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Optimum Seawater Depth in Modified Solar Still Using Vertical Flax Porous Media

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***Abstract*— The world need for portable water is continuously growing because of industrial population and agricultural growth. Solar still is available device that can be used for desalination of brackish and saltwater for drinking purposes. In this work, we study the investigation of the influence of change of depth of saline water inside basin of single slope solar still under the weather condition of south valley university, faculty of engineering, Qena, Egypt (Latitude:26.15878°, Longitude:32.71081°). And tested at real day time 8A.M to 6P.M on different five days from 20/8/2019 to24/8/2019, for different five water depths (0.5,1,2,3, and 5cm), and used vertical flax porous media to enhance the performance of solar still. Result showed that the freshwater productivity at depth of water 0.5cm higher than other depths (1,2,3,5cm). In addition, maximum productivity of freshwater for simple model and modification model 3480 and 4600 ml/m2/day respectively.**

***Keywords*— solar still, desalination, depth of water.**

I. Introduction

Water scarcity has become a major constraint to economic development and threat to livelihood in increasing parts of the world. Since the late 1980s, water scarcity research has attracted much political and public attention(Junguo Liu, Pfister et al. 2017). As the demand increases, so too does the importance of water. This is clearly the case in Egypt, where rainfall is rare and the governmentally enforced quota for withdrawal from the Nile River has not changed since 1959. The water demand has multiplied as a result of population growth, agricultural expansion, as well as industrial development and a rise in the standard of living(Allam 2007). Solar desalination is one of the options to produce fresh water from any type of contaminated water (brackish, contaminated and sea water) in a sustainable way. A solar still is a simple device used to purify the water using solar energy through evaporation and condensation processes. In general, the productivity of the conventional single solar still (CSSS) is about 2–5 l/m²/day (T. Arunkumar and Li Xuan 2019). Table1 showed many studies done on solar still to improve the productivity. The most important study shows that the Glass–water temperature difference Increasing the difference in temperature between the glass cover and the basin water leads to an increase in the natural circulation of the air mass inside the solar still.(S.W. Sharshir 2016).

II. EXPERIMENTAL SET UP

A. *Principle of solar distillation*

A basin of solar still has a thin layer of water, a transparent Glass cover that cover the basin and channel for collecting

Table 1 summary of the mentioned studies in the review of brine depth effect

Author(s)	Productivity	Type of still	Brine depth range	Location	Data of test
(M.K. Phadatare 2007)	2.1 L/m2/day At depth 2 cm	SSSS plastic solar still	2:12cm	India	6-20/1/2200 6
(Rahul Dev 2011)	6.302, 5.576 and 4.299 kg/m2-day	inverted absorber solar still (IASS)	0.01, 0.02 and 0.03 m	Muscat, Oman (23370N latitude, 58350E longitude)	July 2009.
(M.R. Rajamanic kam 2012)	3.07 L/m2/day at depth 0.01m	single basin double slope (DS) solar still	0.01m, 0.025m, 0.05m and 0.075m	Annamalai University, India	11.02.2011 to 19.02.2011
(T.Elango 2015)	double basin insulated and un-insulated stills gave 17.38% and 8.12% higher production than the single basin still	Single and double basin double slope solar stills	1 cm	National Engineerin g College, Kovilpatti (9° 11′ N, 77° 52′ E) Tamil Nadu, India	March–April 2014
(A.E. Kabeela and Hitesh Panchal 2019)	Productivity of absorber plate with and without coating was found to be 6.6 and 6.2 kg/m2 respectively at 1 cm water depth	TiO2 nano black paint coated pyramid solar still	varied from 1 cm till 3.5 cm on a basin	under the climatic condition of Chennai. S.A. Engineerin g College	February2 018
(Rajesh Trioathi 2005)	Yield decrease with increase water depth	Active solar still coupled with flat plate collector	0.05m, 0.1m and 0.15m		
(Hamed Taghvaei 2015)	Decreasing the brine depth reduced both the production and efficiency of active solar stills	Active solar still coupled with flat plate collector	10,8.5 7,5.5 4 cm	latitude of 29°37′N and longitude of 52°32′E in southern Iran.	September
(Abd Elnaby Kabeel, Ravishank ar Sathyamu rthy et al. 2019)	CSS-ISS, ISS, and CSS were 6.2, 5.04, and 4.24 kg,	convention al solar still integrated with inclined solar still	0.02m and 0.04m	…………	………….

The distillate water from solar still. The glass transmits the sun rays through it and saline water in the basin or solar still is heated by solar radiation which passes through the glass cover and absorbed by the bottom of the solar still. In a solar still, the temperature difference between the water and glass cover is the driving force of the pure water yield. It influences the rate of evaporation from the surface of the water within the basin flowing towards condensing cover. Vapor flows upwards from the hot water and condense. This condensate water is collected through a channel(Naga Sarada Somanchi and Sai Phanindra Dinesh Kakarlamudi 2015).

B. Distillation unit

Two identical unit, model (A) represent solar still with flax porous media and model (B) represent solar still without flax, as shown in figure (1.2). Solar still consists of a metallic box having four sides. These sides are made of steel sheet, 2 mm thick. The base of each unit is painted black to increase the solar absorptivity. The outside walls and the base of each unit are insulated with glass wool, 4 cm thick. The condensing surface in each still unit is a glass cover, 5 mm thick with angle 26°. The glass covers of each still box is adjusted on the edge of the rectangular sides. Silicon rubber sealant is used to prevent leakage from any gap between the glass covers and still box. A collection trough is used for each still box to collect the condensed water. The amount of distilled water is measured at hourly intervals.

Figure 1Photographic view of the stills. (A) solar still with flax and (B) without flax porous media.

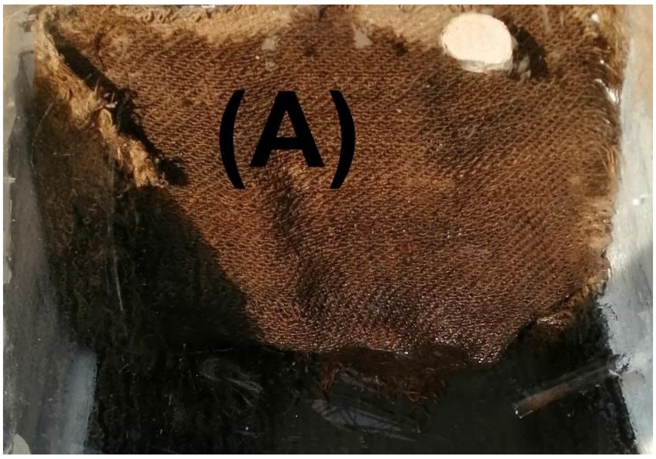

Figure 2 photographic view of flax porous media

C. Instrumentation

Water, glass, outside air temperatures and solar radiation are measure by following instruments in table 2.

Table 2 insrtruments properties of the experimental test.

S.NO	instrument	Manufacturer/model	Range	Error	Accuracy
1	Thermocouple	K-type	0-1000°C	±0.4 %	±1.1ºC
2	Data recorder	Multi Con	16 port	…… …… …..	………… ……..
3	Digital pyranometer	Kipp & Zonen CM4	0-4000 w/m²	±0.93 %	±20 w/m²
4	Beaker	PLASTI BRAND Germany	0-200ml	±0.12 %	±0.1ml
5	Total dissolved solid meter	China	0-9990 ppm	±2%	±10 ppm

III. RESULTS AND DISCUSSION

The ambient, glass, water temperatures and solar radiation it has a big role in the solar still performance. Fig.3 shows variation solar radiation for five days of tests from 20/8/2019 to 24/8/2019 and recorded that the maximum solar radiation 947,926,908,1004W/m^2 ºC, respectively. Fig.4 shows variation of ambient air temperature (Ta) also for same day test. And recorded the maximum air temperature for five-day test 41,42,37,38,44ºC. Fig.5 shows the variation of water temperature (Tw) during all experiments and observed that water temperature in case 0.5 cm depth of basin water higher than other (5,3,2,1) cm that because the amount of water less and need less latent heat energy to evaporation the water. In case 5cm and 3cm depth of basin water tests, observed that through Interval time 2:00pm to 6:00pm the water temperature at experiment of 0.5cm and 1cm is less than 5cm and 3cm that because thermal energy storage inside the body of solar still and also inside water that energy release during the disappearance of the sun. Fig.6 shows the relationship in case modification model (solar still with flax) between glass, water and porous media (flax) temperature during 24/8/2019 where depth of basin water 0.5cm. Fig.7 shows the relationship between glass and water temperature in case simple model (solar still without flax). In fig.6 it is observed that glass temperature higher than water that blocked and reversed the vapor circulation inside still and reduce the productivity of fresh water, using flax porous media that help and can solve this problem. In fig.6 observed that water temperature higher than the glass temperature at almost time period that because the effect of wet flax help to decrease the glass temperature to make natural circulation of vapor to increase the condensation lead to increase the productivity. From fig. (6.7) we can say that glass, water temperature it´s important parameter solar still Depended on it, increasing the difference in temperature between the glass cover and the basin water lead to an increase in the natural circulation of the air mass inside the solar still.

Fig.8 shows the relationship between time in hours and accumulated productivity in ml in all test days at modification model and observed that the accumulated productivity at 0.5cm depth of water test higher than others (5,3,2,1cm) depth of water tests. That because the latent heat of vaporization in case 0.5cm it´s less than others that make evaporation higher leading to higher productivity. The maximum accumulated productivity recorded for modification model and simple model at depth of water0.5cm it´s 4600 ml. Fig.9 shows also the relationship accumulated productivity of fresh water and time in case simple model. And observed that the maximum productivity at 0.5cm depth of water it´s 3480 ml.

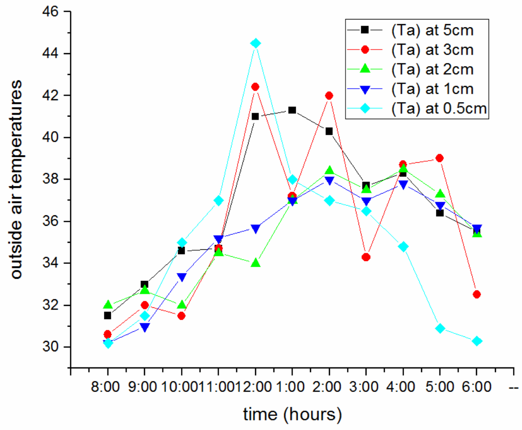

Figure 4variation of air temperature at all experiments.

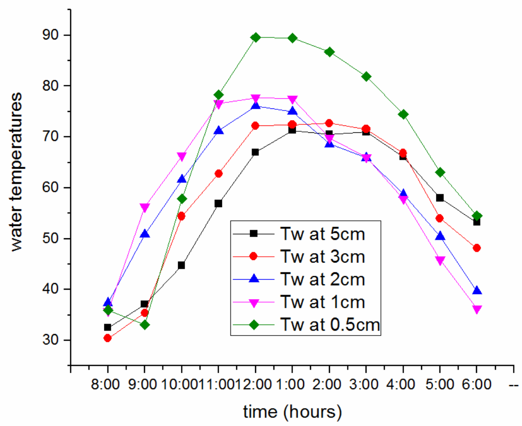

Figure 5variation of water temperature at all experiments.

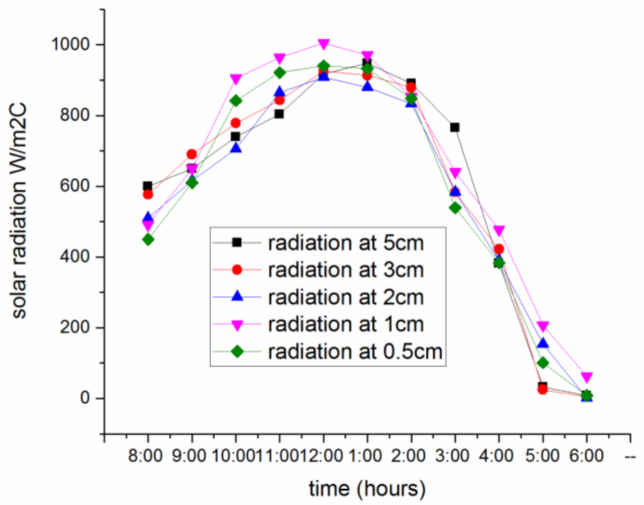

Figure 3variation of solar radiation at all experiments.

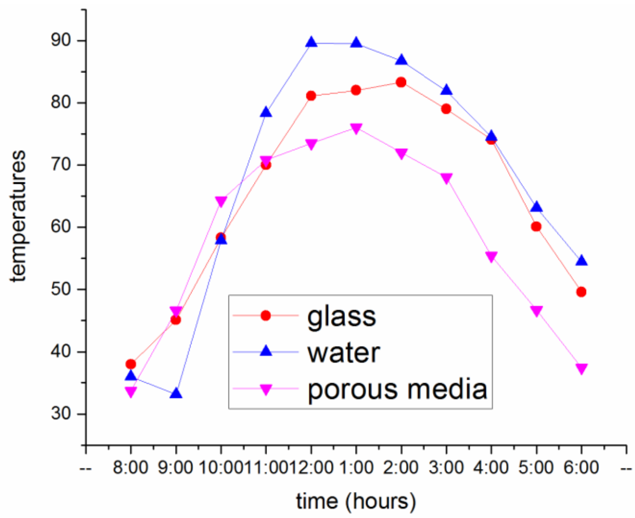

Figure 6 relationship between glass ,water ,porous media temperature at 0.5cm depth of water.

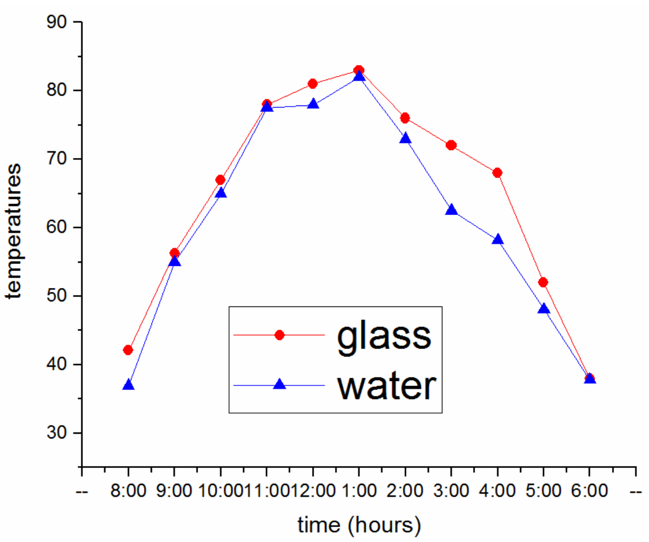

Figure 7 Relationship between water, glass temperature at 0.5cm depth of water.

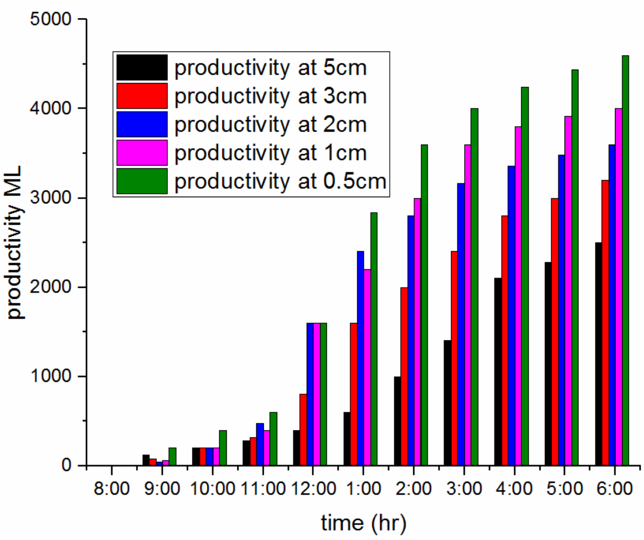

Figure 8 variation of time in hour with accumulated productivity at modification model.

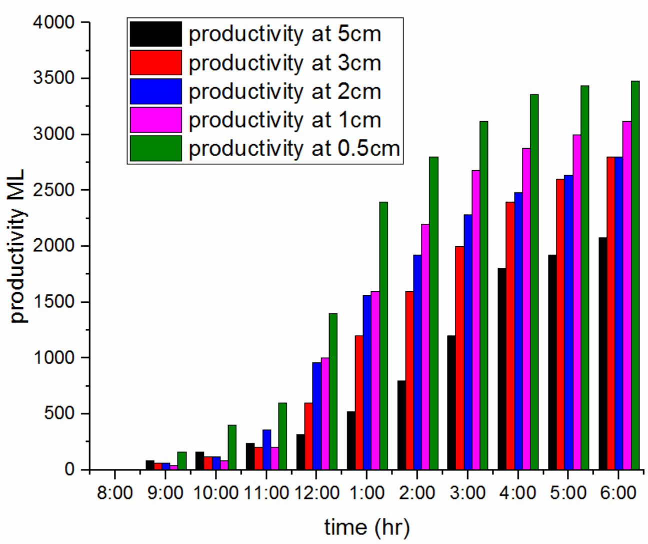

Figure 9 variation of time in hour and accumulated productivity at simple model.

IV. CONCLUSION

In the present study a single slope solar still is experimentally analyzed on the performance with flax porous media solar still with conventional one and tested for Qena Egypt climatic condition. accumulated yield per unit meter square are of solar still with and without flax porous media under a constant water depth of 0.5 cm within the basin were observed as 4600 and 3480 ml respectively. And resulted shown that productivity at depth 0.5cm higher than other depths (1.2.3.5cm) where total dissolved solids 110ppm. The use of porous material has provided the difference in glass and water temperatures resulting in increased productivity.

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