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Biofouling of membrane distillation, forward osmosis and pressure retarded osmosis: principles, impacts and future directions

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Abstract

The water-energy nexus has motivated the quest for new membrane-based technologies that target potable water and energy production. To this end, membrane distillation (MD), forward osmosis (FO) and pressure retarded osmosis (PRO) provide alternative means for the sustainable production of freshwater and electricity from feed water with high fouling potential such as wastewater. MD is a thermally driven process that can utilize low grade (latent) heat sources, while FO and PRO harness osmotic gradients as the driving force. High rejection of contaminants, compact modular design and low fouling propensity make these membrane technologies suitable for treating different types of wastewater. However, the application of feed solutions with high loads of organic matter and bacteria prompts the development of microbial fouling (biofouling), which significantly reduces system performance. Therefore, mitigating biofouling by minimizing bacterial attachment and enhancing the biofilm cleaning efficiency is imperative. We stress that in-depth exploration of the impacts imposed by biofilm in MD, FO and PRO systems is essential before developing new approaches for biofouling mitigation. This comprehensive review compiles the driving forces of these non-pressurized membrane systems, while focusing on the current knowledge regarding the various impacts of biofouling. Moreover, we highlight current and future research directions that focus on the development of new approaches to minimize MD, FO and PRO biofouling.