Rate of Extracellular Transfer of Charge and Bioremediation

Scott Burge (burge@burgenv.com), Russell Burge (russell@burgenv.com), and Evan Taylor (evan@burgenv.com) (Burge Environmental, Inc., Tempe, AZ, USA)
Kiril Hristovski (khristo@mainex1.asu.edu) (Arizona State University, Mesa, AZ)

The extracellular transfer of charge by biofilms is a well-documented electrical phenomenon and serves as the basis of microbial fuel cell (MFC) technology used to extract power from sediments and wastewater. MFC technology operates by shunting the charge between an anode (electron donor) located in an anaerobic environment to a cathode (electron acceptor) located in an oxidizing environment such as atmospheric oxygen. This shunting of the charge by MFC disrupts the charge transfer mechanism of biofilms that were evolved by biological systems to electrically transfer extracellular charge through the environment. It is postulated that microorganisms have optimized biofilms for the long-distance transfer of charge between anaerobic to aerobic environments. This electrical transfer of charge is more efficient than other forms of charge/mass transfer such as molecular diffusion. The rate of this transfer is a factor in the degradation of contaminants in the environment.

The rate of transfer of charge is measured by deploying arrays of microbial potentiometric sensors (MPSs) in the environment. MPS is a bioelectrical technique measuring the charge (electrical potentials) generated by biofilms on the surface of the sensors. The generated potentials are measured with high-impedance, field-deployable instruments. The MPS arrays provide 2-D and 3-D visualizations of the movement of charge through the environment.

We present several investigations of biofilms serving as electrical charge transfer mechanisms of contaminants in the environment such as petroleum hydrocarbons. The implications to the field of bioremediation becomes apparent when one views an oxidizable contaminant as a source of electrons, microbial organisms as extracting charge from the contaminant, and biofilms as the charge transfer mechanism transfer to the ultimate electron acceptor, atmospheric oxygen. The combination of these mechanisms suggests an electrical network. The rate at which the charge is transferred through this network provides a model for calculating the degradation rate of a contaminant in the environment. We will present estimates of degradation rates for contaminants in sediments and aqueous environments.