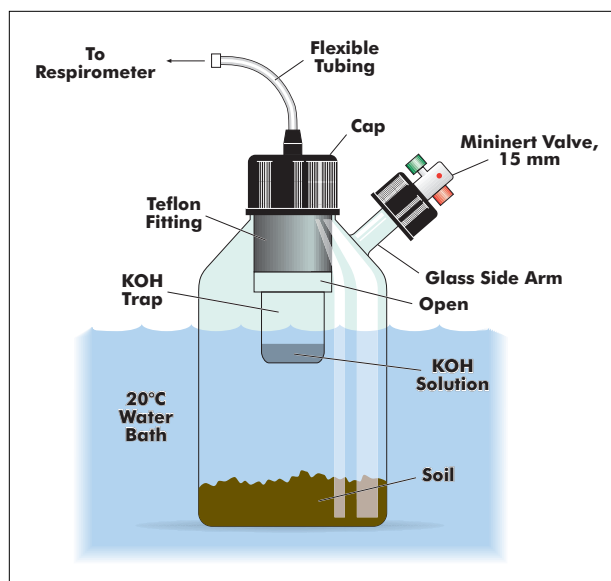


# Kinetics of Cometabolic Biodegradation of Chlorinated Ethylenes in Unsaturated Soil

## U.S. EPA Test and Evaluation Facility Research Project



*Automated Respirometer Flask Reactor*

## Project Relevance:

Leaking underground storage tanks and spills are major sources of chlorinated solvent contamination, found widely in soil and groundwater. This project focuses on developing methods to treat residual contamination in the vadose soil, which is often the source of groundwater contamination. Trichloroethylene (TCE) and lower chlorinated ethylenes, i.e. dichloroethylene (DCE) and vinyl chloride (VC), can be degraded cometabolically under aerobic conditions in the presence of certain compounds. Methane, propane, butane, isoprene, toluene, and phenol are known to induce cometabolic biodegradation of TCE, DCE and VC. In this project, several inducing compounds are used to study cometabolic degradation kinetics of TCE, DCE, and VC found in a contaminated site soil. The experimental results will be used to develop a treatability study protocol for the cometabolic bioventing and biosparging of TCE and lower chlorinated ethylenes from contaminated soil.

## Project Objectives:

- Study the biodegradation kinetics of trichloroethylene (TCE) and lower chlorinated ethylenes in a hazardous waste soil.
- Test the use of compounds, such as toluene and propane, as cometabolic inducing compounds that enhance the degradation kinetics of TCE and lower chlorinated ethylenes.
- Evaluate results achieved using an automated respirometer, which provides continuous oxygen consumption data.
- Evaluate results achieved using sacrificial reactors which provide discrete measurements of oxygen consumption and the concentrations of target volatile organic compounds in the soil and headspace as a function of time.



*Automated Respirometer Unit (N-CON)*

## Experimental Approach:

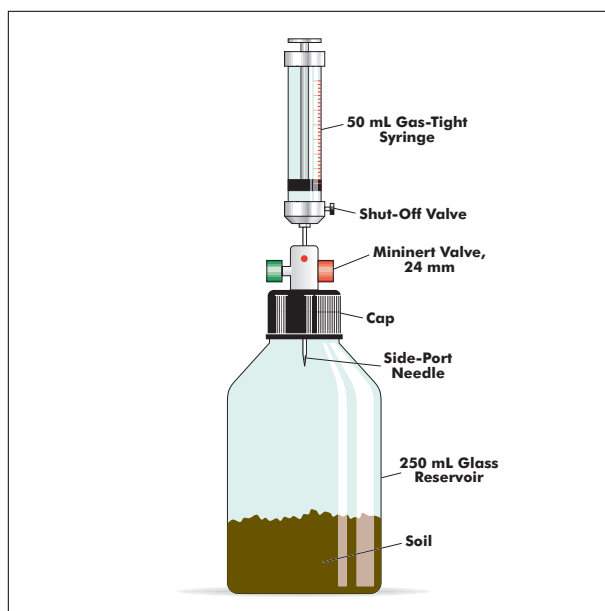
The study utilizes two bench-scale experimental systems located at the EPA's Test and Evaluation (T&E) facility in Cincinnati, Ohio. An 8-flask automated respirometer provides continuous readings of oxygen ( $O_2$ ) uptake for the contaminated site soil under different experimental conditions. The second experimental system includes a set of reactors that are sacrificed over the course of the study for analysis of gas-phase and soil-bound chlorinated ethylenes, inducing compounds, headspace  $O_2$  and carbon dioxide ( $CO_2$ ). The sacrificial reactors provide discrete measurements of the reaction kinetics, whereas the automated respirometer provides continuous kinetics data based on biological oxygen uptake and  $CO_2$  production.

## The Automated Respirometer System:

The automated respirometer contains eight separate 500-mL flask reactors with teflon-lined caps. A 30-mL glass reservoir inside the flask is filled with a strong base, such as potassium hydroxide (KOH), which absorbs evolved  $CO_2$ . As respiration of the contaminants in the soil takes place,  $O_2$  is depleted and  $CO_2$  is produced. Because  $CO_2$  is removed in the KOH trap, the pressure in the reactor drops. The system detects this drop in pressure and delivers  $O_2$  to the reactor in measured increments. In this way, the  $O_2$  demand under each experimental condition is determined and recorded continuously over the course of the study.

## Sacrificial Reaction Flask System:

Each sacrificial reaction flask consists of a 250-mL glass bottle with a Mininert cap. The Mininert cap is constructed of Teflon and incorporates an integral valve to permit introduction and recovery of material through the cap without affecting the integrity of the reactor. Inducers such as propane and toluene are added to a set of the reactors to evaluate cometabolic degradation of chlorinated ethylenes in the site soil. Reactors representing each experimental condition are sacrificed and analyzed for critical contaminants at six to eight discrete sampling events during the study.



*Sacrificial Reaction Flask*

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## EPA Contact:

Gregory D. Sayles, Ph.D.  
U.S. Environmental Protection Agency  
National Risk Management Research Laboratory  
26 West Martin Luther King Drive  
Cincinnati, Ohio 45268  
(513) 569-7607

## IT Contact:

Alan D. Zaffiro  
IT Corporation  
11499 Chester Road  
Cincinnati, Ohio 45246  
(513) 569-7329

