Notice of the Final Oral Examination
for the Degree of Master of Applied Science
of
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BSc (Le Moyne College, 2017)

“Mitigating Biofouling on Reverse Osmosis Membranes via Greener Preservatives”

Department of Civil Engineering

Wednesday, July 22, 2020
8:30 A.M.
Remote Defence

Supervisory Committee:
Dr. Heather Buckley, Department of Civil Engineering, University of Victoria (Supervisor)
Dr. Caetano Dorea, Department of Civil Engineering, UVic (Member)

External Examiner:
Dr. Caren Helbing, Department of Biochemistry and Microbiology, UVic

Chair of Oral Examination:
Dr. Jie Zhang, Peter B. Gustavson School of Business, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

Water scarcity is an issue faced across the globe that is only expected to worsen in the coming years. We are therefore in need of methods for treating non-traditional sources of water. One promising method is desalination of brackish and seawater via reverse osmosis (RO). RO, however, is limited by biofouling, which is the buildup of organisms at the water-membrane interface. Biofouling causes the RO membrane to clog over time, which increases the energy requirement of the system. Eventually, the RO membrane must be treated, which tends to damage the membrane, reducing its lifespan. Additionally, antifoulant chemicals have the potential to create antimicrobial resistance, especially if they remain undegraded in the concentrate water. Finally, the hazard of chemicals used to treat biofouling must be acknowledged because although unlikely, smaller molecules run the risk of passing through the membrane and negatively impacting humans and the environment. It is, therefore, integral to investigate techniques for prevention of biofouling and removal of mature biofilms that are effective, less damaging to the membrane, and safe for humans and the environment.

A common experimental setup is biofilm antimicrobial microdilution susceptibility tests. To acquire meaningful data from these tests, however, appropriate organisms must be tested. Manuscripts 1 and 2 investigate, via semi-systematic review, the question of what organisms are appropriate to represent the complexity of a biofilm in antimicrobial tests. Ultimately, we recommend utilizing the model biofilm-forming, pioneer organism, Pseudomonas aeruginosa for these studies.

Biofouling studies also must present data in a useful manner to the many disciplines that are interested in preventing or removing biofouling. Our goal is to investigate both via antimicrobial microdilution susceptibility tests. In Manuscript 3 we investigate the metrics of each discipline with an interest in anti-biofouling studies. Ultimately we recommend utilizing both crystal violet stain to assess total biomass removal and the LIVE/DEAD BacLight stain to assess cell vitality (including log reduction and MIC, BPC, MBIC, MBC, BBC, and MBEC), to satisfy the metrics of all interested disciplines. Finally, in Manuscript 4 we implement the recommendations from Manuscripts 1-3 for biofilm prevention and biofilm removal antimicrobial microdilution susceptibility tests. In this manuscript, we work with a subset of safer preservatives including, methylisothiazolinone, phenoxyethanol, and sodium benzoate. We found that methylisothiazolinone was the most effective antimicrobial, however, it was not the safest.
Additionally, we investigated the relationship between MBIC and BPC, which was found to vary between the preservatives.

Ultimately, we have provided recommendations for biofilm antimicrobial susceptibility tests that produce widely applicable and useful metrics, as well as utilized these recommendations to investigate the efficacy of safer antimicrobials. All of this work provides a framework for which even safer and effective novel antimicrobials can be investigated.