IOP Conf. Series: Materials Science and Engineering **310** (2018) 012058 doi:10.1088/1757-899X/310/1/012058

Optimization of Water Output by Experimental Analysis on Passive Solar Still

Winners Parekh[1], Mrugen Patel[2] , Nikunj Patel[2], Jaimin Prajapati[2] and Maitrik Patel[2]

[1] Asst. Prof. Mechanical Engineering Department, Silver Oak College of Engineering & Technology, Ahmedabad, Gujarat, India
[2] BE, Mechanical Engineering, Silver Oak College of Engineering & Technology, Ahmedabad, Gujarat, India

E-mail id: winnersparekh.me@socet.edu.in, mrugenpatel96@gmail.com, nikunj9283@gmail.com, jaiminprajapati1996@gmail.com, maitrik21@gmail.com

Abstract
This paper presents experimental analysis obtained using the single slope passive solar still. The experiments were conducted in Ahmedabad (23°03' N, 72°40' E) using a passive solar still with different water depths and basin materials. Salt was added to study the effect of salinity of water on solar distillation. An extra clear glass is used as cover plate as it transmits 91% light into solar still. Rubber plate and Styrofoam were used as insulating material. So, the productivity of solar still was determined by increasing the temperature of water in the basin and glass temperature.

Keywords
Single slope passive solar still, Water depth, Extra clear glass, Basin material, Experimental analysis, Insulating material, Basin and Glass temperature, Output of passive solar still

1. Introduction

One of the major problems in many parts of world is the scarcity of fresh water. Due to climate changes and less rainfall in many parts of the world, fresh water which was available in abundance from rivers, lakes and ponds is becoming scarce. Also the available resources are getting polluted due to discharge of industrial effluents and sewage in large quantities. It is generally observed that in some arid, semi-arid and coastal areas which are thinly populated and scattered, one or two family members are always busy in bringing fresh water from long distance. In this area, solar energy is useful for converting saline water into distilled water by using distillation process. Solar distillation is considered as one of the simplest and mostly used technique for converting sea water into portable water. A solar still is a simple device which converts saline water into portable water using heat of the sun. The basic principle of solar water distillation is simple yet effective, as distillation replicates the way, nature makes rain.

2. Design of Passive Solar Still

The design of passive solar still was done on the basis of previous studies and research works carried out. It was found that the optimum design of passive solar still has already been found. The basin area was kept 1 m^2 and the inclination angle was kept 23.17^o according to the literature survey.

[1] In this research paper reviews various configurations of active solar still which are augmented with evacuated glass tubes to supply external heat to the still. Single slope solar still with evacuated tubes increase the daily productivity by reducing the heat loss. To increase the temperature of water in basin,

flat plate collector, concentrating collector and evacuated glass tubes were used. The evacuated tubes were directly coupled with the solar still which have the area of 1 m^2. For that, 1 m^2 area of solar still was taken into consideration. For constant area, as the number of evacuated tubes increase, productivity was also increased. So, we conclude to take standard basin area as 1 m^2.

[2] In this research paper, an experimental analysis has been conducted on single slope solar still using different operational parameters like wind speed, temperature and water depth. In this solar still, asphalt basin linear and sprinklers increases productivity up to 51%. Mirrors were used inside the solar still and fixed on the inside wall of solar still which concentrate and reflect the scattered rays. By using asphalt basin liner, absorptivity increases. Night production was about 16% of the total daily output due to absence of solar radiation. So, from this research we concentrated on water depth.

3. Construction of Passive Solar Still

Material	-	Mild Steel Sheet
Thickness of sheet	-	2 mm
Basin Area	-	1 m^2
Dimensions - Upper wall height	-	628mm
- Lower wall height	-	200mm
Inclination Angle	-	23.17º
Glass Area	-	1.09 m^2
Glass Type	-	Extra clear
Absorbing Material	-	Black Paint

Figure 1. Solar Still

Solar still was made from mild steel. Its basin area was 1 m^2. Bottom surface of still was painted with black paint. Extra clear glass was used to get maximum transmissivity. Absorptivity of extra clear glass is very low, so that it transmits higher amount of solar radiation into solar still. Beam radiation have higher amount of energy than diffused radiation. So, glass was placed at 23.17º to get beam radiation. As per location, to get maximum solar radiation solar still was kept in south facing direction. Experiments were conducted in April 2017.

Figure 2. Insulating Material

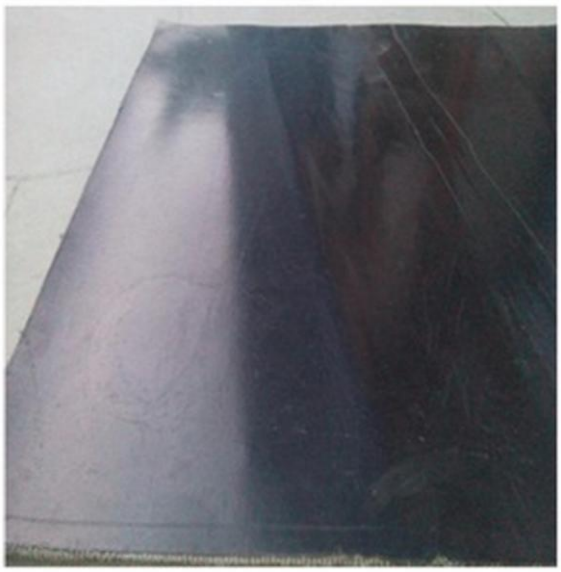

Figure 3. Black rubber sheet

Black rubber plate is used as insulating material. Thickness of rubber plate is 10 mm.

Figure 4. Extra clear glass

Table 1. Glass Performance at Difference Thickness[a].

Thickness (mm)	Light Transmission (%)	Light Reflection (%)	Energy Reflection (%)	Energy Absorption (%)	Solar Factor (%)	UV Transmission (%)
3	91	8	8	4	89	77
4	91	8	8	5	88	74
5	90	8	8	6	87	71
6	90	8	8	8	86	69
8	90	8	8	9	85	65
10	89	8	8	12	83	61
12	88	8	8	14	82	59

[a] All values are nominal values and are subjected to production tolerances. The data were determined according to EN 410.

An extra clear glass is used as cover plate of solar still. Thickness of glass is 4 mm. It transmits 91% of total solar radiation into solar still.

4. Performance Analysis

Solar still was kept in south facing direction to get maximum amount of beam radiation. Performance analysis of single slope passive solar still was done over 21 days for different water depths. Readings were taken for water depth starting from 1 cm to 6 cm. Each depth was kept constant for 3 days and 24 hour output was measured. Then after the spare day the next depth was taken into consideration. From that optimum water depth was found and on that depth readings were taken again for 3 days. Over-night output was also taken into consideration.
Following table shows the output of water for different water depths.

Table 2. Water output for 1 cm water depth.

Time in hour	Quantity of output water in litre
8:00-10:00	0.147
10:00-12:00	0.370
12:00-14:00	0.620
14:00-16:00	0.601
16:00-18:00	0.472
18:00-8:00 (over-night output)	0.131
Total Output	*2.341*

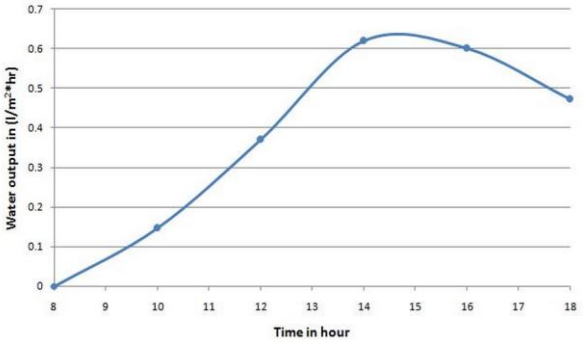

Figure 5. Water output for 1 cm depth

The above readings were taken for 1 cm water depth for 3 days and output measured was 2.335 litre, 2.341 litre and 2.338 litre. Figure 5 shows the output obtained in different time intervals. Here for 1 cm water depth, maximum output is obtained between 2 to 3 PM.

Table 3. Water output for 2 cm water depth.

Time in hour	Quantity of output water in litre
8:00-10:00	0.170
10:00-12:00	0.413
12:00-14:00	0.621
14:00-16:00	0.615
16:00-18:00	0.510
18:00-8:00 (over-night output)	0.139
Total Output	*2.468*

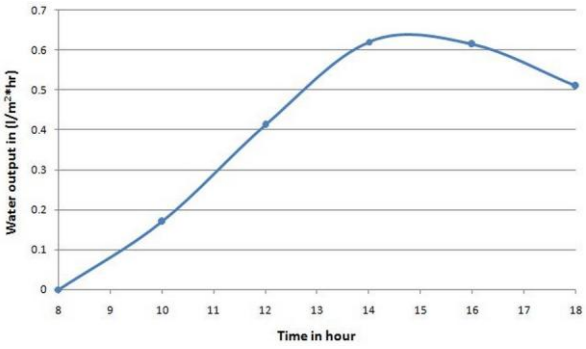

Figure 6. Water output for 2 cm depth

The above readings were taken for 2 cm water depth for 3 days and output measured was 2.465 litre, 2.462 litre and 2.468 litre. Figure 6 shows the output obtained in different time intervals. Here for 2 cm water depth, maximum output is obtained between 2 to 3 PM.

Table 4. Water output for 3 cm water depth.

Time in hour	Quantity of output water in litre
8:00-10:00	0.186
10:00-12:00	0.443
12:00-14:00	0.648
14:00-16:00	0.637
16:00-18:00	0.539
18:00-8:00 (over-night output)	0.148
Total Output	*2.601*

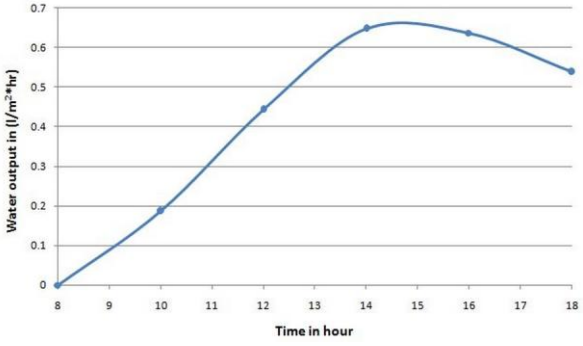

Figure 7. Water output for 3 cm depth

The above readings were taken for 3 cm water depth for 3 days and output measured was 2.598 litre, 2.595 litre and 2.601 litre. Figure 7 shows the output obtained in different time intervals. Here for 3 cm water depth, maximum output is obtained between 2 to 3 PM.

Table 5. Water output for 4 cm water depth.

Time in hour	Quantity of output water in litre
8:00-10:00	0.177
10:00-12:00	0.420
12:00-14:00	0.631
14:00-16:00	0.623
16:00-18:00	0.515
18:00-8:00 (over-night output)	0.145
Total Output	*2.511*

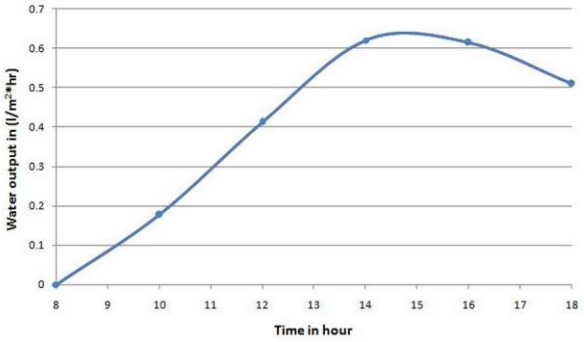

Figure 8. Water output for 4 cm depth

The above readings were taken for 4 cm water depth for 3 days and output measured was 2.506 litre, 2.509 litre and 2.511 litre. Figure 8 shows the output obtained in different time intervals. Here for 4 cm water depth, maximum output is obtained between 2 to 3 PM.

Table 6. Water output for 5 cm water depth.

Time in hour	Quantity of output water in litre
8:00-10:00	0.169
10:00-12:00	0.397
12:00-14:00	0.629
14:00-16:00	0.618
16:00-18:00	0.494
18:00-8:00 (over-night output)	0.142
Total Output	*2.449*

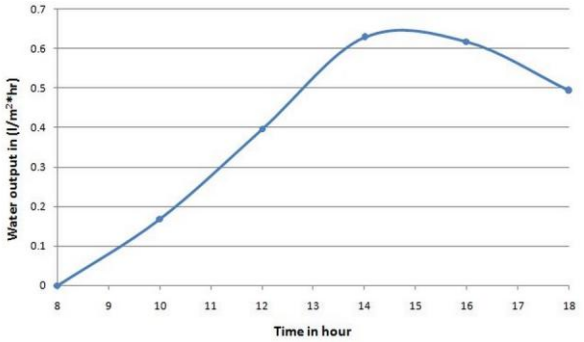

Figure 9. Water output for 5 cm depth

The above readings were taken for 5 cm water depth for 3 days and output measured was 2.449 litre, 2.445 litre and 2.443 litre. Figure 9 shows the output obtained in different time intervals. Here for 5 cm water depth, maximum output is obtained between 2 to 3 PM.

Table 7. Water output for 6 cm water depth.

Time in hour	Quantity of output water in litre
8:00-10:00	0.166
10:00-12:00	0.402
12:00-14:00	0.619
14:00-16:00	0.609
16:00-18:00	0.501
18:00-8:00 (over-night output)	0.135
Total Output	*2.432*

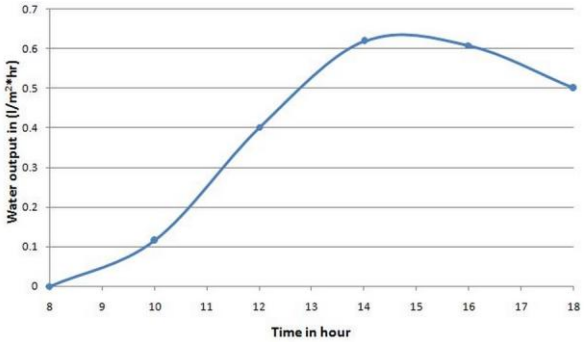

Figure 10. Water output for 6 cm depth

The above readings were taken for 6 cm water depth for 3 days and output measured was 2.430 litre, 2.427 litre and 2.432 litre. Figure 10 shows the output obtained in different time intervals. Here for 6 cm water depth, maximum output is obtained between 2 to 3 PM.

Basin is filled with saline water and then performance of our solar still was checked for different depths of water. As shown in below chart, the maximum water output 2.601 l/day achieved for 3 cm depth.

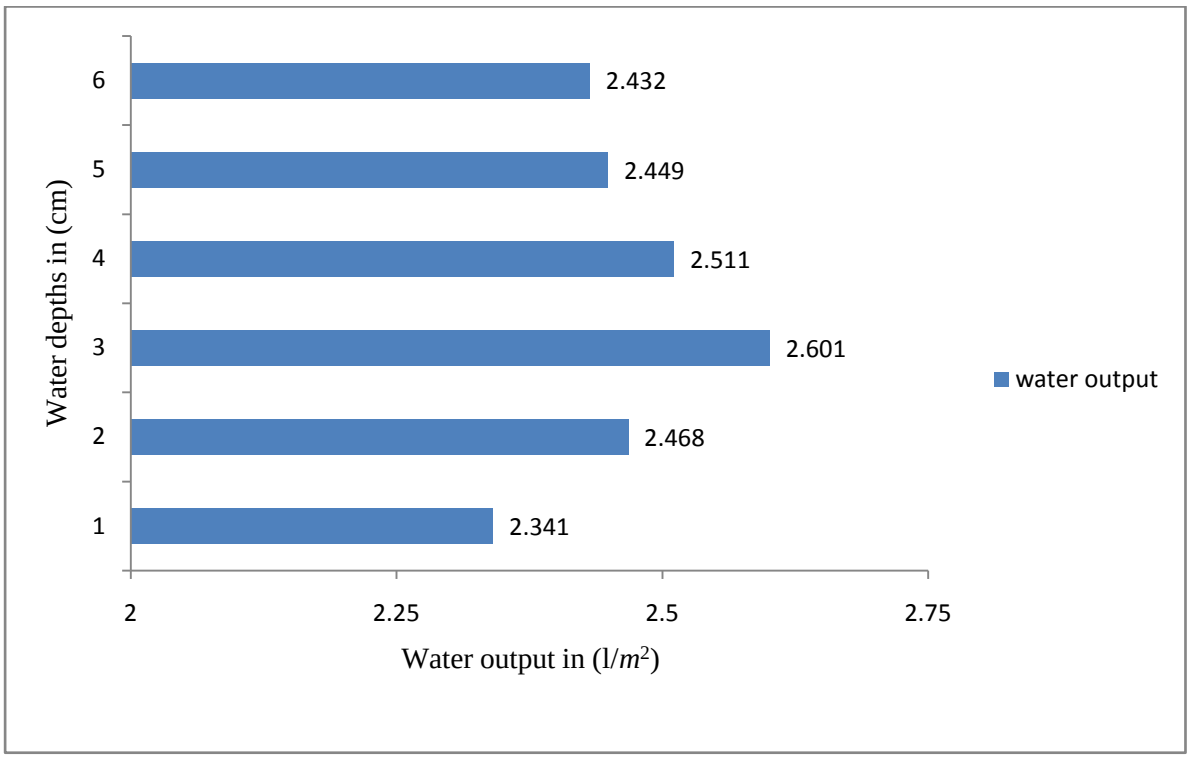

Figure 11. Output for different water depths

5. Conclusion

The Output of water obtained from solar still is dependent on distance between top layer of water and glass cover. If depth of water is less, the distance between the top layer of water and glass cover increases. Hence, water takes more time to evaporate. On other hand, if depth of water is more, then distance between water and glass cover decreases. So, water takes less time to evaporate.

By performing experimental analysis it was observed that ideal depth of basin water in a solar still for maximum output is 3 cm. The output was observed to be 2.601 litres per day which is more than at any other depth of basin water. Hence ideal depth of basin water is found to be 3 cm.

6. References

[1] Winners Parekh and N M Bhatt, 2016 *GIT-Journal of Engineering and Technology* **9** 1-7 ISSN 2249-6157
[2] O O Badran, 2007 *The ninth Arab International Conference on Solar Energy,* AICSE-**9** 136-143
[3] Hitesh N Panchal, 2010 *International Journal of Engineering Science and Technology,* **2(11)** 6626-29
[4] Bilal A Akash, Mousa s Mohsen and Waleed Nayfeh, 2000 *Energy Conservation and Management* **41** 883-890
[5] K Voropoulos, E Mathioulakis and V Belessiotis, 2003 *European conference on Desalination and the Environment* **156** 315-322
[6] Rasool Kalbasi and Mehdi Nasr Erfahani, 2010 *World Applied Science Journal* **10(10)** 1264-71 ISSN 1818-4952

[7] Hitesh N Panchal and Dr. P K Shah, 2011 *International Journal of Renewable Energy Research* ***1(4)*** 212-223
[8] A Alaudeen, K Johnson, P Ganasundar, A Syed Abuthahir and K Srithar, 2014 *Journal of King Saud University – Engineering Sciences* **26** 176-183
[9] Regil Badusha and T V Arjunan, 2013 *International Journal of Mechanical Engineering and Robotics Research* **2(4)** 74-81
[10] Umang R Soni, Dr. P K Brahmbhatt and Hemant B Patel, 2013 *International Journal on Recen and Innovation Trends in Computing and Communication* **1(12)** 843-848
[11] Hiren Patel, Pragna Patel and Jatin Patel,2012 *International Journal of Advanced Engineering Research and Studies* **2(1)** 157-161
[12] Dnyaneshwar Sonawane, Manasi Patil, Onkar Jadhav and Vishvajit Jambuti,2015 *International Journal of Science Technology and Engineering* **2(2)** 192-196
[13] Sadhana, AjeetKumar Rai, Vivek Sachan and Maheep Kumar, 2015 *International Journal of Mechanical Engineering and Technology* **6** 16-20
[14] Mitesh Patel, P M Meena, Sunil Inkia, 2011 *International Journal of Advanced Engineering Research and studies* **1** 4-9
[15] D W Medugu and L G Ndatuwong, 2009 *International Journal of Physical Science* **4(11)** 705-712
[16] T Arunkumar, K Vinodkumar, Amimul Ahsan and Sanjay Kumar, 2012 *International Scholarly Research Network* **2012** 1-10
[17] Suneesh P U and R Jayaprakash, 2012 *Journal of Environmental Research and Development* **7(2)** 756-761
[18] A Bhattacharyya, 2013 *International Journal of Environment and Sustainability* **2(1)** 21-30