THE UNIVERSITY OF HONG KONG

DEPARTMENT OF CIVIL ENGINEERING

SEMINAR

Importance of Membrane Concentration Polarization (CP) in Seawater Reverse Osmosis (SWRO) in Controlling Membrane Biofilm formation

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Date: August 14, 2025 (Thursday)
Time: 3:00 p.m. – 4:00 p.m.
Venue: Room 612B, 6/F Haking Wong Building, The University of Hong Kong

Abstract
Membrane biofouling is the most challenging operational impediment to successful seawater reverse osmosis (SWRO) desalination. Membrane biofouling, caused by bacteria and organics in the seawater, reduces the membrane permeability (flux) and leads to higher operational pressure (specific energy cost). The ability to remove the bacteria and organics from the seawater feed is usually monitored by particulate fouling indices, such as silt density index (SDI) and the modified fouling index (MFI). Although these indices may indicate successful removal of organics and bacteria from the seawater feed, biofilm formation on the SWRO membranes still occurs. What this indicates is that indices, like SDI and MFI which monitor pretreatment effectiveness, are not useful in monitoring membrane biofouling.

A more effective monitoring of SWRO membrane biofouling, other than SDI and MFI, is the use of monitoring membrane CP. There has been shown that CP has a direct correlation to membrane biofouling. As the membrane CP increases, bacteria begin to aggregate to form protobiofilms that are deposited onto the membrane surface and block the membrane pores which decreases the membrane permeability (flux) and increase the operation pressure. This deposition of the bacterial aggregates further enhances the CP resulting in a biofilm enhanced osmotic pressure (BEOP) effect.

In SWRO desalination, most installations are single-staged plants consisting of pressure vessels (PV) with 6 – 8 membranes per PV. Since CP controls biofilm formation, there exists a critical CP of between 1.11 and 1.13 in SWRO that affects the fouling rate. An increase in CP above these critical CP values results in an increase in the rate of clean-in-place (CIP) treatments. Membrane CP is affected by the permeability of the membrane, the recovery rate (flux) and membrane crossflow velocity. In single-stage SWRO, recoveries must be below 40% in order to stay below the critical CP value and control membrane biofouling rate.

To make SWRO cost-effective, recoveries must be between 50-70% which can only be attained by utilizing a bi-turbo brine-stage design, which keeps the recoveries in both stages below 40% and attains the lowest SEC along with controlling membrane biofouling. Brine-staged SWRO facilities now in use have demonstrated that recoveries up to 70% can be attained without the occurrence of any membrane biofouling, while achieving the lowest SEC.

About the Speaker

Harvey Winters is Professor Emeritus at Fairleigh Dickinson University, Teaneck, New Jersey, USA. Professor Winters has also been Visiting Research Associate at Nanyang Technical University in Singapore, supported by Singapore Public Utility board (PUB) and Visiting Professor at KAUST in Saudia Arabia.

Professor Winters received his Ph.D. degree from Columbia University (USA), studying biofilm formation on surfaces and began his research interests into Reverse Osmosis (RO) desalination in 1976 in cooperation with U.S. Bureau of Reclamation and DuPont in the early days of SWRO in the Middle East and eventually became Director of Desalination Technology Transfer Center at Fairleigh Dickinson University in 1980. His research has focused on how to suppress fouling of RO membranes and use of brine-staging in seawater Reverse Osmosis to make desalination more energy efficient. His research has been supported by the U.S. National Scientific Foundation, U.S. Office of Navy Research, U.S. Bureau of Reclamation, Singapore PUB and Middle East Desalination Research Center (Muscat, Oman).

Professor Winters has published papers dealing with membrane biofouling in seawater RO in over 100 peer-reviewed journals and has received the prestigious outstanding researcher award by International Desalination Association in 2010.

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