A two-layer flow occurs in nature in many different places, e.g. saltwater intrusion. In two-layer flows, the shape of the bed plays an important role in types of regimes that may be formed, motion of particle in water, etc. When a two-layer flow is passing over a bed with an obstacle of small height, a specific type of flow called the approach-controlled flow can be seen. While other types of flow regimes can be predicted by assuming a hydrostatic pressure, approach-controlled flow cannot be modeled with this assumption. In this study, we focused on the unsteady two-layer flow when passing an obstacle. The equations of motion for this type of flow were derived. We also modeled the derived equations and observed the process of development of approach-controlled flow.

Electrocatalytic Nitrite and Nitrate Reduction in a Parallel Plate Thin-Layer Flow Reactor

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Nitrate (NO$_3^-$) is the nation’s most ubiquitous groundwater water contaminant, mainly resulting from agricultural activities. Nitrite (NO$_2^-$) often co-occurs with nitrate because it is a transformation product of (de)nitrification. Both nitrate and nitrite can cause adverse health effects and are therefore highly regulated. Electrocatalytic reduction of nitrate and nitrite has emerged as a promising alternative to catalytic reduction due to the elimination of external H$_2$ delivery and the associated H$_2$ mass transfer limitations by generating atomic H from supplied electrons and protons in the solution. However, current studies mostly focus on reaction in batch electrochemical cells. Most designs of continuous flow reactors for electrocatalytic nitrate and nitrite removal still need improvement in order to be scalable and energy efficient. In this study, we designed a new scalable reactor with potential control. The reactor was evaluated under different applied potentials and flow rates for NO$_2^-$ reduction activity, selectivity, current efficiency, and energy consumption. A convection-diffusion-reaction model was applied to simulate the experimental data, to acquire the intrinsic reaction rate constant, and to distinguish kinetic reaction versus mass transfer effects on the overall reaction rates. The parameterized model was then used to determine how cathode dimensions, flow channel thickness, and intrinsic catalyst activity affect reactor scale-up. Preliminary tests on nitrate reduction were also performed and future work involves reducing the overpotential and improving current efficiency.