

**U.S. ARMY CORPS OF ENGINEERS
EASTGATE DEVELOPMENT
MAHONING RIVER
GIRARD, OHIO
CASE STUDY**

Lambda'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 (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 target area to optimize conditions for their survival. In a complex interaction, over 500 individual microbes working both aerobically and anaerobically over time, painstakingly degraded 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, essentially by stripping off chlorines and breaking apart the biphenyls. Each contaminant received the same careful process design. Then all processes were assembled into the consortium and fine-tuned so they would work in concert, rather than at cross-purposes, within the contaminated site environment.

The designated Test Site was a 50-x-50-foot plot on the western bank of the Mahoning River, just upstream of the Liberty Street dam in Girard, OH. The boundaries extended approximately 18 feet into the water. Not only was this an area where contaminated sediments had accumulated behind the dam in the river channel and where COCs were buried as deep as six feet below clean soils in the bank areas, but the concentrations of those contaminants were found to be among the highest in the entire 31-mile study area. TPH was as high as 20,000 mg/kg; PCBs were as high as 3443 ug/kg; selenium, zinc, arsenic, and iron was found in leachable form in the hundreds to tens of thousands of ug/L; and 16 PAHs were at total concentrations as high as 108 mg/kg.



Test Site Looking Downstream Toward Liberty Street Dam

Sediment samples in the Model Reach (uncontaminated upstream area of the river) and Test Site were collected at the beginning of the study to establish a baseline. Cleanup targets were designated as those concentrations found in the Model Reach. Samples of sediments from the Model Reach, a Recovering Area (of moderate contamination), and the Test Site were taken to Lambda's laboratory to be evaluated for indigenous microbial communities, and microbe viability, density, and variability. Four hundred gallons of inoculum, consisting of acclimated microbes, vitamins, enzymes, nutrient broth, and a variety of other ingredients, was grown to inoculate the site. Lambda assembled BioCarb® bags to act as small microbe incubators to be placed in the river under the water line. (These BioCarb bags are composed of granular, activated carbon soaked in the inoculum and will withstand the rigors of flowing water without being dislodged.) The site was inoculated on September 3, 2003. Inoculum was injected along the banks in pre-drilled holes, sprayed onto the surface soils, pressure-injected into the shallow river sediments, and deposited under the water in BioCarb bags.



Wand Used to Inoculate Below the Surface on the Banks of the Test Site

Sediment samples were collected six weeks and five months after inoculation at the Test Site. Based on these results, it was shown that bank sediments exhibited reductions in all types of COCs, while the sediments in the river remained fairly unresponsive to treatment.

RESULTS:

Total PAHs were reduced 35.9% in the river sediments, and from 21.5% to 92.6% on the banks, with benzo(a)pyrene (a carcinogen) exhibiting a 91% reduction.

PAHs responded well to the treatment. Of the 16 compounds initially detected in the samples, 11 exhibited decreased concentrations in all three zones with respect to the initial concentrations. The reductions ranged from 18 to 69 percent, with an

average reduction of 45 percent in five months. Acenaphthene and naphthalene were reduced to below Model Reach concentrations in all three zones, and eight compounds were reduced to Model Reach concentrations in at least one of the three zones. Only six compounds did not achieve Model Reach conditions in any zone, but all exhibited reductions in at least one zone.

Total petroleum hydrocarbons were not reduced in the river sediments, but were reduced up to 93.7% in the bank sediments.

Oil and grease were reduced in all three zones in the Test Site, and TPH was significantly reduced (from 20,000 to 1260 mg/kg) in the ecotone of the Test Site, but remained unchanged in the riparian zone, and actually increased in the river sediments. This increase is likely the result of re-contamination from upstream sediments in the river.

Total pesticides were reduced 43.2% to 98.0% in the bank sediments, but were not reduced in the river sediments.

There were 12 pesticides detected in samples from the Test Site. Beta-BHC and gamma-chlordane achieved reductions in all three zones with respect to initial concentrations. Three other achieved reductions in at least one zone, while two did not exhibit reductions in any zone.

Approximately 77% of Aroclor 1260 (PCB) was shown to be transforming / reduced into lighter aroclors in the bank sediments.

Aroclor 1260 was detected in the Recovering Area (from 62 to 190 ug/kg), but no other congeners were detected there. Aroclor 1260 (the heaviest PCB) was the only PCB detected during the initial sampling of the Test Site ecotone and river zones. After treatment, two lighter aroclors were detected (1232 and 1254), both in the river sediments, but the initial concentration of arochlor 1260 (180 ug/kg) was no longer present. There was no decrease in aroclors in the ecotone or the riparian zones of the Test Site.

Arsenic was reduced 15%, chromium 96%, and manganese 40%.in bank sediments.

Eight leachable metals, subjected to the TCLP procedure, were detected at the Test Site. Of these, three were reduced during the study period: arsenic 15%, chromium 96%, and manganese 40%. Concentrations met Model Reach conditions for arsenic and chromium. The unresponsiveness of some metals to bioremediation simply indicates that five months is not long enough to achieve the desired results at this site.

It was concluded that the technology showed promise as a remedy for treating the contamination on shore, but was less effective in near-shore river sediments, while minimizing potential

damage that could result from the use of a more invasive remedy. Although the study has been concluded, treatment is passively continuing and it is anticipated that further reductions would be exhibited should additional samples be collected.

NOTE: Our study only extended 18 feet out into water and the river is approximately 200 feet wide at the test site. Contaminants in the deeper river sediment showed no change because they were not treated as they were outside the scope of work for the initial study and would have required larger, heavier duty equipment to place the consortium 6-8 feet deep into the river sediment. The shallow river sediment could only be spot treated due to budgetary constraints and it was difficult to mark those particular injection points for possible testing. In addition, the shallow stream area is constantly being re-contaminated from upstream runoff into the river.

The client was pleased with the results and thought bioremediation was a potentially attractive remedy for the contamination along the river banks. It was thought that either another application method was needed to increase the effectiveness in the river, or that bioremediation of the bank sediments would have to be coupled with another, more aggressive technology, such as dredging, in the river. The timeframe for completion of the feasibility study and selection of a final remedy is around 2007. To date there has been no further information regarding this project.