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**Biodegradation of Trichlorofluoromethane by Sediment  
Associated Anaerobic Bacteria from an Aquifer Contaminated by  
Landfill Leachate**

by

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RECORDS ADMINISTRATION



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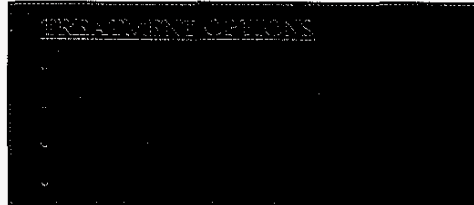
# Q134 Biodegradation of Trichlorofluoromethane (CFC-11) by Sediment Associated Anaerobic Bacteria from an Aquifer Contaminated by Landfill Leachate

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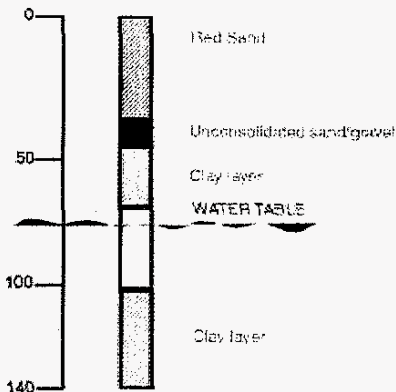
## ABSTRACT

The halogenated aliphatic hydrocarbon trichlorofluoromethane (CFC-11) has been widely used as a refrigerant and aerosol propellant. CFC-11 and related compounds such as CFC-12 (dichlorodifluoromethane) have been implicated in the depletion of stratospheric ozone and have been systematically replaced in the United States by less reactive compounds. Anaerobic groundwater contaminated by landfill leachate, anaerobic soils and sediments have been shown to transform CFC-11. Recently, CFC-11 was detected in an aquifer under a closed landfill site. In the present study, we report the results of microcosm studies using anaerobic landfill sediments capable of degrading CFC-11 with lactate as an electron donor and nitrate as an electron acceptor under acidic pH conditions characteristic to this aquifer.



## SITE CHARACTERISTICS AND SAMPLING METHODS

### TYPICAL BOREHOLE CHARACTERISTICS



Cores composed of Late Cretaceous and Tertiary sediments consisting of unconsolidated interbedded sands, silts, and clays, with some gravel and carbonate deposits were collected using a cone penetrometer (CPT) device at a depth of 50 ft to 70 ft below the ground surface of the landfill (i.e. Aiken Plateau portion of the Upper Atlantic Coastal Plain Province). Soil cores were encased in lexan sheaths and sealed with paraffin wax and stored at 4C.

### GROUNDWATER CONDITIONS

•Sulfate Limited	
•Nitrate Limited	
•pH	3.93-4.33
•Conductivity (mS)	0.030-0.036
•Dissolved Oxygen (%)	1.98-8.94
•Temperature (F)	18.7-19.8
•Depth (ft)	65-80

### INCUBATION CONDITIONS

Landfill samples composed of Late Cretaceous and Tertiary sediments consisting of unconsolidated interbedded sands, silts, and clays, with some gravel and carbonate deposits were transported to the laboratory and homogenized within an anaerobic hood. These sediment samples were mixed groundwater and basal salts medium (Sonier et al. 1994) and added to 40 ml amber serum flasks. Alternate carbon sources such as lactate and acetate were evaluated. Results indicate that lactate not acetate could support freon biodegradation. Lactate was added to a final concentration of 1 mM, 2.5 mM, 5mM and 10 mM). Final pH of the medium was 4.0. Sodium azide (1% v/v) treated sets were used as controls.



Experimental Set-up under either denitrifying or sulfate reducing conditions

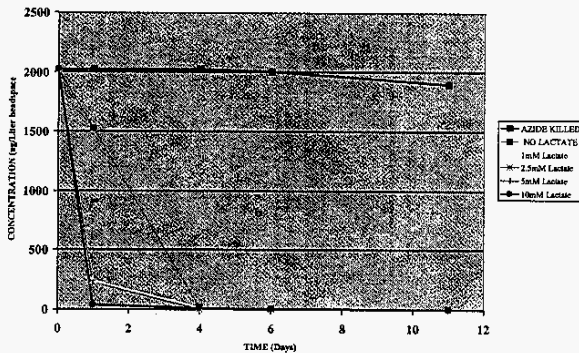
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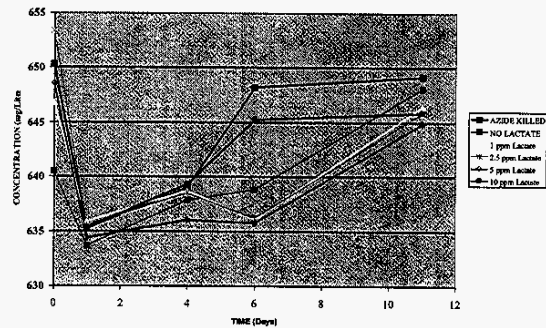
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**RESULTS**

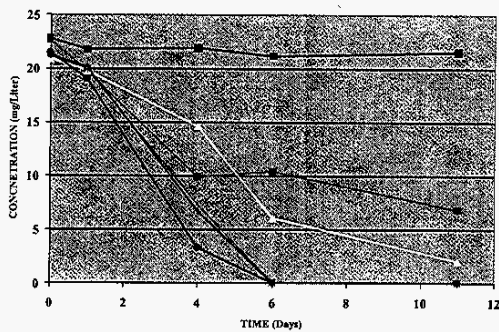
**CFC-11 UTILIZATION**



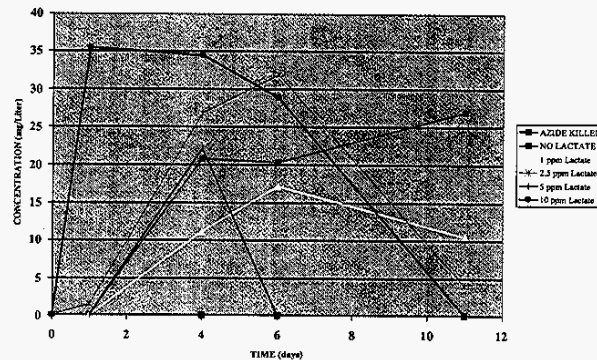
**SULFATE UTILIZATION**



**NITRATE UTILIZATION**



**NITRITE PRODUCTION**



**CONCLUSIONS**

Denitrification rather than sulfate reduction plays a role in CFC-11 elimination from this contaminated aquifer.

CFC-11 biodegradation rates increased at lactate concentrations greater than 5 mM.

This study presents supporting evidence that *in situ* bioremediation presents an environmentally sound option for treatment of this CFC-11 contaminated site.

**REFERENCES**

Sonier, D. N., N. L. Duran, and G. B. Smith. 1994. Dechlorination of Trichlorofluoromethane (CF-11) by Sulfate-Reducing Bacteria from an Aquifer Contaminated with Halogenated Aliphatic Compounds. *Appl. Environ. Microbiol.* 60:4567-4572.

Semprini, L., and P.L. McCarty. 1989. Biostimulation and biotransformation modeling. P. 172-198. In P.V. Roberts et al. (ed.) *In-situ aquifer restoration of chlorinated aliphatics by methanotrophic bacteria*. USEPA/600/S289/033. U.S. Environ. Protection Agency, Washington, D.C.

Lovley, D.R., and J.C. Woodward. 1992. Consumption of Freons CF-11 and CF-12 by anaerobic sediments and soils. *Environ. Sci. Technol.* 26:925-926.

Molina, M. J., and F.S. Rowland. 1974. Stratospheric sink for chlorofluoromethanes: Chlorine atom-catalyzed destruction of ozone. *Nature* 249:810-812.

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