A systematic study of multiple minerals precipitation modelling in wastewater treatment

Mineral solids precipitation is important in wastewater treatment. However approaches to minerals precipitation modelling are varied, often empirical, and mostly focused on single precipitate classes. A common approach, applicable to multi-species precipitates, is needed to integrate into existing wastewater treatment models. The present study systematically tested a semi-mechanistic modelling approach, using various experimental platforms with multiple minerals precipitation. Experiments included dynamic titration with addition of sodium hydroxide to synthetic wastewater, and aeration to progressively increase pH and induce precipitation in real piggery digestate and sewage sludge digestate. The model approach consisted of an equilibrium part for aqueous phase reactions and a kinetic part for minerals precipitation. The model was fitted to dissolved calcium, magnesium, total inorganic carbon and phosphate. Results indicated that precipitation was dominated by the mineral struvite, forming together with varied and minor amounts of calcium phosphate and calcium carbonate. The model approach was noted to have the advantage of requiring a minimal number of fitted parameters, so the model was readily identifiable. Kinetic rate coefficients, which were statistically fitted, were generally in the range 0.35-11.6 h\(^{-1}\) with confidence intervals of 10-80% relative. Confidence regions for the kinetic rate coefficients were often asymmetric with model-data residuals increasing more gradually with larger coefficient values. This suggests that a large kinetic coefficient could be used when actual measured data is lacking for a particular precipitate-matrix combination. Correlation between the kinetic rate coefficients of different minerals was low, indicating that parameter values for individual minerals could be independently fitted (keeping all other model parameters constant). Implementation was therefore relatively flexible, and would be readily expandable to include other minerals.

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