Current Advances in Bioelectrochemical Treatment of Persistent Groundwater Contaminants

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Background/Objectives. Electrochemical (a.k.a. electrolytic) treatment is an emerging technology for the remediation of contaminated groundwater, capable of mineralizing even the most persistent organic pollutants. Using mesh electrodes, this technology can be installed both ex situ and in situ. However, the majority of electrons provided during treatment are spent in water electrolysis, generating molecular oxygen at the anode and hydrogen at the cathode. Over the past few years we have explored the combination of electrochemical treatment with biological processes, in which microorganisms may utilize the side products of electrolysis to enhance contaminant degradation rates. Here, we will provide an overview of current advances in developing bioelectrochemical treatment for field applications.

Approach/Activities. This talk will focus on laboratory-scale flow-through column reactor investigations regarding (1) bioelectrochemical oxidation of 1,4-dioxane by *Pseudonocardia dioxanivorans* CB1190 in the presence of chlorinated solvents, (2) bioelectrochemical oxidation of per- and polyfluoroalkyl substances (PFAS) by *Phanerochaete chrysosporium*, and (3) bioelectrochemical reduction of perchlorate in original site soils. As first pilot-scale demonstrations are on the way, potential field implementation designs will be showcased.

Results/Lessons Learned. For 1,4-dioxane, our results reveal that the combination of electrochemical oxidation with aerobic biodegradation leads to substantially increased degradation rates compared to both processes by themselves. 1,4-dioxane influent concentrations of >100,000 µg/L were treated by some five orders of magnitude to below our detection limit of 3 µg/L, demonstrating the technology's capability of reaching regulatory limits. Inhibition by co-occurring chlorinated solvents can be mitigated through their concurrent removal. Quantitative polymerase chain reaction (qPCR) analyses suggested that microbial activity is primarily promoted ~5 inches downstream of the electrodes. The synergistic treatment effect of bioelectrochemical treatment is based on (1) providing O_2 as electron acceptor, (2) removing the inhibiting chlorinated co-contaminants, and (3) potentially transforming 1,4-dioxane into more readily degradable, growth-supporting organic intermediates. Furthermore, the combination with biodegradation enables high treatment efficiencies at lower applied potentials, increasing electrode service life and decreasing oxidation by-product formation. New results regarding technology transfer to PFAS and perchlorate will be presented. Overall, our findings suggest that bioelectrochemical treatment is a promising synergistic technology for the ex situ and in situ remediation of persistent groundwater contaminants.