Biotreatability Demonstration/2004

Pilot Project to Demonstrate a Large Drainage Ditch Cleanup Using Microbes

A storm water ditch drains a large warehouse facility in Pennsylvania. The ditch contains sediments contaminated from operational activities. These Contaminants of Concern (COCs) include: polychlorinated biphenyl (PCB) Aroclor 1260, polycyclic aromatic hydrocarbons (PAH), arsenic, and other metals. The drainage ditch has been extensively investigated and partially remediated, including excavation of sediment from the most contaminated, upstream 2,200 feet (ft), known as Segment 1. However, portions of Segment 1 and downstream areas still contain COC concentrations significantly above cleanup goals.

Bioremediation is being considered as the final remedy since it can be applied in-situ with minimal disturbance to the vegetation and ecosystem (important since most risk is from exposure of ecological receptors to COC), and is very cost-effective compared with alternatives involving soil excavation. To address whether or not bioremediation could be effective against the particular COC in the ditch, the project team developed a pilot test employing a unique consortium approach.

In March, 2004, Lambda Bioremediation Systems, Inc. (LBSI), Columbus, OH, was subcontracted to perform a large-scale biotreatability demonstration on a 1220-foot long portion of the drainage ditch's Segment 1. The objectives of the project were to demonstrate that the technology will work on the contaminants at the site under actual field conditions and to address the issues that would arise from a large-scale application of the technology.

Drainage Ditch Segment 1 Looking Upstream

Portions of Segment 1 were excavated and replaced with riprap in an effort to remove the contamination and stabilize the banks. The banks above the riprap, which did not undergo excavation, contain the highest concentrations of COCs. Bioremediation is a solution as to how the contamination on steeply sloping banks and in the channel could be addressed without removing vegetation or performing costly and ineffective excavation.

The main COCs and their concentrations are:

- PCB Aroclor 1260 up to 140 mg/kg
- PAH totaling as much as 55 mg/kg, with at least 14 compounds including fluoranthene, phenanthrene, pyrene, benzo(a)anthracene, chrysene, and benzo(a)pyrene
- Pesticides totaling up to 31 mg/kg, mainly 4,4'-DDT, endrin aldehyde, endosulfan, 4,4'-DDE, and endrin
- Metals, comprising arsenic up to 21 mg/kg, chromium up to 44 mg/kg, lead up to 371 mg/kg, and vanadium up to 33 mg/kg

LBSI's unique process is custom designed for the contaminant mixtures and concentrations found at the site. The process uses indigenous site microbes - bacteria, fungus, algae, and protozoa - that have already started adapting to the contamination and fortifies them to do a better job by a special hybridization process and through natural selection (without genetic engineering). COC concentrations that would normally be toxic to the microbes are slowly introduced to "acclimated bugs" in Lambda's laboratory.

Research was performed to identify the microorganisms needed to destroy or transform the contamination, generate needed enzymes, and adjust the pH and oxygen levels in the treated area to optimize conditions for their survival. In a complex interaction, over 500 individual microbes worked both aerobically and anaerobically over time, painstakingly degrading the contamination and all daughter and by-products, step-by-step. Balance within the ecosystem is critical. As an example, the degradation of Aroclor 1260 (a heavy PCB) was one of the most challenging aspects of the project. Their destruction required 35 steps and 51 microbes to transform Aroclor 1260 into carbon dioxide and water. Each contaminant received the same careful process design. Then all processes are assembled into the consortium and fine-tuned so they will work in concert, rather than at cross-purposes, within the contaminated site environment.

Site Inoculation

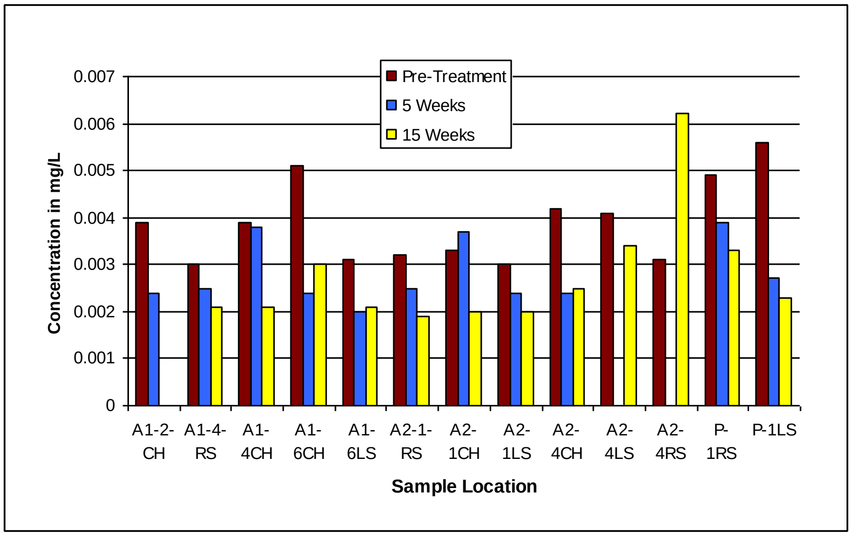
Because each site is unique, a custom-designed formulation may be required to optimize the effectiveness of the treatment under site conditions. Baseline Site characterization revealed that the low (acidic) pH and lack of nutrients in the shallow Site soil would impede the cleanup by depriving the microbes of required nutrients and exposing them to below-optimal pH. This meant that the project team had to supplement the site soil to raise the pH to within acceptable ranges (7 to 8.5) and to add nutrients using LBSI's generic soil enhancer, and a specifically designed compost. The compost was used to raise the pH and supply added nutrients - SO4, NO3, NH4, PO4, K - and trace elements that were negligible or missing from the Site soil. These components are essential for reductive dechlorination and the reduction of most of the metals on the Site. The reductive dechlorination and anaerobic bioremediation was encouraged by the consortium design to decrease or detoxify the pesticides and metals first, then start breaking down the PCB. When crucial nutrients are present in the soil, microbes can achieve a reducing environment. By making these adjustments, the inoculum was given the best chance of achieving success within a reasonable timeframe

LBSI assembled 50-pound BioCarb™ bags to act as small microbe incubators and placed them in the channel under the water line when water is actively flowing in the ditch. (These BioCarb™ bags are composed of granular, activated carbon soaked in the inoculum and will withstand the rigors of flowing water without being dislodged.) Smaller, 30-pound bags were placed just above the riprap. Inoculum was injected along the banks and sprayed onto the surface soils, pressure-injected into the shallow channel sediments, and deposited under the water in BioCarb™ bags.

A total of 3,200 gallons of inoculum was grown. The feed protocol was based on site chemistry and data on the COC. The pH was balanced to produce an environment that was friendlier to facultative anaerobes, methanogenic bacteria, fungi, algae, and protozoa, a complex balance to achieve. Based on microbe density and viability, supplemented with 20 years of professional judgment, the consortium was delivered to the site four weeks after it was placed in the growth tank.

Sediment samples were collected five and 15 weeks after inoculation. Analysis of the trends exhibited pre- and post-treatment in soil samples collected from the 1,200-ft long study area of this pilot project indicate that bioremediation is a suitable and effective treatment technology for the mixture of Site contaminants. Despite only having 15 weeks from inoculation for the initial assessment period, statistically significant declining trends in two COCs were evident and downward trends were shown in all classes of COCs. While the evaluation period is too short to make a definitive statement about the long-term efficacy of this particular bioremediation treatment, the short-term trends that are exhibited demonstrate success in treating pesticides and vanadium, and encouraging trends may be present for PCB Aroclor 1260 and the other COCs.

Graph of Leachable Vanadium Reduction



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