Ozone Pretreatment in High Pressure Membranes

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Introduction:
Potable water reuse is becoming an important component of water resource management (Drewes, Reinhard, & Fox, 2003). The current approach uses microfiltration (MF) followed by nanofiltration or reverse osmosis. Several utilities have included pre-ozonation to reduce fouling of membrane components. Oxidation with ozone has shown promise in transforming organic compounds in water into smaller and more hydrophilic compounds. However, in certain applications, ozone may breakdown organic compounds to the extent that limits the effectiveness of membrane filtration. Because there is trepidation regarding the removal of organic compounds during potable reuse, the purpose of this study was to evaluated the impact of pre-ozonation on finished water quality.

Experimental Overview:
This work examined effluent from a membrane bioreactor (MBR) system that was ozonated at three different dosages based on an initial total organic carbon (TOC) measurement. This ozonated water was then sent through a high pressure membrane system with nanofiltration (NF; NF270) and reverse osmosis (RO; ESPA2) membranes. Analytical water quality characteristics including 3D-Fluroescence scans, UV absorption and TOC readings were taken before and after membrane filtration to examine the effectiveness of the pre-ozonation step in the treatment process.

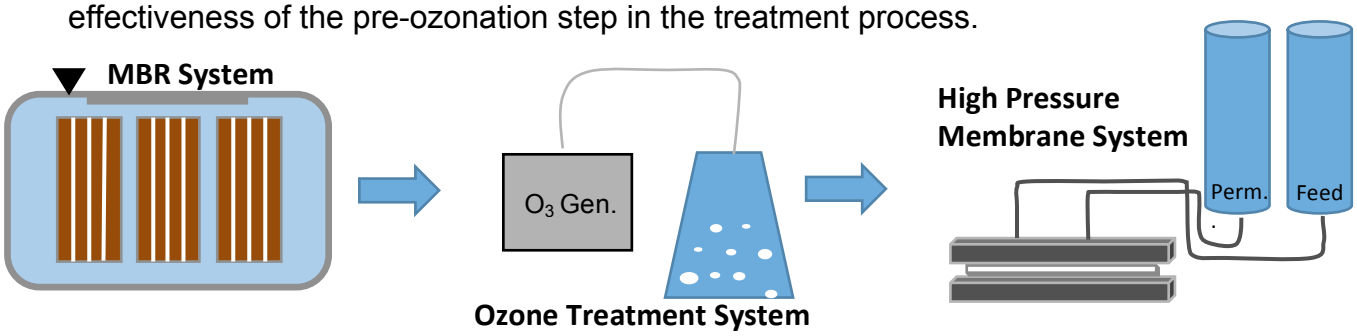

Figure 1. Complete experimental system including membrane bioreactor

Results and Discussion:
Initially, running raw non-ozonated effluent through the system revealed a baseline measurement for the water quality characterization that was used to evaluate the performance of the ozonated water in the system. Preliminary, NF and RO testing showed significant removal of organic compounds after the introduction of ozone as a pre-filtration disinfectant. Total organic carbon and UV_{254} absorbance exhibited a sharp decline after membrane treatment while decreasing at a lower degree through nanofiltration and reverse osmosis with the addition of ozone. There is preliminary evidence that pre-ozonation leads to increased total organic carbon in high-pressure membrane permeate.

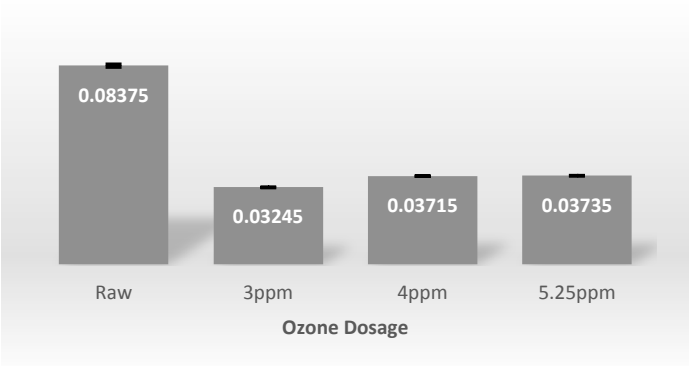

Figure 2. UV_{254} Absorbance with the addition of ozone

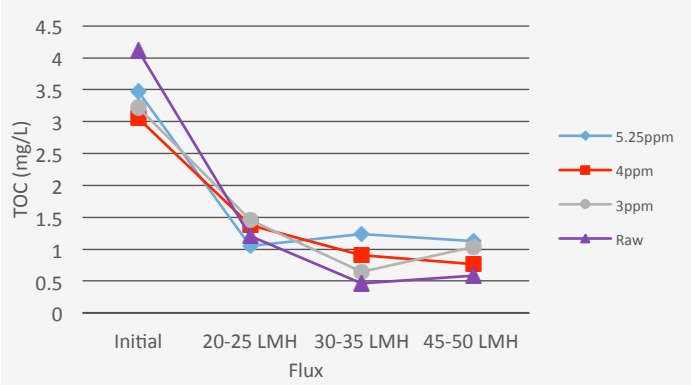

Figure 3. TOC Removal with the addition of ozone through NF at various fluxes

3D-Flourescene scans revealed a similar pattern with a significant decline in carbon activity with the addition of ozone and a lower degree of decrease between ozone dosages and NF pressures.

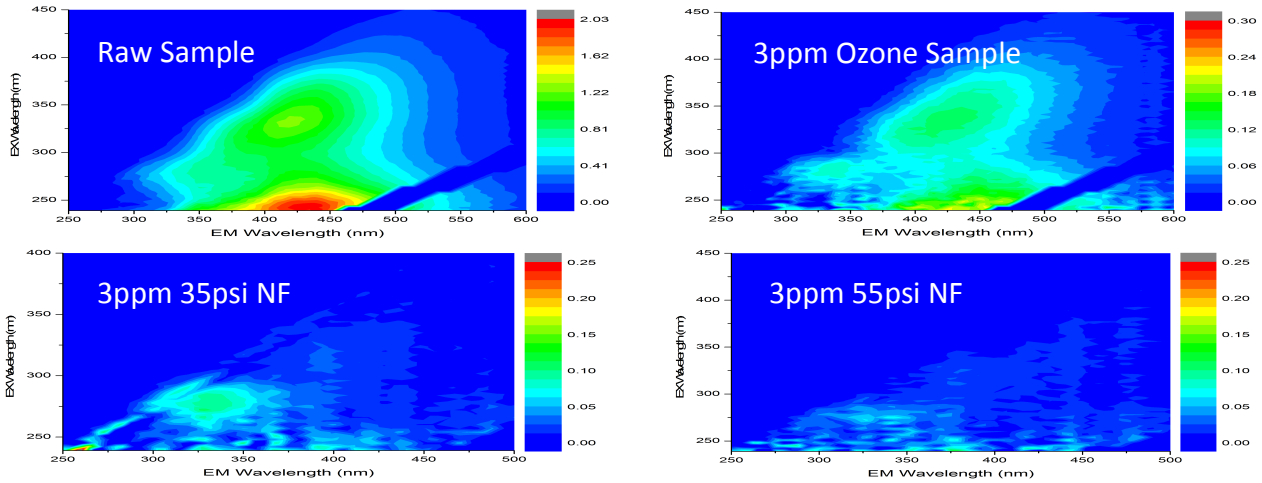

Figure 4. 3D-Flourescene scans that show aromatic carbon activity of the various water samples after noted conditions.

Membrane permeability remained relatively constant throughout the six to eight hour experiments with minimal fouling observed. These results indicate that while ozone is a reliable oxidant, the applied ozone dose and use of NF filtration downstream were not able to meet California potable reuse standards for TOC (0.5 mg/L) . Further work on this project includes examining the impact of ozone pretreatment on the fouling potential of high pressure membrane systems. The project team is currently waiting on water quality results from experiments with an RO membrane which will indicate whether or not pre-ozonation is an effective pretreatment method for potable reuse systems. Additional experimentation also involves the introduction of an ozone treatment system into a pilot scale treatment train with biologically active filtration followed by granular activated carbon to meet potable water quality standards.

Regulation of Water Reuse in the Unconventional Oil and Industry

Various regions in the Western United States are dealing with water scarcity and growing populations, and are in need of additional water supplies. With confirmed fracking activity in twenty-nine states across the country, as of July 2012, there is an increased need for litigation to regulate these activities driven by the scarcity of our country's water resources (McFeeley, 2012). The purpose of this portion of my project was to evaluate regulations concerning the reuse of flowback and produced water. Unfortunately, there is minimal federal administration in control of these water resources, leaving most of the regulation in the hands of state agencies. Major shale areas including Texas, Oklahoma, Colorado, North Dakota and Pennsylvania require disclosure of their fracking activities but the amount of fracking information reported varies greatly between states. Regulatory criteria are outlined by Australian Laboratory Services' fracking regulations by state as; predrilling, groundwater and surface water impact, liquid wastes/fluids and solid wastes. Each state tackles these four main points of regulation in different ways and some states such as Colorado focus on the guidelines for the development of reuse infrastructure of produced water while other states such as Pennsylvania have concentrated their efforts on pre-screening the fracking process to monitor water constituents ("Fracking Regulations by State,"). Other states such as Texas, North Dakota have far less regulatory action in regards to produced water treatment and reuse with no predrilling testing parameters and minimal liquid waste regulations beyond general state water operation laws. Without federal guidelines and minimal state oversight most commercial reuse decisions are left in faith of environmental stewardship for these oil and gas companies. Treatment and beneficial reuse of flowback and produced water could maximize the productivity of oil and gas wells across the country while also minimizing the water strain and environmental side effects on local communities.

References:

Fracking Regulations by State. Retrieved June 29, 2016, from http://www.alsglobal.com/en/Our-Services/Life-Sciences/Environmental/Capabilities/North-America-Capabilities/USA/Oil-and-Gasoline-Testing/Oil-and-Gas-Production-and-Midstream-Support/Fracking-Regulations-by-State

Drewes, J. E., Reinhard, M., & Fox, P. (2003). Comparing microfiltration-reverse osmosis and soil-aquifer treatment for indirect potable reuse of water. *Water Research*, *37*(15), 3612–3621. doi:10.1016/s0043-1354(03)00230-6

McFeeley, M. (2012, July). *State Hydraulic Fracturing Disclosure Rules and Enforcement*. Retrieved from https://www.nrdc.org/sites/default/files/Fracking-Disclosure-IB.pdf