A COMPARATIVE STUDY OF BRACKISH WATER DESALINATION USING INDIGENOUSLY PREPARED SOLAR DESALINATION UNIT

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ABSTRACT

In this research work, the performance of a tent type solar still with a transparent polythene cover coupled with a solar water heater and a single solar still with transparent glass sheet were studied. Hot water from a water heater was given to the first solar still and same quantity of brackish water was given to the solar still 2. The quality of distilled water from both solar stills was measured per day, and the effectiveness of the stills was compared. The performance these stills was checked for 21 days. The different parameters i.e., ambient temperature, inner space temperature, body temperature, heated water temperature and amount of distilled water were studied and analyzed statistically.

Key Words: Water desalination, ambient temperature, solar still, water heater,

1. INTRODUCTION

Introduction

The sun is mankind's future source of energy. The sun's energy can be collected and measured and is available everywhere and infinite. There are three sources on which, we can rely to provide large amounts of energy for a long period of time.

The sun is a free, infinite and non-polluting source of energy. Pakistan possesses a large potential for utilizing solar energy for various purposes e.g., dehydration and distillation.

Water, the part of life, is one of the most abundant and widely distributed substances on earth. Water is tasteless, colourless and orderless and necessary for existence for humans and other forms of life. It may be a carrier of other good or bad solutes or suspensions, sugars, flavors, gases, acids, colours minerals, vitamins, bacteria, fungi or pollution. Many people don't have access to an adequate and inexpensive supply of water. By using the sun's energy, a solar still appears to be well suited for supplying pure fresh water by desalinating the available saline water.

There are many types of solar stills. Three are different from one another in material, geometry and production but include elements serving the same basic function.
In several regions the increasing demand for portable water can be met only by desalination of brackish or seawater. In developing countries desalination technologies with large concentration cannot grow fast due to high investment costs. A solar still needs only low cost material for desalination of water.

In this present research work the performance of a solar still coupled with a solar water heater and a single solar still were studied. The amount of distilled water was measured per day. This was compared for both solar stills for checking the effectiveness and efficiency of solar stills.

2. MATERIALS AND METHODS

2.1 Materials

For solar stills

1. Two thermometers
2. Iron strip
3. Glass polythene sheet
4. Wooden frame
5. Angle iron stand
6. Galvanized Iron (GI) sheet

For solar water heater

1. Glass sheet
2. GI Sheet
3. GI Pipes
4. Glass wool
5. Wooden strips
6. Angle iron stand
7. Three thermometers

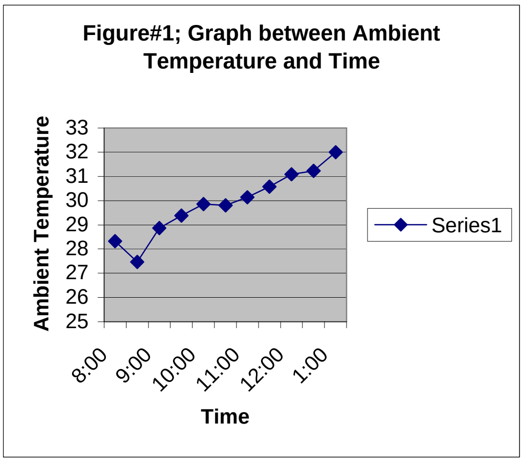
2.2 Method

The GI Sheet was used for the base of solar distillation and wooden strips were used as insulation. The thermometers were attached to the base to note the temperature of the base and inner space.
The polythene sheet was used as a cover (tent type) of the solar still's base.
The whole system was placed over an angle iron stand. The working of a solar still is very simple. In this research work, two solar stills were used; still 1 was coupled with solar water heater and still 2 was single. Every morning these stills were put on the lawn of department of physics, University of Agriculture, Faisalabad. Hot water from a solar water heater was given to still 1 and the fresh brackish water was given to the still 2 through the main supply. These stills were facing the sun and their positions were fixed.
Solar radiation passed through transparent covers and was absorbed by the blackened surface of the stills. These radiations raised the temperature, the water got hot and was evaporated to vapor in the air above the surface. Density of the air reduced due to increase in temperature and caused it to circulate upwards. As result, the vapour pressure of enclosed air was increased and the vapours make contact with the inner surface of the relatively cool transparent cover. The liquid condensed, flowed into the base of the cover and finally through the outlets into the container. The distilled water from both stills was measured to check the best efficiency of the solar still. The data was recorded for 21 days from 8:00 A. M. to 1: 00 P. M.
The correlation and T-test technique were used to analyze data.

3. RESULTS AND DISCUSSION

The present study was concerned with a comparative study of brackish desalination using indigenously prepared solar desalination units. The basic idea of the present study was to compare the efficiency of two solar stills: one having a polythene coversheet was coupled with solar water heater and named as solar still (1), while the other was single, having a glass sheet, which was named as solar still (2). The figures of solar still (1) and solar still (2) are shown in **Appendix-A.** The performance of these two solar stills was studied at the department of physics, University of Agriculture, Faisalabad. This whole apparatus was kept in the sun every morning for five hours (8:00 A.M to 1:00 P.M) in the months of September and October under the climate weather condition of Faisalabad. In this research the following parameters were studied.

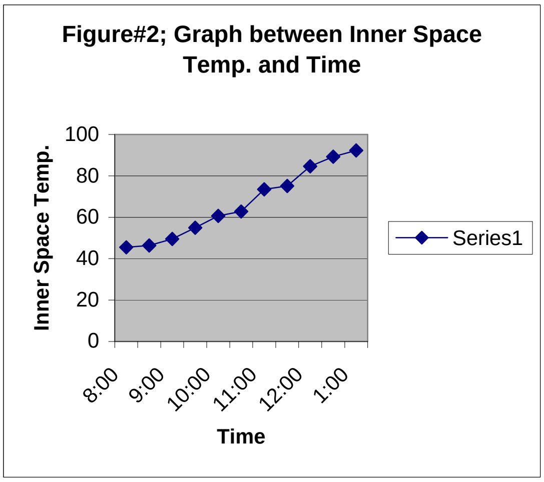
Ambient Temperature (^{0}C)
For the measurement of ambient temperature, an alcoholic thermometer was hung outsides by the solar stills in a shady place. This temperature was recorded after regular half-hour intervals. The maximum ambient temperature increased continuously from 8:00 A.M to 1: 00 P.M.
A graph is plotted between ambient temperature for average value, and time is plotted and was shown in figure#1.



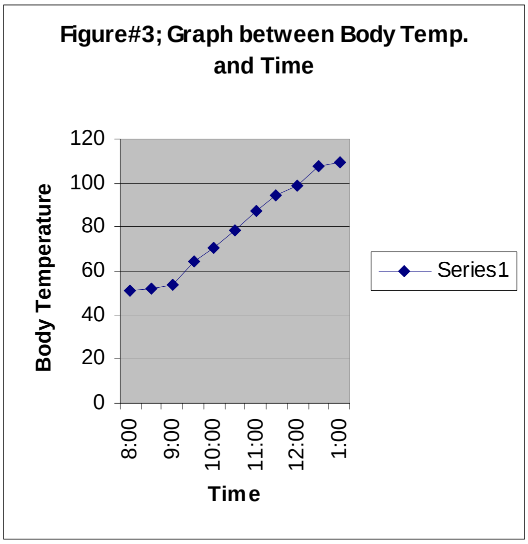
Inner Space Temperature (^{0}C) [solar water heater]
The inner space temperature of the solar water heater was recorded after regular half-hour intervals. A mercury thermometer was hung inside the water heater. The solar radiation fell on the glass cover and the collector plate after passing through the glass; the sodium sulfide coated plate absorbed these radiations. The temperature was noted from 8:00 A.M to 1:00P.M. The maximum inner space temperature was recorded (115^{0}C) at 1:00 P.M. on 22-09-2001. It is also noted

that the inner space temperature increased rapidly during two hours and then increased slowly.

It was also observed that the inner space temperature of the water heater was higher than the inner space temperature of the stills. A graph between the inner space temperatures of the water heater for average values and time is shown in figure#2.

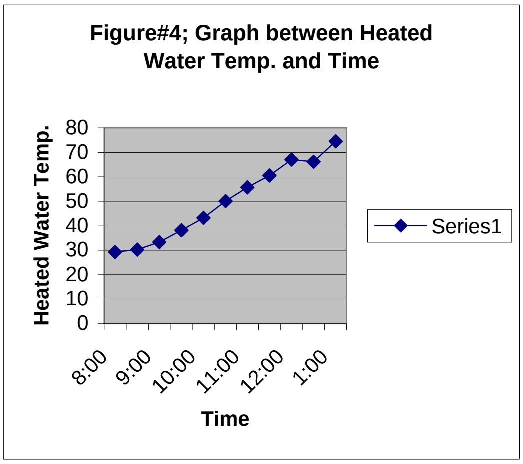


Body Temp (^{0}C) [solar water heater] To note the body temperature of the water heater a mercury thermometer was fixed inside the solar water heater in such a way its bulb would touch the blackened surface of its sheet. Its value is highly increased with the passage of time. The data were recorded from 8:00 A.M. to 1:00 P.M. after a regular intervals of half an hour. The maximum temperature was noted (125^{0}C) at 1:00 pm. on dates 24-09-2001 and 25-09-2001. The average value of body temperature versus time was plotted and shown in Figure#3.



Heated Water Temp (^{0}C) [solar water heater]

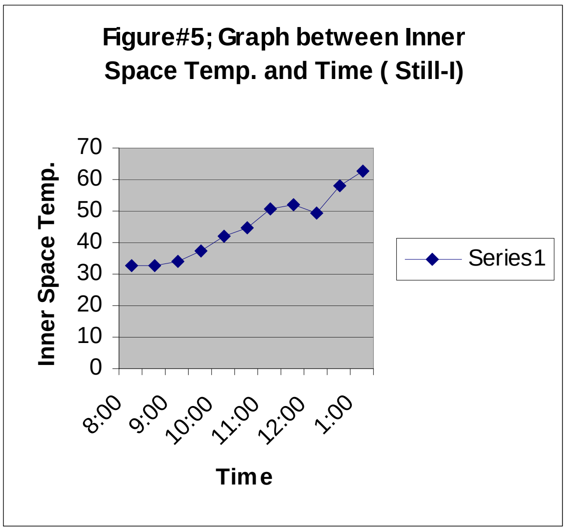
An alcoholic thermometer was hung at the outlet of the solar water heater, from which heated water was given to the solar still (1), and the temperature of that heated water was noted after regular intervals of half an hour. The maximum temperature of heated water was recorded (101 ^{0}C) on date 28-09-2001& 29-09-2001. Its value increased continuously with the passage of time. The average value of heater water versus time was plotted and shown in the Figure#4.



Inner Space Temperature (^{0}C) [solar still-1]

The inner space temperature of solar still 1was recorded after regular half-hour intervals. A mercury thermometer was hung inside the water heater. The solar radiation fell on the transparent sheet cover after passing through the cover, and this radiation was absorbed by the sodium sulfide coated plate. The temperature was noted from 8: A.M to

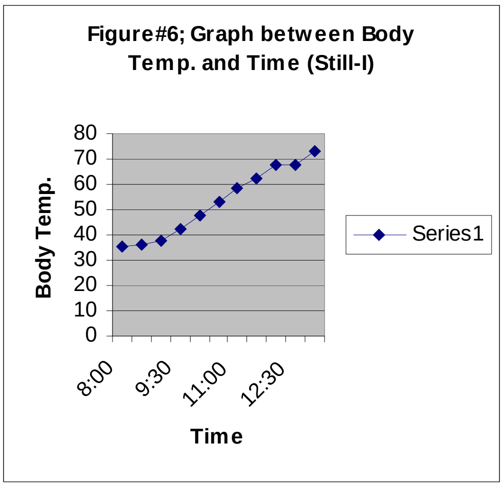
1:00P.M. The maximum inner space temperature was recorded (90^0C) at 1:00 P.M. on 27-09-2001. It is also noted that the inner space temperature increased rapidly during the first two hours and then increased slowly. The inner space temperature of the solar still for average values versus time was plotted and shown in the Figure#5



Figure#5; Graph between Inner Space Temp. and Time (Still-I)

Body Temperature (^{0}c) [solar still -1]

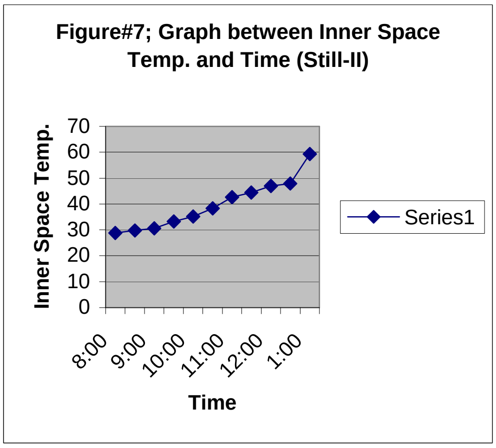
To note the body temperature of solar still (1) a mercury thermometer was fixed inside the solar still in such a way that its bulb would touch the blackened surface of the sheet. Its value is highly increased with passage of time. The data were recorded from 8:A.M to 1: P.M. after regular intervals of half an hour. The minimum, temperature was noted 100^0C on different dates at 1:00 P.M. Thus the inner space temperature of solar still 1 is higher than the inner space temperature of still 2. Inner space temperatures of the still for average values are shown in Figure#6.



Figure#6; Graph between Body Temp. and Time (Still-I)

Inner Space Temperature (^{0}c) [solar still (2)]

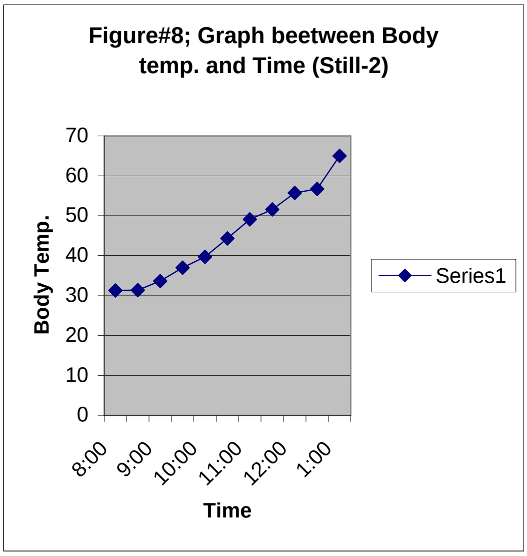
The inner space temperature of solar still 2 was recorded after regular intervals of half hours. A mercury thermometer was hung inside the water heater. The solar radiation fell on the glass cover sheet, and after passing through the glass, this radiation was absorbed by the sodium sulfide coated plate. The temperature was noted from 8:A.M. to 1: P.M. The maximum inner space temperature was recorded (80^0C) at 1:00 P.M. on 27-09-20001. It is also noted that the inner space temperature increased rapidly during mid two hours and then increased slowly. Inner space temperatures of the solar still for average value versus time are plotted and are shown in the figure#7.



Figure#7; Graph between Inner Space Temp. and Time (Still-II)

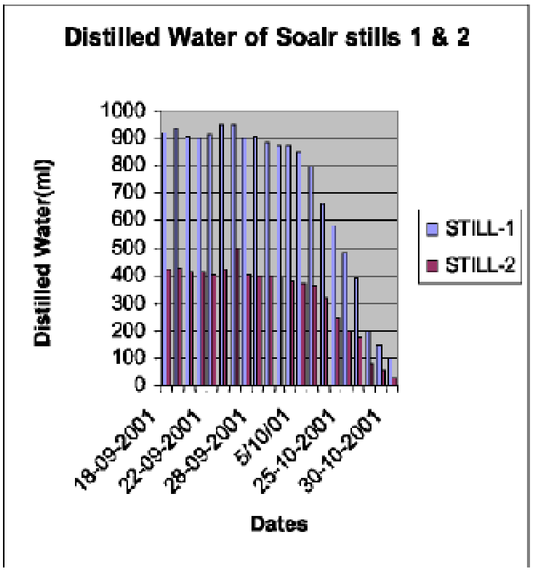
Body Temperature (^{0}C) [solar still -2]

To note the body temperature of the solar still a mercury thermometer was fixed inside the solar water heater in such a way that its bulb would touch the blackened surface of the sheet. Its value is highly increased with the passage of time. The data were recorded from 8: A.M. to 1: P.M. at regular intervals of a half hour. The maximum temperature was noted (95^0C) at 1:00 P.M. on 22-09-2001. Body temperature of solar still (2) for average value versus time was plotted and is shown in figure#8.



Amount of Distilled Water [ml]

The distilled water produced by the stills was collected in the flask and was measured per day. The maximum distilled water produced by the still (1) was 950 ml on 26-09-2001, which was a hot sunny day. During hazy and cloudy days the still worked but the distillate rate was reduced. Distilled water was obtained on a hazy day, however no distillate was obtained when there was a complete cloudy day. The maximum distilled water produced by the still (2) was recorded as 425 ml on 19-09-2001. The average amount of water produced by the still (1) was 721 ml and for still (2) was 337 ml. The amount of distilled water by the stills per day was plotted versus dates as shown Figure# 9.



Statistically Analysis

The difference between the productivity of solar stills was noted, and it was considered that the solar still (1) was more efficient than the solar still (2). This hypothesis was analyzed by applying the T-Test. The statistical results are shown in Figure#2.

Figure#2: Statistically Table

X1	X2	SP(Standard Error)
25	420	
935	425	SP=224.09
910	410	
900	405	ttab = 2.011
915	410	
950	415	
950	500	
900	405	tcal =36.58
905	400	
890	400	If tcal > ttab
875	390	
870	375	
850	370	H0 is reject 36.58 > 2.011
800	365	
660	320	SIGNIFICANT
580	250	
480	200	
390	180	
200	75	
150	60	
100	25	

$\Sigma X1 = 15136$ $\Sigma X2 = 6800$ $\Sigma X1^2 = 1254526$ $\Sigma X2^2 = 257350$

then the efficiency of solar still-1 is better than solar still-2.

Discussion

The average values of the ambient temperature, inner space temperature, water temperature and amount of distilled water were calculated. The total number of observations were 21, taken for the two stills (1) &(2). The efficiency of these stills was tested statistically by the following methods. The analysis of variance table T-test having L.S. 5%.

In this present research there were compared the efficiency of two solar stills, one coupled with a solar water heater while other was single. The following parameters affected the rate of distillation of water.

(a) Seasonal effect for both the stills.
(b) By coupling solar water heater with solar still (1).

(c) Air in the atmosphere.
(d) Temperature.
(e) Dimensions of stills.
(f) Direction and orientation.

It is observed during research the efficiency of that still which was coupled with water heater was greater than the other still because the hot water from heater was given to the still and heated to vapour sooner.

The result shows that the solar still 1 with a solar water heater performed better than the single still because in the single still the water was only heated in the still while in the solar still 1, the hot water from the solar water heater was given to the still so its efficiency increased. This can be illustrated by the first law of thermodynamics, which states that heater entering in the system is equal to the internal energy of the system plus work done by the system

$dQ = dU + dW$

In a solar still (1) the hot water is entered into the still so the still performs no work i.e.

$dQ = dU$

So all the heat entering in the system increased its efficiency and the still performed much better work than the single still.

It was found that the average distillate obtained from solar still (1) was 721 ml and the average distillate obtained from single solar still (2) was 337 ml.

It was also observed that even a small crack in the seals of the still could effect adversely the efficiency of the stills. These effects might occur during transportation of the still. In order to avoid such problem, the still should not be moved frequently and scaling arrangement should be made stronger.

By applying statistical analysis and by using a T-test technique it has been shown that the solar still (1) which is coupled with solar water heater is more efficient than single solar still (2).

4. CONCLUSION

From the analysis, and presentation of data it is concluded that the performance of a solar still (1) is better than that of single solar still (2). It could be seen from the graphs as well as from tables that solar still (1) showed better results regarding the production of distilled water. The performance of the still was related to the atmospheric variables and it was also influenced by factors such as insulation, area of the still, orientation problems etc.

5. REFERENCES

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