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Cathodic Potential Impacts Microbial Community Dynamics and Nitrate Remediation in Bio-electrochemical Systems

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ABSTRACT

Bio-electrochemical systems are a promising strategy for the efficient remediation of nitrate-polluted groundwater, however the treatment of wastewater with low organic carbon to NO3- ratios is hindered by low efficiency and slow removal rates. We describe the impact of cathodic poised potential on the establishment of microbial biofilms and the long-term operation of bio-electrochemical denitrifying (BED) systems. A series of fed-batch and continuously operated BED reactors were poised at either -700 mV or -1100 mV (vs Ag/AgCl) to provoke either direct electron transfer or hydrogen-mediated electron transfer mechanisms, respectively. The BED systems operating at a cathodic potential of -1100 mV increased nitrate removal by up to 600%, when compared with a similar BED operated at ‑700 mV. Biofilm community analysis of BEDs poised at -1100 mV were enriched with known hydrogenotrophic denitrifiers (e.g. Hydrogenophaga spp., Dechloromonas spp., and Simplicispira spp.). In contrast, the BED system poised at -700 mV was dominated by Candidatus Nitrotoga spp., a genus commonly associated with NO2- oxidation, indicating electroactive denitrification capacity. Overall, results indicated that cathodic potential played a critical role in the structure of the microbial biofilm community and enhancing nitrate removal within BED systems. Findings thereby highlighted that adjusting electrode potentials is a viable strategy to improve nitrate remediation efficiency and to selectively enrich for specific microbial taxa for targeted applications in groundwater bioremediation.

KEY WORDS

Bioprocessing ∙ Sustainability ∙ Bio-electrochemical systems ∙ Bioremediation ∙ Denitrification

BIOGRAPHY

Dr. Danish Laidin is a Postdoctoral Researcher at the University of Canterbury focusing on bioprocess engineering. They hold a BEng (Hons) and a PhD in chemical and process engineering, specializing in bio-electrochemical systems and bioremediation. Their research experience includes the heterotrophic growth of extremophilic algae, detection of low molecular weight organic carbon compounds using Solid-Phase Microextraction (SPME), and evaluating microbial electrolytic cells for bio-electrochemical nitrate removal from groundwater. With expertise in scientific rigor, analytical chemistry, bioprocess engineering, and computer-aided design, their work explores innovative approaches to microbial processes and environmental remediation.

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