Chemical and Structural Identification of Organic Matter in Membrane Separations and Advanced Oxidation Processes

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Water reuse is now being integrated into water resource management options. The Orange County Water District (OCWD) commissioned the largest water reuse plant in the world in Fall 2007. The Groundwater Replenishment System (GWRS) has a capacity of 70 million gallons per day (mgd) with the potential for future build-out to 130 mgd. Of the total, 20 mgd will be will be injected into the coastal aquifer to create a hydraulic barrier against seawater intrusion. The remaining 70 mgd will be pumped 13 miles inland along the Santa Ana River to a recharge basin in Anaheim to replenish the aquifers that supply drinking water to cities within the District.

Orange County Sanitation District's (OCSD) secondary-treated effluent is the source water to the GWRS. A mixture of activated sludge and trickle-filtered wastewater is treated by microfiltration and reverse osmosis. Subsequently, disinfection is achieved with ultraviolet (UV) light in combination with an advanced oxidation process (AOP) mediated by the addition of hydrogen peroxide (H_2O_2). The use of UV and AOP mitigates the use of chlorine, which is known to contribute to the formation of disinfection byproducts (DBPs). The UV light provides disinfection against bacteria and viruses and directly photolyzes nitrosodimethylamine (NDMA), a suspected carcinogen. AOP is achieved when UV light reacts with H_2O_2 to form highly reactive hydroxyl radicals (•OH), which oxidize organic components in the feedwater. The inclusion of AOP with H_2O_2 provides an additional layer of disinfection and treatment of contaminants that are not directly photolyzed by UV light.

Therefore, the objectives of this project are to:

(1) Chemically and structurally characterize the organic matter in the RO membrane permeate,
(2) Characterize the organic partial oxidation products of the AOP effluent, and
(3) Assess the efficiency of the AOP process by characterizing the oxidation products of the effluent

The generalized approach will be to utilize liquid chromatography-mass spectroscopy (LC-MS) techniques. Water samples will be collected and analyzed from the following locations under the following conditions:

- After RO, i.e., just before water enters the AOP reactor of the pilot facility (AOP influent)
- After the AOP with UV/H_2O_2 (AOP effluent)
- After the AOP reactor with H_2O_2 in the feedwater but no UV exposure to the feedwater
- After the AOP reactor with UV exposure but no H_2O_2 in the feedwater

Initially these samples will be analyzed using negative ion LC-QTOF (liquid chromatography, electrospray, quadrupole time-of-flight mass spectrometry). This should provide a fingerprint of the organic matter as it passes through the process. It may also provide insight into the change in character of the organic matter.

In parallel, recently published methods for derivatization of complex mixture for analysis by LC-QTOF will be adapted and applied to the water samples. This approach should allow us to determine the individual organic compounds that are in the treated water. We expect that these compounds are of low molecular weight and are quite polar. They may arise from diffusion through the membrane and from the biofilm on the downstream side of the membranes.