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Compartment in vertical flow reactor for ferruginous mine water

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Mine effluents contain varying concentrations of ferrous ion along with other metal ions. Fe(II) that quickly oxidizes to form precipitates in the presence of oxygen under net alkaline or neutral conditions. Thus, passive treatment methods are designed for the mine water to reside in an open containment area so as to allow simultaneous oxidation and precipitation of Fe(II), such as in a lagoon or an oxidation pond. A vertical flow reactor (VFR) was also suggested to remediate ferruginous mine drainage passing down through an accreting bed of ochre. However, VFR has a limited operation time until the system begins to overflow. It was also demonstrated that two-compartment VFR has a longer operation time than single compartment VFR of same size.

In this study, a mathematical model was developed as a part of efforts to explore the operation of VFR, showing dynamic changes in head differences, ochre depth and Fe(II)/Fe(III) concentration in the effluent flow. The analysis shows that Fe(II) oxidation and ochre formation should be balanced with permeability of ochre bed to maximize VFR operation time and minimize residual Fe(II) in the effluent. The model demonstrates that two compartment VFR can have a longer operation time than a single-compartment VFR and that an optimum compartment ratio exists that maximize VFR operation time. Accelerated Fe(II) oxidation significantly affects the optimum ratio of compartment area and reduced residual Fe(II) in the effluent. VFR operation time can be significantly prolonged by increasing the rate of ochre formation not by accelerated Fe(II) oxidation. Taken together, ochre forms largely in the first compartment while overflowed mine water with reduced iron contents is efficiently filtered in the second compartment.

These results provide us a better understanding of VFR operation and optimum design criteria for maximum operation time in a two-compartment VFR. Rapid ochre accretion in the first compartment maintains constant hydraulic head to maximize flow passing down through the ochre bed. Filtration rate in the second compartment is also facilitated by thin ochre bed because of low residual Fe(II) in the overflow. Thus, compartment ratio also significantly affects the operation span of two-compartment VFR. Accelerated Fe(II) oxidation significantly affects the optimum ratio of compartment area and reduced residual Fe(II) in the effluent. VFR operation time can be significantly prolonged by increasing the rate of ochre formation not by accelerated Fe(II) oxidation.