Synopsis
TCE Degradation In Soil Using The BER System And Methanotrophic Bacteria

Summary: Contamination of soil and water by chlorinated solvents is a widespread problem in the U.S.and many industrialized nations. The most prevalent chlorinated aliphatic solvent, trichloroethylene (TCE) is highly toxic, and according to the EPA, is present at 246 out of 1035 superfund sites (1). Bioremediation of TCE is well documented in pure and mixed cultures of aerobic bacteria which co-metabolize TCE and its breakdown products. In addition, TCE degradation occurs by pure cultures and enrichments using anaerobic such as sulfate-reducers and methanogens (2).

The most promising route for removal of TCE by biological means involves using members of the group of bacteria known as methanotrophs. These aerobic bacteria use methane as a sole carbon source for energy and growth by producing the enzyme methane monooxygenase. One such methanotrophic bacterium showed a pseudo first order rate constant of 2.9 L (mg of TSS)$^{-1}$ day^{-1} for TCE in bench scale studies. This organism synthesizes two types of methane monooxygenase, a soluble and a particulate form with the soluble form exhibiting a border range of substrate specificity. It is the soluble form of methane monoxygenase which is the active enzyme for co-metabolic transformation of TCE and other chlorinated, aliphatic compounds.

Innovative Remediation Technologies Inc. researchers investigated a strain of methanotrophic bacteria to enhance the biodegradation of TCE contaminated soils. Researchers modified a soil treatment technique already developed and field proven by Innovative RemediationTechnologies Inc. (BER Process) to accommodate the methanotrophic bacterium.

Results of this study indicated that the methanotrophic bacterium can be successfully adapted to the BER process to effect rapid and inexpensive treatment of TCE in soil.

General Description of TCE Degradation Process: Innovative Remediation Technologies Inc., has already developed a series of aerobic, anaerobic and facultative bacterial cultures for the degradation of a wide variety of industrial compounds. The addition of methanotrophic bacteria is just another addition to a growing product line. Though bacteria are naturally present in contaminated soils, several additional factors are necessary for biodegradation to occur. Typically, sufficient micro and macro nutrients are not present to accommodate the healthy growth and development of the bacteria needed to accomplish the job. Additions of selected nutrients and vitamins in the correct amounts is, therefore, essential. Additionally, the numbers of the bacterial strains which can degrade the target contaminant existing naturally within the soil are normally very low or non-existent. Innovative Remediation Technologies Inc., has repeatedly demonstrated that boosting the numbers of bacteria which can accomplish the job "above the number of organisations which can be achieved under optimum growth conditions" will greatly improve the rate of treatment. A key factor for degrading chlorinated solvents is that methanotrophic bacteria do not obtain energy for growth from the target contaminated and, thus, bioremediation of these compounds is a little more complicated. Biodegradation occurs in a co-metabolic fashion, that is, the same enzyme which the methanotrophic bacteria mananufacter to degrade a food source fortuitously degrades the chlorinated compounds of interest. Thus, the bacterial enzyme breaks down two compounds at once, one natural compound which it needs for growth and

energy and the other one a man-made soil contaminant. Thus, in order for effective bioremediation to occur, a growth substrate must be added to the soil for the methanotrophic to grow. The growth substrate is dictated by the type of bacterium used.

TCE Soil Treatment Results: The evidence for soil removal is shown in Figure 1 where Innovative Remediation Technologies Inc., added the methanotrophic bacterium to a TCE contaminated soil along with nutrients in a sealed headspace filled with air and methane. The control, which contains added nutrients, did not have sufficient methanotrophs present, if any, for effective removal of TCE. The EPA TCLP limit (0.5 mg/L) was reached in approximately 8-9 days under these laboratory conditions utilizing the enhancement process. This experiment has since been repeated several times with similar results. The lab test was specifically with our Biosolids Enhanced Remediation (BER) system in mind. Degradation of TCE occurs with a slight modification of our already proven BER system used for hydrocarbon bioremediation . This modification involves the adequate mixing of macro-and micro-nutrients to the pulverized soil along with an available auxiliary food source for the methanotrophic to grow.