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Data Article

Assessing biomimetic aquaporin membrane for forward osmosis desalination process: A dataset



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ABSTRACT

This paper presents the performance of aquaporin forward osmosis membrane using chemical fertilizers as a draw solution. The comprehensive evaluation conducted for five conventional fertilizers ((CO (NH₂)₂, KCl, CaCl₂, (NH₄)₂SO₄) and (NH₄)₂HPO₄) as draw solutions. The diluted fertilizer can be used directly for farming as fertigation. In this process, DSs do not need to be recovered and it is a single step desalination process. The data include the characterization of the intrinsic properties of the membrane samples and their performance under FO and PRO modes of operations. In addition, the data for various draw solution concentration under feed solution with deferent total dissolved solids (TDS) were evaluated. For example, a water flux of 17.5 L m⁻² h⁻¹ and 23.92 g m⁻² h⁻¹ reverse solute flux (RSF) was achieved under the FO operation mode for 3 M KCl.

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Specifications Table

Subject area	Separation and purification technology
More specific subject area	Forward osmosis, Biomimetic thin film composite membrane
Type of data	Figure, table, schematic
How data was acquired	Schottky Field Emission Scanning Electron Microscope (SEM, Zeiss Supra 55VP, Carl Zies AG, Germany) Optical Tensiometer (Attension Theta Lite 100, Biolin Scientific, Finland)
Data format	Raw and Analyzed
Experimental factors	Performance new Aquaporin forward osmosis membrane was evaluated with five fertilizers as draw solution and feed solution with different TDS.
Experimental features	The desalinated water containing diluted fertilizer to be used directly or after further dilution for farm fertigation.
Data source location	Research and Technology Centre of Membrane Processes (RTCMP), School of Chemical, Petroleum and Gas Engineering, Iran University of Science and Technology (IUST), Narmak, Tehran, Iran Department of Environmental Health, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran Department for Management of Science and Technology Development, Ton Duc Thang University, Ho Chi Minh City, Vietnam Faculty of Environment and Labour Safety, Ton Duc Thang University, Ho Chi Minh City, Vietnam
Data accessibility	The raw data files are provided in the supplementary file. All other data is within this article.

Value of the data

- FO process requires much lower energy than the existing desalination technologies.
- Energy requirement is even lower when the diluted draw solution (fertilizers) can be used directly for farm irrigation.
- This data provides valuable information and gives more insights on the newly commercialized Aquaporin FO membrane.
- The key parameters in utilizing fertilizer as a draw solution applying biomimetic FO membrane were explored.

1. Data

Fig. 1 presents the SEM images for the top surface rejection layer and non-woven backing fabric support for Aquaporin FO membrane. The Biomimetic FO membrane top surface (rejection layer) which is formed by AQP proteins is similar to conventional thin film composite membrane polyamide layer in terms of topology.

Table 1. Presents the AQP membrane characterization. Figs. 2 and 3 present the membrane performance in terms of water flux in the FO mode with five different fertilizers as DS different using 10 gr/L and 20 gr/L NaCl as FS, respectively. The performance was in the following order: $\text{KCl} > (\text{NH}_4)_2\text{SO}_4 > \text{CaCl}_2 > (\text{NH}_4)_2\text{HPO}_4 > \text{Urea}$. Fig. 4 also shows the amount of wasting draw solute through phenomenon called reverse solute flux (RSF). The RSF plays a central role in the valuation of the FO process in terms of economic measure and membrane fouling tendency. Figs. 5–9 present the performance of each specific DS with five different concentration of feed solution (0–5–10–20–35 g/L NaCl) in terms of water flux in FO operation mode.

Finally, Fig. 10 shows the membrane performance in FO and PRO modes using DI water as FS at different Molar concentration for 2 selected fertilizers, KCl and $(\text{NH}_4)_2\text{SO}_4$. In the PRO mode, the net gain water flux was more compared to the FO mode. This indicates the effect of ICP in the PRO mode is less than FO mode of operation. The raw data presented in the supplementary file as well.

2. Experimental design, materials, and methods

2.1. Feed and draw solutions preparation

$(\text{NH}_2)_2\text{CO}$, KCl, CaCl_2 , $(\text{NH}_4)_2\text{SO}_4$, $(\text{NH}_4)_2\text{HPO}_4$ were used as draw solutions provided by (SAMCHUN, Korea). 0.5, 1, 2, and 3 M molar concentration levels were prepared. DI water and NaCl (5–10–20–35 g/L) were prepared as a feed solution (FS).

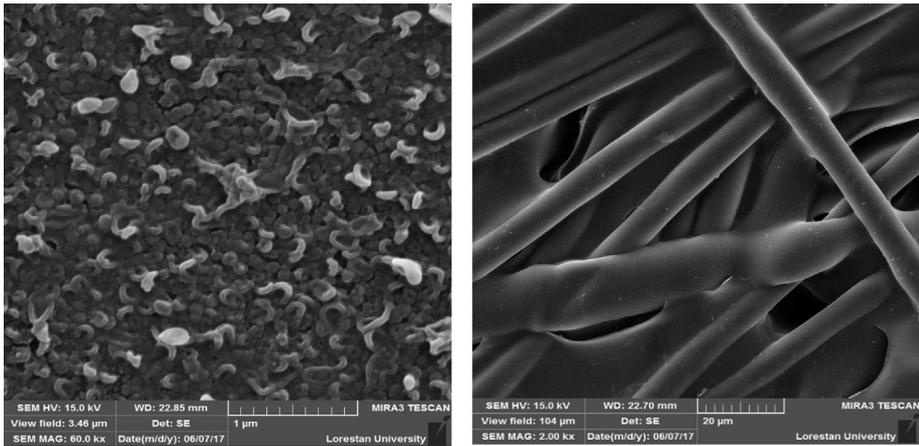


Fig. 1. SEM images for the top rejection layer and non-woven backing fabric support for the virgin Aquaporin FO membrane in this study.

Table 1
Characterisation of AQP's FO membrane.

Membrane ID	Thickness (μm)	Porosity (%)	Contact angle ($^{\circ}$) Active layer
AQP's	135 ± 2.0	69	51

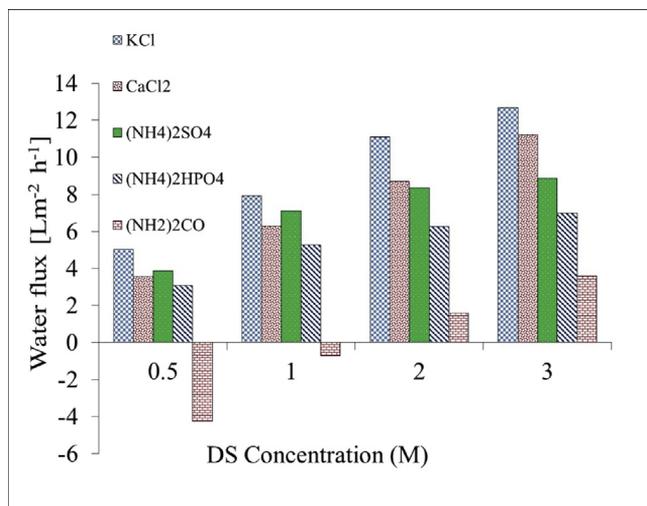


Fig. 2. Comparison of the water flux for different fertilizers as a DS at different concentrations using 10000 mg/L NaCl as feed solution in the FO mode.

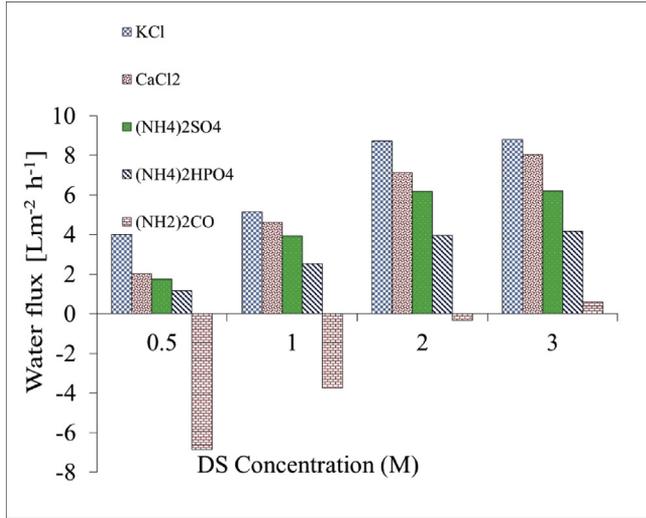


Fig. 3. Comparison of the water flux for different fertilizers as a DS at different concentrations using 20000 mg/L NaCl as feed solution in FO mode.

2.2. Measurement of intrinsic properties of the membrane

Intrinsic properties of the Biomimetic-FO membrane were determined by RO testing mode by utilizing the FO membrane cell and applying hydraulic pressure (0–5 bar). Water permeability (*A* value) was calculated based on the following equation:

$$A = \frac{\Delta V_a}{\Delta t_a \times A_m \times \Delta P} \tag{1}$$

Water permeability was obtained by placing DI water in the FS container and adjusting hydraulic pressure of 5.0 bar. ΔV_a is the acquired permeate water over a specific time, ΔP is the applied hydraulic pressure difference and A_m and Δt_a is the membrane area.

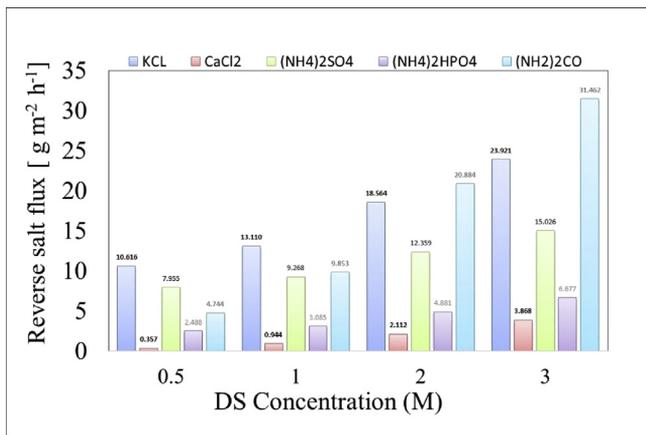


Fig. 4. Comparison of RSF of five fertilizers as DS at different concentrations using DI water as FS in the FO mode.

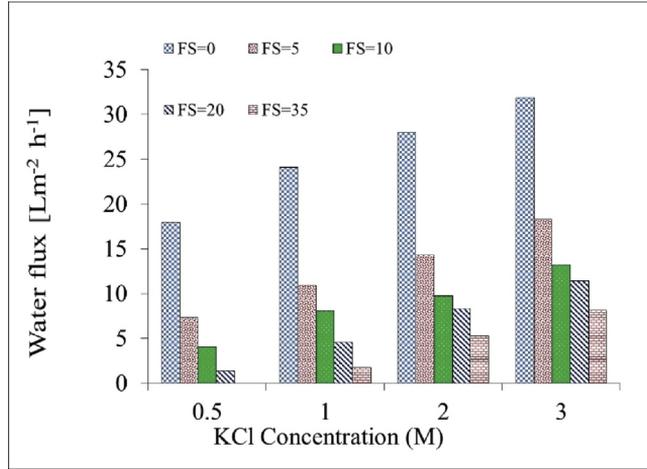


Fig. 5. Performance of KCl in terms of water flux at different M concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.

NaCl rejection property of the Biomimetic-FO membrane was calculated by the following equation.

$$R = \frac{C_f - C_p}{C_f} \times 100\% \quad (2)$$

where C_f and C_p are the amount of NaCl concentrations for the feed and permeate container [1,2].

The salt permeability coefficient (B) was calculated by the following equation:

$$B = \frac{A(1 - R)(\Delta p - \Delta \pi)}{R} \quad (3)$$

where A is water permeability, R is the salt rejection, Δp is the applied pressure and $\Delta \pi$ is the osmotic pressure difference for the Aquaporin FO membrane [3–6].

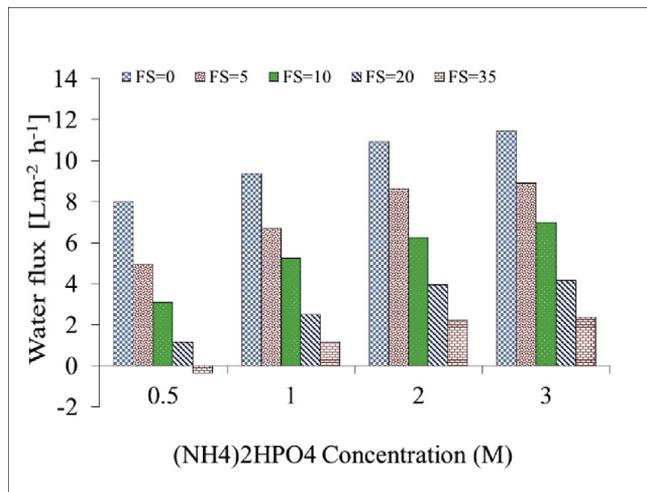


Fig. 6. Performance of (NH₄)₂HPO₄ in terms of water flux at different M concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.

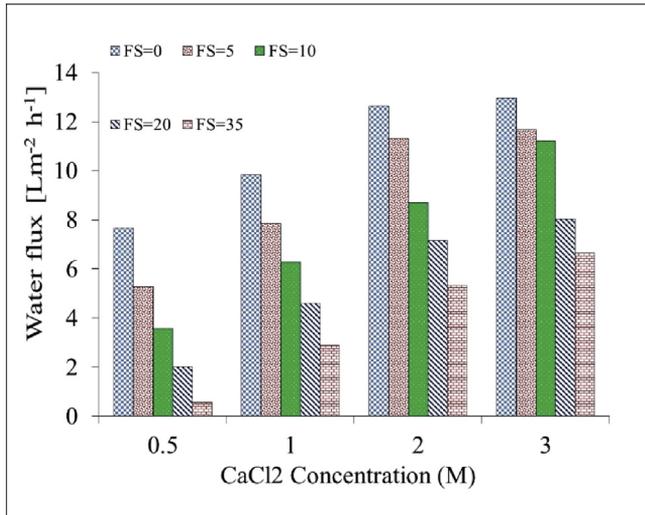


Fig. 7. Performance of CaCl₂ in terms of water flux at different M concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.

2.3. Substrate characterization

The membrane morphologies were assessed using (FE-SEM, MIRA3-LMU model, Czech Republic) a high-resolution Schottky Field Emission Scanning Electron Microscope.

Membrane porosity (ϵ) was calculated by weighing the wet mass (W_1) and the dry mass (W_2) of membrane samples based on the following equation:

$$\epsilon = \frac{(W_1 - W_2) / \rho_i}{\left[\frac{W_1 - W_2}{\rho_i} \right] + [W_2 / \rho_m]} \times 100\% \quad (4)$$

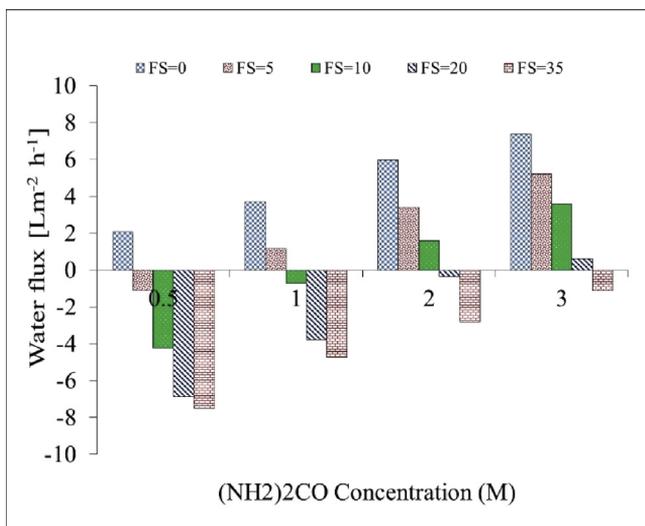


Fig. 8. Performance of Urea in terms of water flux at different M concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.

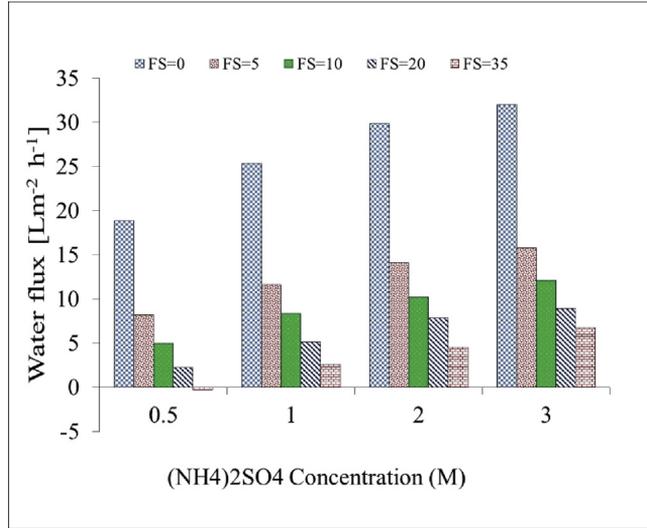


Fig. 9. Performance of (NH₄)₂SO₄ in terms of water flux at different Molar concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.

where ρ_i is the density of the used wetting solvent, and ρ_m is the density of the membrane sample. The thickness of the membranes was measured by a digital micrometer (293–330 Mitutoyo, Japan).

2.4. Membrane tests under FO and PRO processes

Performance tests under the FO and PRO processes were assessed in the designed FO cell presented in Fig. 11 provides a useful area of 6.2 cm² with 2 cm in width, 3.1 cm in length and 0.3 cm in depth on both sides. The reverse solute flux (RSF) was assessed by observing the electrical conductivity (EC)

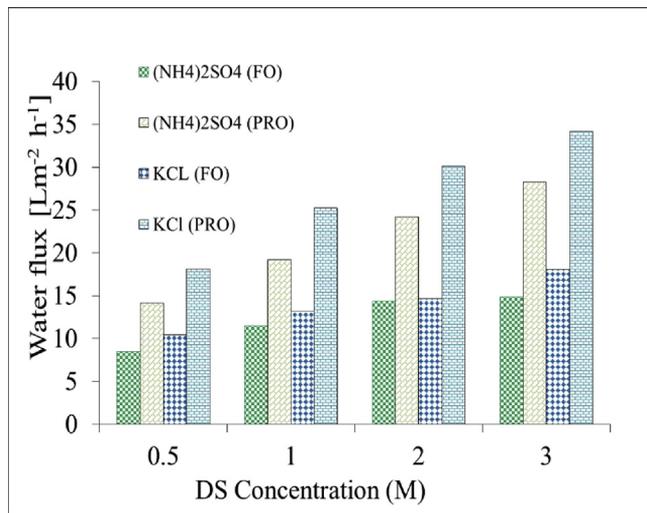


Fig. 10. Comparing water flux in FO and PRO modes using DI water as FS at different Molar concentration for KCl and (NH₄)₂SO₄.

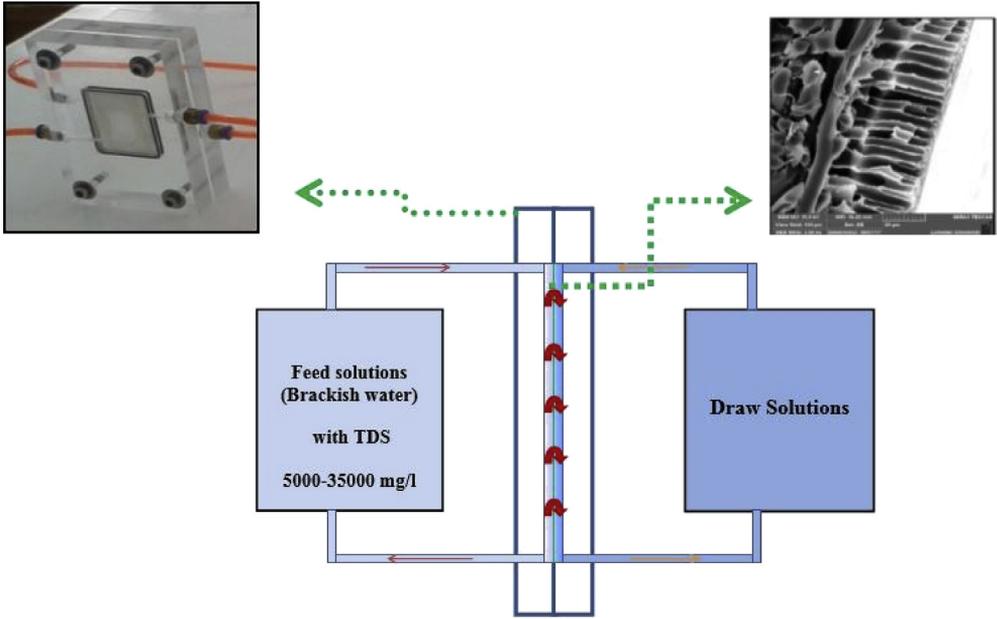


Fig. 11. Schematic of the lab-scale FO experimental setup.

applying a multimeter (Lutron-CD4303, Germany) where deionized water is used as feed water [7,8] (see Fig. 12).

3. Application for fertigation

The desalinated water via FO process using fertilizer as a draw solution can be used directly for farming as fertigation [9,10]. In this process, draw solutions do not need recovery and directly will be used for farming [11,12]. Thus that is a single-stand desalination process [10,11].

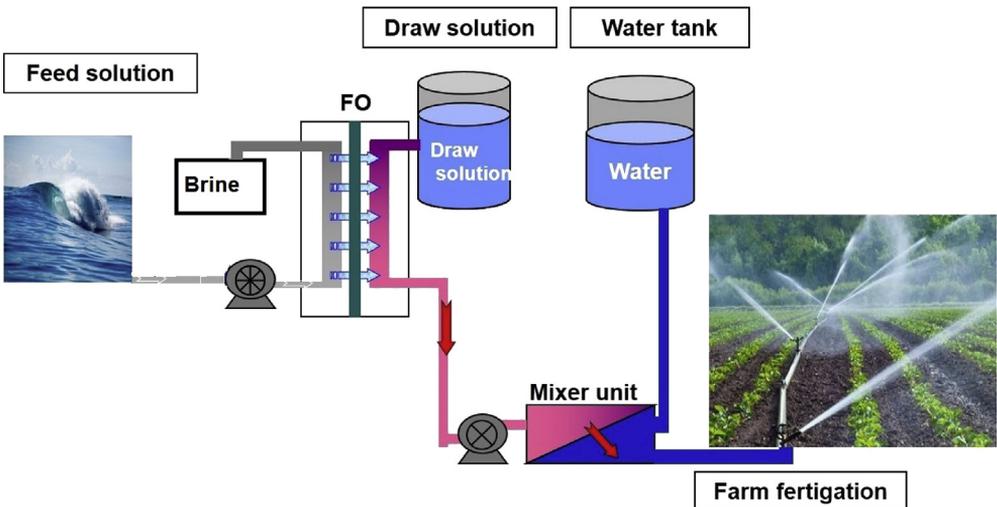


Fig. 12. Schematic of using brackish water for farm fertigation via FO process.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dib.2019.104482>.

References

- [1] Z. Naghdali, S. Sahebi, R. Ghanbari, M. Mousazadeh, H.A. Jamali, Chromium removal and water recycling from electroplating wastewater through direct osmosis: modeling and optimization by response surface methodology, *Environ. Health Eng. Manag. J.* 6 (2019) 113–120. <https://doi.org/10.15171/EHEM.2019.13>.
- [2] S. Sahebi, M. Sheikhi, B. Ramavandi, A new biomimetic aquaporin thin film composite membrane for forward osmosis: characterization and performance assessment, *Desalin. Water Treat.* 148 (2019) 42–50. <https://doi.org/10.5004/dwt.2019.23748>.
- [3] S. Sahebi, *Developing Thin Film Composite Membranes for Engineered Osmosis Processes*, 2015.
- [4] S. Sahebi, S. Phuntsho, Y.C. Woo, M.J. Park, L.D. Tijing, S. Hong, H.K. Shon, Effect of sulphonated polyethersulfone substrate for thin film composite forward osmosis membrane, *Desalination* 389 (2016) 129–136. <https://doi.org/10.1016/j.desal.2015.11.028>.
- [5] J. Zyaie, M. Sheikhi, J. Baniasadi, S. Sahebi, T. Mohammadi, Assessment of a thermally modified cellulose acetate forward-osmosis membrane using response surface methodology, *Chem. Eng. Technol.* 41 (2018) 1706–1715. <https://doi.org/10.1002/ceat.201800084>.
- [6] S. Sahebi, S. Phuntsho, L. Tijing, G. Han, D.S. Han, A. Abdel-Wahab, H.K. Shon, Thin-film composite membrane on a compacted woven backing fabric for pressure assisted osmosis, *Desalination* 406 (2017) 98–108. <https://doi.org/10.1016/j.desal.2016.06.001>.
- [7] S. Sahebi, H.K. Shon, S. Phuntsho, B. Ramavandi, Fabricating robust thin film composite membranes reinforced on woven mesh backing fabric support for pressure assisted and forward osmosis: a dataset, *Data Brief* 21 (2018) 364–370. <https://doi.org/10.1016/j.dib.2018.10.007>.
- [8] T. Majeed, S. Phuntsho, S. Sahebi, J.E. Kim, J.K. Yoon, K. Kim, H.K. Shon, Influence of the process parameters on hollow fiber-forward osmosis membrane performances, *Desalin. Water Treat.* 54 (2015) 817–828. <https://doi.org/10.1080/19443994.2014.916232>.
- [9] T. Majeed, S. Sahebi, F. Lotfi, J.E. Kim, S. Phuntsho, L.D. Tijing, H.K. Shon, Fertilizer-drawn forward osmosis for irrigation of tomatoes, *Desalin. Water Treat.* 53 (2015) 2746–2759. <https://doi.org/10.1080/19443994.2014.931524>.
- [10] S. Phuntsho, J.E. Kim, T. Majeed, F. Lotfi, S. Sahebi, M.J. Park, H.K. Shon, Fertiliser-Drawn forward osmosis desalination for fertigation, *Forw. Osmosis Fundam. Appl.* (2015) 395–426. <https://doi.org/10.1061/9780784414071.ch17>.
- [11] S. Phuntsho, S. Sahebi, T. Majeed, F. Lotfi, J.E. Kim, H.K. Shon, Assessing the major factors affecting the performances of forward osmosis and its implications on the desalination process, *Chem. Eng. J.* 231 (2013) 484–496. <https://doi.org/10.1016/j.cej.2013.07.058>.
- [12] S. Sahebi, S. Phuntsho, J.E. Kim, S. Hong, H.K. Shon, Pressure assisted fertiliser drawn osmosis process to enhance final dilution of the fertiliser draw solution beyond osmotic equilibrium, *J. Membr. Sci.* 481 (2015) 63–72. <https://doi.org/10.1016/j.memsci.2015.01.055>.