PREDICTION OF \( \text{Fe}^{2+} \) CONCENTRATIONS USING LABORATORY RATE LAW IN WETLANDS CONSTRUCTED FOR ACID MINE DRAINAGE TREATMENT

by

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Abstract. Laboratory rate laws for abiotic and biological \( \text{Fe}^{2+} \) oxidation were combined into a model to predict \( \text{Fe}^{2+} \) concentrations in ponds constructed for mine drainage treatment. Field measurements were made in twenty-two ponds seven passive treatment facilities with \( 2.8 < \text{pH} < 6.8 \) and \( 7.5 \text{ mg/L} < \text{Fe}^{2+} < 240 \text{ mg/L} \). Model inputs include initial \( \text{Fe}^{2+} \) concentration, \( \text{pH} \), dissolved oxygen (DO) and estimated \text{\textit{T. ferrooxidans}} \) concentrations, temperature (T), pond volume, and flow rate. Predicted \( \text{Fe}^{2+} \) concentrations are within approximately 10% of measured \( \text{Fe}^{2+} \) except where seeps enter the treatment systems. Using only an abiotic rate law, the model accounts for \( \text{Fe}^{2+} \) concentrations in facilities which have \( \text{pH} > 5.5 \). Combining abiotic and biological (\textit{T. ferrooxidans}) rate laws allows prediction of \( \text{Fe}^{2+} \) concentrations in ponds with \( 3 < \text{pH} < 3.5 \). Where \( 5.5 < \text{pH} < 6.5 \), increasing \( \text{Fe}^{2+} \) oxidation rates (decreasing \( \text{Fe}^{2+} \) concentrations in ponds) occur due to increasing parameters in the following order of effectiveness: \( \text{pH} = \text{T} > \text{pond volume} = \text{initial \text{Fe}^{2+} \text{concentration}} > \text{DO} \). These results suggest that treatment facilities may be undersized unless \( \text{pH} \) and \( \text{Fe}^{2+} \) oxidation are considered. Measured \textit{T. ferrooxidans} concentrations are four to six orders of magnitude lower than concentrations required in the model to reproduce measured \( \text{Fe}^{2+} \) concentrations, which suggests that either the measured bacteria concentrations from this study are too low, the biological rate law attributes too little catalytic effect to each bacterial cell, or both. Results also suggest that \textit{T. ferrooxidans} survive circumneutral \text{pH} values or at least repopulate ponds where \text{pH} drops due to insufficient alkalinity.


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