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ORIGINAL ARTICLE

Study on stepped type basin in a solar still

A. Alaudeen [a], **K. Johnson** [b], **P. Ganasundar** [b], **A. Syed Abuthahir** [c], **K. Srithar** [b],*

[a] *Department of Mechanical Engineering, Mohamed Sathak Polytechnic College, Kilakarai, Tamil Nadu 623 806, India*
[b] *Department of Mechanical Engineering, Thiagarajar College of Engineering, Madurai, Tamil Nadu 625 015, India*
[c] *Department of Mechanical Engineering, Pet Engineering College, Tirunelveli, Tamil Nadu 627 117, India*

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Abstract In this work a stepped solar still is used to enhance the productivity of the solar still. The concept of integrating the stepped solar still along with inclined flat plate collector is introduced in this research work. In this stepped type solar still, a conventional basin of area 1 m^2, was placed at the bottom. Another absorber plate, stepped type was fixed on the top of the conventional basin. It consists of subsequent trays and inclined flat plate collectors. This ensures an additional exposure area which augments the evaporation rate. Experiments were conducted with various depths in the conventional basin. A conventional still was fabricated and run parallel with the experimental set up for comparison. Sensible heat storage mediums such as rocks, pebbles were added to the top basin of stepped trays and bottom conventional basins to increase the temperature of water in the still. Wicks were placed on the inclined flat plate collector to augment the evaporation rate due to capillarity. A higher evaporation rate is obtained in the packing material with wicks and pebbles in tray combinations. Theoretical analysis was performed and it agrees with experimental values. Efficiency of the system was also compared with conventional solar still.

1. Introduction

Water is the one of the resources that is potentially useful to all living beings. Often water sources are brackish containing harmful bacteria and therefore cannot be used for drinking. Distillation is the one of the processes that can be used for water purification. Desalination refers to the process of removing salt and other minerals from water. Water is desalinated in order to convert salt water to fresh water which is suitable for human consumption or irrigation. Most of the research in desalination was focused on developing cost effective ways of providing fresh water for human use.

Various research works are being carried out to improve the performance of the still. The basin area of the still, free surface area of water, inlet temperature of water, wind velocity, solar radiation, depth are some of the factors that affect the productivity of the solar still. Experimental investigations have been done by Moustafa et al. (1979) on stepped solar still and wick type evaporator still and the efficiency of the still improved by reducing the radiation losses from the basin. A simple expression was derived by Gandhidasan (1983) to calculate

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* Corresponding author. Tel.: +91 9842185302; fax: +91 4522483427.
E-mail address: ponsathya@hotmail.com (K. Srithar).

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Nomenclature

English letters

A	area, m^2
C_p	specific heat, J/kg K
$I(t)$	solar flux on an inclined collector, W/m^2
p	partial pressure, Pa
Q	heat transfer rate, W
T	Temperature, °C
dt	time interval, s
h_{fg}	enthalpy of evaporation at T_w, J/kg
m	mass, kg
m_c	condensate, kg/m^2
U	side heat loss coefficient from basin to ambient, W/m^2 K
V	wind velocity, m/s

Greeks

ε	emissivity
α	absorptivity
ρ	density, kg/m^3
β	Collector surface inclination, °
σ	Stefan–Boltzmann constant, W/m^2 K^4

Subscripts

a	ambient
b	basin
c	convective
e	evaporative
g	glass
r	radiative
w	water
p	pebble
loss	side loss

the amount of water evaporated from the tilted solar still. The energy balance equations in terms of various heat transfer coefficients of the solar were discussed by Tiwari (2002). Double glass cover was used and studied by Zurigat and Abu-Arabi (2004). Modeling of the system along with performance analysis was also compared. Aybar et al. (2005) tested the absorber plate with black cloth, wick materials and the experimental results showed an increase in the fresh water generation rate by two to three times more than the conventional system. Abdel-Rehim and Lasheen (2007) used the oil heat exchanger to preheat the saline water inside the solar still and got 18% increase in productivity. Suleiman (2007) studied the effect of water depth on productivity and their experimental results showed that a higher productivity of 6.7 L/day was obtained for a low water depth. Velmurugan and Srithar (2007) used sponge cubes in the still and acquired 57.8% more yield than the conventional still. Dimri et al. (2008) have done theoretical and experimental analyses of a solar still with a flat plate collector with various condensing materials. Velmurugan et al. (2009a) worked with an industrial effluent in a fin type single solar still and a stepped solar still separately. The maximum output was found in the fin type solar still. Also Velmurugan et al. (2009b) used solar integrated along with solar still to enhance productivity. Many materials such as sponges, fins, wick and pebbles are added in the still and maximum 78% productivity was found for fin, sponge combinations.

A new design of a stepped solar desalination system with a flashing chamber was experimentally investigated by El-Zahaby et al. (2010). Effect of a spray system for sea water was investigated experimentally at different velocities. Kalidasa Murugavel et al. (2010) fabricated a still and tested it with different sensible heat storage materials like quartzite rock, red brick pieces, cement concrete pieces, washed stones and iron scraps. It was found that a inch quartzite rock is the effective sensible heat storage medium among the other materials.

Dev et al. (2011) fabricated an inverted absorber solar still and the experimentation was carried out for different water depths and total dissolved solids. Results were compared with the conventional single slope solar still. Kalidasa Murugavel and Srithar (2011) used different wick materials like light cotton cloth, sponge, coir mate, waste cotton pieces in a double slope solar still. Higher yield was obtained by using light black cotton cloth. Omara et al. (2013) made a comparison study between a modified stepped solar still with and without reflector and compared it with a conventional solar still. It was shown that about 20% of daily efficiency has been improved in the modified still.

The objective of this work is to increase the evaporation rate by means of providing a stepped tray type basin along with a conventional basin. It was shown in previous research works by the corresponding author, K. Srithar, that evaporation rate was substantially increased by means of placing the stepped solar still. In this work, in addition to stepped trays, subsequent inclined flat plate collectors are introduced. This will ensure more evaporation due to the lower depth in stepped trays and more exposure area by means of capillary action in the wicks placed on the flat plate collectors. Three small stepped trays sandwiched among three inclined flat plate collectors. Each set of trays has four small segments with a total area of 240 cm^2. There are three inclined flat plate collectors with an area of 60×70 cm^2, each was sandwiched among the trays. The saline water from storage tank got collected in the first tray. The excess water glided over the inclined flat plate collector and reached the second tray and so on. Finally, the pre heated saline water entered the conventional basin. As soon as a constant depth was reached in the conventional basin the supply was stopped. This procedure was repeated for every one hour. Little effect of evaporation from the conventional basin was experienced whereas high evaporation rates were observed from stepped type basin. In order to improve the area of exposure packing materials which consist of coconut coir, wooden chips, sand and coal were used in the inclined flat plate. To improve the capillary effect and thereby exposure area, sponges of various sizes were placed on the stepped trays and conventional basins. Sensible heat storage materials like rocks and pebbles were also used in stepped tray basin and conventional basin to increase the temperature of the saline water.

A conventional still was also running in parallel along with the stepped type solar still for drawing comparisons. Theoretical analyses were performed by solving the governing energy balance equations. The governing equations were solved by finite difference method using MAT-Lab software. Validations of theoretical and experimental results match well with each other.

2. Experimentation

The experimental setup is shown in Fig. 1. The setup comprises of a wooden box with an area of $1.1 \times 1.1\ \mathrm{m}^2$ and height 0.61 m in one end and 0.4 m at the other end. The gap of 0.2 m between the sides of the tray and wooden box is filled with saw dust. This will prevent the side loss of heat through conduction. Conventional basin of area $1\ \mathrm{m}^2$, is placed at the bottom of the still. Another absorber plate of stepped type is fixed on the conventional basin as shown in Fig. 1. Stepped solar still has subsequent trays and inclined flat plate collectors. The trays consist of four compartments having total area of $240\ \mathrm{cm}^2$. The trays are made of iron sheet with 2 mm thickness because of low cost and easy fabrication. Three inclined flat plate collectors of size $60 \times 70\ \mathrm{cm}^2$ each are sandwiched among the three trays. Wicks are placed on the inclined flat plate collectors to improve the evaporation rate by capillary action. A glass of 3 mm thickness and $1.1 \times 1.1\ \mathrm{m}^2$ area is fitted on the top to receive solar radiation. The glass cover is fitted with an angle of 11° and facing toward the south which is the latitude of Madurai, Tamilnadu, India. The water condensed on the glass surface is directed to be collected in the collection trough by a piece of glass gutter attached to the bottom of the glass. The storage tank with a capacity of 30 L supplies feed water through a pipe. A gate valve V_1 is provided at the inlet of the tank. A plastic drain tank is used to collect the impure brackish water from the basin. Value V_2 is connected between basin and the drain tank.

The saline water from storage tank entered the first tray stepped type basin. The excess water is overflowed to the subsequent trays through the inclined flat plate collector which connects the two trays. Since the flat plat collector is covered with wicks, the saline water wets the wick. Finally the excess water is collected in the conventional basin at the bottom. Copper-constantan thermocouples integrated with a temperature indicator and selector switch are used for measuring temperatures. Thermocouples are attached to the basin stepped trays, inclined flat plate collector and conventional basin to record the temperature of water and basin. Thermocouples are also attached to the glass cover to indicate glass cover temperature. Solar radiations are measured by using a Kipp–Zonen Pyranometer. Wind velocity is measured by a vane type digital anemometer. This stepped tray type solar still was fabricated and tested at Thiagarajar College of Engineering, Madurai, India during February 2011–May 2011. The experiments were conducted with some modifications listed below.

(i) Different water depths of 2 cm, 3 cm, 4 cm are maintained in the conventional basin and a constant depth of 2 cm is maintained in the stepped tray. Wick is placed on the inclined flat plate collector. Different packing materials namely, coconut coir, wooden chips, sand and coal were packed in the wicks.
(ii) To increase the free water surface area and capillary effect sponges are used in the conventional basin and stepped trays. In this work 12 sponges of $12.5 \times 6.5 \times 8\ \mathrm{cm}^3$ and 24 sponges of $4 \times 4 \times 4\ \mathrm{cm}^3$ are placed on the stepped trays and conventional basin. The volumetric ratio of 20% is maintained between the sponges and water.
(iii) Rocks and pebbles are placed on each stepped tray basin and also in the conventional basin.

3. Theoretical simulation

Theoretical analysis was made for both conventional still and stepped solar still. The basin plate temperature, water temperature and glass temperature can be evaluated at every instant by solving the energy balance equation for the absorber plate, brackish water and glass of the solar still respectively.

In the conventional solar still, energy received by the basin plate is equal to the summation of the energy gained by the basin plate, energy lost by convective heat transfer between basin and water and side losses.

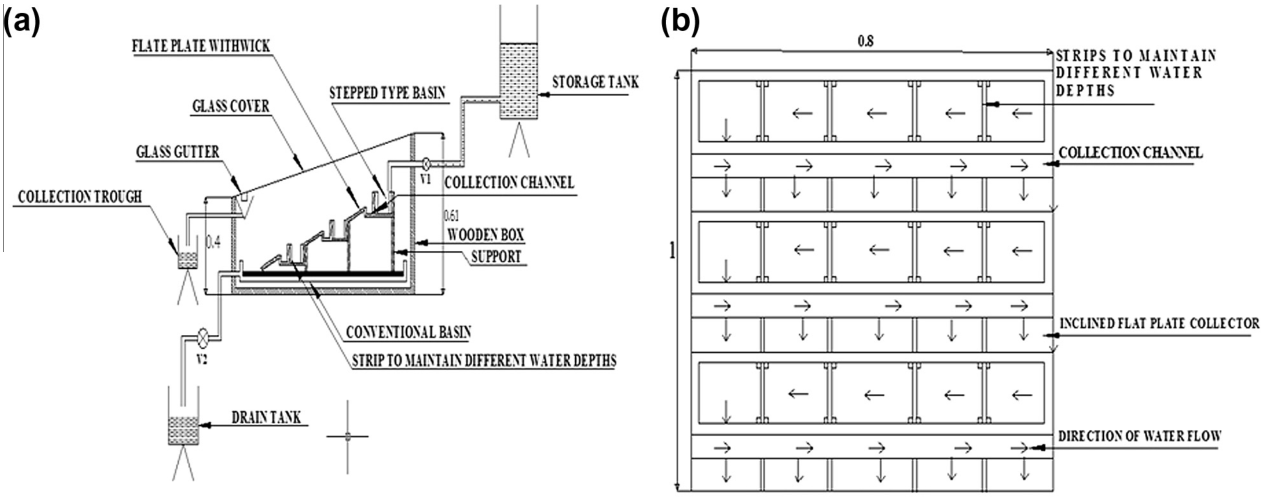

Figure 1 (a) Sectional view of the stepped type solar still. (b) Top view the Stepped type basia.

Since the meteorological ranges are almost the same as in previous work by Gandhidasan (1983), Tiwari (2002) and Zurigat and Abu-Arabi (2004), same correlation and constants used by the previous authors were assumed in this work also. Energy received by black surface is given by,

$$I(\mathrm{t})A_{\mathrm{b}}\alpha_{\mathrm{b}} = m_{\mathrm{b}}C_{\mathrm{p,b}}\left(\frac{\mathrm{dT_b}}{\mathrm{dt}}\right) + Q_{\mathrm{c,b\text{-}w}} + Q_{\mathrm{loss}} \tag{1}$$

Energy received by the brackish water in the still (from sun and base) is equal to the summation of energy lost by convective heat transfer between water and glass, radiative heat transfer between water and glass, evaporative heat transfer between water and glass and energy gained by the brackish water.

$$\begin{aligned} I(\mathrm{t})\alpha_{\mathrm{w}}A_{\mathrm{w}} + Q_{\mathrm{c,\ b\text{-}w}} = {} & Q_{\mathrm{c,w\text{-}g}} + Q_{\mathrm{r,w\text{-}g}} + Q_{\mathrm{e,w\text{-}g}} \\ & + m_{\mathrm{w}}C_{\mathrm{p,w}}\left(\frac{\mathrm{dT_w}}{\mathrm{dt}}\right) \end{aligned} \tag{2}$$

Energy gained by the glass cover (from sun and convective, radiative and evaporative heat transfer from water to glass) is equal to the summation of energy lost by radiative and convective heat transfer between glass and sky, and energy gained by glass.

$$\begin{aligned} & I(\mathrm{t})\alpha_{\mathrm{g}}A_{\mathrm{g}} + Q_{\mathrm{c,w\text{-}g}} + Q_{\mathrm{r,w\text{-}g}} + Q_{\mathrm{e,w\text{-}g}} \\ & \quad = Q_{\mathrm{r,g\text{-}sky}} + Q_{\mathrm{c,g\text{-}sky}} + m_{\mathrm{g}}C_{\mathrm{p,g}}\left(\frac{\mathrm{dT_g}}{\mathrm{dt}}\right) \end{aligned} \tag{3}$$

At the first iteration, water temperature, glass temperature and plate temperature are taken as ambient temperature and the increase in basin temperature ($\mathrm{dT_b}$), brackish water temperature ($\mathrm{dT_w}$) and glass temperature ($\mathrm{dT_g}$) is computed for every time interval (dt) of 5 s by solving Eqs. (1)–(3) respectively. For evaluating, the above said temperatures in the simulation, the experimentally measured values of solar radiation, wind velocity and ambient temperature of the corresponding day and hour are used. This iteration is performed for total duration from 9 am to 5 pm of a day.

Constant level of water is maintained in the stepped solar still by adding water equivalent to the condensate (m_{c}) in every half an hour. The area of basin (A_{b}) and the area of brackish water (A_{w}) are taken as 1 m^2. The area of glass (A_{g}) is taken as 1.1 m^2. Mass of the glass (m_{g}) is taken as 12.5 kg. The absorptivity of the still α_{b} is taken as 0.95. The absorptivity of the water, α_{w} and absorptivity of the glass, α_{g} are taken as 0.05. The specific heat of the brackish water, $C_{\mathrm{p,w}}$ is calculated.

For the next time step, the parameter is redefined as,

$$T_{\mathrm{w}} = T_{\mathrm{w}} + \mathrm{dT_w} \tag{4}$$

$$T_{\mathrm{g}} = T_{\mathrm{g}} + \mathrm{dT_g} \tag{5}$$

$$T_{\mathrm{b}} = T_{\mathrm{b}} + \mathrm{dT_b} \tag{6}$$

The total condensation rate is given by,

$$\frac{\mathrm{dm_c}}{\mathrm{dt}} = \frac{h_{\mathrm{e,w\text{-}g}}(T_{\mathrm{w}} - T_{\mathrm{g}})}{h_{\mathrm{fg}}} \tag{7}$$

The convective heat transfer between basin and water is taken as

$$Q_{\mathrm{c,\ b\text{-}w}} = h_{\mathrm{c,\ b\text{-}w}}A_{\mathrm{b}}(T_{\mathrm{b}} - T_{\mathrm{w}}) \tag{8}$$

The convective heat transfer co-efficient between basin and water, $h_{\mathrm{c,b\text{-}w}}$ is taken as 135 $\mathrm{W/m^2\,K}$The heat loss from basin to ambient is calculated from

$$Q_{\mathrm{loss}} = U_{\mathrm{b}}A_{\mathrm{b}}(T_{\mathrm{b}} - T_{\mathrm{a}}) \tag{9}$$

where U_{b} is taken as, 14 $\frac{\mathrm{W}}{\mathrm{m^2K}}$. The convective heat transfer between water and glass is given by,

$$Q_{\mathrm{c,w\text{-}g}} = h_{\mathrm{c,w\text{-}g}}A_{\mathrm{w}}(T_{\mathrm{w}} - T_{\mathrm{g}}) \tag{10}$$

where the convective heat transfer co-efficient between water and glass is given by,

$$h_{\mathrm{c,w\text{-}g}} = 0.884\left\{(T_{\mathrm{w}} - T_{\mathrm{g}}) + \frac{[P_{\mathrm{w}} - P_{\mathrm{g}}][T_{\mathrm{w}} + 273.15]}{[268.9 \times 10^3 - P_{\mathrm{w}}]}\right\}^{1/3} \tag{11}$$

The radiative heat transfer between water and glass is determined by,

$$Q_{\mathrm{r,w\text{-}g}} = h_{\mathrm{r,w\text{-}g}}A_{\mathrm{w}}(T_{\mathrm{w}} - T_{\mathrm{g}}) \tag{12}$$

The radiative heat transfer co-efficient between water and glass is given by,

$$h_{\mathrm{r,w\text{-}g}} = \varepsilon_{\mathrm{eq}}\sigma[(T_{\mathrm{w}} + 273)^2 + (T_{\mathrm{g}} + 273)^2](T_{\mathrm{w}} + T_{\mathrm{g}} + 546) \tag{13}$$

where

$$\varepsilon_{\mathrm{eq}} = (1/\varepsilon_{\mathrm{w}} + 1/\varepsilon_{\mathrm{g}} - 1) - 1 \tag{14}$$

The evaporative heat transfer between water and glass is given by,

$$Q_{\mathrm{e,w\text{-}g}} = h_{\mathrm{e,w\text{-}g}}A_{\mathrm{w}}(T_{\mathrm{w}} - T_{\mathrm{g}}) \tag{15}$$

The evaporative heat transfer co-efficient between water and glass is given by,

$$H_{\mathrm{e,\ w\text{-}g}} = (16.273 \times 10^{-3})h_{\mathrm{c,w\text{-}g}}(p_{\mathrm{w}} - p_{\mathrm{g}})/(T_{\mathrm{w}} - T_{\mathrm{g}}) \tag{16}$$

The radiative heat transfer between glass and sky is given by,

$$Q_{\mathrm{r,g\text{-}sky}} = h_{\mathrm{r,g\text{-}sky}}A_{\mathrm{g}}(T_{\mathrm{g}} - T_{\mathrm{sky}}) \tag{17}$$

The radiative heat transfer co-efficient between glass and sky is given by,

$$H_{\mathrm{r,g\text{-}sky}} = \varepsilon\sigma[(T_{\mathrm{g}} + 273)^4 - (T_{\mathrm{sky}} + 273)^4]/(T_{\mathrm{g}} - T_{\mathrm{sky}}) \tag{18}$$

The effective sky temperature is taken from,

$$T_{\mathrm{sky}} = T_{\mathrm{a}} - 6 \tag{19}$$

The convective heat transfer between glass and sky, $Q_{\mathrm{c,g\text{-}sky}}$ is given by,

$$Q_{\mathrm{c,g\text{-}sky}} = h_{\mathrm{c,g\text{-}sky}}A_{\mathrm{g}}(T_{\mathrm{g}} - T_{\mathrm{sky}}) \tag{20}$$

where $h_{\mathrm{c,g\text{-}sky}}$ is taken from,

$$H_{\mathrm{c,g\text{-}sky}} = 2.8 + 3.0\,V \tag{21}$$

The daily efficiency η_{d} was obtained by summing up the hourly condensate production m, multiplied by latent heat of evaporation h_{fg} and divided by average solar radiation I_{g} over the whole area.

$$\eta_{\mathrm{d}} = \frac{\sum mh_{\mathrm{fg}}}{\sum AI_{\mathrm{g}}} \tag{22}$$

3.1. Modifications in still

The theoretical simulation is performed in stepped solar still for different types of operations as discussed below with modification as stated below.

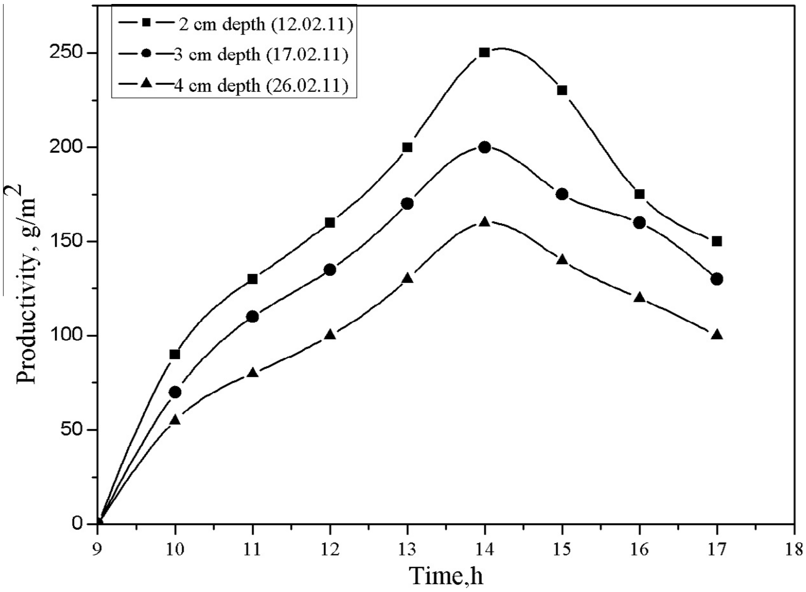

Figure 2 Effect of water depth on productivity.

3.1.1. Still with different water depths

The mass of water for 2 cm, 3 cm, 4 cm are taken as 25.8 kg, 38.4 kg, 51.6 kg respectively. Mass of wick is taken as 0.8 kg.

3.1.2. Still with wick packed with packing materials

The mathematical model of the simple still discussed in Section 3.1, is used for this modification also. In this equation, the area of the basin plate and free surface area are taken care of by the increase in exposure area due to packing materials. In addition to the heat capacity of ($m_b c_{pb}$) the heat capacity of wick and packing materials is added in Eq. (1).

3.1.3. Still with rocks and pebbles in the stepped trays basins

Rocks and pebbles are used as a sensible heat storage medium. The addition of rocks and pebbles in the basin surface and in the stepped trays increases the water temperature and increases evaporation rate. Rocks of 1 cm diameter, 185 numbers are used. The basin area and mC_p product will be taken care of by this addition of rocks and pebbles.

4. Uncertainty

The errors that occurred in measuring instruments are shown in Table 1. The errors were calculated for thermocouples, solar meter, anemometer and collection tank. The minimum error that occurred in any instrument is equal to be ratio between its least count and minimum value of the output measured.

Table 1 Accuracies and ranges of measuring instruments.

Sl. No.	Instrument	Accuracy	Range	% error
1.	Thermocouple	± 1 °C	0–100 °C	0.25
2.	Thermometer	± 1 °C	0–100 °C	0.25
3.	Kipp–Zonen solarimeter	± 1 W/m^2	0–5000 W/m^2	0.25
4.	Anemometer	± 0.1 m/s	0–15 m/s	10
5.	Collection tank	± 10 ml	0–1000 ml	10
6.	Measuring jar	± 10 ml	0–500 ml	10

5. Results and conclusions

5.1. Effect of water depth on productivity

Water depth was varied in conventional basin and constant water depth of 2 cm was maintained in the trays of the stepped type basin. The maximum evaporation rate of about 1320 kg/m^2 was obtained in 2 cm water depth whereas 3 cm water depth records a productivity of 1246 kg/m^2 and 4 cm depth records as 1150 kg/m^2. Minimum water depth ensures the low volumetric heat capacity (ρC_p) and so increases the heat transfer rather than storing heat. This increases the temperature of the saline water. Hence a high evaporation rate is obtained as shown in Fig. 2.

5.2. Effect of different modifications on daily efficiency

Fig. 3 shows the daily efficiency for different modifications made in the stepped type basin as well as the conventional basin. Maximum efficiency of 16% is observed for wick with wooden chip as packing material in the flat plate of the stepped type basin. It is also observed from Fig. 3, that the daily efficiency of the conventional stills tested on the various days were ranging from 1% to 10% whereas in the stepped type basin still it is recorded up to a maximum efficiency of 16%. As the packing material increases the exposure area and the capillary rise effect provided by the packing materials more heat will be absorbed in the inclined flat collector. Also providing high sensible heat by providing pebbles or rocks in the trays of the stepped solar still, more energy is stored. Thus the efficiency is increased.

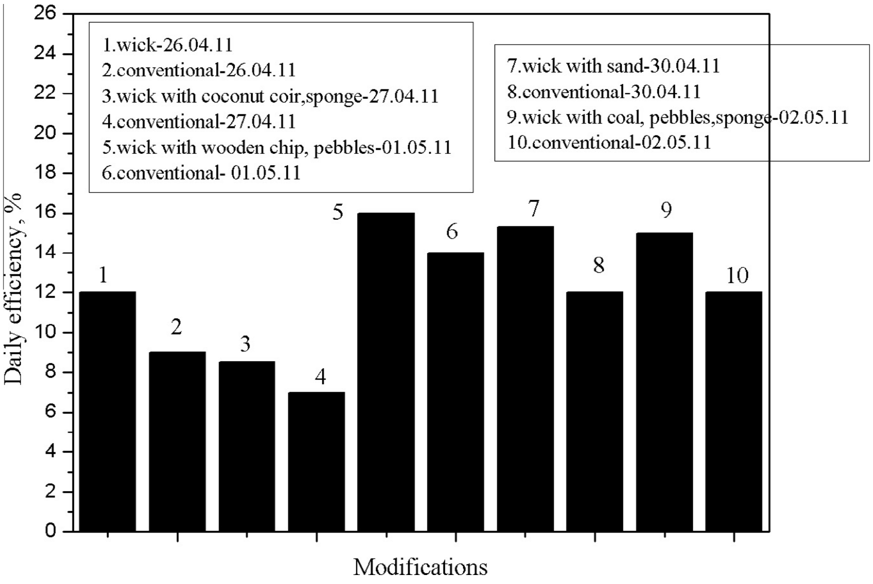

Figure 3 Effect of different modification on daily efficiency.

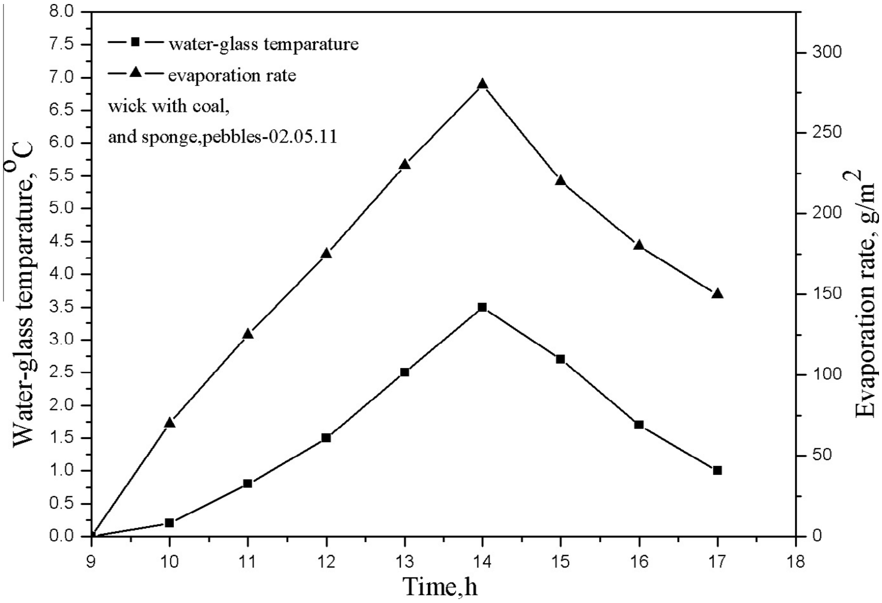

Figure 4 Effect of water–glass temperature difference on productivity.

5.3. Effect of water glass temperature on productivity

Fig. 4 shows the water glass temperature difference against productivity. It is noted that for the maximum water – glass temp difference $T_w - T_g$ of 3.8 °C, productivity is 300 kg/m^2. Water–glass temperature difference inside the solar still is the driving force for evaporation rate. From Eq. (15), it is clear that, increase in water–glass temperature difference increases the evaporative heat transfer rate. Hence the evaporation rate increases with higher water–glass temperature differences.

5.4. Comparison of experimental and theoretical values

Theoretical analyses were performed by using MAT Lab software. These values were also compared with the experimental values and plotted in Fig. 5. It is found that there is only 10% of deviation from the theoretical values and in some points both are matching well. In theoretical analysis, average values of solar intensity, wind velocity, water temperatures, and glass temperatures are considered between any time interval. But in actual case fluctuation of solar intensity and wind velocity gives lesser evaporation than the theoretical value.

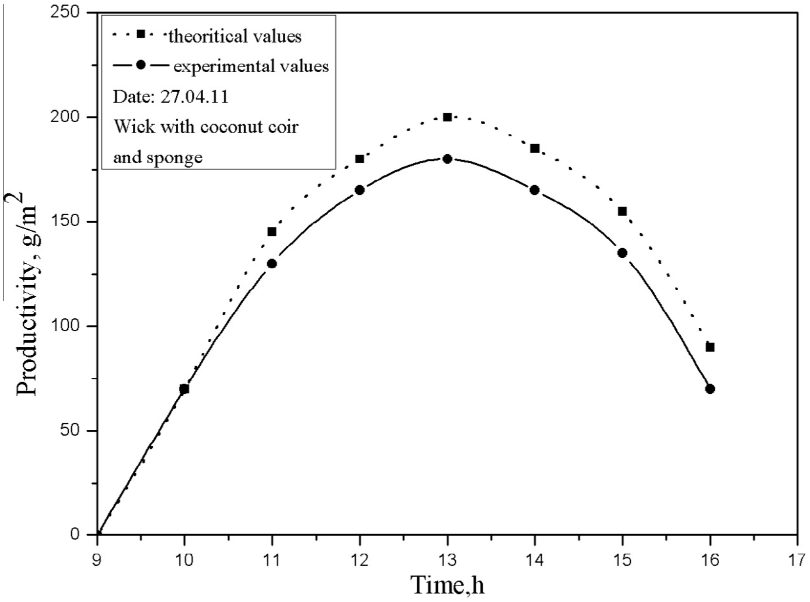

Figure 5 Comparison of experimental and theoretical values.

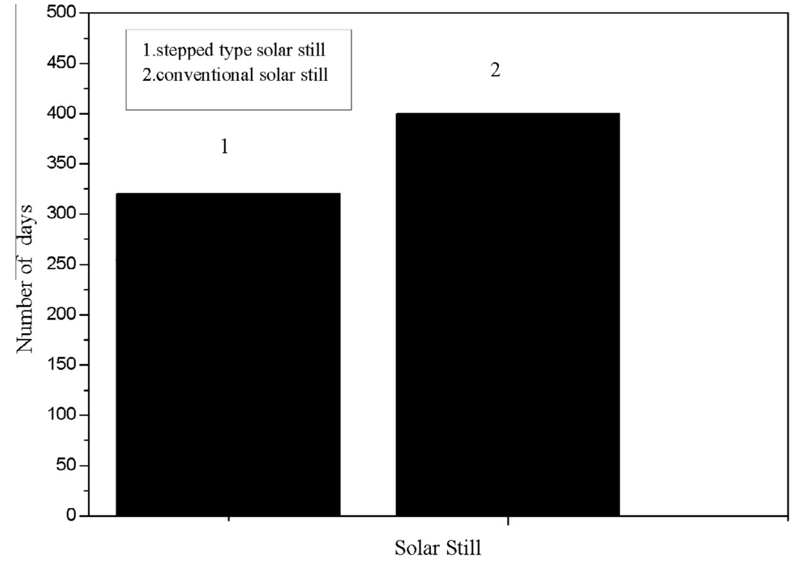

Figure 6 Payback analysis.

6. Cost analysis

The payback period of the experimental setup depends on overall cost of fabrication, maintenance cost, operating cost and cost of feed water. The overall fabrication cost of both conventional and stepped type tray is Rs.8000 ($160). The cost of feed water in negligible. No maintenance cost. The cost per liter of distilled water is Rs.20 ($.0.2) and the average productivity of the stepped still 1.250 kg/m^2 and the conventional still produces an average of 1 kg/m^2. Thus the cost of water produced per day is Rs.25 ($0.25) for stepped solar still and Rs.20 for conventional still.

Hence net earnings for the stepped solar still

$$= \text{Cost of water producedmaintenancecost} = \text{Rs.}(25 - 0) = Rs.25(\$0.25)$$

For conventional solar still it is Rs.20. and pay back period

$$(\text{stepped solar still}) = \text{Investment/Net earnings per day} = 8000/25 = 320\,\text{days}.$$

and payback period(conventionalsolarstill)

$$= \text{Investment/Netearningsperday} = 8000/20 = 400\,\text{days}.$$

As shown in Fig. 6, about 20% of the days are saved in the stepped solar still compared to the conventional solar still.

7. Conclusion

For improving the evaporation rate, a stepped tray type basin along with an inclined flat plate collector and a conventional basin is constructed. The water collection areas were improved by connecting the stepped trays of 12 number. Different water depths of 2 cm, 3 cm, 4 cm were used in the conventional basin while a constant 2 cm water depth was maintained in the stepped tray type basin. Maximum productivity of 1468 kg/cm^2 was obtained for 2 cm water depth and lowest production of 1150 kg/m^2 is obtained for 4 cm water depth. Sponges are added to improve the capillary action. For 2 cm water depth with wick and sponge combination the maximum output of 1305 kg/m^2 was obtained. The lowest productivity was recorded for 4 cm water depth with sponges combination (1280 kg/m^2).

Different packing materials such as wooden chips, sand, coal, coconut coir, were added in the inclined flat plate collector to increase the area of exposure. For different packing material analyzed, rock, sponge and wick combination gains the maximum productivity of 1745 kg/m^2 and lowest productivity is for sand and wick combination (1200 kg/m^2). The daily efficiency of various combinations was calculated: of them coconut coir and wick combination produced 16.36%, nearly 3% increase in efficiency when compared to conventional still. Theoretical analysis was also performed and compared with experimental results. A maximum deviation of less than 10% between theoretical and experimental analysis was obtained. Cost analysis was also performed for this still, and a payback period of 320 days is required for this still which is 80 days less than that of the conventional still.

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