This dissertation consists of research that focused on pretreatment strategies to reduce fouling of ultrafiltration (UF) membranes used for drinking water treatment, and was segmented into four key components. (1) In the first component of the work, the long-term fouling behavior of a polyethersulfone (PES) hollow-fiber UF membrane was studied at the pilot-scale for treatment of surface water over a one-year period. Pilot testing of a coagulation-flocculation-sedimentation (CFS) pretreatment system revealed that chemically irreversible fouling was poorly correlated with turbidity and total organic carbon. It was also shown that recycled backwash water may have impacted membrane process performance, and that chemically irreversible fouling was responsive to changes in pretreatment configuration. (2) In the second component, pre-oxidation with ozone (preozonation) was then studied as a pretreatment process to reduce natural organic matter (NOM) fouling at the pilot-scale. This work suggested that preozonation reduced long-term chemically irreversible fouling. The chemically reversible fouling index increased by 59%, indicating that preozonation changed the characteristics of the foulants, yielding more effective chemically enhanced backwashes. (3) Bench-scale work that studied changes in NOM characteristics associated with the improved process performance were performed using fluorescent excitation-emission (EEM) spectroscopy and high-performance size-exclusion chromatography (HPSEC). Specifically, ozone was applied prior to a CFS-UF process and compared to a CFS-UF condition without ozone as the control. Although CFS reduced turbidity by 29%, ozone, when integrated with CFS increased turbidity by 58%, impacting downstream UF performance. As expected, ozone, when integrated with CFS and UF reduced filtrate true color by 40%, UV254 absorbance by 11%, and SUVA by 30%, relative to the control, indicating that preozonation changed the characteristics of the dissolved organic carbon present in the source water. (4) Follow-up bench-scale research using fluorescent EEM spectroscopy and HPSEC assessed operational strategies that impacted organic fouling. Specifically, the fate of fluorescing substances during the recycling of membrane backwash water (MBWW) ahead of CFS-UF process was investigated. Bench-scale UF membranes were used to generate MBWW from a CFS-treated surface water containing 21 mg/L dissolved organic carbon (DOC) registering a 0.95 cm⁻¹ UV254 absorbance that had been coagulated with 100 mg/L with polyaluminum chloride. CFS settled water, when processed with UF, produced MBWW containing 9 mg/L DOC registering a 0.25 cm⁻¹ UV254 absorbance. HPSEC with UV254 detection demonstrated an analogous UV254 reduction as measured by detector response. However, fluorescence EEM spectroscopy revealed that protein-like substances, known to be associated with irreversible fouling, had been concentrated in the MBWW. In order to evaluate recycling operations on overall DOC removal in a CFS-UF process, a blend of 30% MBWW with 70% of raw water was treated, resulting in an overall DOC removal of 73%. However, without MBWW recycle, the CFS-UF process removed less of the influent DOC (63%). In summary, this research demonstrated that NOM characteristics within MBWW should be considered when recycling backwash water in PES membrane operations, and that preozonation reduces chemically irreversible fouling when incorporated into a CSF-UF system.
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The public is welcome to attend.