An Experimental and Statistical Analysis of Double Slope Single Basin Solar Still in Active and Passive Mode with Different Water Depth.

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Abstract

In the present work, experimental work on double slope single-basin still is investigated. The statistical analysis shows the effect of various factors related to the efficiency of still. The water level in the basin investigated at 10 cm, 6 cm and 2 cm depth. The process temperature $T_W$, $T_G$ and $T_B$ were recorded one each day. The still is used in the Agra city climate. The mode of operation affects its water yield as an active mode of operation produces more water yield than a passive mode of operation. In the statistical analysis $R^2=99.29$ (passive mode) and $R^2=99.11$ (active mode) recommend the satisfactory agreement of the factorial design regression model.

Keywords: Statistical analysis, Solar Still, Double Slope, Active mode, Passive mode

1. Introduction

The desalination of brackish water by solar radiation systems is a sensible and promising advancement for generating consumable water in the approach of each one. Which is a major problem of the area of potable water availability? Non-availability of drinking water is one of the difficult issues are being faced by the people who are residing in interior parts of countries all around the world. Around 97% of the water on the planet is in the ocean. Generally, 2% is secured as ice in the polar region, and 1% is new water available for the need of the plants, animals and human life. As trademark new water resources are limited, seawater has a basic effect as a hotspot for drinking water too. To use this water, it must be desalinated. Normally discovering that outside air and consumable water are two basic components for the sustenance of human life. In most parts of the world, for instance, shoreline front domain and completely dry zones, the absence of the fresh water is a champion among the most basic stresses of humankind. Consistently around the world, in typical, six million youngsters pass on due to the non-appearance of consumable water. Consumable water not only is crucial always and consistency of condition, yet what's more for a private, mechanical and rustic reason. Pretty much 0.014% of overall water in the earth is available to individual and distinctive living things. Facilitate vocations of water from sources like conduits, lakes, sea and underground water supplies are not always fitting, in light of the proximity of higher aggregate salt and risky animals. The higher improvement rate in all-out people and adventures achieved a broad elevating of enthusiasm for new water. The openness of freshwater is in like manner imperative for life in remote zones or dry territories. Despite high sun-fueled power in those domains, the nature of most water resources is low. Desalination, vapour weight, pivot digestion and electrodialysis are being used to give freshwater from saline water.

Nevertheless, the cost of imperativeness usage of these methods is high.
On the other hand availability of essentialness in remote regions and most dry areas is low. In this ground, desalination is the most prepared methodology to clean the water. Since the reasonable power sources, for instance, wind and sun are open to use in different zones, it gives the idea that utilizing the practical power sources are the best choice to make consumable water. The ordinary source can satisfy a confined need, and this prompts an extraordinary lack of crisp water. It is as needs be useful to mishandle sun controlled essentialness explicitly by presenting sun situated stills. Of course, sea water includes 97.5% of overall water, so it will, in general, be used consequently by changing over it to refined water [1].

In this present study solar distillation was observed in double slope, single basin still. The operative mode of still was passive and active to differentiate the water yield by enhancing the evaporation and condensation process effective. The process efficiency depends on the temperature of water gained inside the still due to the temperature of the glass and bottom of still. In the two-mode of working of still, one is passive which is a natural operative way and second is an active mode in which Peltier module and water sprinkler were used to make the distillation effective.

A factorial design with two factors was adopted to analyse the effect of glass and bottom temperature over water temperature. Due to the analysis, the influence of factors and their intensity and their interaction can be observed over the response. To do understand the effective working of still this factorial regression analysis was done and to derive a regression equation between factors and response.

2. Literature Review

There are many techniques used for water conversion to potable water, in this series of solar radiation which is plenty available on the earth surface may be utilized for this purpose. This power source is limitless, no storage, transportation is needed, but harnessing of this energy is important to get drinkable water in the area’s have a scarcity of usable water. In this direction, many investigators worked a lot for humankind favour.

Nafey et al. [2] had focussed on the cooling of water inside the still for making its performance effective. They have worked with the economic aspect of still performance, for its productivity [3]. Sun based desalination is a response to these issues. Daylight-based stills are humble; having low help and sun situated essentialness is copious, never persisting, and available on the area, and sullying free. At any rate sun based stills encounter the evil impacts of their low productivity [4]. A dim painted bowl contains salty or sea water. This is encased in an absolute water/air verification envelope formed by a wooden edge and a direct cover, best case scenario. The dull bowl ingests the most outrageous bit of the transmitted radiation through the cover. In this manner, water contained in the bowl heated up and disappears in the inundated condition inside the still. Water vapour rises until it cooperates with the cooler interior surface of the cover. There, they accumulate as unadulterated water, slides down along the cover base surface given gravity and is assembled by using waste. The improvement of this sort of still can without a lot of a stretch be performed by even people at nation domain using the locally available materials. To enhance the efficiency of a solar still, by accelerating the condensation process, PCMs are used. The PCM application has a positive impact on the performance of still in the context of water yield [5].

This makes the system significantly uneconomical. An incredible work has been finished by researchers, to upgrade the age furthest reaches of the still by getting differing strategies.
Starting late, the advances in improving the suitability of the sun situated still has been investigated [6]. The performance of still can be enhanced by coupling of parabolic trough collector (PTC) with still. The PTC concentrate the radiation can make the still more effective in winter weather [7].

The bowl water significance is having an imperative effect on the benefit of the bowl. Examinations exhibit that, the water significance is alternately comparing to the effectiveness of still [8–9]. By using this direct development of sun, sun situated stills are likely a champion among the best mechanical get together which can be used. The coupling photovoltaic thermal (PVT) compound parabolic concentrator (CPC) work in a single unit can enhance the performance in dual direction. The PVT-CPC device increases the evaporation and condensation simultaneously to improve the performance of the still [10].

Over the earlier decade, a broad and creating combination of composing has focused on the game plan of the solar energy based refining systems [11–19]. The enhancement in the evaporation of water inside the still can increase the output of still. The evaporation rate is increased by using a thermo electric heating module to increase water temperature [20].

Starting various late undertakings have been made either to set up the various types (clear inclination [21], weir-type [22], two fold slope [23]). The overall thermal efficiency of solar still was enhanced by a modified model of the basin of still. This type of basin is termed as multi-wick solar still (MWSS) [24].

For extending the execution and gainfulness of daylight based stills (using edge [25,26]. Twofold glass cooling [27-28]. The performance of still was hiked with pin-finned wick evaporation surface to accelerating the rate of water evaporation and finally water yielding [29].

Air development inside still [30,31] and sandy warmth store [32]). The different experimental design and data analysis have been carried in the previous years by F Yates [33]. Mason has described the different model of experimental design and sustainability in his book [34]. Author had made a statistical approach of experimental design approach in the still solar performances in his work.

3. Experimental Setup

3.1 The raw and saline water The brackish water is taken as inlet water, which is the groundwater of Agra city (TDS 450-700 ppm). The raw water chemistry is shown in Table-1.

| Presence of Chemical constituents more than permissible limit (e.g. EC, F, As, Fe) | Higher concentration of Flouride (>1.5mg/lit.) and higher values of EC at so many places. |
| Type of water | Brackish to Saline in deeper |
| TDS | 480 to 4698 mg/lit |

3.2 The passive solar still

The still was designed and fabricated with a galvanised iron sheet with the black painted bottom to absorb more solar radiation. The solar still specified as a single basin and double slope has been fabricated with GI sheet and glass sheet of (4 mm thick) as shown in Fig-1.
3.2.1 The water tank
The dimension of the basin is 76cm×75cm×10.5cm, and the outer cover is 37.5 cm×32.31cm×76cm. The space between the basin and top covering which is made with glass sheet as hut top. The outer part is made up of GI sheet. The top of the basin is covered with two glasses of thickness 4 mm in such a way so that two slope to observed sun rays incident in any orientation of placing of still. Thermocouples were used to measure the temperature of the bottom of the basin (T_B), and glass surface (T_G) and water layers (T_W) fitted with insulation to prevent heat loss. The condensed water is taken in the V-shaped spool integrated at the lower edge of the glass on both sides of the still. The condensate yield collected by flexible pipe and stored in a measuring container.

3.2.2 Solar still
An opening in the bowl side divider permits embeddings the thermocouples for the estimation of the bowl water, still and condensate temperature. Four thermocouples were put in the bowl at various areas. Two thermocouples are put in each side of the deplete to quantify the condensate temperature. The gap is shut with protecting material to keep away from the warmth and vapour misfortune. Another opening is accommodated water delta through this gap, water tube from piezometer is embedded to supply crude water persistently to the bowl from capacity tank through control valves which manage the stream, to keep the mass of water in the bowl constantly consistent as in Fig-2.
3.2.3 The Measuring Instruments

The Measuring Instruments their accuracy and range with standard deviation is tabulated as Table-2.

3.3 The active solar still

To enhance productivity by receiving more radiation to raising the water temperature and eventually increasing evaporation. Therefore sprinkler arrangement has been made to get an atomised form of water because smaller size of water droplet absorbed less latent heat and vapourised faster hence enhance the evaporation rate. The condensation of accelerated evaporated water rate must be done with a similar rate; hence thermo electrical module was used to provide refrigeration effect to increase the condensation rate hence to increase the water yield as shown in Fig-2. The specifications of the components used in the experiments with the models and manufacturers are listed in Table-3. Accuracies, ranges and standard uncertainty of measuring instruments are shown in Table-1.

| Table-2: Measuring Instruments |
|-------------------------------|
| **Instrument** | **Accuracy** | **Range** | **Uncertainty Standard** |
| Thermocouple | ± 0.1°C | 0-100°C | 0.06°C |
| Measuring Jar | ±10ml | 0-1000ml | 0.1ml |
| PH Meter | 0.01 PH | 0-14 PH | 0.006 PH |
| TDS Meter | 10 ppm | 0-1000 ppm | 0.1 ppm |

| Table-3: Components used in the experiments |
|---------------------------------------------|
| **Component** | **Properties** | **Model/suppliers** |
| Peltier Module | Area-40mm × 40mm 450Pn Junction Volt-12 V, 60W Current-5A | CP-14125840S Layered Technology |
| USB submerge pump | Volume-4cm × 3cm × 2.5cm Flow Rate-4-5 Litre/hour Volt-12 V Current-1.5A | Local Market |
| Solar Panel | Size-360mm × 220mm × 20m | LS1215 Luxmi Solar™ |

4. Methodology

The double slope single-basin still was placed on the top of the building and the climatological data of Agra Uttar Pradesh (27.1767° N latitude and 78.0081° E longitude) Indian are fortunate enough for having longest south-north facing toward the sun. Therefore maximum solar energy catching area can be utilized for harnessing this energy. Solar radiation intensity 24 hours harnesable between mornings at 6.00 a.m. to 5.00 a.m. The weather condition was chosen as the month of June-2018. The glass sheet of the experimental setup was cleaned properly for ensuring transparency. To receive a good amount of radiation without loss. The brackish water feeding arrangement regulates the varying depth of water level as 10 cm, 6cm and 2 cm in two way first with Passive Still three test and similarly with
Active Still. The observation of temperature of the bottom of basin (T$_b$); water temperature (T$_w$); glass temperature (T$_g$) were made along with distil-water yield as per water filled inside the basin had been recorded. In this experimental work, observations were made for parameters still bottom temperature, water in the basin temperature, glass lower surface temperature. All these parameters were observed on the regular time interval of one hour during the 24 hours working cycle.

The observations have been done in two sets of reading as one for passive still operation (T1; T2; T3) and second for active still operation (T4; T5; T6). Similarly, water yield also is recorded as a test performed in phase I and phase II. The water property as an input was tabulated as in Table-1. The climate condition during the operation has been considering from the data provided by Central Ground Water Board-New Delhi as per Table-4, for reference of operation condition and maintenance of setting up during test condition period.

### Table-4 Climatological Data of the Agra U.P.

| Article | CLIMATOLOGICAL DATA OF AGRA UP  |
|---------|--------------------------------|
| Article | I  | L  | |
| Article | an | eb | ar | pr | ay | un | ul | ug | ep | ct | ov | ev | Total |
| Article | 2.2| 5.7| 1.9| 7.7| 1.8| 0.5| 4.8| 2.8| 3.2| 3.3| 9.2| 4.1| 2.27|
| Article | 0.3| 1.6| 7.2| 9.2| 7.0| 4.3| 5.2| 9.1| 9.1| 9.1| 9.1| 9.1| 9.1|
| Article | 4.8| 4.8| 0.9| 9.3| 8.9| 6.2| 8.9| 7.0| 4.1| 9.1| 9.1| 9.1| 9.1|
| Article | 5.5| 5.5| 0.5| 9.8| 8.9| 7.0| 4.1| 9.1| 9.1| 9.1| 9.1| 9.1| 9.1|
| Article | 6.2| 6.3| 10.2| 2.798| 0.577| 0.058| 0.078| 0.171| 0.071|
| Article | .935| .437| .167| .294| .204| .567| 2.798| .777| .058| .078| .171| 5.91|
| Article | 2.6| 2.6| 26| 62| 08| 04| 45| 23| 32| 16| 8| 9| 466|
| Article | .6| .2| .9| .4| .9| .8| .9| .6| .2| .6| .9| .5| 9|
| Article | 2.2| 6.0| 2.2| 6.0| 2.2| 6.0| 2.2| 6.0| 2.2| 6.0| 2.2| 6.0| 2.2|
| Article | 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6| 5.6|

5. Result & Discussion

The present work performed to study the contribution of double slope to receive solar radiation in a larger amount with the conjunction of single basin. The two sloped surfaces of glass contribute to gain more heat energy to heat water inside the tank. For its consecutive evaporation and condensation to purifying the water at cheaper and convenient, economical way as well.

Three temperature of the bottom of basin (T$_b$); water temperature (T$_w$); glass temperature (T$_g$) were observed to conclude the internal physics behind the evaporation and condensation process execution with these temperature differences occurred inside the system.
Secondly, to accelerate the rate of evaporation and condensation to get more distil water yield, few arrangements have been made such as a thermoelectrical device to produce refrigeration effect to promote condensation and water spraying arrangement with a water pump to change to water form or to atomised form to enhance fast evaporation of brackish water.

Here we study the phenomenon of phase conversion due to the temperature difference between incident heat at basin bottom, glass and water layers. Due to thermal equilibrium heat interaction takes place and phase is changing phenomenon evaporation, and condensation occurs to response to the water purification.

The first operating of still was done in a passive mode means sprinkler arrangement and Peltier module were not there, entire processing was being done under natural condition. Afterwards, operating mode had been changed to an active mode in which Peltier module for condensation and water sprinkler for evaporation of water used.

The Analysis of water level in the tank, also affect the distil water production, this effect had been considered at three distinct levels as 10 cm, 6 cm and 2 cm to see the impact on working of solar still under same working condition.

Test-1
When still was operated with 10 cm water level in the passive mode, observation of three operating temperature as in Figure-3(a). The Figure shows that during the operation water reached highest temperature 64.8°C. The highest temperature water due to maximum radiation was at a peak in noon time. As compared to water temperature, the glass temperature attained the maximum value 60.5°C. The glass reflects a neutral role in the aspect of gaining solar energy. In this series glass is behaving like a transparent medium which has no gain of solar heat. At morning time 5 AM bottom temperature 31.4°C and the water temperature were 31.8°C and glass at 30.4°C at 3 pm which shows that direct heat interaction between bottom and water, scaling was going on in the phenomenon.

Test-2
In the next test water level was maintained at 6 cm and a cycle of 24 hours was repeated to collect three distinct temperature of solar still system. In this experiment when water depth decreased to 6 cm effective absorption of radiation was observed this could be illustrated by Figure-3(b). Here maximum temperature had been attained by water 68.4°C and followed by bottom as 68.2°C and glass at 67.8°C at 3 pm which shows that radiation trapped inside the system was intact.

Test-3
This series of the test had been conducted with the water level in tank 2 cm, and all the condition remained the same as earlier. In this operating of still, from morning 6 am to 5 pm glass temperature standing above the water and bottom temperature. Between 10 am to 5 pm water temperature leading to a bottom temperature which senses that effective radiation at minimum water layer inside the tank. Ultimately distil water yield also increases as in Fig. 3(c). The highest temperature attained by the glass is 70.4°C corresponding to this water 68°C and bottom 65.3°C at 2 pm in the day time, the minimum temperature at 6 am for glass 33.3°C and around 30°C for water and bottom.
Figure 3 $T_W$ (T-Water), $T_G$ (T-Glass), $T_B$ (T-Bottom), variation with respect to time for (a) Test-1 (b) Test-2 (c) Test-3 (d) Test-4 (e) Test-5 (f) Test-6
**Test-4**

In this test phase still was operated in an active mode, with 10 cm water level in the tank. This is a new one observation to record temperature of three distinct surfaces, heat interaction among these three key points decides the flow of heat, and final objective of water purification was done. The highest temperature is gained by water 63.8°C and bottom has 61.7°C, and for glass, it was 53.2°C at 3 pm in the day time, while lowest temperature of system 34.2°C for glass and 33.4°C for bottom and 33.5°C for water. In between 2 pm to 5 pm water temperature is higher than the other two and glass temperature was low from 9 am to 6 pm. The spacious volume difference enhances the water evaporation. On the other hand, lowering the glass temperature increase the condensation rate, more water yield to be stored in the still as in Figure-3(d).

**Test-5**

This test was conducted on still in active mode with water level 6 cm when observation recorded as the maximum temperature 62.1°C of water surface and 60.6°C of the bottom were obtained while glass temperature was 50°C. As in Fig.3 (e), the temperature trend varies between 6 am to 11 am glass temperature remained above the water and bottom temperature. Between 11 am to 5 pm glass temperature was down steeply, and the water temperature was highly above to other parameters, this trend of variation followed until the end of the cycle. This shows that at a peak intensity of sun radiation water temperature got higher temperature while in low radiation hourglass has more temperature than other two parameters this shows during these hour heat interaction was poor, and in day time this was quite high.

**Test-6**

The sixth test was conducted at water level at 2 cm in basin tank in the active mode of still operation. At this operation thermoelectrical device and water, sprinkler arrangement was working effectively, both of them were responded as to increase condensation and evaporation rate. The observed data of temperature at the highest value for water was 67.8°C and for the bottom of the basin was 67°C while for glass temperature it was 65°C lowest at 2 pm of running a cycle of observation. The minimum temperature was recorded at 5 am 32.9°C for the bottom of still and 32.5°C for water and for glass it was 30.8°C.

The trend line of temperature variation as up to 1 pm three parameters were in very close range with respect to each other after 1 pm to till the end glass temperature line get down while water and bottom line was close to each other which shows that heat interaction between surface continued for a long time which produces more distil water yield. This is good evidence of a higher rate of evaporation and condensation as well, which illustrated in Fig.3 (f).

5.1 Statistical Analysis of water temperature

The design of experiments for two factors of full factorial design was adopted, with complete 24 runs. The glass temperature and bottom temperature are the factors while water temperature considered a response. The predicted T-water and actual T-water are also plotted for comparative study. Although the main objective of this study is to conclude the mode of operation active versus passive values of T-water optimal and their comparison concerning T-Glass and T-Bottom. The regression analysis consists of the influence of factor over the response and the influence of factors interaction of response. The form of the mathematical model as

\[ Y = X_0 + X_1A + X_2B + X_3AB \] (1)
The variables which affect the T-water inside the still and the respective p values are presented in tabular form. The statistical importance (p values) of the analysed model evaluated as the degree to which in influence the response. In briefly revealed word increased p-value decreases the reliability of the result [38]. The higher value of p is the less will be the belief in Factorial design technique which is used for making a relationship between factors and responses. The regression models were used in applied research and other experimentation work studies. Regression coefficients for basic factors and their interactional impact are presented in the separate sheet. The relationship between the basic factors and responses can be developed by using regression coefficients.

5.2 Statistical analysis of T_W of still in passive mode
The regression analysis was done for still operating in a passive mode for water temperature T_W which influence the still yield and T_G and T_B influenced the T_W. The two-factorial regression model fit suitable to the process of still parameters the R²=99.29 which shows the best fit of a model for process parameters. The p-values show that the degree of influence of T_G on the response. As in Table-5 shows that p-value for T_G is 0.02 reveal the significant influence over T_W and for T_B it is 0.001 which indicate major influence over T_w. The interactions of TG and TB have 0.136 value implies very less effect over T_W.

| Source      | DF | Adj SS | Adj MS | F-Value | P-Value |
|-------------|----|--------|--------|---------|---------|
| Model       | 3  | 4071.16| 1357.05| 932.00  | 0.000   |
| T_G         | 1  | 25.25  | 25.25  | 17.34   | 0.020   |
| T_B         | 1  | 271.57 | 271.57 | 186.51  | 0.001   |
| T_G * T_B   | 1  | 0.34   | 0.34   | 0.23    | 0.136   |
| Error       | 20 | 29.12  | 1.46   |         |         |

The regression equation for T_W is shown as

\[ T_W = -0.14 + 0.173 \, T_G + 0.776 \, T_B + 0.00106 \, T_G \ast T_B \]  \hspace{1cm} (2)

5.3 Statistical analysis of T_W of still in active mode.
The regression analysis was done for still operating in a passive mode for water temperature T_W which influence the still yield and T_G and T_B influenced the T_W. The two-factorial regression model fit suitable to the process of still parameters the R²=99.11 which shows the best fit of a model for process parameters. The p-values show that the degree of influence of T_G on the response. As in Table-6 shows that p-value for T_G is 0.04 reveal the significant influence over T_W and for T_B it is 0.0001 which indicate major influence over T_w. The interaction of T_G and T_B have 0.090 value implies very less effect over T_W.
Table 6: Regression Analysis of Water Temperature ($T_W$) in Active Mode

| Source | DF | Adj SS  | Adj MS  | F-Value | P-Value |
|--------|----|---------|---------|---------|---------|
| Model  | 3  | 3456.67 | 1152.22 | 739.89  | 0.000   |
| $T_G$  | 1  | 4.48    | 4.48    | 2.88    | 0.040   |
| $T_B$  | 1  | 82.53   | 82.53   | 53.00   | 0.0001  |
| $T_G$ * $T_B$ | 1 | 3.02    | 3.02    | 1.94    | 0.090   |
| Error  | 20 | 31.15   | 1.56    |         |         |

The regression equation for $T_W$ is shown as

$$T_W = -9.03 + 0.396T_G + 1.008T_B - 0.00381T_G \times T_B$$  \hspace{1cm} (3)

The Pareto chart of imperative factors which are related to response is shown in Figure 4. This is a tool for expressing the results obtained by experiment; in the pictorial view. Pareto chart is a presentation of factorial design effects, evaluation of factors from the largest absolute value to the smallest absolute value. The amount of each influence is represented by a bar that indicates how much an effect has to be statistically significant. Figure 4(a) shows that the bottom temperature has a significant effect on the water temperature. The glass temperature has a secondary effect on water temperature, and their interaction has an insignificant effect on water temperature in the passive working of still.

For the active working of still, the bottom temperature again prevalent effect on water temperature and the effect of glass temperature reduces comparatively passive mode. But the interaction of bottom and glass temperature has a significant influence on water temperature as shown in Figure 4(b).

![Pareto chart for the model on (a) passive working of still (b) active working of still](image)

The distil water generated amount during 24 hours running of solar still was recorded for both type or working active mode of working and passive mode of working, which was documented as in Table-7
### Table-7: Water Yield per 7 Lt. of Brackish Water

| Water Depth | Yield ml/7 Lt of brackish water | Yield ml/7 Lt of brackish water |
|-------------|--------------------------------|---------------------------------|
| 10 cm       | 398 (Passive-Mode)             | 510 (Active-Mode)               |
| 6 cm        | 449                            | 718                             |
| 2 cm        | 497                            | 772                             |

The analysis of distilling water production was taken in milli-litre per 7-litre brackish water input since here we are varying the water depth level that does not mean that we had fixed the head of the water level, this was an average distil water generated in the proportionate volume of brackish water of 7 litres. Here three level of water depth has been taken as 2 cm, 6cm and 10 cm, the volume of water stored inside the tank was calculated as area × depth (approximately equal to 7 litres).

![Figure- 5 The distil water yield versus water depth in the basin](image)

Brackish water, at water depth 2 cm in the basin when it was operated in active mode. While lowest distil water generation 398 ml/7 litre of brackish water occurred at 10 cm water depth when still was working in passive mode.

When still operated in passive moderate of evaporation and condensation was moderated which was also influenced with water depth which is due to higher and lowering of bottom temperature as per water storage layer inside the basin which promotes simultaneous phase changes water to vapour and again vapour to water.
As the operation was done with active mode equipment, they balanced the equilibrium state of temperature differences between water and bottom temperature to promote vapour generation and condensation as well.

As the water depth increases from 2 cm to 10 cm, distill water yield decreases from 497 ml/7 ml of raw water to 398 ml/7 ml of raw water in passive mode. For active mode, it decreases from 772 ml/7 ml of raw water to 398 ml/7 ml of raw water.

6. Conclusion

Some points have been concluded with the facts from the experimental study as

1. As the test conducted on still by passive mode with a water depth of 10 cm, temperature variations have noted as the glass temperature leading in values higher than water and bottom temperature for the period 6 am to 10 am and also for 10 am till the end of the cycle. The maximum temperature reached in value for bottom 65°C and minimum value for glass temperature 60.5°C.

2. For the test on still with passive mode with 6 cm, the same behaviour of glass temperature 6 am to 10 am and 4 pm to end of the cycle, and very close values with water and bottom temperature. The water and bottom temperature follow each other. The maximum temperature reached in value for water 68.4°C and minimum value for glass temperature 67.8°C.

3. During the test with passive mode with 2 cm water depth on still, glass temperature has a higher value for the period 6 am to 5 pm after this it follows the water and bottom temperature which one follow to each other values variation. The maximum temperature reached in value for glass 70.40°C and minimum value for water temperature 65.3°C.

4. The active mode of still with 10 cm water depth shows the glass temp reaches the temperature values below the water and bottom with significant value, but water and bottom temperature values follow to each other in temperature variation — the maximum temperature reached in value for water 63.80°C and minimum value for glass temperature 53.2°C.

5. The active mode of still with 6 cm water depth reflects that the glass temperature reaches the higher than water and bottom initially up to 11 am afterwards it decreased by a significant amount. The maximum temperature reached in value for water 62.40°C and minimum value for glass temperature 50°C.

6. The active mode of still with 2 cm water depth shows that the water, glass, bottom temperature follow each other variation for the period 6 am to 2 pm after that glass temperature decreases by a certain amount. The maximum temperature reached in value for water 67.80°C and minimum value for glass temperature 65°C.

7. In the regression analysis \( R^2 = 99.29 \) (passive) and \( R^2 = 99.11 \) (active) is strongly state that the model is well fitted to the experimental process. The value \( p=0.020 \) (passive) for \( T_G \) is lower the value \( p=0.040 \) (active) which conclude that glass temperature has greater influence in water yield due to water temperature.

8. The \( p=0.001 \) is same for passive and active which mean that bottom temperature has equal and more significant contribution to raising water temperature.

9. The \( p=0.136 \) (passive) for glass-bottom temperature interaction which is greater than 0.1, indicating interaction has not any influence over water temperature, therefore, lower water yield for active operating \( p=0.090 \) for interaction which shows active participation of water temperature hence greater yield.
10. The maximum distils water to yield 772 ml/7 Lt of brackish water was obtained when still was operated in active mode with 2 cm water depth. The minimum distil water to yield 398 ml/7 Lt of brackish water was obtained when still was operated in passive mode with 10 cm water depth.

References
[1] A.E. Kabeel, Performance of solar still with a concave wick evaporation surface, Energy 34 (2009) 1504–1509.
[2] A.S. Nafey, H.E.S. Fath, S.O. El-Helaby, A.M. Soliman, Solar desalination using humidification dehumidification processes, part I: a numerical investigation, Energy Conversion Management. 45 (2004) 1243–1261.
[3] A. Kaushal, Varun, Solar stills: a review, Renewable Sustainable Energy Rev. 14(2010) 446–453.
[4] Kalidasa Murugavel K, Chockalingam KNKSK, Srithar K. Progresses in improving the effectiveness of the single basin passive solar still. Desalination 2008;220:677–86.
[5] A.E.Kabeel, Y.A.F.El-Samadony, Wael M.EI-Maghlany, “Comparative study on the solar still performance utilizing different PCM” Desalination, Volume 432(2018) Pages 89-96
[6] Cooper PI. Maximum efficiency of single effect solar stills. Sol Energy 1979;15:205.
[7] Mohamed Fathy, Hamdy Hassan, M.Salem Ahmed, “Experimental study on the effect of coupling parabolic trough collector with double slope solar still on its performance”, Solar Energy, Volume 163(2018) Pages 54-61
[8] Phadatare MK, Verma SK. Influence of water depth on internal heat and mass transfer in plastic solar still. Desalination 2007;217:267–75.
[9] Ahsan A, Imteaz M, Thomas UA, Azmi M, Rahman A, Daud NNN. Parameters affecting the performance of low cost solar still. Appl Energy 2014;114:924–30.
[10] D.B.Singh, G.N.Tiwari, “Performance analysis of basin type solar stills integrated with N identical photovoltaic thermal (PVT) compound parabolic concentrator (CPC) collectors: A comparative study”, Solar Energy Volume 142(2017) Pages 144-158
[11] Ahsan A, Islam KMS, Fukuhara T, Ghazali AH. Experimental study on evaporation, condensation and production of new tubular solar still. Desalination 2010;260:172–9.
[12] Al-Hinai H, Al-Nassri MS, Jubran BA. Effect of climatic, design and operational parameters on the yield of a simple solar still. Energy Convens Manage 2002;43:1639–50.
[13] Dwivedi VK, Tiwari GN. Comparison of internal heat transfer coefficients in passive solar stills by different thermal models: an experimental validation. Desalination 2009;246:304–18.
[14] Fotouhi Bafghi E, Rahbar N, Esfahani JA. Productivity improvement of tubular solar still, using CFD simulation. J Model Eng 2013;11:45–56.
[15] Rahbar N, Esfahani JA. Estimation of the convective heat transfer coefficient in a single-slope solar still: a numerical study. Desalination Water Treat 2012;50:387–96.
[16] Rahbar N, Esfahani JA. Productivity estimation of a single-slope solar still: theoretical and numerical analysis. Energy 2013;49:289–97.
[17] Rahbar N, Esfahani JA, Fotouhi-Bafghi E. Estimation of convective heat transfer coefficient and water-productivity in tubular solar still–CFD simulation and theoretical analysis. Sol Energy 2015;113:313–23.
[18] Tiwari GN, Kumar A. Nocturnal water production by tubular solar stills using waste heat to preheat brine. Desalination 1988;69:309–18.
[19] Kabeel AE, Omara ZM, Essa FA. Enhancement of modified solar still integrated with external condenser using nanofluids: an experimental approach. Energy Convers Manage 2014;78:493–8.
[20] M.A. Samee, U.K. Mirza, T. Majeed, N. Ahmad. Design and performance of simple single basin solar still, Renewable Sustainable Energy Rev. 11 (2007) 543–549.
[21] S.B. Sadineni, R. Hurt, C.K. Halford, R.F. Boehm. Theory and experimental investigation of weir-type inclined solar still, Energy 33 (Jan 2008) 71–80.
[22] N. Rahbar, A. Gharaiian, S. Rashidi. Exergy and economic analysis for double slope solar still equipped by thermoelectric heating modules - an experimental investigation, Desalination, Volume 420(2017)Pages 106-113
[23] V.K. Dwivedi, G.N. Tiwari. Experimental validation of a thermal model of a double slope active solar still under natural circulation mode, Desalination 250 (2010) 49–55.
[24] V. Velmurugan, M. Gopalakrishnan, R. Raghu, K. Srithar. Single basin solar still with a fin for enhancing productivity, Energy Convers. Manage. 49 (2008) 2602–2608.
[25] V. Velmurugan, C.K. Deenadayalan, H. Vinod, K. Srithar. Desalination of effluent using fin type solar still, Energy (2008) 1719–1727.
[26] Piyush Pal, Pankaj Yadav, Rahul Dev, Dhananjay Singh. “Performance analysis of modified basin type double slope multi-wick solar still”, Desalination, Volume 422,(2017) Pages 68-82
[27] M. Abu-Arabi, Y. Zurigat, H. Al-Hinaib. Modeling and performance analysis of a solar desalination unit with double-glass cover cooling, Desalination 143 (2002) 173–182.
[28] H.M. Ali. Effect of forced convection inside the solar still on heat and mass transfer coefficients, Energy Convers. Manage. 34 (1993) 73–79.
[29] H.M. Ali. Experimental study on air motion effect inside the solar still on still performance, Energy Convers. Manage. 32 (1991) 67–70.
[30] Lovedeep Sahota, G.N.Tiwari. “Effect of Al₂O₃ nanoparticles on the performance of passive double slope solar still, Solar Energy, Volume 130(2016)Pages 260-272
[31] W.M. Alaian, E.A. Elnegiry, Ahmed M. Hamed. “Experimental investigation on the performance of solar still augmented with pin-finned wick”, Desalination, Volume 379 (2016) Pages 10-15
[32] F. Tabrizi, A. Zolfaghari. Experimental study of integrated basin solar still with a sandy heat reservoir, Desalination 253 (2010) 195–199.
[33] Abdenacer PK, Nafila S. Impact of temperature difference (water–solar collector) on solar-still global efficiency. Desalination 2007;209:298–305.
[34] Bacha HB, Dammak T, Abdallah AAB, MaalejAY, Dhia HB. Desalination unit coupled with solar collectors and a storage tank: modelling and simulation. Desalination 2007;206:341–52.