

Surface Complexation Mechanism and Engineering Implications in Chemical Phosphorus Removal

I. Takács*, S. Murthy**, A. Szabó***, S. Smith****, I. Licskó*** and G. Daigger*****

*EnviroSim Associates Ltd., (E-mail: imre@envirosim.com)

**DCWASA, DWT, Washington, DC U.S.A.

***Budapest University of Technology and Economics, Budapest, Hungary

****Wilfrid Laurier University, Waterloo, Ontario, Canada

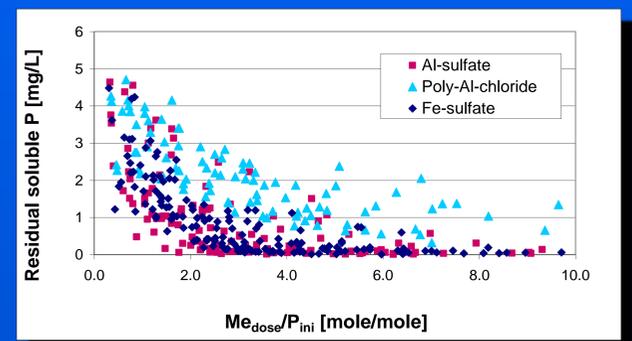
*****CH2M HILL, Englewood, CO, USA

Phosphorus removal by metal salts

Metal (ferric and aluminium) salt addition is frequently used for phosphorus removal in wastewater treatment. Very low levels of orthophosphate (below 10 µgP/L) are achievable in practice. The chemical mechanism is not well understood and consequently the design of chemical dosage systems is empirical. Current models do not predict multi-point dosage, variable metal-phosphorus stoichiometry and low residuals reliably and in accordance with established chemical principles.

Objectives and methods

Experiments were performed to develop a model based method that can be used to reliably predict the required metal dose and location to reach a desired P residual. Experiments included traditional jar tests, titrations, electron microscopy and dye sorption measurements.

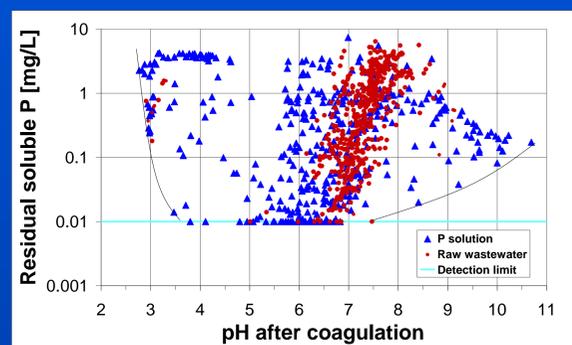


Significant overdoses are required to achieve low P residuals

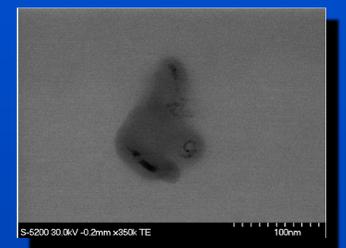
Experiments

Factors influencing the efficiency of chemical phosphorus removal were investigated, including:

- pH
- alkalinity
- metal dose
- metal type
- initial phosphate concentration
- residual phosphate concentration
- mixing energy
- reaction time
- age of flocs
- organic content of wastewater



pH values above 7 hinder P removal



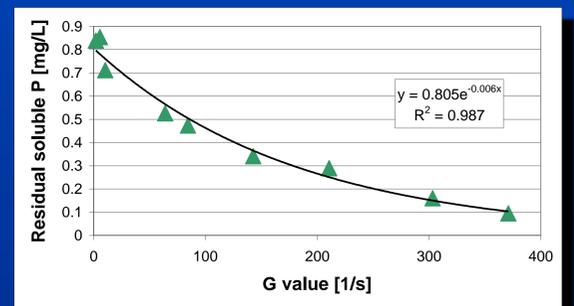
HFO floc

Results and proposed mechanism

Most of the investigated variables had an effect on P residuals, the most significant being chemical dose. For design and operation, mixing energy and reaction time (or SRT) of the chemical sludge formed is also very important.

The chemical mechanism is postulated as

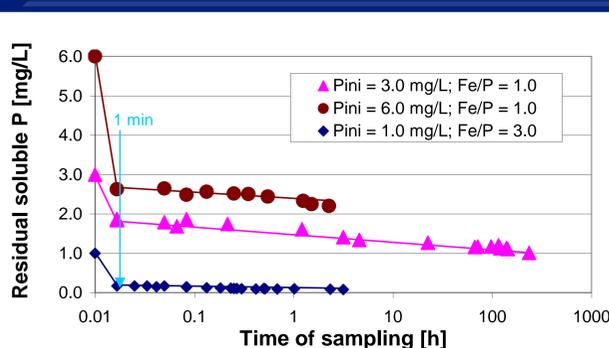
1. rapid precipitation of hydrous ferric oxides (HFO), which bind phosphate ions by two mechanisms
2. mechanism #1: simultaneously with HFO formation, in the first few seconds, co-precipitation, i.e. chemisorption and occlusion of phosphate occurs, and
3. mechanism #2 : after HFO formed, slower kinetic sorption binds P for a significant time.



Fast mixing (large G) is required at the dosage point

Conclusions

Pure iron phosphate (FePO_4) does not form at normal pH levels. For well mixed systems and phosphate exposed to ferric chloride during HFO precipitation there is a phosphate capacity of 1.18 phosphate ions per iron atom. In poorly mixed systems the capacity decreased to 25% of the well-mixed value. Experiments show that significant savings in chemical cost can be achieved by vigorously mixing the added chemical at the point of dosage, and providing a longer contact time. A chemical equilibrium/kinetic reaction based model is being developed using the large experimental database.



Fast and slow P removal mechanisms