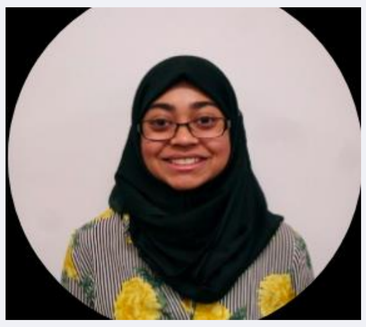
Ion Wind Effect

Rayat Rashid

The University of Texas at San Antonio, San Antonio TX, 78249



Name: *Rayat Rashid*
Status: *(Junior, Undergraduate Student)*
Department: *Engineering*
Area of Study: *Civil Engineering*
USDA/UTSA Mentor(s): *Dr. Drew Johnson*

WeARE Research Area

Water is a daily necessity. Due to current circumstances with increasing population and water use, fresh water is in short supply. However, many areas contain brackish and saltwater resources and energy efficient alternative water treatment technologies are needed to create fresh water from these potential waster sources. This research is based on the manipulation of electric fields for enhanced water desalination through water evaporation. The electric field effect on the water evaporation occurs through the ion wind effect.

Motivation or Background

High voltages ionize air to produce charged ion wind. The ionized air creates increased collisions between air molecules causing an increase in air movement. The increased air movement separates water molecules away from the liquid water surface before these water molecules can reach an equilibrium with the liquid water molecules. This leads to enhanced water evaporation with energy supplied directly to the air-water interface. Thus, high voltage causes increased ion wind which increases the rate of evaporation due to the extra charge and air movement with the potential for high energy efficiency.

Objectives

1. Explore an alternative means to separate pure water from salt and brackish water sources
2. Manipulate high voltage electric fields to provide energy necessary to separate water from salts through water evaporation.
3. Quantify how an electric voltage separates water molecules through ion wind
4. Examine how the change in distance between the voltage source and water controls water evaporation rates.

Methodology

An electric voltage is applied above a $CaCO_3$ saturated water surface placed on a digital balance. For each test, 6 V was supplied to an air ionizer to produce an ionization voltage of ~ 8 kV on a 4 mm metal ball and positioned above the water source. The evaporation rate of water was measured for different distances of the voltage source to the water surface. The balance displayed the weight of the water which changed with time due to water evaporation. Environmental conditions and mass data was recorded using LabView software and analyzed in Excel where slopes of the graphs represented the water evaporation rates. Lastly, there was an analysis of data to find trends of the ion wind effect.

Results

Shown in Figure 1 are the evaporation data collected for the metal ball placed at 0.3 cm. Shown in Figure 2 are the environmental conditions during the test. Results for evaporation rates for all tests combined are shown in Figure 3. The results indicate that the evaporation rates were increasing until the metal ball was at 3 cm from the water surface. If the metal ball was moved further than 3 cm, the evaporation rates began a parabolic decrease. This shows that 3 cm is the max point on the graph which represents an inflection point. Also, distances which were further from 3 cm on both sides of the inflection point, had a steeper slopes. The overall graph created a parabola showing the evaporation rate for each distance. After analyzing the data and graphs, it was concluded that about 3 cm is the best distance for the highest water evaporation rate for the conditions studied.

The ion wind effect is created by the high voltage metal ball ionizing the air. This increased air movement results in enhanced water molecule movement away from the water surface. One would expect this to be most effective when the electric metal ball is close to the water surface. However, for evaporation to occur, air circulation patterns must develop that favor evaporation. When the charged ion wind is close to the water surface, only air with high water content circulates. Since the air becomes quickly saturated with water, additional water evaporation is minimal. As the ball moves further away from the water surface, more air that is not saturated with water vapor contacts the water surface and evaporation rates increase. As the ball moves too far away from the water surface, the air circulation ceases. These competing mechanisms causes a parabolic decrease in the evaporation rate with distance. These results indicate that each electric voltage applied will have an optimal distance between the voltage source and the water surface from where the ion wind effect will be the most effective and result in the highest evaporation rates.

Min	Retentate Mass (gm)
0:00:00	0.13033
0:01:00	0.12928
0:02:00	0.12546
0:03:00	0.13062
0:04:00	0.12928
0:05:00	0.1285
0:06:00	0.12591
0:07:00	0.12488
0:08:00	0.12607
0:09:00	0.12545
0:10:00	0.1238
0:11:00	0.12603
0:12:00	0.12427
0:13:00	0.12425
0:14:00	0.12205
0:15:00	0.12089

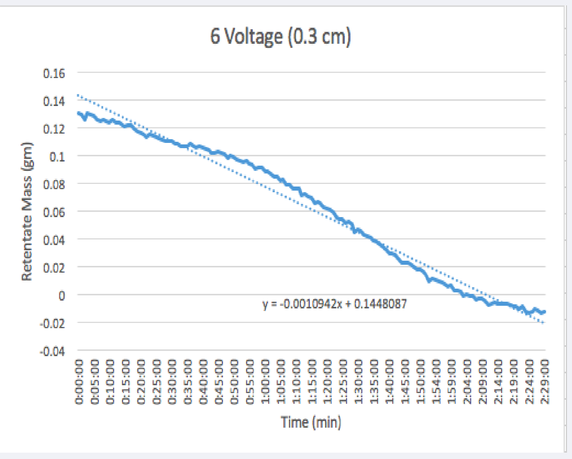


Fig. 1 : *Data for 6 volts applied to the water surface from a distance of 0.3 cm plotted on a graph with a linear trend line for the evaporation rate*

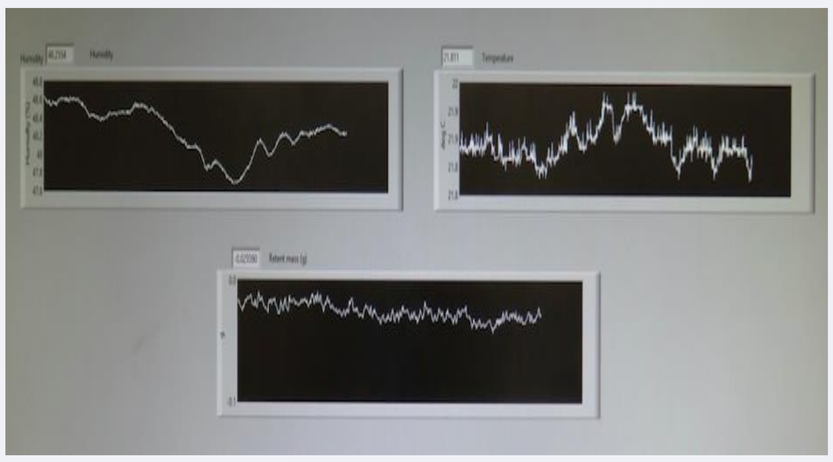


Fig. 2: *Humidity, temperature, and retentate mass being recorded in LabView*

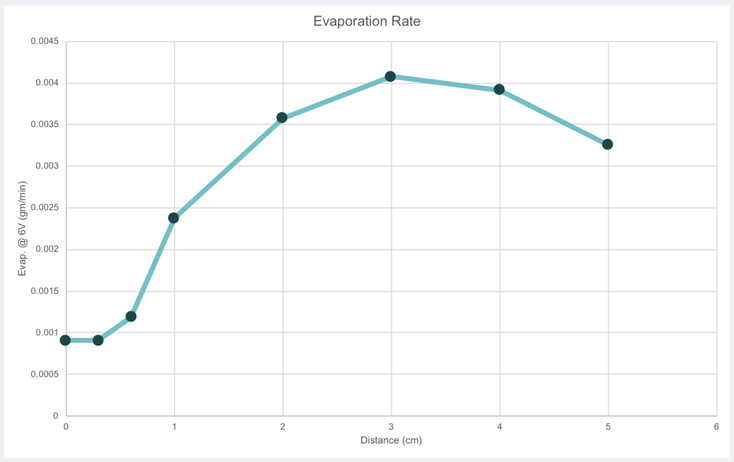


Fig. 3: *Evaporation rates at 6 volts for each separate distance forming a parabola*

Skills and Experience

- Manipulating electric fields for enhanced water desalination
- Measuring water evaporation changes due to changes in distance between the electric source and water
- Programming of data collection on LabView into Excel forming equations and graphs
- Using different materials to create a cooperative system in which electric voltage is applied to the water surface
- Understanding that water evaporation is occurring and changing rates due to the ion wind effect

What I Learned

An important part of water evaporation is the ion wind effect. The ion wind effect is impacted by distance. Evaporation rates will increase until the voltage source is at the max distance from the water surface. Afterwards, the evaporation rates will result in a parabolic decrease. A change in distance can heavily affect the evaporation of the water, because the ion wind effect will not work as productively anymore. Each electric voltage has a peak distance between the voltage source and the water surface from where the ion wind effect will lead to the highest evaporation rates.

Future Plans

The ion wind effect is one way water can be evaporated. Another way water may be evaporated is the water dipole effect. Since water is dipolar, an electric field can partially align water, which can cause hydrogen bonds to bend or break. This has the potential to enhance water evaporation rates by allowing more water molecules to escape liquid water in the form of water vapor. The idea would be to create another cooperative system, but this one uses the water dipole effect to evaporate water. The analysis of another method of water evaporation may present a more effective and beneficial way of water evaporation. This can help reach the goal of forming clean drinking water from brackish and salt water.

Acknowledgments

Special thanks to
- Dr. Drew Johnson
- UTSA Engineering Undergraduate Research

This work is supported by the USDA National Institute of Food and Agriculture, Interdisciplinary Hands-on Research Traineeship and Extension Experiential Learning in Bioenergy/Natural Resources/Economics/Rural project, U-GREAT (UnderGraduate Research, Education And Training) program (2016-67032-24984).

References

- Barthakur, et al. “Enhancement of Evaporation Rates from Thin Layers of Liquids Exposed to Air Ions.” *International Journal of Biometeorology*, Springer-Verlag, 1 Jan. 1983, link.springer.com/article/10.1007/BF01045274.
- Buchanan, Mark. “Water Molecules Need Help to Evaporate.” *Physics*, American Physical Society, 30 Nov. 2015, physics.aps.org/articles/v8/118.