A Microbial Fuel Cell enhances Bioremediation of Gasworks Contaminated Groundwater

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Microbial Fuel Cell (MFC) technology has been applied to many different remedial technologies, including bioremediation of contaminated groundwater. As of yet full scale implementation of the technology in relation to remediation projects has not been proven. In regards to groundwater bioremediation a MFC consists of bacteria oxidising contaminants such as organic pollutants within an anaerobic area of a plume (the anode) and the transfer of electrons through a circuit to a cathode where terminal electron acceptors are reduced. This results in the generation of a low current and the depletion of contaminants.

From geophysical analysis a large MFC (50+mV) was observed to be functioning at a gasworks site containing high levels of organic and ammonium contamination in groundwater. The aim of this research is to investigate what parameters play a role or drive the MFC and can it be utilised as a sustainable remediation tool.

Experiments involve constructing a MFC with graphite electrodes connected by wire that provides a direct circuit from high contamination (the anode) to an area of bioelectric activity (the cathode). A variable resistor and datalogger are used to monitor current production. Comparison of water samples using chemical analysis (monitoring levels of TOC, Ammonium, Nitrate & Nitrite) and molecular microbiology techniques (characterising the microbial population at the anode and cathode using PCR, DGGE, and metagenomics approaches) before and after electrode operation would indicate whether the MFC has enhanced bioremediation. Initial results indicate considerable microbial diversity between the anode and cathode on site and a large Self-Potential (electrical) difference. There is also evidence of microbial utilisation of ammonium.

Genetic analysis of the shift in microbial population before and after MFC installation would highlight the involvement of microbes in the bioremedial process. Characterising the microbial biofilm formed at the anode and cathode would give a better understanding of the role the active microbial communities play in electrical conductivity and ultimately a better understanding of the potential bioremedial/ bioelectric potential of the native microbial consortia which can be exploited for bioremediation.

Comparing the soil solution chemistry of soils amended with nano-sized copper oxide, micron-sized copper oxide, and with a copper salt.

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Engineered copper oxide nanoparticles (nano-CuO) are likely to be used in agriculture in the future but little is known about their effects on soil biota. As nano-CuO particles dissolve, they release Cu^{2+}, which can be measured as Cu activity, and which is thought to be the main form of bioavailable Cu in soils. Copper bioavailability may change over time as the Cu redistributes between soil solid and solution phases. Soluble Cu salts have been used to evaluate Cu^{2+} transformations but they can reduce soil pH and increase the concentration of dissolved cations in the soil solution, and they may overestimate bioavailable Cu. In this study, we amended two natural soils with 500 mg Cu / kg soil as nano-sized or micron-sized CuO, or as Cu nitrate, and measured the change in Cu activity, pH, and concentrations of dissolved Ca, Mg, and Zn in the amended soils over a period of 56 d. The initially low Cu activity in the oxide-amended soils increased over the course of the experiment, whereas the initially high Cu activity in the salt-amended soil declined. Soil pH was lower and dissolved cation concentrations were higher in the salt-amended soils than in the oxide-amended soils for the duration of the experiment. We conclude that amending soils with Cu nitrate does not accurately reflect Cu^{2+} transformations in soils amended with nano- and micron-sized CuO.