Solar Membrane Desalination

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Introduction

The project focusses on controlling scaling resistance in solar membrane distillation by monitoring the role of temperature, hydrodynamic conditions and concentration polarization. The researcher hypothesized that the maximum solar water production efficiency will be found in a medium between scaling resistance and high flux. The objectives of this research are characterizing the tradeoff between flux and scaling resistance, investigating the fundamental mechanism of inorganic fouling on self-heating surfaces, and determining the scaling propensity of self-heating membranes. The results of this study will inform the development of more resilient solar desalination systems for off-grid water treatment.

Figure 1: The imbedded reverse osmosis unit empowered by solar panels

Figure 2: The testing site: Shalateen, Egypt

Research Question & Objectives

Research question: Does a high or low flux allow for maximum solar desalination production efficiency?

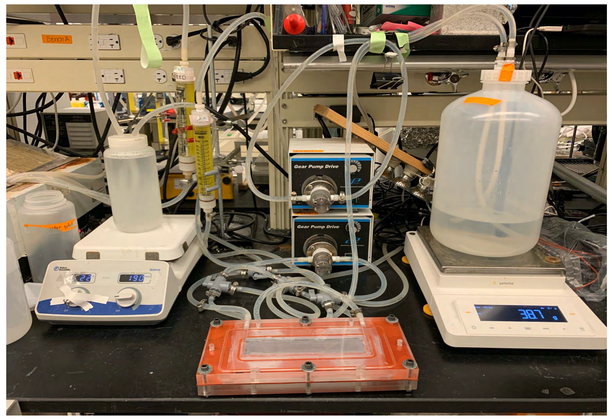
Objectives:

1. Manipulating the feed water temperature in 10℃ to determine scaling behavior in the solar membrane distillation

2. Isolating the effect of temperature from water flux by keeping the temperature gradient constant (ΔT= 20℃)

Methodology

1. A synthetic 1L salt solution is made according to the water conditions in Egypt.
2. 2 tube that feeds heated water and draws water out of the salt solution is inserted.
3. The tubes are connected to a pump and into a constructed solar membrane distillation cell.
4. The system is turned on for 15 minutes with the valves to the solar membrane closed to allow the salt solution to come to temperature.
5. After 15 minutes, the temperature of the salt solution and the draw bottle are recorded, and the difference of temperature is recorded.
6. The valves to the solar membrane are opened and the system is allowed to run for 24 hours.
7. On the next day, the system is turned off and the membrane is extracted, air dried and taken to imaging.



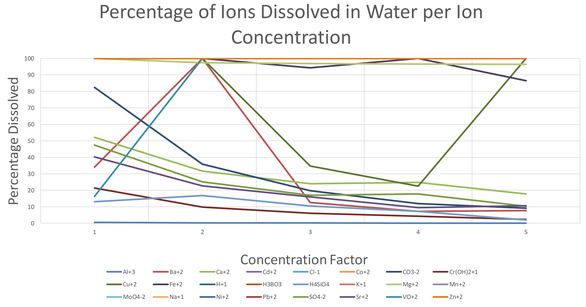


Figure 3: The percentage of Ions Dissolved in water per Ion Concentration

Table 1: Synthetic salt solution mixture

Species	Concentration (mM)
$CaCl_2 \cdot 2H_2O$	63.275
$MgCl_2 \cdot 6H_2O$	19.2962963
NaCl	230.6101408
$KHCO_3$	0.971916722
$NaHCO_3$	0.527670277
Na_2SO_4	19.27232979
H_3BO_3	0.162242161
$Na_2SiO_3 \cdot 5H_2O$	0.684694949
$SrCl_2 \cdot 6H_2O$	0.709769459
$BaCl_2$	0.00033
$CuSO_4 \cdot 5H_2O$	0.000699
$FeSO_4 \cdot 7H_2O$	0.001911
$ZnSO_4 \cdot 7H_2O$	0.000089
$Na_2MoO_4 \cdot 2H_2O$	0.000107
$Ni(No_3)\ 6H_2O$	0.000111
$K_2Cr_2O_7$	0.000527

Results and Findings

- In Figure 3, That graph generated through visual Minteq which is a software that generates a mathematical model how many ions have dissolved as the salt concentration factor is double or tripl.
- Inorganic fouling of the membrane led to a gradual flux decline over time, with flux being reduced by half at less than 50% water recovery
- Through electron scanning microscopy analysis of the fouled membrane surface revealed a high accumulation of inorganic species on the surface, which agrees with the flux decline data and confirm membrane scaling

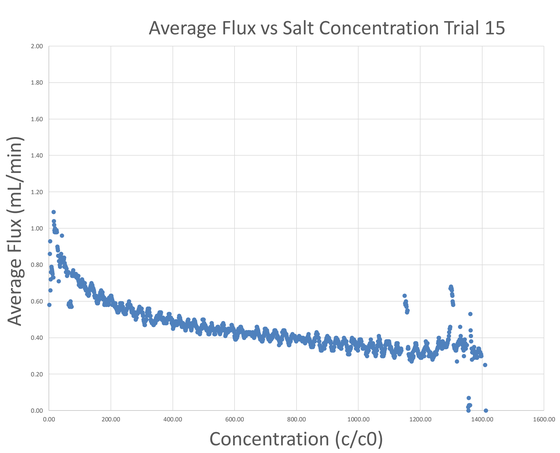
Conclusion

- With the current data, we can conclude that a higher temperature resulting in a higher flux is not the most efficient way to decrease scaling.

Next Steps

- More experimental trials are required to validate whether the increase in flux does in fact result in a decrease in scaling.
- After sufficient data is collected, the research team in Egypt can look into making a larger scale system.

Results



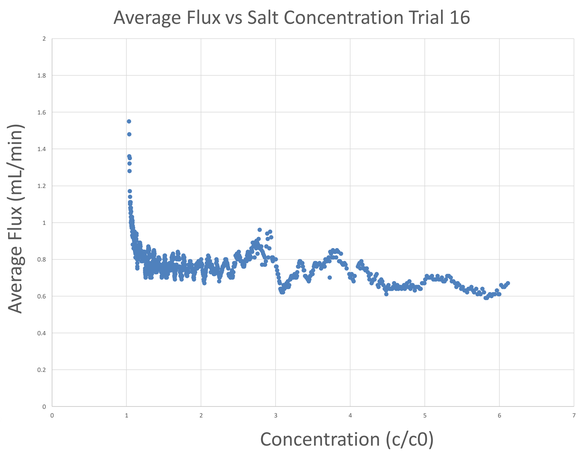


Figure 4 & 5 : The Average Salt vs Salt Concentration Trial 15 and 16

References

Fang Li, Jiahui Huang, Qin Xia, Mengmeng Lou, Bo Yang, Qing Tian, Yanbiao Liu, Direct contact membrane distillation for the treatment of industrial dyeing wastewater and characteristic pollutants,Separation and Purification Technology, Volume 195,2018,Pages 83-91,ISSN 1383-5866, https://doi.org/10.1016/j.seppur.2017.11.058

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