Homework 10 Solar Power Africa
Due Monday October 30, 2023

Charlie Paton from Seawater Greenhouse spoke with the class on Thursday last week. Seawater Greenhouse uses evaporation of seawater to humidify air for agriculture and then condenses the humid air to produce desalinated water.

https://en.wikipedia.org/wiki/Seawater_greenhouse#cite_note-:0-1
https://seawatergreenhouse.com

a) Charlie showed a plot of wet bulb and dry bulb temperatures to give an idea of the conditions needed for the seawater greenhouse. Explain how the wet bulb and dry bulb temperatures are measured. What is the relative humidity and the dew point if the wet bulb temperature is 16°C and the dry bulb temperature is 28°C? (Show how you obtained the relative humidity and dew point from a psychometric chart or from calculations.) https://www.youtube.com/watch?v=H1kJttETOMo
b) Would the conditions of question "a" be good to evaporate 40°C solar heated seawater with 3.5% by weight NaCl? Calculate the equilibrium evaporated amount and the amount of brine and the salt content of the brine that would result from 10,000 liters of sea water. How would this differ with a dry bulb temperature of 32°C? (You need the vapor pressure of sea water as a function of salt content which changes as you evaporate.)
    1) Given $T_{wet\ bulb}$, $T_{dry\ bulb}$ get RH, T_{dew}, and g/kg water/air from psychometric chart (this is part a)
    2) Use equation 6 from the Nayar paper (attached) to get the $P_{v,w}$ at $T_{dry\ bulb}$
    3) Calculate $P_{v,sw}$ at 40°C for various S values from equation 5 of Nayar paper (attached) until it equals the value of $P_{v,w}$ from "2)". This is your brine concentration. (you could use "solver" in Excel to do this or trial and error or just solve the equation)
    4) Do a mass balance on water and salt to find the amount of brine and the amount of evaporated water that you produce if you can reach equilibrium.
    5) Repeat for the second dry bulb temperature and compare results.
c) If the humid air produced from the second part of "b" were condensed using a condenser cooled to 15°C by sea water what fraction of the water would condense at equilibrium? Assume 85% relative humidity after evaporating the seawater and a dry bulb temperature of 20°C due to evaporative cooling.
    1) Determine the amount of water in the humid air g/kg using the psychometric chart
    2) Determine the amount of water that air at 15°C and 100% humidity can hold
    3) Find the difference doing a mass balance based on 1 kilogram of air and take the ratio to find the weight percent of the humidity (water content) that is condensed.
d) *Al-Ismaili AM, Jayasuria H, Seawater greenhouse in Oman: A sustainable technique for freshwater conservation and production* Ren. Sus. Eng. Rev. **54** 643-664 (2012) review the seawater greenhouse technology. Explain how their facility works and how it differs from questions "a" to "c".
e) Akinaga T, Generalis SC, Paton C, Igobo ON, Davies PA, *Brine utilisation for cooling and salt production in wind-driven seawater greenhouses: Design and modelling* Desalination **426** 135-154 (2018) describe the use of seawater greenhouses to deal with brine from desalinization plants. Describe the process that they outline.