Membrane Fouling Mitigation for Municipal Wastewater Reclamation Using Innovative Electromagnetic Field (EMF) and Reverse Osmosis Membranes (RO)

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The development of alternative water sources is critical to alleviate the demand for freshwater and improve water supply resiliency. Water reuse provides sustainable and local water supply. In addition, the reclamation of municipal wastewater has been widely recognized as a reliable, economically feasible, and environmentally sensitive means to maximize water resources and reduce freshwater demands while protecting remaining water sources from being polluted.

Reverse osmosis (RO) technology has been increasingly used in the advanced treatment of municipal secondary effluents due to its ability to effectively remove pathogens, dissolved organic carbon (DOC), trace organic compounds, and total dissolved solids (TDS). However, membrane fouling and scaling have been a significant challenge for the successful implementation of this technology because they deteriorate the performance of the membrane, lower water recovery, increase energy demand and treatment cost.

In this study, we evaluated different strategies for fouling control of RO membranes treating municipal secondary effluent. To address the intensive chemical demands (e.g., antiscalants, acids, and chemicals for softening), we used a non-chemical pretreatment with an electromagnetic field (EMF). EMF can be applied by magnetic fields using ferrite magnets or wires wrapped around or positioned near a pipe through which water flows or directly around membrane vessels.

The bench-scale testing demonstrated the EMF provides an effective pretreatment to control membrane fouling treating municipal secondary wastewater effluent. The EMF device increased water recovery from 60% without pretreatment to 68% with EMF, while combined with antiscalant, it increased to 89%. At 60% water recovery, flux decline was 80% using no pretreatment, 15% using EMF, and 8% using EMF combined with antiscalant. To better understand the water flux results, water quality analysis and membrane autopsy were conducted using ultraviolet-visible spectroscopy (UV/VIS full wavelength scan), fluorescence excitation-emission spectroscopy (F-EEM), scanning electron microscope, energy-dispersive X-ray spectroscopy, confocal fluorescence microscope, and chemical extraction analysis.

The results show EMF may significantly reduce chemical demands during the treatment of municipal reclamation wastewater controlling membrane fouling. Therefore, this technology can significantly reduce operational costs, energy demand, negative environmental impacts of water reuse technologies, increase the RO membrane lifetime,

and meet the pressing need for a more effective and less expensive water reclamation method.