Soy Based Aerobic Co-Metabolism Remediation

For Rapid Remediation of Chlorinated Hydrocarbons in Groundwater

Introduction

Don Blackert, PG of KU Resources developed and successfully tested and employed an aerobic co-metabolism technology at ten field pilot test and full-scale groundwater remediation sites in several states. Additional pilot tests and full-scale applications are currently underway in West Virginia, Texas, and Kansas. The technology has been successfully used for remediation of several common halogenated hydrocarbons including trichloroethene, dichloroethene, tetrachloroethene, carbon tetrachloride, and chloroform, as well as several less common hydrocarbons and fluorocarbon compounds present in groundwater. The technology results in rapid, cost-effective reduction in concentrations of Constituents of Concern (COCs), with reductions typically exceeding 95% within the first few months of operation. Recent studies have shown dramatic increases in microorganism populations and corresponding decreases of 90% or more in COC concentrations within 3 to 4 weeks after co-metabolite injection. From 2000-2013, full-scale applications have resulted in “no further action” (NFA) status at several sites throughout the U.S. Remediation results have been documented in reports to U.S. EPA and state regulatory agencies, and have been presented and published at several conferences and proceedings.

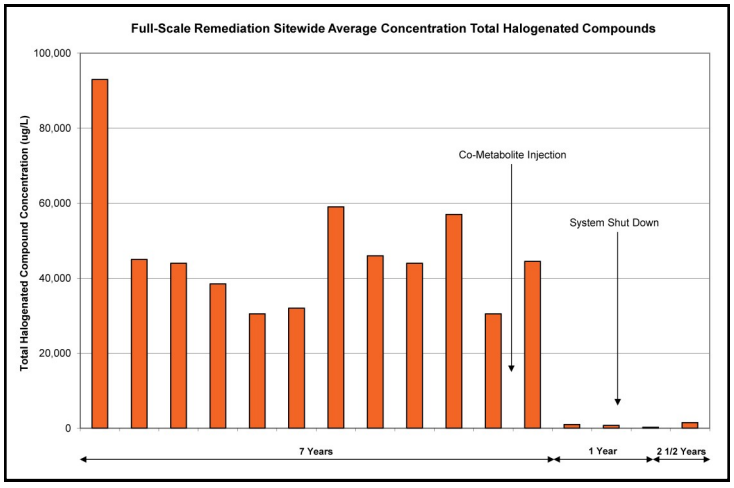
Method Development and Use

In-situ aerobic co-metabolism was initially evaluated in 2000 at a Union Carbide Corporation site in West Virginia, in an effort to simulate a toluene oxygenase enzyme co-metabolic process observed elsewhere on site in a mixed toluene and halogenated hydrocarbon plume. Various biodegradable vegetable-based mixtures were tested on the bench scale to evaluate delivery methods and dispersion/migration characteristics under simulated aquifer conditions. A soy methyl ester and a biodegradable surfactant blend has been tested and used extensively for full-scale field application.

Long-term data from the first two site-wide remediation projects indicate that site-wide average COC reductions greater than 96% were achieved within 6 to 8 months. Re-sampling of site groundwater 2 years after the conclusion of active remediation indicated that only minimal rebound had occurred, with overall COC reductions exceeding 95% compared to pre-remediation concentrations.

The process consists of several specific steps including:

- Injection and dispersion of a highly biodegradable soy methyl ester/surfactant blend;
- Creation and maintenance of aerobic conditions;
- Stimulation of indigenous aerobic microbe populations to increase concentration up to several orders of magnitude; and
- In the process of metabolizing the methyl ester, large microbe populations produce oxygenase enzymes which are capable of breaking molecular bonds of chlorinated molecules – resulting in degradation of chlorinated hydrocarbons to basic components of carbon dioxide, water, chloride, and trace elements.



Graph showing minimal chlorinated hydrocarbon reduction during 7 years of active air sparging and pump and treat remediation versus the 99% removal achieved within 8 months after co-metabolite injection. Minimal rebound occurred during 30-month period after shutdown of all remediation.

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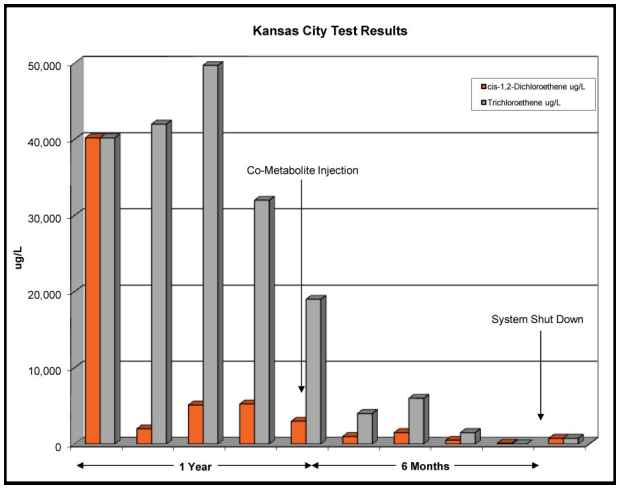
Process Description

A specific blend of soy methyl ester is used as a biological co-metabolite for the *in-situ* remediation of chlorinated hydrocarbons and other COCs in soil and groundwater. The product serves as a carbon source to stimulate and support indigenous subsurface microbe populations. The co-metabolite is readily biodegradable and typically results in several orders of magnitude increase in microbe populations. The actual co-metabolism process occurs when non-compound specific enzymes produced by the microorganisms result in the simultaneous biological degradation of both the soy oil and the COCs. The product consists of a refined soy oil blended with a food-grade surfactant and is water miscible and oil soluble, allowing dispersal within groundwater aquifers and sorption of hydrocarbon compounds. The oil/surfactant blend helps strip adsorbed hydrocarbons from the aquifer soil matrix resulting in minimal rebound after shutdown of the remediation. Characteristics of the oil/surfactant blend include:



Graph showing typical comparison of TCE and DCE reduction during air sparging versus aerobic co-metabolic remediation. Minimal rebound is indicative of removal of COCs from both the soil and groundwater matrices.

- Very highly biodegradable, resulting in high microorganism populations when properly applied
- Specific Gravity of 0.88 allows the product to “sweep” through the aquifer when injected below the zone of contamination
- Low Viscosity - Flows and Disperses Readily at Aquifer Temperatures
- Non Hazardous/Non-Toxic – HMIS Health 0, Reactivity 0, Flammability 1
- Low Odor, Low VOCs, Low Evaporative Emissions
- Easily Handled, Stored, and Dispensed

Summary

Results from the applications of the aerobic co-metabolism process have been documented in reports to U.S. EPA and state regulatory agencies, peer-reviewed presentations, and publications. Results consistently indicate that the technology has reduced concentrations of chlorinated hydrocarbon and fluorocarbon compounds to levels meeting target cleanup criteria. Long-term data from the first two site-wide remediation projects indicate that site-wide average COC reductions greater than 96% were achieved within 6 to 8 months after initial injection, and re-sampling of site groundwater more than 2 years after the conclusion of active remediation indicated that significant rebound had not occurred.

Benefits

This process offers the following advantages:

- Safe *in-situ* process
- Effective for a wide variety of chlorinated hydrocarbons without generation of daughter products
- Rapid and cost-effective
- 95-99% removal efficiency typical in 6-12 months
- Combined microbial and co-solvent processes minimize post-treatment rebound by treating both groundwater and saturated soil

For more information, to request a copy of recent publications, or to discuss application of the technique, please contact Don Blackert by phone at (724) 228-8314, by email at dblackert@kuresources.com, or by mail at 485 Horne Run Road, Amity, PA 15311.