

Enhanced Bioremediation of Polychlorinated Biphenyls (PCBs) in Sediment: Application of Biofilm-Activated Carbon Aggregates as a Delivery Vehicle

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Background/Objectives. Removal of polychlorinated biphenyls (PCBs) from contaminated sediments is a priority because of their ability to enter the food chain and due to their toxicity. Commonly adopted remedies include dredging and capping which are associated with challenges including disruption of existing habitat and high cost. While in situ microbial degradation of PCBs represents an improvement, previous attempts have failed because of PCB stability, low bioavailability, low abundance and activity of indigenous PCB-degrading microorganisms. The high efficiency of activated carbon (AC) and other sorptive substrates to quickly adsorb PCBs from sediments has been demonstrated. Co-localizing PCB-degrading microbes onto surfaces of sorptive particles as biofilms and utilization as a delivery system provides a novel approach to address PCB contamination. In this study, several biofilm covered adsorbent materials including AC were evaluated for enhancement of PCB dechlorination in sediment.

Approach/Activities. Biofilms of anaerobic *Dehalobium chlorocoercia*, enrichment cultures from wastewater and soil containing organohalide respiring bacteria as well as aerobic *Burkholderia xenovorans* strain LB400 were formed on sorptive materials. The materials consisted both of activated carbons and biochars based on plant and animal waste products such as coconut shell, pine wood, acai and bone. The formation of biofilm on the sorptive materials was quantified using culture based methods, molecular (PCR, Q-PCR, Illumina sequencing) and microscopic approaches (Confocal Laser Scanning Microscopy). Mature biofilms were inoculated into PCB contaminated sediment mesocosms, where PCB concentrations and individual congener concentrations were determined by GC-MS. The toxicity of the 12 dioxin like congeners was also investigated. Techniques included in this study were: DNA extraction, q-PCR with specific 16S rDNA primers, identification by DHPLC and Illumina sequencing and microscopic analyses with DAPI, PNA-FISH and CLSM.

Results/Lessons Learned. Biofilm formation of DF1, LB400 and enrichment cultures onto the array of tested sorptive materials was observed via microscopic techniques and quantified via Q-PCR. Coal based activated carbon as well as bone based biochar showed the fastest colonization (1 day) and the highest number (10^9 cells per g) of bacteria after seven days (*B. xenovorans*). Anaerobic organohalide respiring biofilms inoculated into sediment mesocosms showed a two-fold increase and enhanced PCB degradation (1.5 chlorines/biphenyl for biofilms (31%) versus 0.3 chlorines/biphenyl for planktonic inoculum (6%) over 200 days. The bacterial diversity, with up to eight indigenous species of organohalide respiring bacteria, was not affected thus not causing the difference in dechlorination. The application of biofilm-AC aggregates enhanced the PCB degradation in the mesocosms significantly. This was likely due to PCB adsorption onto AC ensuring direct contact between the PCB degrading biofilms and the adsorbed PCBs. The factors involved in this mechanism are currently being further evaluated. This two-phased approach will provide an efficient and cost-effective method for delivering microorganisms for bioaugmentation of PCB contaminated sites thus enabling complete on-site bioremediation.