Draft Proposal for Research Addressing Feasibility

of Biological Treatment of PCB-Contaminated Site

Introduction and Background

Biological remediation of sites contaminated with toxic waste chemicals can represent a more natural and cost effective restorative solution for the environment than the alternative approaches of incineration, solidification and containment. This technology is rapidly developing as a result of significant research findings in biodegradation. Synthetic chemicals such as PCBs previously thought to be biologically inert have been shown to undergo substantial degradation. General Electric, with research support from US EPA, has made a major commitment to understanding PCB degradation in the laboratory and in the environment.

Recent work from their laboratories and from those of James Tiedje and others has confirmed that, with time, anaerobic biological processes in sediments can lead to significant alterations in the chlorine content and congener distribution of Arochlors. The overall trend observed is one of reductive and selective dehalogenation, usually of meta and para-substituents to yield congeners with fewer chlorines (enriched with ortho-chlorine substituents), increased aqueous solubility, and with decreased toxicity and enhanced aerobic biodegradability. Significant changes in different Arochlor mixtures have been observed in different sediments and microbial

dehalogenation activity can be shown to occur at uncontaminated as well as contaminated sites. General Electric is currently evaluating the effectiveness of an in situ treatment technology for Hudson river sediments that employs aerobic microorganisms to degrade the products of anaerobic dehalogenation of Arochlors. This is based on research that has established that various aerobic bacteria can readily catabolize the products of anaerobic dehalogenation.

Rationale

Biological treatment of PCB- contaminated sediments is currently being evaluated as a natural competitive cost-effective method of restoring ponds, riverine, and estuarine environments. Its application to relatively small volume, contained areas of PCB-contamination would appear to be a logical and straight forward step. Before its application is attempted at any PCB-contaminated site, however, it is essential that a feasibility study be conducted to assess whether biological treatment can be effective. Insofar as the site in question is a contained system of limited volume located in a mild climate area, it has promise as a suitable candidate for implementing biological treatment. There are, however, a number of factors that may limit its successful treatment. The site water has been held at a pH of 1-2 because of the nature of the ponded effluent. It also contains copper, borate and various organic residues from an adipic acid production plant that can

contain various oxidation products derived from cyclohexane. Consequently this site cannot be expected to be biologically active. Before this site can become biologically active and maintain populations of aerobic and anaerobic microorganisms, adjustment of pH and supplementation with suitable nutrients will be required. Inoculation and additions of active sediment may be necessary to acheive a rapid colonization of the system. The work proposed will address what measures are necessary to treat the site sediments and overlying water, before aerobic and anaerobic microbiological processes can be established. A primary objective is to establish conditions that are optimal for the implementation of anaerobic dehalogenation of contaminant Arochlor. As such it will determine whether biological remediation is a feasible approach to site cleanup.

Approach

Restoring Biological Activity

The proposed research will initially be a laboratory study of site sediments and water to determine the chemical and biological treatments necessary to convert an inactive impoundment into a biologically active system in which microbial activities in the water column can promote and sustain the activities of anaerobic organisms in the underlying sediment. Suitable microcosms for these studies will accomodate both site-water and sediment and will either be maintained in the laboratory or in the external environment to simulate site conditions. Obviously pH adjustment is a crucial

step; various neutralizing agents such as $CaCO_3$ addition will be evaluated as treatments to adjust pH to permit microbial colonization and activity. Measurements of microbial numbers and activities will be used to indicate the effectiveness of different treatments which will include additions of nutrients and electron acceptors, inoculation with water samples, and introduction of active sediment samples. Biological formation of methane and sulfate reduction will be used as quantitative indicators of the anaerobic activity of sediments and compared with activities of long-established anaerobic sediments. One important consideration here will be the time frame required for onset of active biological processes. Successful establishment of communities of anaerobic microorganisms will provide evidence of the requisite physiological conditions for the maintance of organisms with anaerobic dehalogenation ability.

Site Characterization

While sediment sampling and analysis have revealed the presence of PCB congeners indicative of Arachlor 1254 contamination it is not clear whether this material is well distributed in site sediments or whether it is "puddled". Results from the General Electric experience at the Hudson river site suggest that Arochlors well mixed in river sediments through river water movement, flooding etc, are more amenable to anaerobic dehalogenation than is material in "puddled" deposits. If mixing of site sediments is necessary to optimize Arochlor bioavailability this process is best

accomplished before procedures are initiated to restore biological activity to the site. Cored samples will be collected at different sites in the impoundment, frozen and sectioned before analysis for PCBs. Data from sampling and analysis will be used to determine whether sediment mixing should be undertaken before the implementation of other measures.

Development of Anaerobic Dehalogenating Activity

Once it is evident that site sediments can be treated so as to support anaerobic microbial communities and that this can be accomplished in a timely manner, studies of Arochlor dehalogenation will be initiated.

These studies will be conducted using replicate bottles or vials containing site water and sediment previously shown to have an established, active anaerobic microflora. Additionally these sediments will have been treated to ensure that the Arochlor contaminant is uniformly distributed. Entire bottle/vial contents will be extracted at selected times for PCB congener distribution using currently accepted extraction and capilary GC analyses. The primary goal of these studies is to determine the conditions and times necessary to initiate anaerobic dehalogenation processes and to estimate their overall and congener-specific rates. The information derived from these studies will allow assessment of the feasiblity of biological treatment of the Arochlor-contaminated impoundment.