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New design of the stepped solar still

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Abstract

This research a stepped solar still has been constructed and its performance has been evaluated under different atmospheric circumstances of Basra city(Iraq) (Latitude 30° 33' 56.55"N, Longitude 47° 45' 5.86"E) . The still has consists of a basin with area of (0.075 m^2) which divided into three basins , area of each basin is(0.025 m^2) and provide each basin by reflector (mirrors) area of each one is (0.025 m^2), the internal reflectors help to concentrate the sun ray on the basins to increase the productivity of the distilling water(fresh water). The stepped solar still inclined at an angle of (15^o), The maximum efficiency of the experimental still varies from (40.6% -75%).

Key words :Water, Saline Water, Solar Still, Stepped Solar Still, Desalination.

1.Introduction

Water is considered one of the prime elements responsible for life on earth. It covers three-fourths of the surface of the earth[1].

Saline water (brackish water) represents very high percentage of the total water on the surface of the earth, (97% - 97.5%), and the rest is fresh water (3% - 2.5%), so the fresh water which is available for use is very small fraction [2-7].

The remote arid warm places in the Middle East and North Africa and other regions in the world are suffering a sharp shortage of fresh water. These regions are characterized by high salinity of ground water, lack of rains and a good solar energy in Iraq (specific Basra). It is an international problem and the best solution, is the use of solar energy for desalination of salt water[8].

Solar stills can be the best suitable units to be used as low-capacity and self-reliance water supply systems, since they can produce pure water by using solar energy only[9].in Iraq (specific Basra)

Radhwan, study the transient analysis of a stepped solar still for heating and humidifying agriculture greenhouses, the experimental efficiency of the still in study was 63% with (4.92 L/m^2) total daily production [10].

H. Tanaka and Y. Nakatake, study the increase in distillate productivity by inclining the flat plate external reflector of a tilted-wick solar still in winter, the daily amount of distillate of a still with an inclined reflector would be about 15% or 27% greater than that with a vertical reflector when the reflector's length is half of or the same as the still's length[11].

2.Experimental set-up

A stepped solar still has been constructed and its performance has been evaluated under different atmospheric circumstances of Basra city(Iraq) (Latitude 30° 33' 56.55''N, Longitude 47° 45' 5.86''E)

The still has been consists of a basin with area of (0.075 m^2) which divided into three basins , area of each basin is (0.025 m^2) , the three basins were manufacture from tinplate, and all of them linking with reflector (mirrors), area of each reflector is (0.025 m^2). The basin surfaces were painted with black paint to absorb a large amount of solar radiation incident on them, and the fig.(1) shows the diagram of the basin with mirror while fig. (2) shows a photograph picture of this basin.

The still consists from the glass walls with thickness of (3mm) ,a glass cover with the area of (1500cm^2).A plastic tube with (1cm) diameter was used to provide salt water to the still.

The distilled water was collected in special channel inside the solar still. The channel has width (5 cm), and outlet through plastic tube to the collecting flask.

The base of the still was insulated with pieces of wood (wood block) with thickness of (1 cm) to avoid the thermal losses to the external ambient, proved the basins on the base by silicon rubber .The solar still inclined at an angle of (15^o) and orientation of the solar still to the geographic south direction for to get a longer period of solar radiation [12] .Fig. (3) shows the schematic diagram of stepped solar distilled and figure (4) shows a photograph picture of this still.

The experiments on the stills were carried out during some days of (February, March, , April, May, and June 2012) to study their performance under different field conditions. During each experiment, the hourly amount of extracted distilled water and the total daily amount of distillate water were recorded.

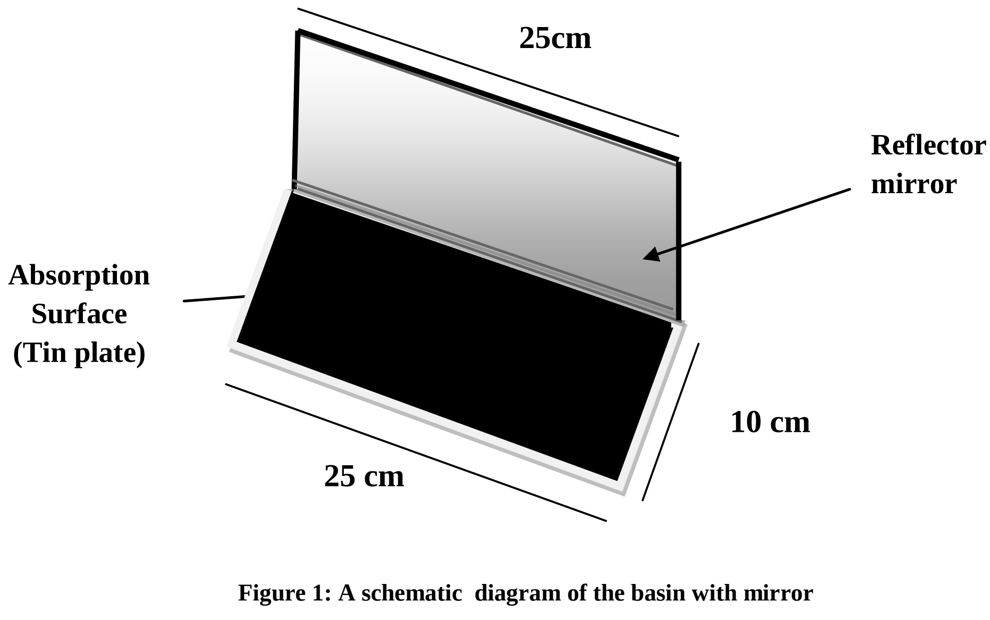

Figure 1: A schematic diagram of the basin with mirror

Figure 2: A photographic picture of the basin

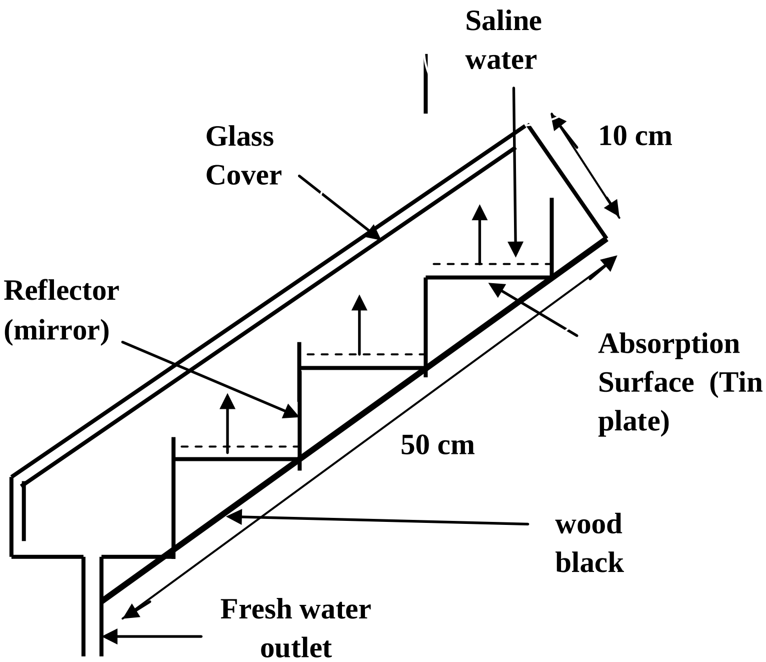

Figure 3: A schematic diagram of the Stepped Solar Still (SSS)

Figure 4: A photographic picture of the Stepped Solar Still (SSS)

3.Results and discussion

Figure (5) show the daily production of distilled water of the stepped solar still with the solar radiation through some days of (February to June 2012), this figure shows that the daily production has a maximum value arrived to (8004 ml/m^2)for the day (22/4/2012)where the sky is clear (there is no dust) ,where the production of the solar still has been depending on the intensity of solar radiation ,while the less value of production is (5002 ml/m^2)for the day of (21/2/2012) where the sky is not clear but partly cloudy and the weather contains some dust storms, and the figure (6) shows the relation between the daily productivity and the solar radiation.

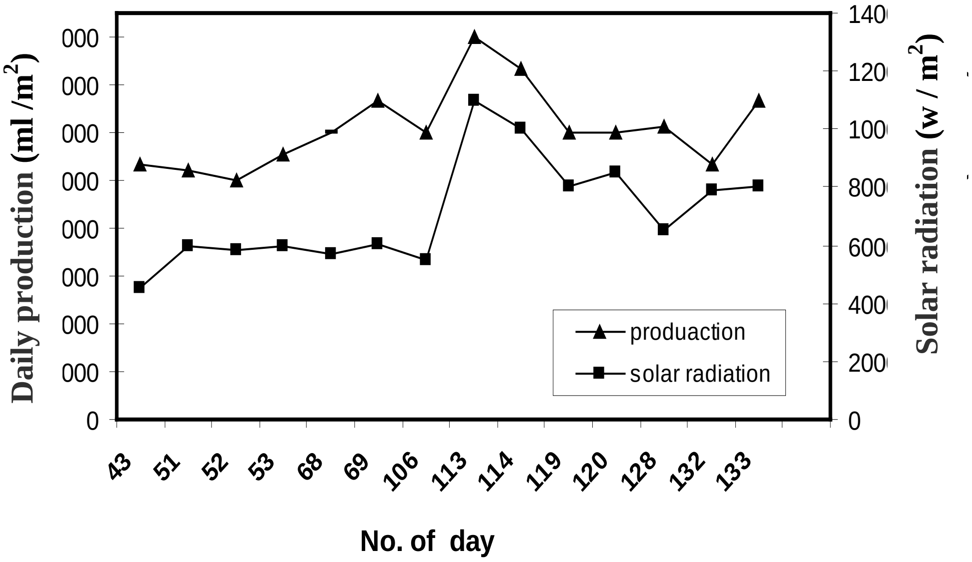

Figure 5: Daily production of the solar still with the solar radiation through some days of (February to June 2012)

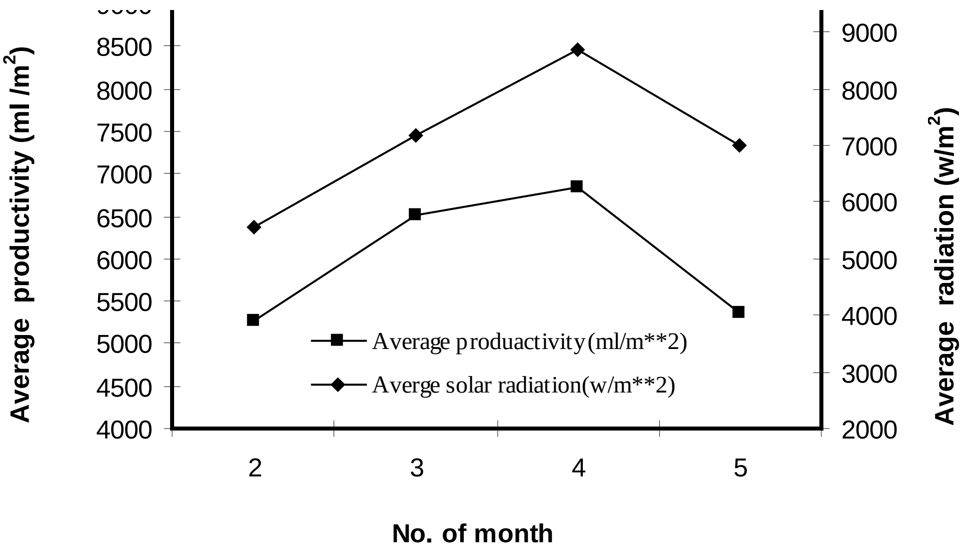

Figure 6: Relation between the average productivity and the average solar radiation.

The results shown in fig. (6) indicate that still has the same behaviour and the variation in its productivity from one month to another due to the variation in the solar radiation, the high rate of productivity solar still has been in the month (April) arrived to (6863 ml/m^2),when value of the solar radiation to(8675 W/m^2),while the less rate of productivity solar still has been in the month (February) arrived to(5268 ml/m^2),when value of the solar radiation to (5570 W/m^2), where the productivity of the solar still has been depending on the intensity of solar radiation.

Fig.(7) shows the hourly production of distilled water of the solar still in the day (19/5/2012), where the sky is clear and the absence of dust . A maximum of the production of the solar still is at midday while a lower one is at the beginning and the end of the day, the maximum value production arrived to (947 ml/m2) in the hour (13 pm) while the lower value arrived to (200 ml/m2) in the hour (18 pm).

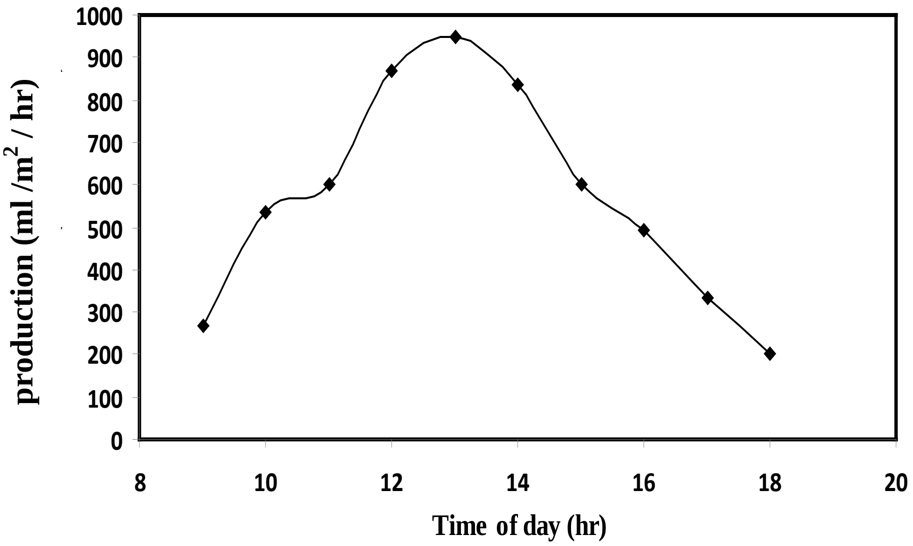

Figure 7: The hourly production of the solar still in the day ((19/5/2012).

The distance between the basin and the glass cover of the stepped solar still has been (5cm) , then the distance was increased to (10cm) and (15cm), the three stills have been operated in the same conditions for the period time from (1 July 2012) to(5 July 2012). The results are shown in fig. (8).

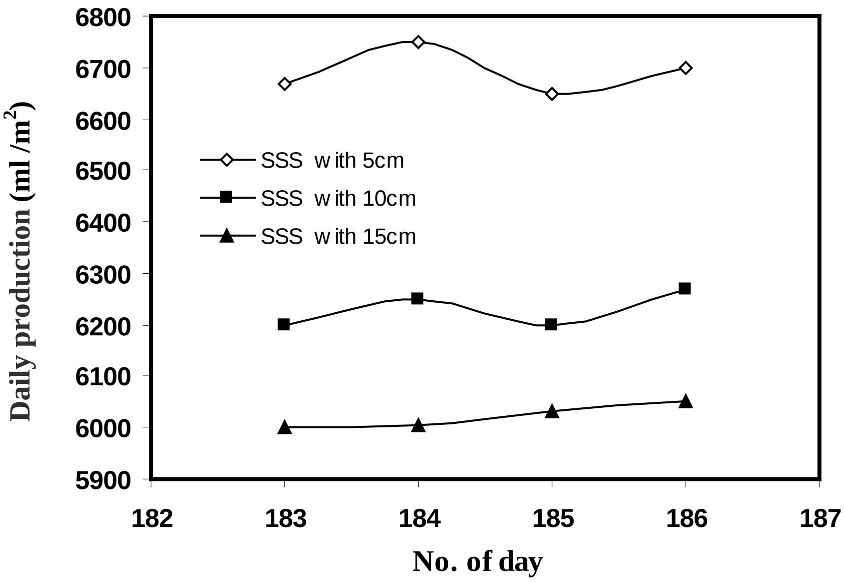

Figure 8: Daily production of the solar still (with the 5,10,15 cm) for some days of (July 2012).

The results shown in figure (8) indicate that all stills have the same behaviour . However, its clear that the solar still (SSS with 5cm) has the best productivity, due to the less losses in the condensing water on the inner surface of the glass where these losses are observed in other devices. The maximum value of the daily production arrived to (6750 ml/m^2) for the (SSS with 5cm),while the maximum value of the daily production arrived to (6270 ml/m^2) for the (SSS with 10cm) and the maximum value of the daily production arrived to (6050 ml/m^2) for the (SSS with 15cm).

The thermal efficiency (E) of the still was calculated for the some days using the following equation [13] .

$$E_{bsn} = \frac{P \times \mathrm{L}}{\mathrm{I} \times \mathrm{A_b}}$$

Where:

E_{bsn}**:** Thermal efficiency.

P**:** Daily output of distilled water.

L**:** Latent heat of water evaporation (KJ / Kg).

I**:** Daily solar radiation (W / m^2. day).

A_b**:** Area of the basin if the still (m^2).

Figure (9) shows the thermal efficiency (E) for the stepped solar still through some days of (February to June 2012) , the maximum for the thermal efficiency arrived to (75 %) while a less value(45.6 %).

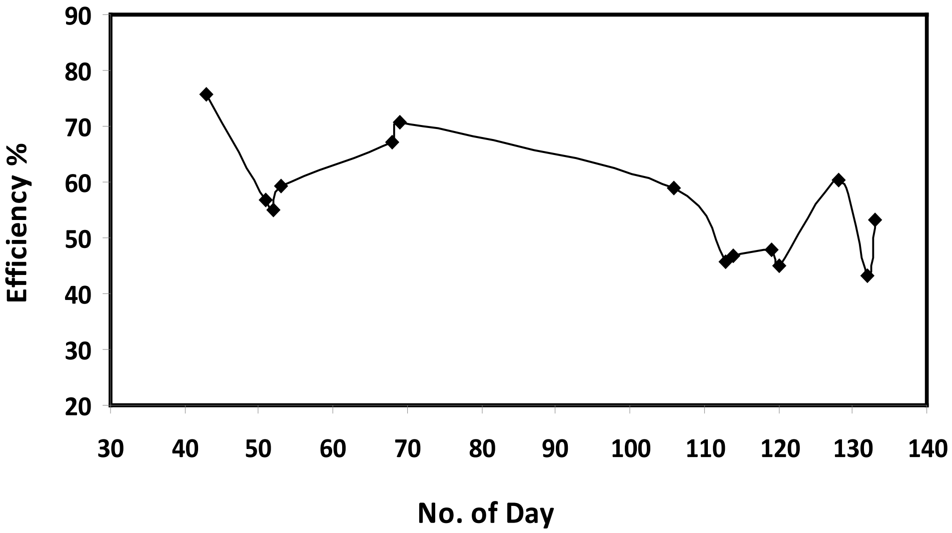

Figure 8: Thermal efficiency of the solar still through some days of (February to June 2012).

conclusions

The main observations and conclusions that can be obtained from the results of this work are the following:

1. The largest part of distillate production was seen to take place between noon and sunset, where the productivity was increased with the increase of solar radiation.
2. The high distillate production of the a stepped solar stills occurred in April, which was related to the high incident solar radiation.
3. The monthly average of distillate production of the stepped solar still has the same behaviour and the variation in its productivity from one month to another due to the variation in the solar radiation and the other metrological factors like clouds.
4. The maximum of the thermal efficiency arrived to(75 %) , while a less value is(45.6 %).
5. The (SSS) with a distance of (5cm) between the basin and glass cover has a best productivity in comparison with the other stills with (10 and 15 cm) .

Reference

[1] A.E. Kabeel , A. Khalil , Z.M. Omara and M.M. Younes, , Desalination 289 (2012) 12–20.
[2] H.T. El-Dessouky and H. M. Ettouney, "Fundamentals of Salt Water Desalination", Dep. of Chemical Engineering , College of Engineering and Petroleum , Kuwait University, Printed in The Netherlands, 1st edition 2002
[3] K.Soteris , Applied Energy 60 (1998) 65-88 .
[4] S.P.Bindra and W.Abosh, Desalination 136 (2001) 49– 56.
[5] E.Kuusisto , " World water resources and problems ", part four , p (153) , Hydrologist, Finnish Environment Institute (SYKE),lectures given by the author on 26 August 2004.
[6] V.Velmurugana and K. Srithar , Desalination 216 (2007) 232–241.
[7] I.Mahamud ,"Prospects of Water Desalination in the Gaza Strip", TRITA-LW MSC. Dep. of Land and Water Resources Engineering, Royal Institute of Technology, Stockholm 2003.
[8] H.M.Qiblawey and B.Fawzi, Desalination 220 (2008) 633–644.
[9] A.Tiwari and G.N. Tiwari, Desalination 207 (2007) 184–204.
[10] Abdulhaiy M. Radhwan, Desalination 16 1 (2004) 89-97 .
[11] H.Tanaka and Y.Nakatate, Solar Energy 83 (2009) 785–789.
[12] A. J. Mohammed," Study the effect of reflector and mirrors on solar still efficiency", M.Sc.Thesis, Iraq, Basrah University,2010.
[13] J.M.Al-Asadi, N.A.Abdullah and A.J.Mohammed, Journal of the Science of Dhi Qar 3(2012) 77-83.

التصميم الجديد للمقطر الشمسي السلمي

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المستخلص:

في هذا البحث تم بناء مقطر شمسي سلمي تحت الظروف الجوية لمدينة البصرة (العراق)الواقعة على (خط عرض 56.55"N '33 °30 ، خط طول 5.86"E '45 °47) ، يتكون المقطر من حوض مساحته ($0.075\ m^2$) مقسم إلى ثلاثة أحواض مساحة كل حوض ($0.025\ m^2$)، وكل حوض مرتبط بعاكس (مرايا) مساحة العاكس هي ($0.025\ m^2$) . يعمل العاكس الداخلي على تركيز أشعة الشمس على أحواض المقطر الشمسي لزيادة إنتاجية الماء المقطر (الماء العذب) . يميل المقطر الشمسي بزاوية مقدارها (15^o) ،وكانت كفاءة المقطر الشمسي التي تم الحصول عليها تتفاوت بين (45.6 % – 75 %).