In situ study of the mechanisms of biofouling in wastewater reuse

Emily Tow and
Robert Kostecki
werri.lbl.gov

Motivation

Water scarcity has broad impacts on food security, industry, human health, and the environment. Wastewater reuse can play a role in alleviating water scarcity by augmenting local water supplies. Potable reuse technologies (Fig. 1a) can purify wastewater to drinking water quality using much less energy than needed to desalinate seawater or transport water long distances (Fig. 1b). However, the energy *efficiency* of water reuse is still low—that is, there is significant potential to reduce the energy consumption associated with wastewater reuse.

Technological Challenges

Membranes used in wastewater reuse processes are prone to biofilm growth, known as biofouling. Biofouling necessitates energy-intensive pretreatment and frequent membrane cleaning, which raise energy consumption and water cost. Pretreatment alone consumes 0.2-0.4 kWh of electricity per cubic meter of water [1], which is up to half the energy required for municipal wastewater reuse. However, with better understanding of biofilm dynamics in wastewater reuse, more targeted pretreatment processes, cleaning steps, and membrane materials can be developed to reduce the cost and energy consumption of wastewater reuse.

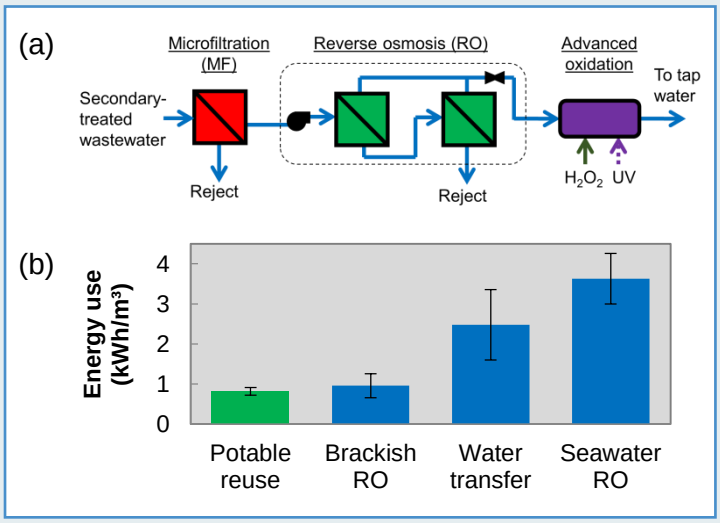

Figure 1. *(a) Typical potable reuse treatment train and (b) energy use of water supply augmentation options.*

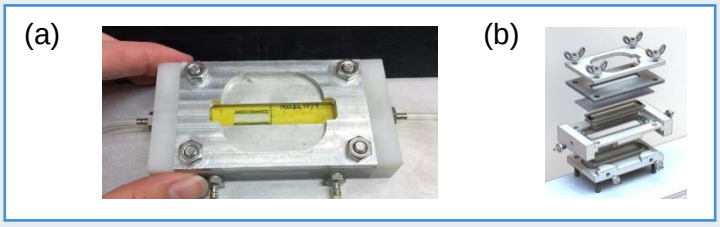

Figure 2. *Membrane fouling visualization cell.*

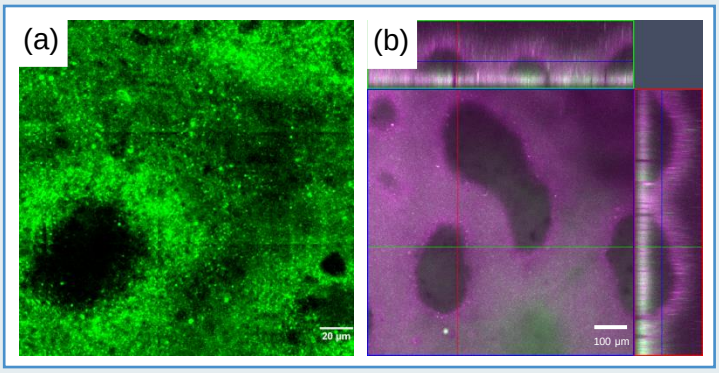

Figure 3. *Biofouling of ultrafiltration membranes: (a) channels in EPS and (b) bubble-wrap-like biofilm conformation (cells stained green and EPS stained pink).*

Research

To enhance understanding of biofilm behaviors in wastewater reuse, we are using confocal microscopy to observe membrane biofouling *in situ.* Municipal wastewater is circulated through a membrane fouling visualization cell (Fig. 2) under hydrodynamic conditions typical in wastewater reuse. This method allows for visualization (Fig. 3) of both cells and the extracellular matrix (EPS) during two periods that are critical to understand if we want to efficiently mitigate biofouling: (1) the initial transition from planktonic to biofilm state and (2) the eventual biofilm departure. Through better understanding of biofouling mechanisms, we hope to develop more targeted mitigation strategies that prevent bacteria from forming a biofilm or stimulate existing biofilms to detach from the membrane.

References

[1] Shaffer et al., *J. Membr. Sci.*, 415-416:1-8, 2012.

Acknowledgements

ITRI-Rosenfeld Postdoctoral Fellowship
MOLECULAR FOUNDRY
EBMUD
BERKELEY LAB