Numerical Model for Electro-catalytic Nitrite Reduction in a Thin Layer Flow Cell
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A model was developed to simulate experimental data for electro-catalytic reduction of nitrite to $N_2$. In the experiments, the nitrite solution recirculates between a 40 mL reservoir and a small electro-catalytic reactor, where the latter promotes nitrite reduction at the cathode. The model combines a numerical solution for recirculation between the reservoir and the catalytic reactor, with an analytical solution for two-dimensional laminar flow through a rectangular duct with catalytic reaction on one side of the duct. Reactor dimensions, flow rate, and diffusion coefficient were model inputs, and catalytic reaction rate constant, $k_w$ was the fitting parameter. The optimal $k_w$ was determined by minimizing the sum of relative squared errors. Model profiles with the optimal $k_w$ match experimental data for three of the four flow rates, but deviate for highest flow rate, indicating the model may not be considering all mechanisms affecting the experimental data. A dimensionless number ($K_w$) that relates the reaction rate constant to the diffusion coefficient was determined, and it is much less than one. This indicates that overall process is limited by electro-catalytic reaction, and not diffusion.

Numerical Modeling of the Saint-Venant Equations: Effects and Adaptations for Bottom Slope Discontinuity
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The solution stability of river models using the one-dimensional (1D) Saint-Venant equations can be easily undermined when source terms in the discrete equations do not satisfy the Lipschitz smoothness condition for partial differential equations. Although instability issues have been previously noted, they are typically treated as model implementation issues rather than as underlying problems of the form selected for the governing equations. This study investigates the effects of bottom-slope discontinuity on the stability of numerical solutions for the Saint-Venant equations. A new “reference slope” concept is proposed to ensure smooth source terms and eliminate potential numerical oscillations. It is shown that a simple algebraic transformation of channel geometry provides a smooth reference slope while preserving the correct cross-sectional flow area and the piezometric pressure gradient that drives the flow. The reference slope method ensures a Lipschitz-continuous source term while maintaining all the underlying complexity of the real-world geometry. This concept is tested with the SPRNT model in a series of test cases and a small urban creek. Validation comparisons are made with analytical solutions and the HEC-RAS model. The new method reduces numerical oscillations and instabilities without requiring ad hoc smoothing algorithms.