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EXPERIMENTAL INVESTIGATION ON SINGLE BASIN AND DOUBLE BASIN SOLAR DESALINATION

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ABSTRACT

The present investigation is required to make a contribution towards the global efforts in addressing the shortage of clean water supply in many areas of the world. In this context, the aim of the present investigation is to develop a solar still that would assist in increasing the availability of clean water in remote and isolated areas. To achieve this goal, a double basin double slope and single basin slope stills are fabricated and installed. The experiments were carried out in actual solar condition with different depth of water and wick materials. The performance of the still was studied with different depth of water, different wick materials (jute cloth and waste cotton pieces), Porous material (clay pot) and energy storing material (mild steel pieces).

Key words: Double basin double slope, Single basin slope, Solar Still.

INTRODUCTION

The water and the energy are the two most essential things for the sustaining of life. Both are to be conserved and preserved for the sustainable development of the world. There is an acute shortage of both energy and water. Water and civilization are the two inseparable things. Water is a nature's gift but around 97% of the water in the world is in the ocean, approximately 2% of the water in the world is at present stored as ice in polar region, and 1% is fresh water available for the need of the plants, animals and human life. The left over 1% water is available in rivers, lakes and underground reservoirs. This ground water has also

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been polluted due to industrial, agricultural and population growth during the current years. All ecosystems and every field of human activity depend on clean water and it is one of the most precious resources in today's world. Water is a primary need of the life, health and sanitation and is the most important issue on the international agenda. It is the most abundant and important substance in nature.

EXPERIMENTAL

Solar still construction materials

Transparent cover

The most influential property of a transparent material needed in solar technology is transmittance. Clear glass has transmission values of 88- 92% at normal incidence (Duffie, 1962; Greenwald and McHugh, 1985). A glass cover is fitted on the top part of the evaporator unit to allow solar radiation to reach saline water in basin placed under the cover. One or more transparent covers can be used with an air gap between them to reduce heat losses from the top of the evaporator. Multiple glazing reduces top heat loss significantly which leads to high temperatures of the glazing and a decrease in the rate of evaporation-condensation. Thus, single glazing is commonly used for solar distillation systems (Tleimat and Howe, 1969; Phadatare and Verma, 2007; Dev and Tiwari, 2009). Therefore clear window glass (4 mm thickness) is selected as a transparent cover material.

Basin material

Upper basin

Upper basin is an additional area to increase the evaporation rate. The work of the upper basin is to contain the water for evaporation as well as transfer the radiation to lower basin. Therefore, the material should be transparent. Therefore, 5 mm clear window glass is selected as upper basin material. Silicon glue is used to fix the glasses.

Lower basin

Solar radiation that passes through the transparent cover is absorbed by saline water and the basin liner of a solar still. So, the basin liner acts as an absorber of solar radiation and it is important for the liner to have a relatively high absorptance for solar radiation (Duffie, 1962). In practical applications, basin liners can be made of plastic or metal-sheet (Cooper and Ready, 1974; Mowla and Karimi, 1995). Some plastics are relatively cheap while others are expensive (Köhl et al., 2005). Common metal sheets applied in solar collection are copper, aluminum and steel (Martin and Goswami, 2005). The important property of a metal for application in solar engineering is thermal conductivity. Copper and aluminum have relatively high thermal conductivities (k = 200 $Wm^{-1} K^{-1}$ for aluminum and k = 390 $Wm^{-1}K^{-1}$ for copper) while the thermal conductivity of steel is relatively low (k = 48 $Wm^{-1}K^{-1}$). Nevertheless, copper and aluminum are more expensive (more than two times the cost of galvanized steel). With these considerations, black coated steel plate is selected for increase its solar absorption.

Insulation

Heat loss from the bottom and sides of a solar still is undesirable because it reduces distillate yield. Consequently, it is necessary to minimize this loss by insulating the relevant surfaces. This enables most of the absorbed solar radiation to contribute to the evaporation of saline water and thereby augment the distillate yield. The most important property of an insulator is the coefficient of heat conduction (k). Materials with low values of k are suitable for use as insulators due to their relatively high resistance to flow of heat. Glass wool and thermo cool contain low conductivity and low cost. Therefore thermocol is chosen as insulating material.

Fig. 1: Single basin double slope

Fig. 2: Double basin double slope

RESULTS AND DISCUSSION

Comparison of experimental results

Fig. 3 shows the variation of solar radiation and wind velocity for a day on March 2015. It shows radiation reaches maximum around 1.00 PM and wind velocity is low in morning hours and increases at evening hours. Fig. 4. Compares the variation of different temperature of SB solar still experimentally (Exp) at 2 cm depth. Fig. 5 shows the variation of different temperature of DB solar still experimentally (Exp) at 2 cm depth. While comparing the experimental results of DB and SB still Fig. 6 and Fig. 5, respectively, it shows that the temperature of the basin is the maximum followed by the temperature of lower basin water that has been heated by the basin in convection Process to incident rays. Upper basin water receives more radiation than the lower basin, but the temperature is less than the lower basin water due to the low heat capacity of the upper basin. The water temperature was around 27°C at early mornings and reaching up to 67°C and 62°C as a maximum temperature for lower and upper basin respectively at 2.00 PM. In SB still maximum value of the basin and water was around 75°C and 74°C, respectively. It was 12°C higher than DB water temperature.

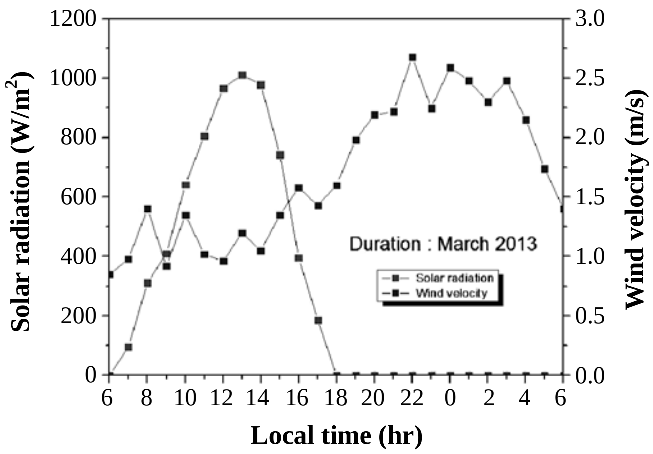

Fig. 3: Variation of solar radiation and wind velocity

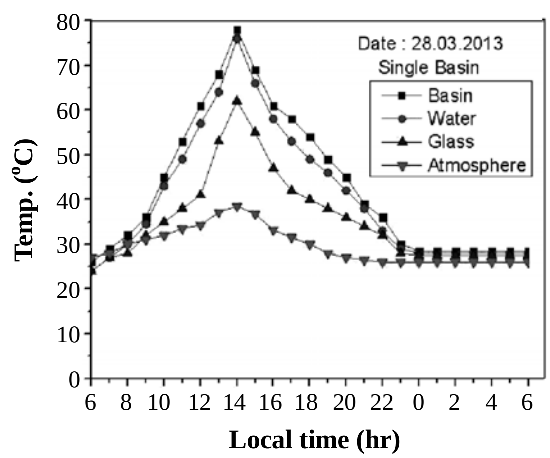

Fig. 4: Variations of temperatures in single basin still

Fig. 5 and 6 compare the variation of water temperature experimentally for DB and SB still respectively. Mass of water in upper basin was constant and small variation only occurred for all experiments. Therefore lower basin water temperature variation only considered in DB still. Also it was noted, experimentally water temperature slowly decreasing for the higher depths. While comparing the experimental results of DB and SB still Fig. 5 and 6, respectively, it can be seen that SB still water temperature is higher than the DB water temperature for all depth. The water temperature increasing in the still is depending upon the solar radiation reaching the basin of the still. In SB still single glass cover is available between the basin and atmosphere, so maximum radiation reaches the basin. In DB still, additional basin (upper basin) reduces the amount of radiation entering into the lower basin. Therefore, the temperature of water in the lower basin increases slowly.

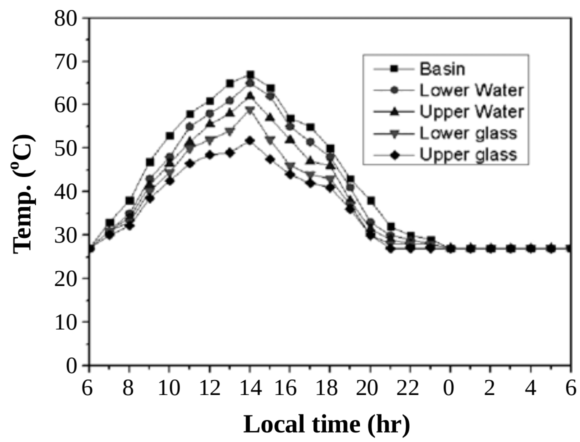

Fig. 5: Variation of water temperatures in single basin still

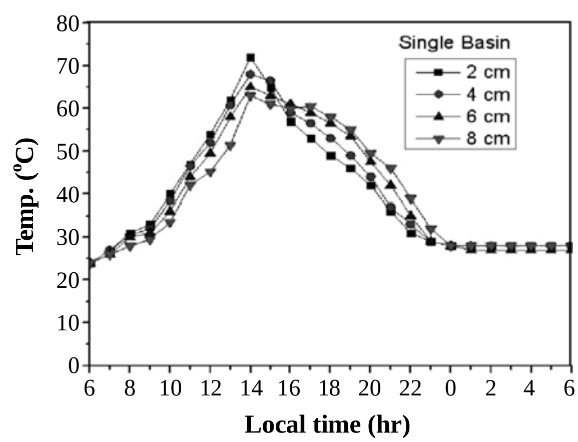

Fig. 6: In double basin still

Fig. 7 shows the experimental variations of different parameters in the single basin still with 2 cm depth of water in basin. It also shows variations of water and glass temperatures are proportional with production rate. The water–glass temperature difference reaches maximum during noon hours when the water temperature is around 70ºC and thereafter continuously decreases in single basin still. Fig. 8 shows the experimental variations of different parameters in the double basin still with 2 cm depth of water in basin. In double basin still upper basin water-glass temperature difference reaches maximum at 2.00 PM and lower basin difference reaches maximum at 3.00 PM. similar behaviors are observed for both stills with different basin conditions. The maximum water and glass temperature reached is inversely varying with the total heat capacity of the water and basin condition.

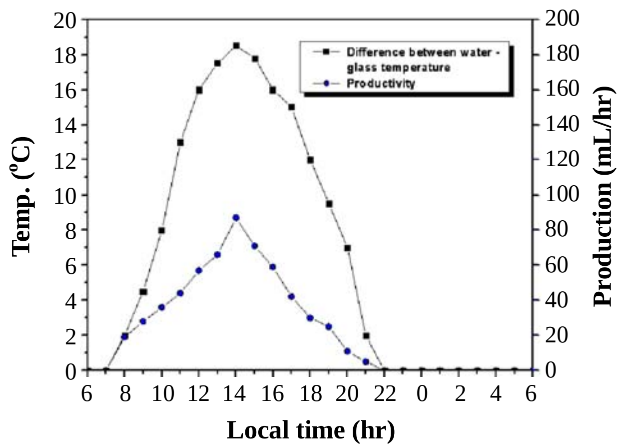

Fig. 7: Variation of different parameters in single basin still

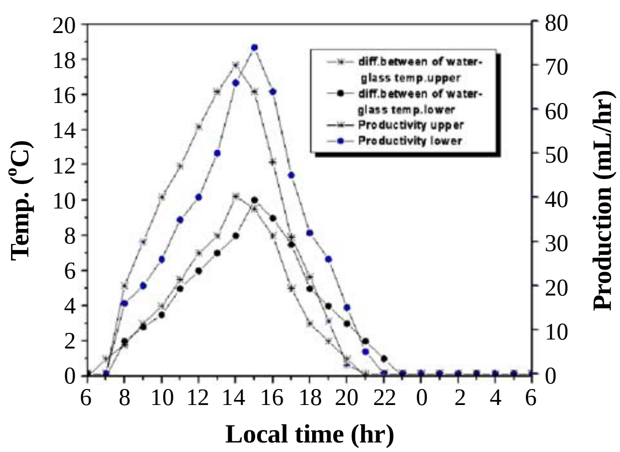

Fig. 8: In double basin still

Fig. 9 and 10 compare the cumulative production rate for SB and DB still experimentally. Compares the actual cumulative production rate variations of the DB and SB still, for different different depth in the basin. Like the production rate variations, the cumulative production was higher through the entire day for the still with lower depth of water in both stills.

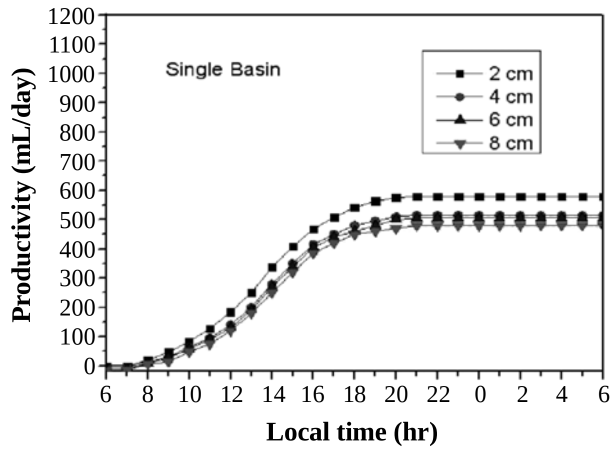

Fig. 9: Variation of production rate for different depths in single basin

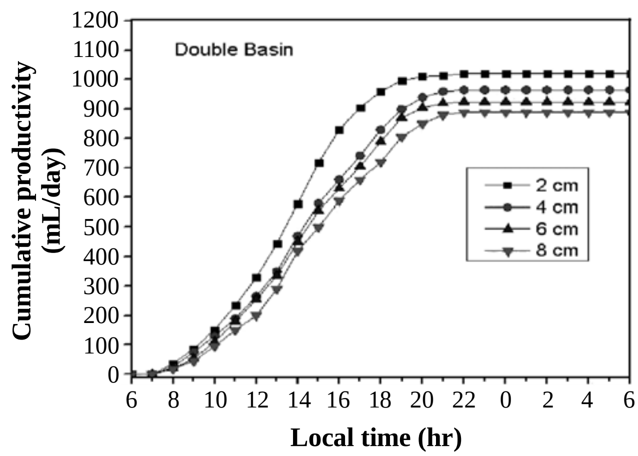

Fig. 10: in Double basin

Comparative analysis of still with different basin materials

From the above results, it is concluded that minimum mass of water increases the productivity. Therefore 2 cm depth of water used in the lower basin with different materials. Also the experiments were conducted in SB still and compared with DB still. The experiments have been conducted during May 2015 with actual solar condition. Different wick materials, porous material and energy storing material are used in the lower basin. Fig.

11 shows the photograph of different materials used in this study. The wick materials are fully spreaded in the lower basin along with water.

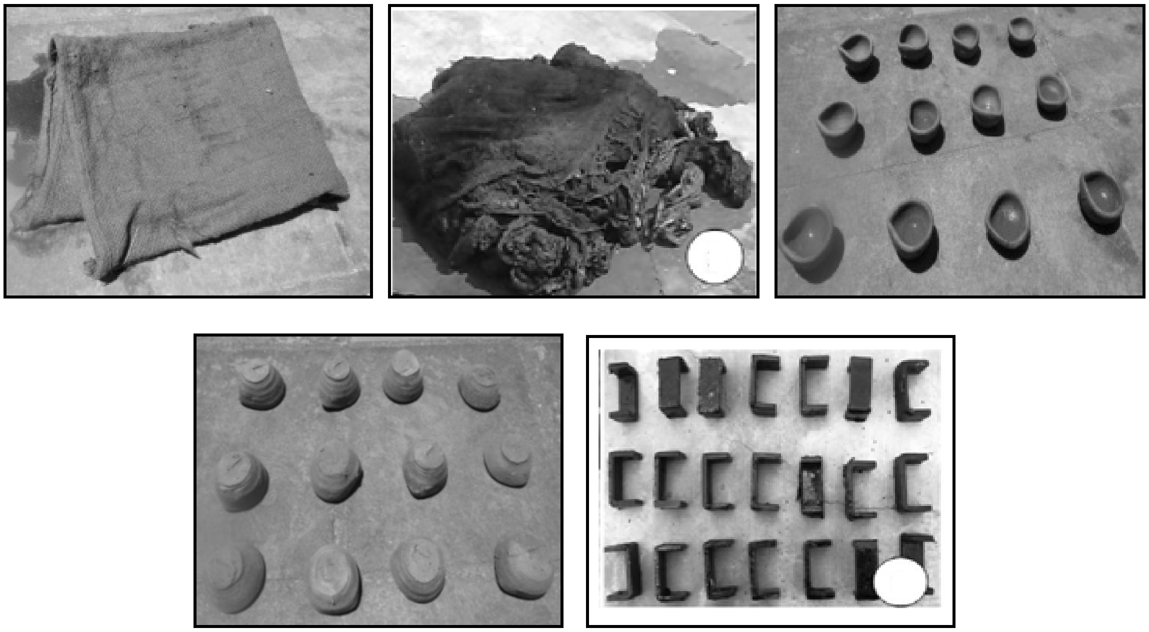

Fig. 11: Photographic view of materials used (1. Jute cloth, 2. Waste cotton pieces, 3. Clay pot – facing up, 4. Clay pot-facing down, 5. Mild steel pieces)

Fig. 12 and 13 shows the variation of different temperature of DB and SB solar still. The lower basin water temperature reaches the maximum values at this configuration. Since the water mass in lower basin is less and black cloth absorb more radiation. The basin temperature reaches maximum of 67ºC in DB still and 78ºC in SB still. So it is get heated and evaporated easily. While the mild steel pieces using in the basin, the water temperature increases slowly due to absorbing of heat by the material. At the same time, it releases the heat at evening and icreases the night production

Fig. 12 and 13 shows the cumulative production rate variations of the still, for different materials in the basin. Like the production rate variations, the cumulative production was higher through the entire day for the still with black cotton cloth in the basin than other materials. Clay pot was having higher production than mild steel pieces in morning hours. Clay pot contains minute holes; it leads to increases the production rate. Heat stored in the mild steel pieces releases in evening time and increases the productivity than any other materials and attained the higher overall productivity.

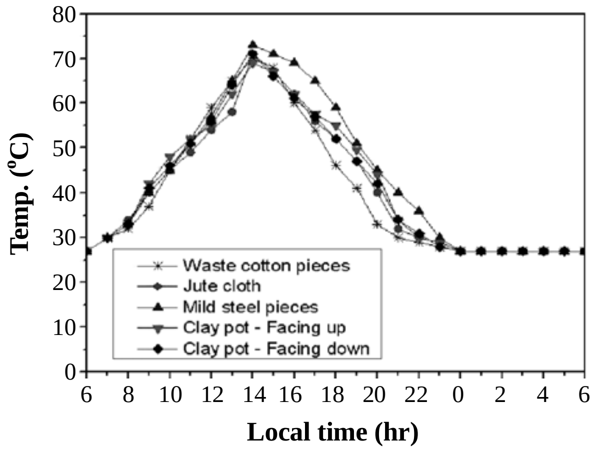

Fig. 12: Variation of water materials in single basin

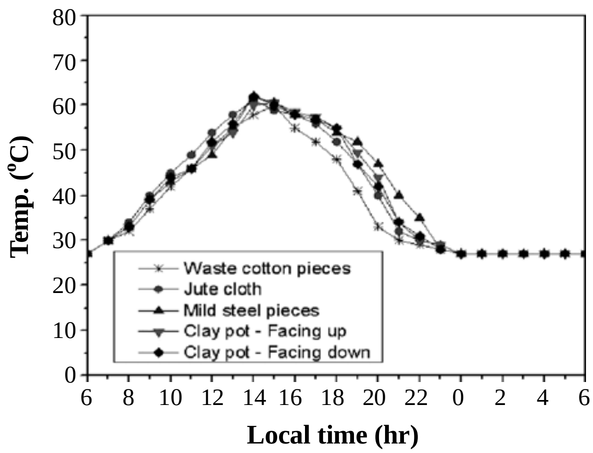

Fig. 13: In double basin temperature for different

Table 1: Compares the productivity of SB and DB still at different configuration

S. No.	Basin condition	Single basin		Double basin		% Increase (single basin still)
		(mL/day)	% Increase	(mL/day)	% Increase	
1	8 cm	480	ref	890	ref	85.42
2	6 cm	505	4.95	925	3.78	83.17
3	4 cm	515	6.80	965	7.77	87.38

Cont…

S. No.	Basin condition	Single basin		Double basin		% Increase (single basin still)
		(mL/day)	% Increase	(mL/day)	% Increase	
4	2 cm	580	17.24	1020	12.75	75.86
5	Clay pot (Facing down)	610	21.31	1040	14.42	70.49
6	Clay pot (Facing up)	635	24.41	1050	15.24	65.35
7	Waste cotton pieces	595	19.33	1045	14.83	75.63
8	Jute cloth	645	25.58	1135	21.59	75.97
9	Mild steel pieces	695	30.94	1220	27.05	75.54

CONCLUSION

From the experimental investigation we find that ,it Providing additional basin increases the total cost a little, but increases the distillate by huge The highest distillate production from both SB and DB solar still occurred with minimum depth (2 cm) of water in basin. It is also noted that, provision of wick or porous or energy storing material in the basin increases the distillate output. Especially for mild steel pieces in the basin gives maximum of 1 220 mL/0.25 m^2/day for DB still. The presents of additional basin increases the daily productivity around 75% than single basin still. The night productivity is improved with passive double basin as 49.2%

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