Report as of FY2006 for 2006AK49B: "Effect of Raw Water Characteristics on Membrane Fouling for Filtration of Surface Water with High Organic Matter Content"

Publications

Project 2006AK49B has resulted in no reported publications as of FY2006.

Report Follows

Effect of raw water characteristics on membrane fouling for filtration of surface water with high organic matter content

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Problem and research objectives

Problem:

Due to the limited availability of groundwater for drinking water production in many areas of Alaska, such as those where permafrost is present, surface waters, which are sometimes of a lower quality, have to be used for drinking water production. Some types of surface water such as rivers or tundra ponds contain large amounts of dissolved or particulate organic matter. When such waters are chlorinated during the process of drinking water production, chlorine reacts with organic matter to form harmful disinfection byproducts.

These byproducts are of growing concern and regulations about maximum byproduct concentrations have become increasingly stringent. One approach to decreasing the formation of these byproducts is to eliminate organic matter from the water before chlorination. This can be achieved with membrane filtration. Membrane filtration also has the benefit of generating a high water quality. However a drawback of using membranes to treat surface waters with a high organic matter content is that the presence of organic matter increases membrane fouling. Fouling reduces flux across the membrane and/or requires a higher pressure for filtration, which adds to operating costs. Therefore research is required to investigate under which conditions severe fouling can occur to address this problem and design the process accordingly. The effect of several important water quality parameters on fouling will be investigated in this study.

Hypotheses

Electrostatic attraction and repulsion between organic matter and the membrane can explain why fouling is more severe under certain conditions. At low pH, high ionic strength, or when a high concentration of cations such as Ca^{2+} or Fe^{2+} exists, the negative charge of organic matter is neutralized, which allows aggregation of DOM into larger agglomerates and subsequent removal by deposition on the membrane, which leads to fouling. If the organic matter charge and membrane charge have opposite signs, fouling is reduced by repulsion.

Research Approach

The goal of this research is to determine suitable conditions where membrane filtration can be applied for drinking water production without excessive fouling.

The pH of the solution will be varied in the pH range 4 – 8 to obtain variations in the DOM charge properties. Carboxyl groups, which have a pKa around 5, are abundant in DOM and therefore undergo changes of charge in the investigated range, being neutral below pH 5 and negatively charged at higher pH.

Calcium nitrate will be added to stepwise increase the calcium concentration till the organic matter charge is neutralized.

The ionic strength will be varied by stepwise addition of sodium nitrate. While sodium can balance the negative charge of the organic matter, it typically does not form any complexes with organic matter but is only bound by weaker electrostatic interactions.

The DOM of a chosen surface water source will be characterized in terms of size classes and charge. The organic matter will be fractionated into anionic and cationic constituents with the help of ion exchange resins. In later experiments, rather than studying surface water DOM with naturally varying properties, model solutions with typical organic substances of known chemical characteristics (e.g. same size, different charge) may be employed to create a better defined basis of comparison. Waters containing different types of DOM will be subjected to membrane filtration.

Different types of membrane material, characterized by positive, negative or neutral membrane charge, will be used. To allow a fair comparison, all membranes will feature the same pore size. Flat circular membrane sheets will be employed in a dead end filtration cell to allow easy sampling of the cake layer after the experiment. The permeate flux rate will be determined by continuously monitoring the permeate quantity.

After the filtration tests, the quantity and type of DOM in the permeate will be characterized to evaluate the filtration efficiency and determine which classes of DOM were able to penetrate the membrane without causing fouling. Complementary to that, the cake layer accumulated on the membrane will be characterized in terms of quantity and properties (such as charge).

<u>Progress to Date</u>

This project will support an MS student, but due to difficulties in recruiting a suitable graduate research assistant, the project was delayed in starting. We have requested an extension from Dr. Kane, Director of the Water & Environmental Research Center. While work is underway currently, we have no results to report yet. Results will be reported in the FY2007 Annual Report.