

Effects of Chlorinated Methanes (CMs) on the Reductive Dehalogenation of Trichloroethene

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Background/Objectives. Chlorinated solvents, such as trichloroethene (TCE), are among the most prevalent subsurface contaminants in the United States. Reductive dehalogenation is an anaerobic biotransformation pathway that can transform TCE to less chlorinated products and ethene. Complex sites may harbor chlorinated solvent mixtures that include chlorinated methanes (CMs) alongside TCE. In batch studies with TCE-dehalogenating cultures not previously acclimated to CMs, TCE and CT have been shown to be simultaneously transformed, however, few conclusions have been drawn thus far regarding the interplay between the transformation rates of chlorinated ethenes (CEs) and CMs. Furthermore, the potential for inhibitory or toxic effects of CF on the cultures was indicated. It is prudent to explore these dynamics so that bioremediation schemes may be optimized for complicated cases. The objectives of this study were to: 1.) establish the effects of CM exposure on CE transformation rates in reductive dehalogenating cultures, 2.) test the reversibility of toxic effects of CM exposure, 3.) determine whether relationships exist between concentration and time of CM exposure and toxicity results and 4.) establish if the CM effect is primarily due to CF.

Approach/Activities. Transformation tests were conducted in triplicate batch reactors with TCE-dehalogenating cultures that had been continuously grown in chemostats for over six years. The batch reactors were anaerobically prepared by transferring cells and supernatant to bottles sealed with butyl rubber septa and then sparged with furnace-treated gas. The tests were conducted in multiple stages to determine the effects at different CM exposure times, whether by CT itself or any of its transformation products, such as CF. Each test began on day 0 with the addition of CT or CF, 50 μ M TCE, and 2 mM formate as a hydrogen source. Additional TCE/formate additions were delivered at 1, 2 and 14 days, marking new stages. Select reactors were sparged to remove CMs just prior to a final TCE addition at 28 days to evaluate whether CM inhibition was reversible. Reactor headspace concentrations were measured via gas chromatography throughout the duration of the tests. CE rates for each stage were estimated by determining the linear rates of product formation and through a Multi-Fit Monod model.

Results/Lessons Learned. On day 0, TCE transformation to vinyl chloride (VC) was always rapid and occurred before CT was completely transformed, with rates within the range of controls performed in the absence of CMs. The major transformation step affected by the first addition of CT was that from VC to ethene, while the first addition of CF did not appreciably affect CE rates. CE rates within 2 days of CT exposure were comparable to those from 14 day CT exposures, with an order of magnitude reduction in transformation rate observed for TCE, cis-dichloroethene (cDCE) and VC. In contrast, direct exposure to CF resulted in less reduction in CE transformation rates. This suggests that CF alone does not cause these CE rate decreases. Rates for CE transformations after the sparging of CMs suggest no recovery, with rates staying about the same between day 14 and 28 additions. This suggests permanent damage to the cells, however, transformation of VC to ethene still occurred slowly. A doubling in initial CT concentration resulted in a further lowering of the rates of CE transformation within 14-day periods. The results indicate both a concentration and a time dependent effect on the CM toxicity, and the decrease in CE transformation rates during the period of CT transformation

indicates that the latter is likely responsible for reduction in CE rates. Work to identify why CT exposure appears more detrimental to the culture than direct CF exposure is ongoing.