NA
Pebulate	NONE	3.5	<MDL	NA
Vernolate	NONE	4.0	<MDL	NA
Sumathion	NONE	<MDL	<MDL	NA
Methyl carbophenethion	NONE	4.6	<MDL	NA

MDL method detection limit
NA not applicable
* The level of DDD at T_0 consists of the original DDD value in the soil (162.5 mg/kg), plus the amount converted from DDT in the first few weeks of treatment.

The cleanup level specified in the ROD was achieved for DDE, DDT, dieldrin, and molinate, but not for chlordane, DDD, or toxaphene. Concentrations of DDD and toxaphene were reduced by more than 90%, and chlordane by nearly 90%. Many of the other constituents were reduced to concentrations less than their method detection limit. According to the vendor, concentrations continued to decline throughout the demonstration.

Performance Data Quality

Quality assurance procedures included use of a standard operating procedure for soil sampling, collection of composite samples, and use of chain of custody procedures. The researchers identified a concern about the analytical data due to the elevated concentrations of toxaphene. Toxaphene was analyzed using two different methods, and the results were reported as "conservative in nature". No other QA concerns were noted by the researchers.

Cost Information [3, 7]

No data are available about the cost for the field demonstration at this site.

Typical costs for a cleanup using Xenorem™ composting technology were provided by the vendor, and shown in Table 2. These costs are for treating high concentrations of persistent chlorinated pesticides. This table shows a total project cost of $192/yd^3$, including $132/yd^3$ for treatment using Xenorem™. Costs for permitting, RI/FS, and EPA oversite are not included.

In addition, a commercial RCRA Subtitle C facility in Lake Charles Louisiana has quoted a price for treatment using Xenorem™ and disposal of pesticide impacted soils of $200/ton including guarantees.

Table 2. Typical Costs, As Reported by Vendor [6]

Cost Element	Costs per Cubic Yard of Soil Treated
Soil excavation, screening and post-treatment placement	$30
Site facilities	$15
Soil delineation analytical	$10
Consultant oversite	$5
Treatment Cost Using Xenorem™	
Amendments	$30
Equipment rental	$20
Process analytical	$7
Labor	$40
Supervision	$10
Technical support	$5
Supplies and services	$20
Total Cost for Treatment	**$132**

Observations and Lessons Learned [1, 7]

Only two of the five times that amendments were added were identified by the researchers as having been operated under optimal environmental/process conditions (first and fourth amendments). Problems with the other three amendment periods included poor quality amendments and poor mixing equipment. The researchers found that the mixing equipment and duration of the mixing steps was important to the overall efficiency of the process. They found that the SCAT turner was the most efficient of the equipment evaluated.

Based on the results from the demonstration trial, amendment quality specifications have been established, along with experience with a broader range of amendment types. At the time of this report, SMC is treating 4,000 yd^3 batches of contaminated soil using Xenorem™. Other commercial projects have started.

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