Nanofiltration concentrate treatment for increasing the water recovery in drinking water production

Research objectives

Nanofiltration (NF) is an attractive method for the production of drinking water out of surface water, because it removes a broad range of recalcitrant pollutants in one treatment step. However, membrane fouling limits the water recovery to 80-85%. The aim of this research is to devise a closed cycle where specific pollutants in the NF concentrate are removed, so that the treated concentrate stream can return to the feed side of the membrane without increased membrane fouling. In this way, a closed cycle with a recovery of almost 100% may be obtained.

Project outline

Introduction

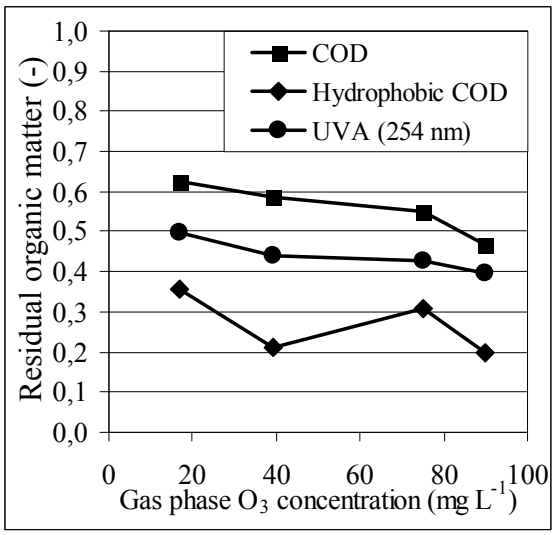
Natural organic matter (NOM) with a hydrophobic chemical structure or a high molecular mass are the most severe membrane foulants. O_3 is able to transform hydrophobic organic matter into more hydrophilic groups and decomposes macromolecules into smaller fragments. In addition, reactive $^{\cdot}OH$ radicals are formed. These radicals react non-selectively and are used for the mineralization of O_3-resistant compounds. The salts in the concentrate are removed by electrodialysis (ED). ED is the most economical desalination process for brackish water and has a high water recovery (> 90%).

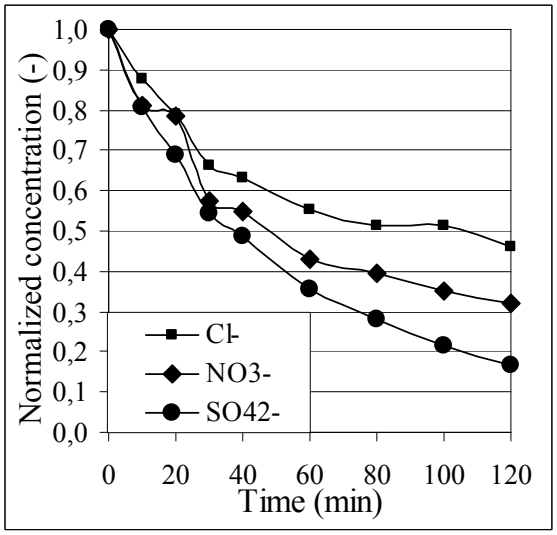
Approach

First, ozonation of concentrated humic acid solutions is investigated. The degree of mineralization (COD, UVA), the change in functional structure (hydrophobic COD, IR spectra) and molecular mass (UF fractionation) and the retention by NF membranes is investigated. ED experiments are conducted with single salt solutions and afterwards with a model solution of six salts that represents the salt composition of NF concentrates. In the future, the focus will be on the efficient mineralization of the ozone reaction products and the permselectivity of divalent ions with respect to monovalent ions in ED.

Results

O_3 oxidation of natural humic acid solutions showed that O_3 is able to decompose the hydrophobic part of the organic matter very efficiently. However, it is not possible to achieve a high mineralization degree with pure O_3 oxidation (see left figure). The oxidation of the reaction products rather than the primary organic matter dictates the required oxidants doses and treatment cost. The addition of H_2O_2 to the solution could slightly improve the mineralization degree. ED experiments were conducted with the membranes FTAM and FTCM of Fumatech. The permselectivity of SO_4^{2-} ions with respect to Cl^- was higher than one, which makes these membranes very attractive for this application (see right figure). This proves that permselectivity of specific ions through anion exchange membranes is governed mainly by the balance of hydration energy of anions with hydrophilicity of the membranes, instead of the difference of hydrated ionic size of anions.





Scientific relevance

Combinations of chemical oxidation and membrane filtration are very promising to tackle problems encountered in both technologies. For instance, O_3 oxidation can mitigate membrane fouling by NOM and membranes are important to resolve catalyst recovery problems in heterogeneous photocatalysis. Research about hybrid oxidation/membrane systems is necessary to reduce the cost of both technologies and make them more attractive in drinking water and wastewater industry. For ED, the desalination of other salts than NaCl is hardly investigated. Although the presence of other ions in the feed solution has a large impact on the separation efficiency, the effect of a mixture of monovalent and multivalent ions on the performance of ED is unknown.

Social relevance

As problems with water scarcity are expected to grow worse in the coming decades, even in regions currently considered water-rich, it cannot be tolerated that 20% of the feed water is wasted. Therefore, it is necessary to develop technologies that make the discharge of concentrate streams superfluous.

Literature

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Van Geluwe S., Braeken L. and Van der Bruggen B. Chemical oxidation for the mitigation of membrane fouling by natural organic matter: A review. Part II: Advanced oxidation (In preparation)

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