Electrochemically-induced Reduction of Nitrate in Aqueous Solution

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In this study, we evaluated the removal of nitrate from synthetic groundwater by a cathode followed by an anode electrode sequence in the electrochemical flow-through reactor. We also tested the feasibility of the applied electrode sequence to minimize the production of ammonia during the nitrate reduction. The performance of monometallic Fe, Cu, Ni, and carbon foam cathodes was tested under different current intensities, flow rates/regimes, and the presence of Pd and Ag electrode coating. With the use of monometallic Fe and an increase in current intensity from 60 mA to 120 mA, the nitrate removal rate increased from 7.6% to 25.0%, but values above 120 mA caused a decrease in removal due to excessive gas formation at the electrodes. Among tested materials, monometallic Fe foam cathode showed the highest nitrates removal rate, which further increased from 25.0% to 39.8% in the presence of Pd catalyst. In addition, the circulation under 3 mL min⁻¹ elevated the nitrate removal by 33%, and the final nitrate concentration fell below the maximum contaminant level of 10 mg L⁻¹ nitrate–nitrogen (NO₃-N). During the treatment, the yield of ammonia production after the cathode was 92±4%, while after the anode (Ti/IrO₂/Ta₂O₅), the amount of ammonia significantly declined to 50%. The results proved that flow-through, undivided electrochemical systems with Fe cathodes can be used to remove nitrate from groundwater to safe levels with the possibility of simultaneously controlling the generation of ammonia via anodic processes.

Keywords: electrochemical; nitrates; ammonia; groundwater; cathode.

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