Hexavalent Chromium Reduction in a Biocathodic Microbial Electrolysis Cell

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Background/Objectives. Groundwater is the environmental matrix most frequently affected by anthropogenic hexavalent chromium contamination. Due to its cancerogenicity, Cr(VI) has to be removed, hopefully using environmental-friendly and economically sustainable remediation technologies. To overcome the limits of the currently applied bioremediation technologies, an alternative strategy is the use of bioelectrochemical systems (BESs) to stimulate bioreduction of Cr(VI). BESs include a set of technologies based on biological reactors where an electrode (anode) can function as the final electron acceptor for the oxidation of organic compounds; then electrons flow through the circuit and reach the cathode that acts as the electron donor for the bioreduction of oxidized species. In the present study, we have assessed if Cr(VI) can act as an efficient terminal electron acceptor for an anaerobic biocathode in a microbial electrolysis cell (MEC).

Approach/Activities. The cathode was first inserted into the anodic compartment of a dual-chamber microbial fuel cell, and inoculated with sludge from an anaerobic digester. After 50 days of acclimation, the electrode was transferred into the cathodic chamber to work at -300 mV (versus standard hydrogen electrode) as the biocathode in a Cr(VI)-reducing MEC. An abiotic control and an open circuit control were also operated in parallel. Hexavalent chromium dissolved concentration was analyzed at the initial, during the experiment and final time by spectrophotometric method, while the dissolved total chromium was analyzed by ICP-MS. During the entire test, the current intensity was monitored. At the end of the experiment, the microbial characterization of the communities enriched on the biocathode and in the cathodic solution was performed by 16S rRNA gene sequencing.

Results/Lessons Learned. The acclimation phase in the MFC allowed the formation of an electroactive biofilm on the electrode. A decrease in Cr(VI) concentration was observed at the end of the tests, both in the polarized reactor and in the open circuit reactor. However, the bioelectrochemical system ensured higher removal efficiency than the pure chemical process. In addition, higher current values were measured in the BES compared to the abiotic control, due to the biofilm interaction with the electrode. The results from microbial characterization showed that the bacterial community on the surface of the electrode was affected by the cathodic polarization, and it was different from the biomass on graphite in the open circuit system.