Degradation of Polychlorinated Biphenyl (PCB) Mixtures (Aroclors) and Sediments Contaminated with PCBs with Encapsulated Oxidoreductase Enzymes

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Background/Objectives. Polychlorinated biphenyls (PCBs) are a family of compounds with a wide range of industrial applications in heat transfer fluids, hydraulic fluids, plasticizers and organic diluents. In the United States, these complex PCB mixtures were manufactured under the name Aroclors. Three commonly used Aroclors are 1242, 1254 and 1260 which contain 42, 54 and 60% chlorine by weight with an average of 3, 5 and 6 chlorines per biphenyl molecule, respectively. Aroclors consist of a number of congeners which differ in the number and distribution of chlorines on the biphenyl nucleus. Approximately 150 Aroclors were reported to date in the soil and sediment environments as a result of improper disposal of industrial PCB wastes and leakage of PCBs from electrical transformers. Due to stable molecular structure and hydrophobicity, PCBs are persistent in the environment and show low potential for biodegradation. However, some PCB congeners have been shown to be transformed by both anaerobic and aerobic bacteria. While bacteria are the most studied microorganisms for the biological destruction of PCBs, their efficacy of remediation is low in the highly polluted habitats. The potential to use fungal derived, oxidative exoenzymes such as lignin peroxidase, manganese peroxidase and laccase is promising as lignin-degrading enzymes are known to mineralize a wide range of chloroaromatic environmental pollutants to CO_2. This project presents results of a study in which selected Aroclors and sediments contaminated with PCBs were treated with a triage of fungal exoenzymes.

Approach/Activities. Preliminary studies show low levels of mineralization of 0.9 to 1.1% for individual PCB congeners, such as 3,3', 4,4'-chlorobiphenyl (CB), 2,2'4,4'-CB and 2,2'4,4'5,5'-CB when these were added to cultures at a low concentration. There is also a limited number of studies that show the ability of the fungal exozenzymes to substantially degrade PCB mixtures at environmentally relevant concentrations or at levels degraded by known microbial systems. Thus, this study applied fungal exoenzymes that were further purified, concentrated and encapsulated into a biodegradable, diffusive shell. In this project selected Arocolor mixtures and four sediments contaminated with PCBs from a contaminated site were treated with fungal exoenzymes. At three selected time points during the 28-day experiment, a subset of samples was pooled to analyze for: 1) total congener content using congener specific analysis and, 2) by-products of PCB degradation, including any toxic daughter products that may have formed during enzymatic degradation processes, using GCxGC-TOF-MS analysis. Finally, selected sediment samples were analyzed using 16S rDNA sequencing to identify changes in microbial community that may be involved in degradation of PCBs present in the samples.

Results/Lessons Learned. The vast amount of data collected from experiments show degradation of most of the PCB congeners in selected Aroclor mixtures and in environmental sediments containing PCBs. Detailed analysis of the data sets is still ongoing.