

Phosphate Removal from Membrane Concentrates

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Keywords: membrane concentrate; adsorption; precipitation; granular ferric hydroxide

Due to the rejection of polyvalent anions by nanofiltration (NF) and reverse osmosis (RO) membranes, high concentrations of phosphate occur in membrane concentrates. Since even small phosphate concentrations can cause eutrophication, phosphorus-rich concentrate streams should not be discharged into surface water bodies. There is a need for technologies that selectively remove phosphorus from membrane concentrates. Granular ferric hydroxide (GFH) has shown high capacities for arsenate and phosphate adsorption from aqueous solutions. Since most brines are supersaturated with respect to calcium phosphate compounds, induced crystallization of calcium phosphates using an appropriate seed material might be an alternative treatment option. This study investigates the suitability of GFH adsorption and precipitation for phosphate removal from membrane concentrates.

Adsorption equilibrium isotherms are developed for NF concentrates of tertiary effluent and drinking water. It is shown that solid-phase concentrations for NF concentrate of tertiary effluent and tap water at pH 7 are highly comparable. This is in agreement with the similar concentrations of dissolved organic carbon (DOC) and calcium in tap water concentrate and tertiary effluent concentrate. Adsorption capacity is significantly decreased at pH 8, confirming the decisive influence of pH for GFH adsorption. Competition of DOC present in the membrane concentrate is likely to be compensated by the presence of divalent cations (Ca^{2+} , Mg^{2+}). These ions adsorb onto the metal oxide surface and increase the pH_{PZC} (point of zero charge), thereby promoting the adsorption of negatively charged $\text{HPO}_4^{2-}/\text{H}_2\text{PO}_4^-$ ions.

Operation of a fixed-bed crystallizer shows that calcite can provide a condensation surface for the precipitation of calcium phosphates. Precipitation is a promising option to remove phosphate from membrane concentrates. Both adsorption onto GFH and calcium phosphate precipitation are shown to be generally effective for phosphate removal from NF concentrates. Currently, further investigations are under way regarding the combination of precipitation and GFH phosphate adsorption. In a first step, a calcite crystallizer may precipitate phosphate from the supersaturated membrane concentrate, thus also preventing clogging of a subsequently operated fixed-bed GFH column, which efficiently removes the remaining phosphate (polishing step).