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Analysis and modelling of iron reduction kinetics in activated sludge

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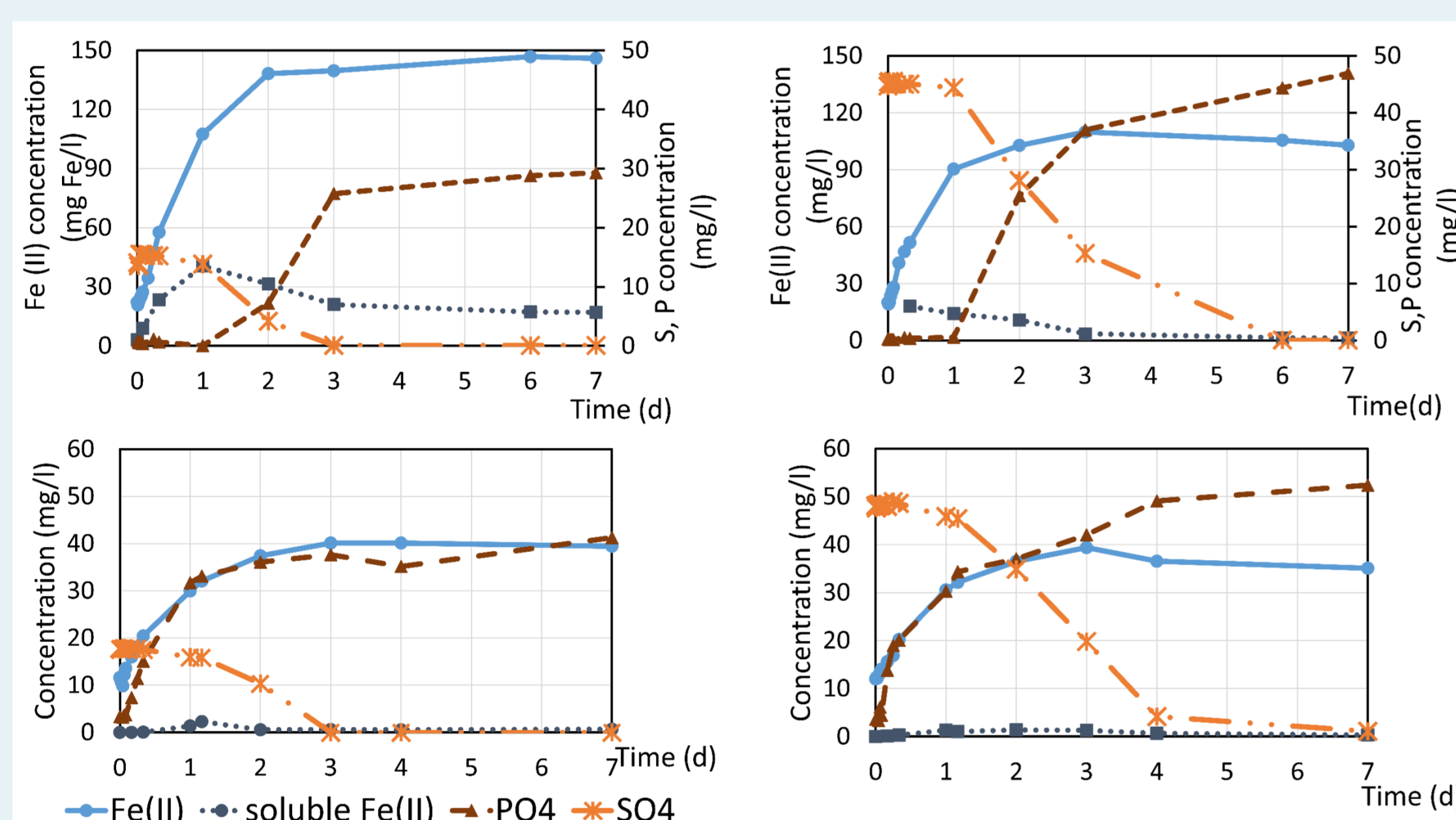
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Objectives

- Improve process modelling for P removal and recovery in presence of iron
- Following Fe(III) reduction in activated sludge in anaerobic condition, with different scenarios to define influencing parameters, interaction with phosphate and sulfur.

Materials and Methods

- Sludge collected from two WRRFs with activated sludge combining biological and physical-chemical P removal (9500PE, 4M PE)
- Anaerobic batch tests, constantly mixed, room temperature (24-26°C)
- Measurements: Total Fe, Total Fe(II), soluble Fe(II), PO₄, SO₄, TSS, VSS, SCOD, pH
- Influence of various levels of initial Fe(III), SO₄ and VSS

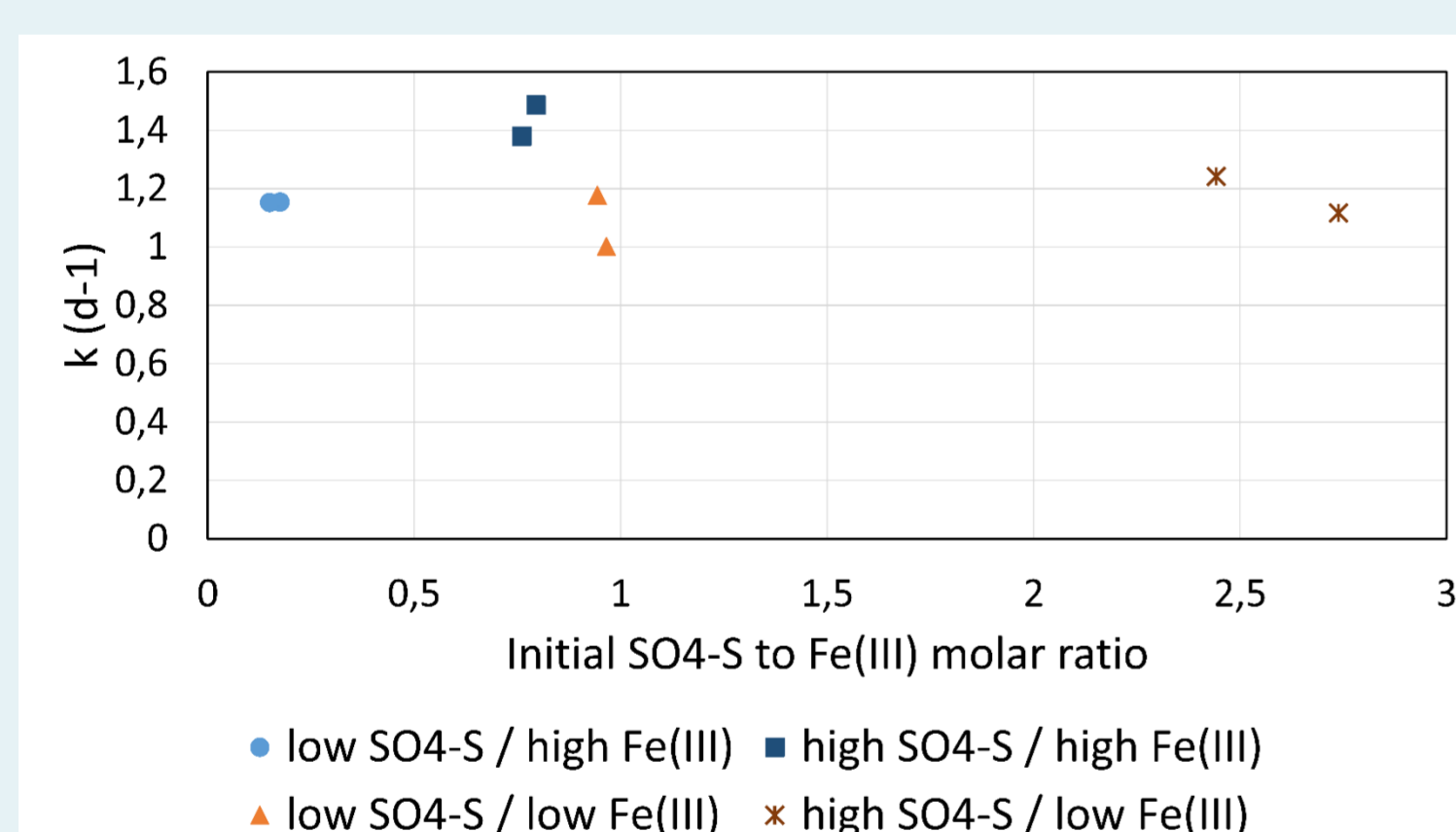


Fe(III) reduction kinetics

- 90% of Fe(III) is reduced after 48 h
- Fe(III) reduction into Fe(II) follows first order kinetics
- $\frac{d[Fe^{3+}]}{dt} = -k \cdot [Fe^{3+}]$
- $k = 1.21 \pm 0.15 \text{ d}^{-1}$ in standard condition (25°C, VSS=3,2 ± 0.2 g VSS/l)

Phosphate release

- At low Fe(III) dosage, PO₄ release concomitant with Fe reduction
- For high Fe(III) dosage, PO₄ released only after 24h with sulphate reduction (explained by FeS precipitation)
- Sulphate reduction enhances PO₄ release



Interaction with sulphate reduction

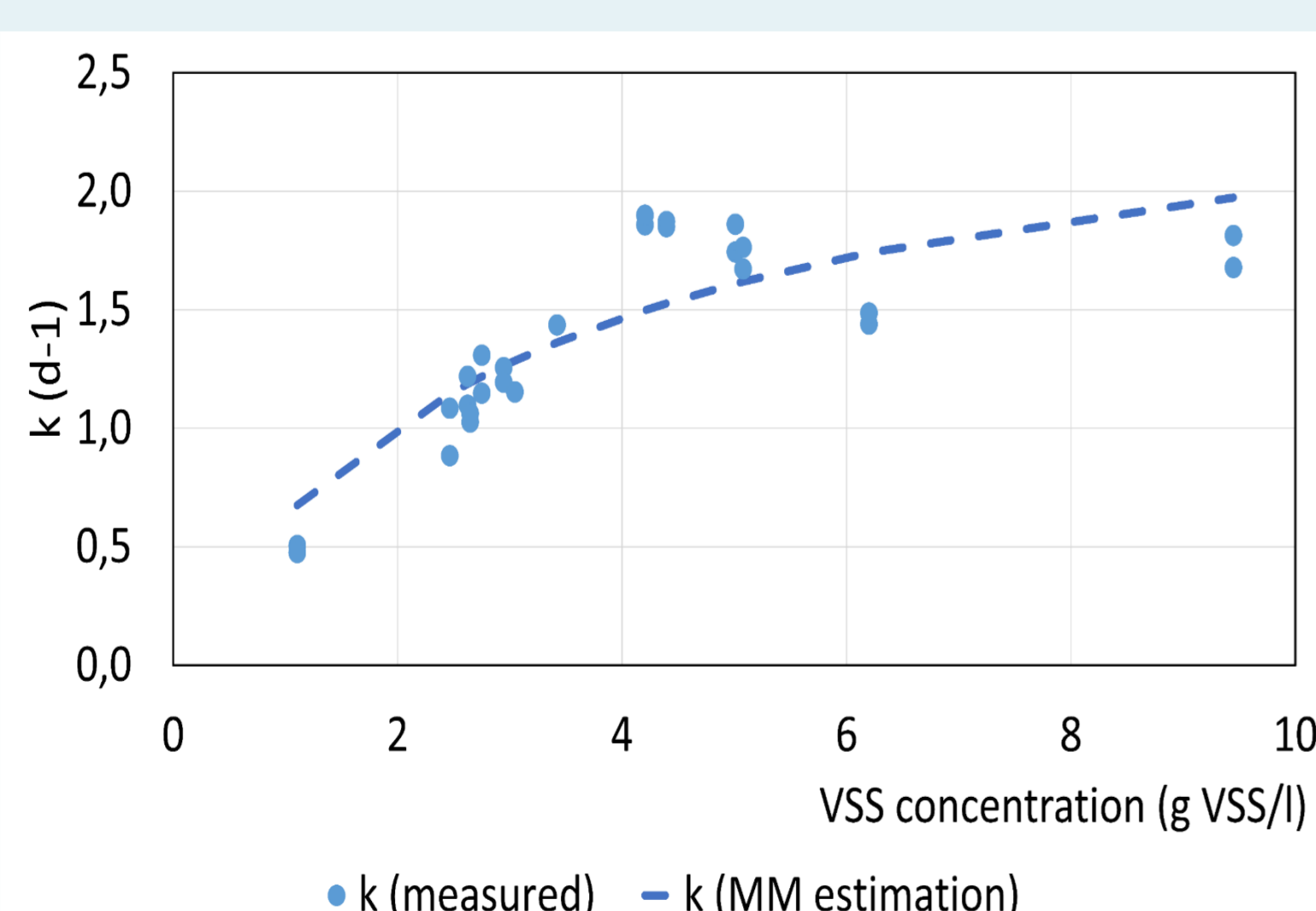
- Fe(III) reduction prior to sulphate reduction (some overlap)
- Fe(III) reduction rate is not influenced by initial SO₄ concentration and variable SO₄:Fe(III) ratio

Conclusions

- Fe(III) reduction follows first order kinetics in activated sludge when anaerobic condition is imposed
- Reduction rates depends on MLSS concentration and a model is proposed
- Reduction rate is not dependent on initial sulphate concentration nor SO₄:Fe(III) ratio
- Fe(III) reduction is followed by sulphate reduction with a significant influence on PO₄ release
- These results could help to predict anaerobic PO₄ release, and P recovery systems with Fe (vivianite)

MLSS dependency

- Reduction rates were determined for various VSS concentration (1.1 – 9.5 gVSS/l)



Proposed model :

$$k = k_{max} * \frac{X_{VSS}}{(M_{sat,VSS,Fe,red} + X_{VSS})}$$

- k_{max} is maximum reduction rate constant calibrated value: **2.65 d⁻¹**
- $M_{sat,VSS,Fe,red}$ is saturation parameter calibrated value: **3.23 gVSS/l**
- X_{VSS} is VSS concentration in gVSS/l