COST AND PERFORMANCE REPORT

Cometabolic Bioventing at Building 719, Dover Air Force Base
Dover, Delaware

March 2000

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

Cometabolic Bioventing at Building 719, Dover Air Force Base, Dover, Delaware

Summary Information [1,3,7]

Site Name, Location	Dover Air Force Base, Building 719, Dover, Delaware
EPA ID Number	DE8570024010
Mechanism(s)	Aerobic Oxidation (Cometabolic and Direct)
Technology	Electron Acceptor Addition (Oxygen) Electron Donor Addition (Propane)
Configuration	Direct Injection
Technology Scale	Field demonstration (pilot test)
Media/Matrix Treated	Soil
Contaminants Targeted	TCE, 1,1,1-TCA, *cis*-1,2-DCE
Period of Operation	Propane acclimation period: December 1997 to April 1998 Bioventing operation: May 1998 to July 1999

Site History/Source of Contamination [1,2,3]

Dover Air Force Base (AFB), located in Dover, Delaware, is a 4,000 acre military installation that began operating in 1941. Building 719 is a jet engine inspection and maintenance shop where a variety of materials, including solvents, JP-4 fuel, and hydraulic fluids, have been used in shop operations. Until the mid-1960s, wastes from the shop were discharged to a drainage ditch and sanitary sewer. In addition, the northeast area of the building is the location of two former leaking underground storage tanks (USTs), an oil/water separator, and a former neutralization tank. The results of investigations showed that soil and groundwater in the area of the former USTs were contaminated with fuel (BTEX - benzene, toluene, ethylbenzene, and xylene) and solvents. Results of samples of the vadose zone of Building 719 found concentrations of TCE as high as 250 mg/kg; TCA ranging from 10 to 1,000 mg/kg; and DCE ranging from 1 to 20 mg/kg. TCE concentrations in groundwater were reported as high as 19,000 ug/L.

Dover AFB was listed on the National Priorities List in March 1989. The remediation of Dover AFB is managed by EPA Region 3 and the Delaware Department of Natural Resources and Environmental Control. Interim RODs were signed in September 1995 that identify the following technologies for remediation at Dover: anaerobic reductive dehalogenation, cometabolic bioventing, and monitored natural attenuation. The area in the vicinity of Building 719 was selected for a pilot test of cometablic bioventing. The cometabolic bioventing pilot test was conducted for the In Situ Bioremediation of Chlorinated Solvents Work Group of the Remediation Technology Development Forum (RTDF).

Geology/Hydrogeology [1,2,7]

Dover AFB is underlain by glacial-fluvial deposits of sand, silt, and clay of the Columbian Formation. The soil in the vicinity of Building 719 was sand with clay, silt, and gravel. Depth to groundwater was 6 to 10 feet (ft) below ground surface (bgs).

Matrix Characteristics for the Building 719, Dover AFB Site [1, 6]

Matrix Characteristic	Value
Soil Type	Sand with varying amounts of clay, silt and gravel. Fine-grained clay and silt to a depth of 5 ft bgs; underlain by more permeable layer of silt and sand.
Soil Permeability	1.9×10^{-7} to 7.0×10^{-8} cm^2
Depth to Groundwater	6 to 10 ft bgs
DNAPL Presence	None identified
Hydraulic Conductivity	0.017 to 0.052 cm/sec
pH - Soil	6.0 to 11.0 (median 7.7)
Total Chloride	8 mg/kg (median)
Total Kjeldahl Nitrogen	42 mg/kg (median)
Total Phosphorus	30 mg/kg (median)
Total Organic Carbon	0.11% (w/w) (median)

Technology Description and Performance [1,2,4,5,7]

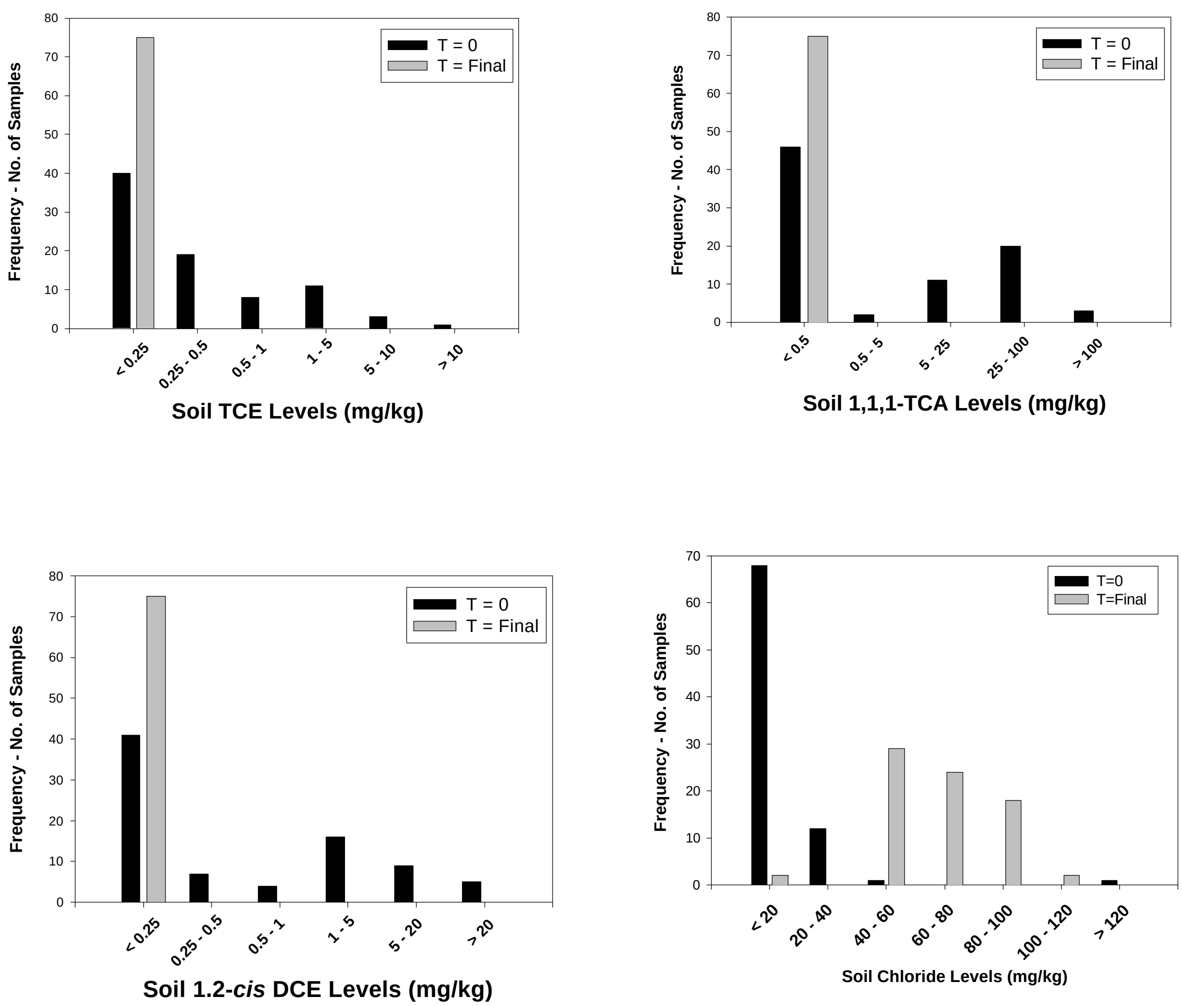
The primary objectives of the pilot test were to determine the efficiency and demonstrate the viability of an in situ cometabolic bioventing process for CAHs under field conditions (benzene, toluene, ethylbenzene, and xylene were not targeted for treatment). Prior to the pilot test, laboratory tests were performed on soils from the area of Building 719 to evaluate candidate substrates. Propane was selected because of its ability to stimulate cometabolic activity towards both TCA and TCE.

Based on the results of site investigations in the vicinity of Building 719, the location of the test plot was identified as an area of high concentrations of chlorinated aliphatic hydrocarbons (CAHs). The test plot was approximately 30 ft long, 20 ft wide, and 10 ft deep with a volume of 4,500 ft^3 of soil . The mass of soil in the test plot was estimated to be 450,000 lbs, based on an assumed density of 100 lbs/ft^3. Prior to the pilot test, a total of 80 soil samples were taken from the test plot to provide a contaminant profile and to estimate the mass of contaminants in the test plot. This information was used to develop an order of magnitude estimate of the mass of CAHs and BTEX in the soil for a total gross estimate of 26 lbs of CAH and BTEX constituents in the subsurface soils of the test plot. 1,1,1-TCA made up approximately 70% of the total estimated mass of contaminants.

The pilot system includes three injection wells, screened to a depth of 10 ft bgs, which was the lowest expected water table elevation. In addition, 13 soil gas monitoring points were installed to monitor soil gas conditions throughout the demonstration. Each of the soil gas monitoring points was equipped with two gas probes (one at a depth of 4-5 ft and one at a depth of 8-9 ft bgs). Another 11 “temporary” soil gas monitoring points were installed for use during initial air permeability testing, and were used during system operation to monitor soil gas. A blower and a mass flow controller were used to inject a mixture of air and propane (300 ppm in air) through the three wells at a rate of 1 cfm.

Figure 1 shows histograms of initial and final concentrations of TCE, TCA, DCE and chloride from the soil in the test plot, including reductions in the concentrations observed for TCE, TCA and DCE during treatment. These reductions can be at least partly attributable to biodegradation by noting the large increase in the soil chloride levels during treatment. Chloride is a product of the biodegradation of chlorinated solvents.

Figure 1. Histograms of initial and final TCE, TCA, DCE and chloride concentrations from soil in the cometabolic bioventing test plot [7]



Technology Cost

Cost data were not available at the time of this report.

Summary Observations and Lessons Learned [7]

The researchers provided the following observations:

- Over a 14-month period of operation, cometabolic bioventing was successful in removing TCE, TCA and DCE from soils in the test plot.

- Laboratory treatability testing identified propane as a useful cosubstrate to drive cometabolism of TCE and TCA (DCE may have been biodegraded via cometabolism or by direct aerobic bioprocesses). The lab studies also successfully predicted the need for a significant time period (weeks) for the test plot to begin using propane after initial exposure. Thus, a cosubstrate acclimation period may be a common element of cometabolic bioventing startup.

- In aerobic bioventing, the amount of fuel biodegraded during treatment can be estimated by oxygen use. In cometabolism, oxygen use and chlorinated solvent biodegradation are not stoichiometrically related. Thus, in cometabolic bioventing, indirect measures must be employed to show that biodegradation is removing contaminant. These may include chloride accumulation in soil, and previous lab studies using site-contaminated soil which have shown that biodegradation of cosubstrate (which can be measured in the field using a shut down test) implies biodegradation of the chlorinated solvent. There is a need for innovative approaches to proving that biodegradation is occurring in the field.

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References:

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2. Sayles, G.D. at al, Abstract, *Development of Cometabolic Bioventing for the In-Situ Bioremediation of Chlorinated Solvents*, April 1998.

3. U.S. EPA Region 3. Hazardous Site Cleanup Division. Dover AFB. August 1998.

4. RTDF Update. May 1998.

5. E-Mail from Diane Dopkin, EMS, to Dawn Carroll, U.S. EPA. Bioventing. February 18, 1999.

6. Fax Transmittal from Dr. Greg Sayles, U.S. EPA to Dawn Carroll, U.S. EPA. Comments on Cometabolic Bioventing Case Study. February 22, 1999.

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