Interfacial Evaporation of Waste Water Under Solar Irradiation

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Introduction

The big idea behind this research is that solar driven interfacial evaporation(SDIE) is more efficient in both terms of cost and evaporation output.[1]

- This technology of using solar distillation has been around since ancient times, however was not used to its full potential.[2]
- The way solar energy was approached made it complex to manufacture, which led to high cost and high maintenance costs. For example, distillation and membrane techniques had a high cost in treating waste water, along with not being very effective.[3]
- SDIE is based on the idea of taking solar energy and directly turning it into thermal energy, where heat is concentrated at the surface. So the water is heated enough to escape as a vapor, making it more efficient because the heat is concentrated instead of all through out the bulk liquid.[3]

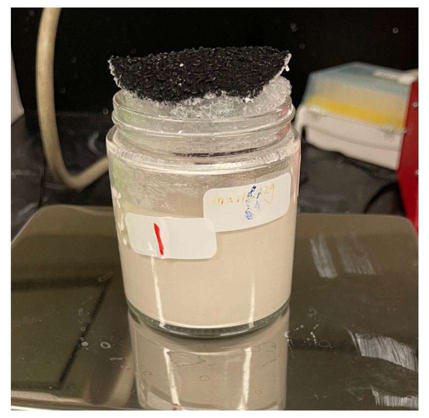
Methods

We build a small scale solar interface evaporation device (Fig 1.A).

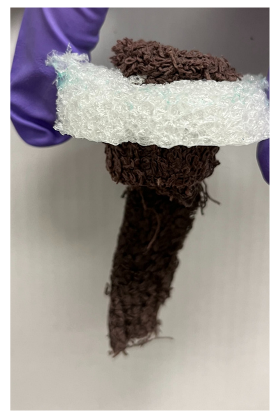
- Using a small jar (150 ml) to hold the bulk liquid.
- Cutting pieces of cotton cloth to wick the water up to the solar absorber.

Solar absorber:

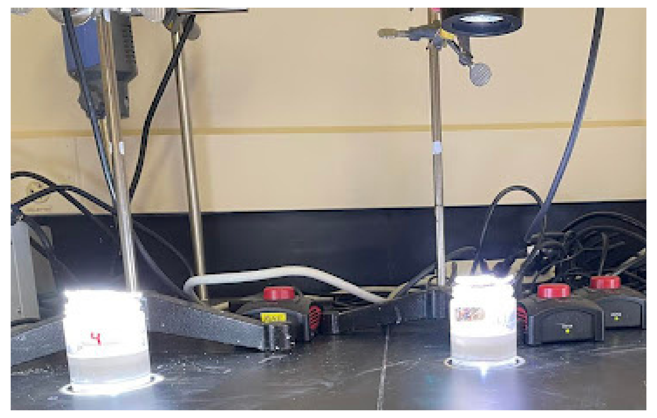
- A circle cotton cloth, with a diameter of 5 cm.
- Its color is made by coating it in a carbon sodium alginate solution (polymer), until it is completely a uniform black. Then soaked in a calcium chloride solution to prevent any loss of carbon material from the cloth, creating a protective layer.
- That rests on a piece of foam that keeps the heat from transferring to the bulk liquid.



(Fig 1.A)



(Fig 1.B)



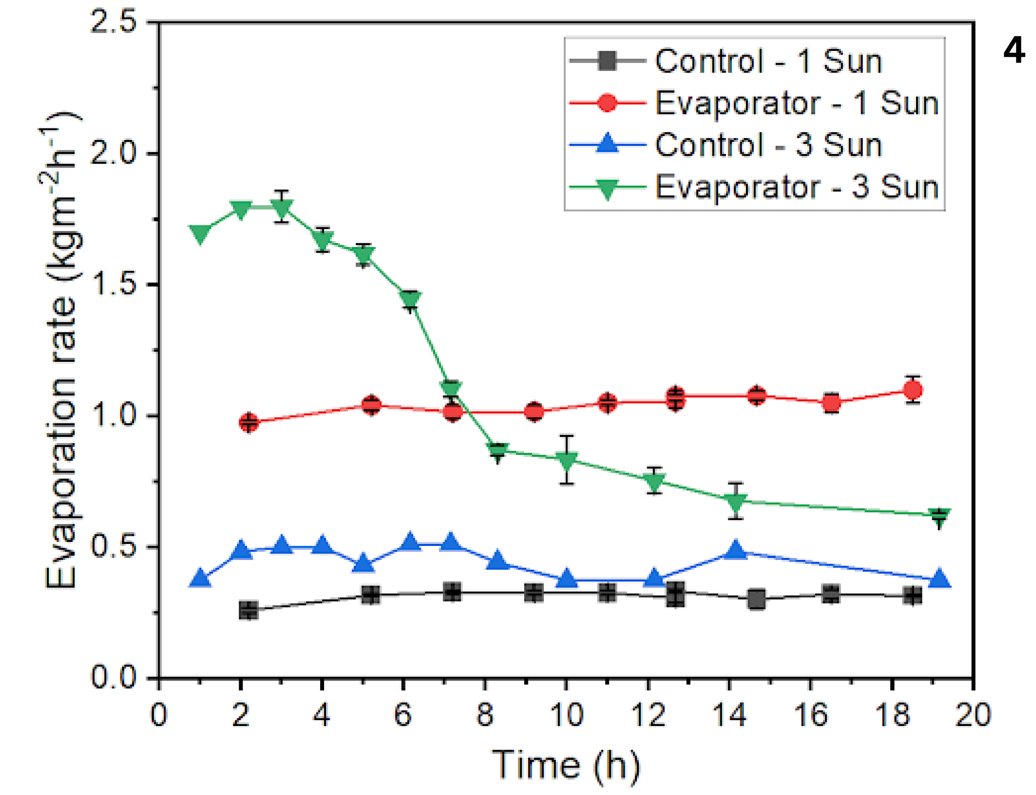
(Fig 1.C)

Trying to achieve the greatest rate of evaporation.

- The surface area of the wicking cloth is 12 cm^2, (Fig 1.B)
- How the experiment was set up (Fig 1.C).

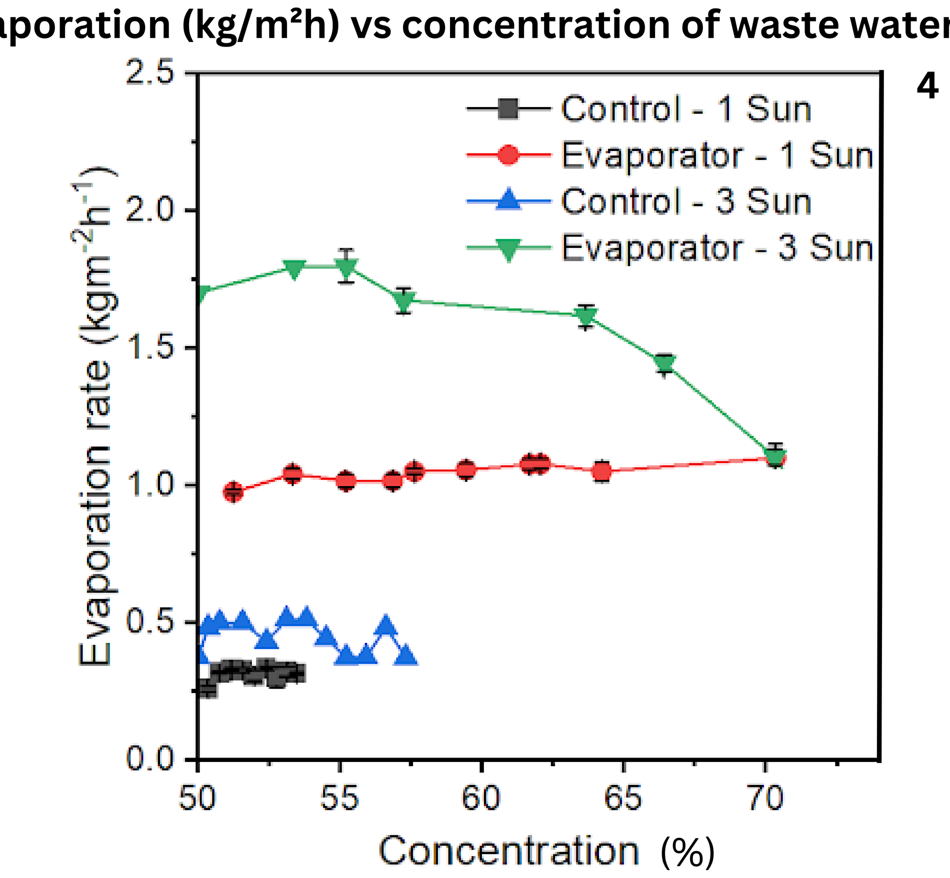
Results

Rate of evaporation (kg/m^2h) every hour (Fig 2.A)



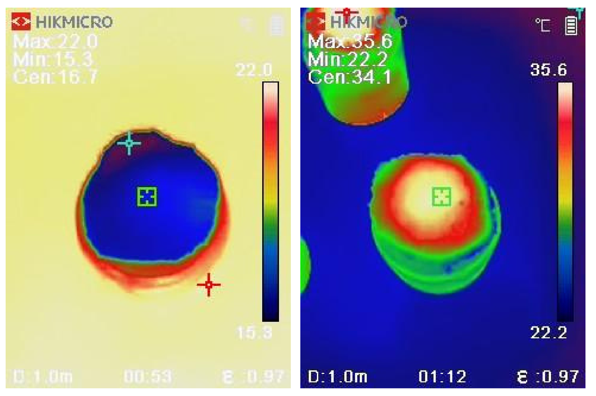
In Fig 2.A we can see a significant difference in using a solar interface evaporation system even if there is only 1 sun, its effect is remarkable compared to the control with 3 suns.

Rate of evaporation (kg/m^2h) vs concentration of waste water (Fig 2.B)

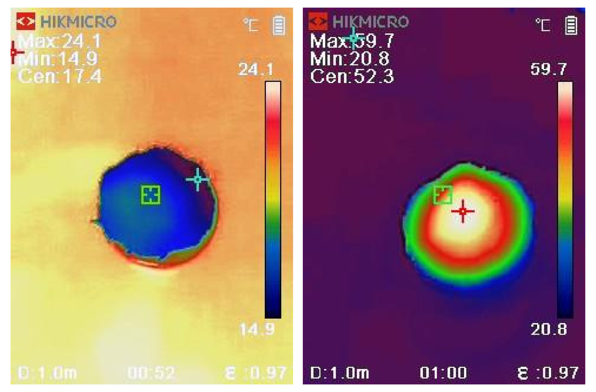


In Fig 2.B we can see how the concentration of the waste water is impacting the rate of evaporation in all the systems. Most noticeable in the 3 sun evaporator because it is losing water efficiently which raises the concentration.

1 Sun (Fig 2.C) v.s **3 Suns** (Fig 2.D)



0 min 5 min



0 min 5 min

In Fig 2.C&D you can observe how the amount of suns make an impact on the temperature in each solar absorber.

Conclusions

The evaporators we used was an efficient way of drying waste water. All systems proved to be roughly 5 times more efficient than the control.

- Looking at the data that has been collected in our experiment the factors that impact the rate of evaporation is the amount of thermal energy that each system has generated.
- Concept of how the temperature affects the rate of evaporation is backed up in the 3 suns systems (Fig 2.A) The rate of evaporation is the highest.
- In Fig 2.D we can see that the solar absorber with 3 suns reaches a higher temperature than Fig 2.C, which results in an initial higher rate of evaporation.
- In one sun system the evaporation rate is stable.

In conclusion the most effective system was the one with 3 suns. Due to the fact that it had a higher temperature on the solar absorber.

Citations

1. Personal conversation with my SI, Tanay Kumar & Sidi Zhu.
2. Zhang, Y., Xiong, T., Nandakumar, D. K., & Tan, S. C. (2020). Structure architecting for salt-rejecting solar interfacial desalination to achieve high-performance evaporation with in situ energy generation. Advanced Science, 7(9), 1903478.
3. Tao, P., Ni, G., Song, C., Shang, W., Wu, J., Zhu, J., ... & Deng, T. (2018). Solar-driven interfacial evaporation. Nature energy, 3(12), 1031-1041.
4. Parts of the graph data was given by a graduate student, Tanay Kumar. This research was done before I joined the project

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