Bioremediation of Heavily-Contaminated Marine Sediments by Petroleum Hydrocarbons Using Sediment Microbial Fuel Cells (SMFCs)

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Background/Objectives. Contamination by petroleum hydrocarbons constitute a major problem in aquatic environments where large amounts of oil could be released. Even after so many years of natural weathering of the spilled oil, a variety of organic contaminants can still be usually detected in high concentrations in the anaerobic sediments due to various limitations, including the stability of the organic compounds, and the limited availability of oxygen and nutrients required for biodegradation. Although there is a variety of physical, chemical and biological methods used to handle an aquatic oil spill and the subsequent treatment of the resulting contaminated sediments, assessment of sediment microbial fuel cells (SMFCs) for the purpose of remediating the sediments in such cases is also important, given that the successful implementation of such a system will provide a passive method for the treatment of lingering oil with little external human intervention. As such, it is important to assess the performance of SMFCs for oil hydrocarbons attenuation, rather than limiting the investigations to few target pollutants as is usually practiced. The results thus would be much more significant and representative of the field conditions, showing possible interactions among various contaminants that could be unnoticeable otherwise. Therefore, this study addresses the bioremediation of weathered crude oil in contaminated marine sediments using SMFCs.

Approach/Activities. Weathered crude oil was spiked into marine sediments at a concentration of 1 g/Kg of dry sediment to simulate a heavily contaminated marine environment. Cylindrical SMFCs with a relatively large volume of 4.4 L were used for this aim. Conventional SMFCs were used with carbon fiber brushes as the anode and cathode components, and were enhanced with ferric iron. A natural attenuation control was prepared and operated under open circuit condition with the anode and cathode placed in the bioreactors but left unconnected. Five SMFCs' sacrificing events were conducted throughout the biodegradation experiments which lasted for 4 months. At each event, triplicate SMFCs per condition (the closed circuit and the controls) were sacrificed for extraction and quantitation of total petroleum hydrocarbons, which were performed using an accelerated solvent extraction system (ASE) and gas chromatography coupled to a mass spectrometer (GCMS), respectively.

Results/Lessons Learned. General enhancement of the degradation rates of total petroleum hydrocarbons was observed in the operated SMFCs compared to the controls. Several low molecular weight PAHs and short-chained alkanes showed similar removal rates compared to the controls, indicating the involvement of abiotic processes, such as volatilization, in their removal, as in the case of naphthalenes, phenanthrenes, and C10 to C20 alkanes. However, several compounds, namely high molecular weight PAHs and several long-chained alkanes were persistent under all operating conditions, showing little degradation over the duration of the experiments. The results of this study indicate that using SMFCs as a bioremediation approach for petroleum-contaminated marine sediments could not be a sustainable nor a feasible system given that the persistent pollutants will not readily degrade. These stable compounds include several EPA-listed priority pollutants. Furthermore, NMDS plot showed clear clustering of microbial communities in Fe stimulated SMFCs, where the genus *Gordonia* dominated, compared to the natural attenuation control, where *Marinobacter* dominated. As such, further investigations are needed to better optimize SMFC systems for a more feasible approach for the bioremediation of contaminated sediment.