

Summary

The disposal of membrane concentrates seriously limits the inland application of nanofiltration (NF) and reverse-osmosis (RO) membrane processes. Besides salinity, high phosphate concentrations in the membrane brine may prevent dis-

charge into surface water bodies. Adsorption onto granular ferric hydroxide (GFH) and calcium phosphate precipitation were tested with respect to their suitability to remove phosphorus. Both techniques have been shown to be generally effective for

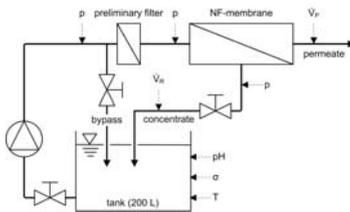
phosphate removal from nanofiltration concentrates and can be used to achieve higher recoveries in high-pressure membrane filtration as a step towards zero liquid discharge, as well as a polishing step for the concentrate to facilitate environmentally safe discharge.

Background

Due to the rejection of polyvalent anions by NF and RO membranes, high concentrations of phosphate occur in membrane concentrates. Since even small phosphate concentrations can cause eutrophication, these concentrate streams should not be discharged into surface water bodies. There is a need for technologies that remove phosphorus from membrane concentrates [1]. GFH has shown high capacities for phosphate adsorption from aqueous solutions [2]. Since most brines are supersaturated with respect to calcium phosphate compounds, induced crystallization was tested as alternative treatment option.

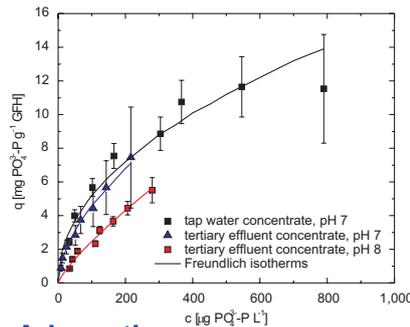
Methods

- Concentration of tertiary effluent from Berlin's WWTP, WCF: 0.7 - 0.8, rejection of phosphate: 0.94



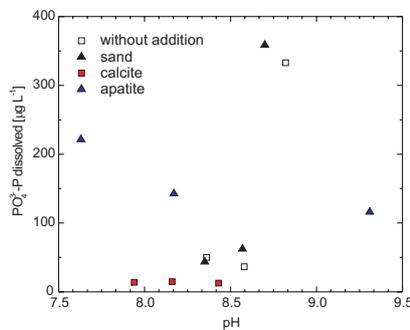
- Development of adsorption isotherms for phosphate
- Experimental determination of the surface diffusion coefficient, D_s , using differential-column batch reactor (DCBR) tests and the homogeneous surface diffusion model (HSDM)
- Operation and monitoring of a GFH fixed-bed column and simulation of the breakthrough curve (HSDM)
- Screening of potential seed materials for accelerated precipitation of calcium phosphates from the supersaturated tertiary effluent brine (sand, apatite, calcite)
- Operation and monitoring of a fixed-bed crystallizer using calcite as a seed material

Results



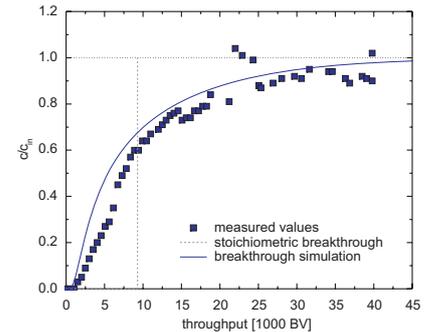
1. Adsorption:

- Capacities range between 4 - 6 mg/g P at 200 - 400 µg/L P and a pH of 8
- Ca^{2+} and Mg^{2+} improve adsorption and increase the pH_{PZC} , competition of DOC is compensated by divalent cations
- Adsorption is strongly pH dependent

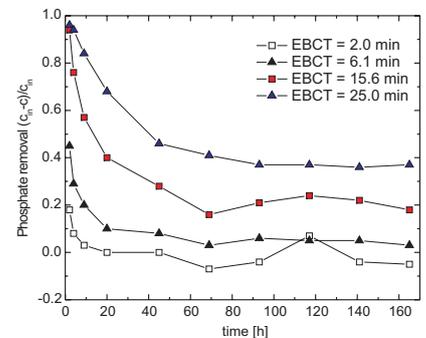


2. Precipitation:

- Sand did not accelerate the precipitation of calcium phosphates
- Apatite decreases the removal of phosphate by precipitation at $\text{pH} < 8.5$
- Calcite was identified as a suitable seed material
- Calcite improves removal of phosphate at $\text{pH} 7.9 - 8.4$; P removal > 96%



- Fixed-bed breakthrough curve of phosphate can be simulated using the HSDM ($D_s = 6 \cdot 10^{-15} \text{ m}^2/\text{s}$)
- Longer operation shows high head-loss caused by precipitates and microbial growth



- Adsorption onto calcite initially increases P-removal; steady-state is reached after approx. 70 h
- P-removal of 37 % at an EBCT of 25 min by precipitation
- Equilibrium is not yet reached; increased P-removal at higher EBCT is possible

Conclusions

- Adsorption onto GFH and calcium phosphate precipitation are effective to remove phosphate from membrane concentrates
- Further investigations using NF concentrate from the Tel-Aviv demo-site are envisaged
- These techniques can be used to achieve higher recoveries in SAT-NF hybrid systems and facilitate environmentally safe discharge

[1] Nederlof, M.M., van Paassen, J.A.M. and Jong, R. (2005). Nanofiltration concentrate disposal: experiences in The Netherlands. Desalination, 178(1-3), 303.

[2] Sperlich, A., Zheng, X., Ernst, M., Jekel, M. (2007) An integrated wastewater reuse concept combining natural reclamation techniques, membrane filtration and metal oxide adsorption, Conference Proceedings IWA WRRS2007 - Wastewater Reclamation & Reuse for Sustainability, Antwerp.