

# Study on Parabolic Concentrator Assisted Solar Still System with Continuous Top Cover Cooling

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**ABSTRACT:** Renewable technologies are considered as clean energy sources and optimal use of these resources minimizes environmental impacts and produces minimum secondary wastes, and such resources are sustainable based on current and future economic and social societal needs. Energy in various forms has been playing an increasingly important role in worldwide economic progress and industrialization. The growth of world population coupled with rising material needs has escalated the rate of energy usage. Rapid increase in energy usage characteristic of the past 50–100 years cannot continue indefinitely as finite energy resources of earth are exhaustible. Therefore, there is a need to explore the renewable energy sources to meet out the energy demand in present context.

This paper presents a modification of parabolic concentrator (PC) – solar still with continuous water circulation using a storage tank to enhance the productivity. Four modes of operation were studied experimentally: (i) PC-solar still without top cover cooling; (ii) PC-solar still with top cover cooling. The experiments were carried out for the cooling water flow rates 120 ml/min; 140 ml/min, 160 ml/min, 180 ml/min and 200 ml/min. Diurnal variations of water temperature ( $T_w$ ), ambient air temperature ( $T_a$ ), top cover temperature ( $T_{oc}$ ) and production rate are measured with frequent time intervals.

**KEYWORDS:** Parabolic concentrator, Solar still, Top cooling system.

## I. INTRODUCTION

The continuous increasing pressure of energy demand, the degradation of environment through greenhouse gas emissions and the rise in fuel prices are the main driving forces behind the efforts for more effectively utilizing various sources of renewable energy. Renewable technologies are considered as clean energy sources and optimal use of these resources minimizes environmental impacts and produces minimum secondary wastes, and such resources are sustainable based on current and future economic and social societal needs. Energy in various forms has been playing an increasingly important role in worldwide economic progress and industrialization. The growth of world population coupled with rising material needs has escalated the rate of energy usage. Rapid increase in energy usage characteristic of the past 50–100 years cannot continue indefinitely as finite energy resources of earth are exhaustible. Therefore, there is a need to explore the renewable energy sources to meet out the energy demand in present context. Solar energy is the one most abundant renewable energy source and emits energy at a rate of  $3.8 \times 10^{23}$  kW, of which, approximately  $1.8 \times 10^{14}$  kW is intercepted by the earth. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in a multitude of ways.

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Today the world is tested to give adequate unadulterated water assets to human needs. An ongoing report demonstrates that the ground water levels and precipitation are in decrease. Later on, with populace and per capita utilization development, the circumstance will turn out to be significantly progressively troublesome.

In any case, desalinization is one class of arrangements that holds critical guarantee. A case of refining is a sunlight based still, which is a basic gadget that can be utilized to change over saline or bitter water into drinking water [1]. Abu-Hijleh and Mousa [2] expanded the previous work and incorporated the dissipation impact of a water film streaming over the glass spread. Lawrence et al. [3] approved their model by fusing the impacts of water stream over the spread and warmth limit of water in the bowl. They found an expansion of 7–10% in proficiency of the sun oriented still because of water stream over the glass spread. A stage type sun based still with inherent idle warmth warm vitality stockpiling has been researched by Radhwan [4]. Tiwari et al. [5 &6] consolidated the progression of waste boiling water in the bowl alongside water stream over the glass spread and got an expansion in distillate yield comparable with the increment in gulf water temperature in the bowl. Suneesh et al. [7] explored a 'V' type sun oriented still with cotton cloth cooling. They presumed that water streaming over the buildup surface expands the profitability. Tiwari et al assessed the exhibition of a sun based still with water stream over the glass spread. Arunkumar et al. [8] investigated the impact of water stream over a cylindrical sun based still. They presumed that the water stream over the spread expands the distillate efficiency.

Ahsan et al. [9] considered the minimal effort triangular sun based still to be utilized in country and seaside zones for changing over saline water into consumable water utilizing sun oriented vitality. Abu-Hijleh [10] if your paper is proposed for a gathering, if it's not too much trouble contact your meeting editorial manager concerning satisfactory word processor. Hypothetically explored the viability of film cooling under various working attributes; his outcomes showed that the best possible utilization of the film cooling parameters can build the still proficiency by 6% yet poor parameters can lessen still productivity. Karimi Estahbanati et al. [11] examined the impact of number phases of dissipation and buildup on the presentation of multi-impact sun oriented stills and their consequences for efficiency. They inferred that with more stages, the generation improvement is more in the ceaseless mode contrasted with the non-constant mode.

Water streaming over the gathering spread has been examined by numerous writers working in the field of desalination. These days' concentrators are utilized in different applications. Numerous creative research exercises have been performed on concentrator frameworks, for example photovoltaic frameworks, structures, air conditionings and cooling-warming. Concentrator fueled sun oriented refining frameworks assume a critical job in creating desalted water. By and by numerous analysts are engaged with these exercises to collect top notch de-salted water through concentrator-helped frameworks.

An exploratory examination on a regenerative sun powered still with warm vitality stockpiling medium has been considered by Sakthivel et al. [12]. This change was ease as the jute material is extremely modest and promptly accessible. Arjunan et al. [13] explored the presentation of a basic sun powered still with various vitality stockpiling materials like dark rock, rocks, blue stone, and paraffin wax. The impacts of warmth stockpiling bed and water profundity are examined by Omara and Kabeel [14]. They demonstrated that capacity bed (sandy layer) improved the sunlight based still profitability.

A sun based still with implicit inside and outer reflectors has been examined by Omara et al. [15]. They found that the profitability improvement was 125% because of the impact of reflectors. El-Agouz [16] considered the water stream over a ventured sunlight based still. The creator inferred that the proficiency of the proposed sun powered still was 20% more noteworthy than regular sun powered stills. A straightforward sun powered still with various shaded wipe liners on the internal divider surfaces was examined by Arjunan et al. [17].

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A solitary bowl twofold slant sun based still with various vitality putting away materials has been examined by Kalidasa Murugavel et al. [18]. They found that quartzite shake is the more viable in expanding creation every day. Sodha et al. [19] introduced the impact of color on the sun based still execution. They inferred that dark and violet colors were discovered more compelling than different colors.

Numerous scientists have dissected the effect of cooling of the buildup surface of sun oriented stills. Somwanshi and Tiwari [20] found that the distillate yield increments somewhat with an expansion in water stream rate over the top spread. They inferred that the still's productivity is 57% contrasted with 61% for the still without stage change material.

They inferred that the 5 mm thickness wipe liner gives 35.2% higher yield than the traditional still and a dark wipe gives more yield than the others, which is 43.5% higher than the customary still. The exploratory and hypothetical examination finished up with a normal relative blunder of 42% for the distillate stream rate. Numerous creators have played out the refining procedure with concentrator-helped methods. El-Sebaii [21,22] contemplated the presentation of single slant sun powered still with stage change material. Gude [23] investigated vitality stockpiling for desalination forms with waste warmth sources.

## II. MATERIALS AND METHODS

The parabolic concentrator sun based still comprises of a round area gatherer (generally explanatory) and a hemispherical safeguard. The hemispherical part was independently structured and appended to the bowl base piece of the still. This whole hemispherical safeguard volume goes about as water stockpiling for the still. The safeguard is made out of copper with 4 mm thickness. The measurement of the hemispherical base is 0.22 m. The internal and external surfaces were painted dark and a ¼ in. channel pipe filled in as a water delta. A Pyranometer is utilized to screen the sunlight based radiation. The water temperature, air temperature, surrounding temperature, inward spread temperature. The vulnerability of the estimating gadgets are in Table . The warmth extricated water was gathered and it is utilized in the equivalent sun powered still for refining reason for the following day.

The top surface of the still is a front of region 0.25 m x 0.25 m. The top spread is made out of straightforward glass 2 mm thick. The top spread was put over the notches with uniform resting slant of 110 from the flat. A water gathering portion was likewise given at the fitting spot. The fragment has a length of 0.27 m and a width of 0.025 m. This whole setup was mounted at the point of convergence of the concentrator underneath. A capacity tank mounted on a steel structure provided crude water and cooling water. The water tank produces weight head. Prior to initiation of the trial, the required stream rate from water tank to the PC still was ceaselessly tried and afterward water was permitted to stream over the glass spread. The schematic perspective on the parabolic concentrator sunlight based still with the cooling framework is appeared in Figs. 1.

In this work, an explanatory concentrator-sunlight based still has been manufactured that is not the same as every past work since it couples an allegorical concentrator with top spread cooling. Testing for the present investigation was completed for Pune India climatic conditions amid March–May, 2019. Additionally, the bowl of the sunlight based still is made as hemispherical bowl, where the sun based radiation is engaged to a point to build the temperature of the water inside the still. To build the buildup of water on the internal surface, spread cooling is conjured. The trial included diverse stream rates over the top spread. So as to improve the medium-term efficiency. The sun based radiation is transmitted through the single incline sun powered still spread henceforth, these temperatures increment, some portion of the vitality consumed by the bowl is exchanged by convection to the water.

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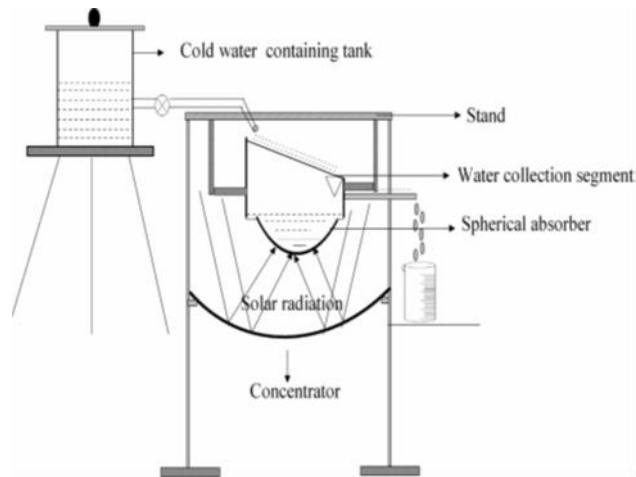


Fig. 1. Schematic diagram of parabolic concentrator solar still with top cover cooling unit.

### III. RESULTS

Fig. 2 & 3 demonstrates the variety of sun oriented radiation and surrounding temperature as for time. Respectively Sunlight based insolation and encompassing air calm are the two most significant ecological parameters to the exhibition of any sun oriented desalination framework. It very well may be seen from assume that the greatest recorded encompassing temperature is 370C at 1.30 PM. Correspondingly the most extreme recorded sunlight based radiation is 1050 W/m<sup>2</sup>. Two parabolic concentrator-sun based still frameworks were manufactured to analyze the outcomes. This is the best way to foresee the definite outcomes in the equivalent climatic conditions. Fig. 4 (a-f) demonstrates the variety of temperatures in the PC-sun oriented still for various cooling water stream rates. The bowl water temperature isn't greatly influenced by the cooling water due to the concentrator impact. In the meantime, the glass temperature step by step diminishes with expanding cooling water stream rate from 120 ml/min to 200 ml/min. The consolidated impacts of top spread cooling improve the efficiency of the PC-sun oriented still. The all out creation of the framework is outlined in Table. 1 that the impact of cooling spread improves the yield by 6% with an expansion in the stream rate of water. Because of the expanded driving temperature inclination between the bowl water and glass, the buildup of water inside the spread is expanded.

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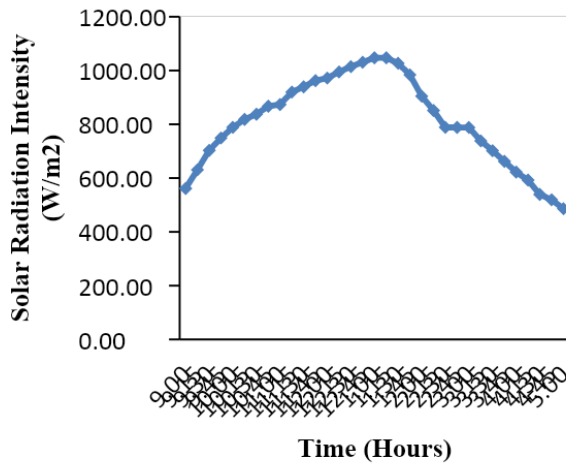


Fig. 2. Variation of solar radiation intensity with time

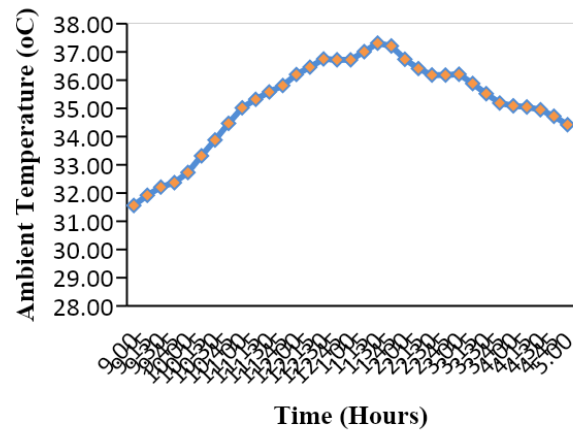


Fig. 3. Variation of ambient temperature with time

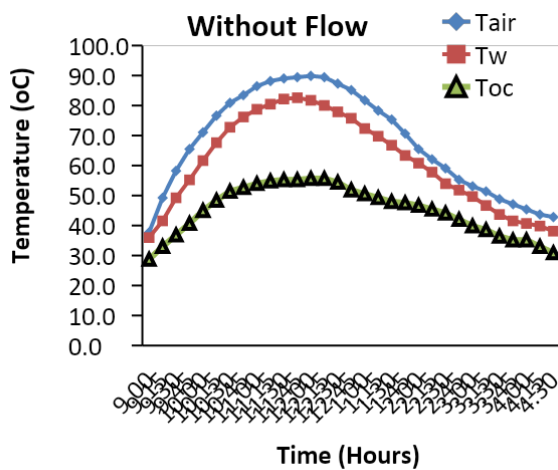


Fig. 6(a)

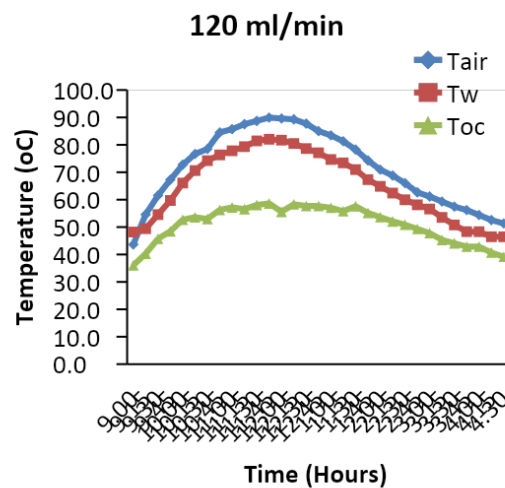


Fig. 6(b)

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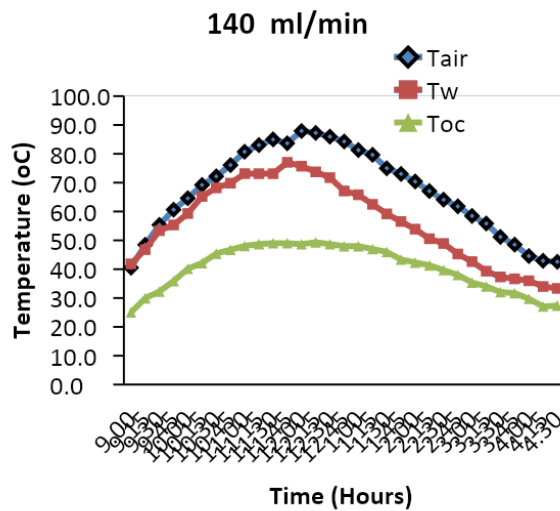


Fig. 6(c)

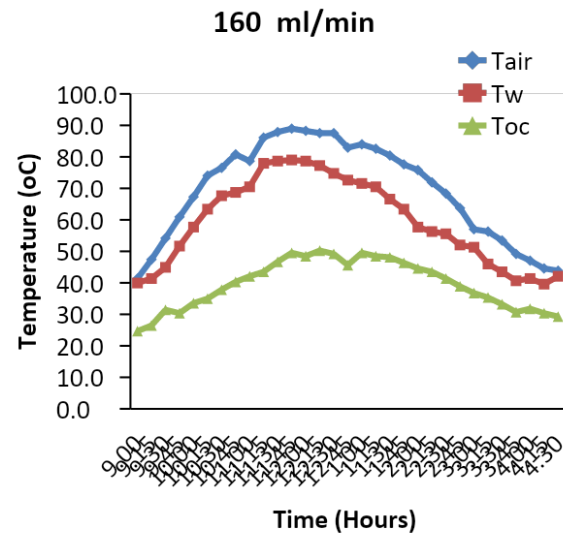


Fig. 6(d)

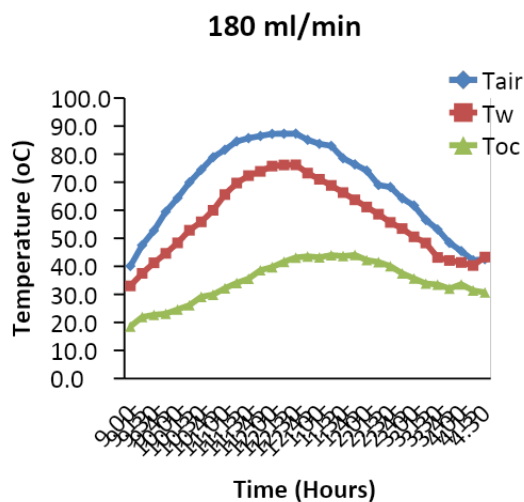


Fig. 6(e)

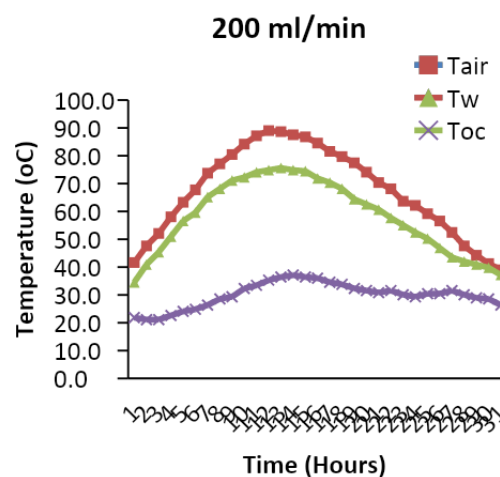


Fig. 6(f)

Fig. 4. (a-f) Hourly variation of temperature with respect to time without PCM for top cover cooling different flow rates (including zero).

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Sr.No	Cooling Water Flow Rate (ml/min)	Output of Distilled Water (ml/day)
1	0	3540
2	120 ml/min	3620
3	140 ml/min	3840
4	160 ml/min	4050
5	180 ml/min	4220
6	200 ml/min	4450

Table:1 Productivity of Solar Still

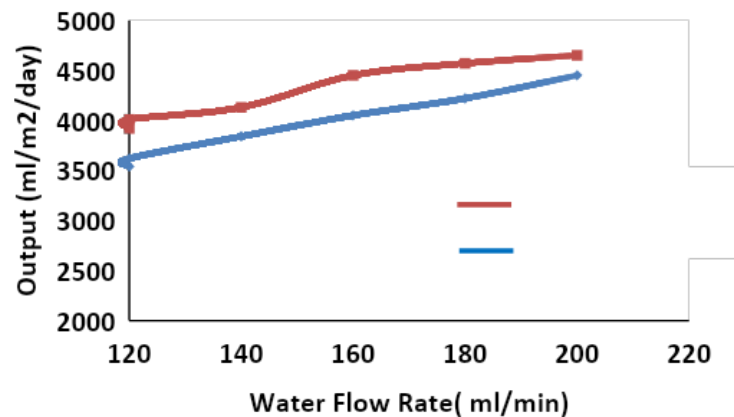


Fig. 5. Variation of solar still output with and without incorporation of phase change material

## IV. CONCLUSION

An parabolic concentrator attached single slope, sun slanting still (PC sun oriented still) has been manufactured and tentatively tried with various cooling water flow rates to improve the conception further. In this assessment article, four individual stream rates over the top glass spread are contemplated. The concentrator persistently supplies the radiation, which is changed into warmth vitality on the base of the sun powered still round safeguard in the meantime the stream water separates the warmth from the glass spread. The accompanying ends are drawn from the exploratory outcomes:

- Productivity increments with expanding the stream rate of the cooling water over the top spread.
- The cooling water stream is legitimately corresponding to the efficiency and contrarily relative to the spread temperature. Because of this impact, the temperature distinction between the top spread and the bowl water temperature increments.
- In this sort of PC-sun powered still, the bowl water temperature isn't influenced by the cooling water. This occurs because of the impact of the concentrator.



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## REFERENCES

1. Abu-Hijleh Bassam AK, Mousa Hasan A. Water film cooling over the glass cover of solar still including evaporation effects. *Energy* 1997;22:43–7.
2. Lawrence SA, Gupta SP, Tiwari GN. Effect of heat capacity on the performance of solar still with water flow over the glass cover. *Energy Convers Manage* 1990;30:277–85.
3. Radhwan Abdulhai M. Transient performance of a stepped solar still with built-in latent heat thermal energy storage. *Desalination* 2005;171:61–6.
4. Tiwari GN, Bapeshwara Rao VSV. Transient performance of a single basin solar still with water flowing over the glass cover. *Desalination* 1984;49:231–41.
5. Tiwari GN, Madhuri, Garg HP. Effect of water flow over the glass cover of a single basin solar still with an intermittent flow of waste hot water in the basin. *Energy Convers Manage* 1985;25:315–22.
6. Suneesh PU, Jayaprakash R, Arunkumar T, Denkenberger David. Effect of air flow on “V” type solar still with cotton gauze cooling. *Desalination* 2014;337: 1–5.
7. Arunkumar T, Jayaprakash R, Amimul Ahsan, Denkenberger David, Okundamiya MS. Effect of water and air flow on concentric tubular solar water desalting system. *Appl Energy* 2013;103:106–15.
8. Ahsan A, Imteaz M, Thomas UA, Azmi M, Rahman A, Nik Daud NN. Parameters affecting the performance of a low cost solar still. *Appl Energy* 2014;114: 924–30.
9. Abu-Hijleh Bassam AK. Enhanced solar still performance using water film cooling of the glass cover. *Desalination* 1996;107:235–44.
10. Karimi Estabbanati MR, Feilizadeh Mehrzad, Jafarpur Khosrow, Feilizadeh Mansoor, Rahimpour Mohammad Reza. Experimental investigation of a multieffect active solar still: the effect of the number of stages. *Appl Energy* 2015; 137:46–55.
11. Sakthivel M, Shanmugasundaram S, Alwarsamy T. An experimental study on a regenerative solar still with energy storage medium – Jute cloth. *Desalination* 2010;264:24–31.
12. Arjunan TV, Aybar HS, Sadagopan P, Sarat Chandran B, Neelakrishnan S, Nedunchezian N. The effect of energy storage materials on the performance of a simple solar still. *Energy Source Part A* 2014;36:131–41.
13. Omara ZM, Kabeel AE. The performance of different sand beds solar stills. *Int J Green Energy* 2014;11:240–54.
14. El-Agouz SA. Experimental investigation of stepped solar still with continuous water circulation. *Energy Convers Manage* 2014;86:186–93.
15. Kalidasa Murugavel K, Sivakumar S, Riaz Ahamed J, Chockalingam KnKSK, Srithar K. Single basin double slope solar still with minimum basin depth and energy storing materials. *Appl Energy* 2010;87:514–23.
16. Sodha MS, Kumar A, Tiwari GN, Pandey GC. Effects of dye on the performance of a solar still. *Appl Energy* 1980;7:147–62.
17. Somwanshi Aneesh, Tiwari Anil Kumar. Performance enhancement of a single basin solar still with flow of water from an air cooler on the cover. *Desalination* 2014;352:92–102.
18. Samuel Hansen R, Surya Narayanan C, Kalidasa Murugavel K. Performance analysis on inclined solar still with different new wick materials and wire mesh. *Desalination* 2015;358:1–8.
19. El-Sebaei AA, Al-Ghamdi, Al-Hazmi FS, Faidah Adel S. Thermal performance of a single basin solar still with PCM as a storage medium. *Appl Energy* 2009;86:1187–95.
20. El-Sebaei AA, Yaghmour SJ, Al-Hazmi FS, Faidah Adel S, Al-Marzouki FM, Al-Ghamdi AA. Active single basin solar still with a sensible storage medium. *Desalination* 2009;249:699–706.
21. Gude Veera Gnaneswar. Energy storage for desalination processes powered by renewable energy and waste heat source. *Appl Energy* 2015;137:877–98.
22. Sathyamurthy Ravishankar, El-Agouz SA, Dharmaraj Vijayakumar. Experimental analysis of a portable solar still with evaporation and condensation chamber. *Desalination* 2015;367:180–5.
23. Chong K.K., Wong C.W., “General formula for on-axis sun-tracking system and its application in improving tracking accuracy of solar collector”, *Solar Energy* 83, 2009, pp. 298–305.
24. YingYeha P., Po-ChingY., Jia-YushY., Tsung-TsongW., Pei-Ling L., Chia-Ling W., Ching-Yu P., “Focal point tracking system for concentration solar power collection” *Renewable and Sustainable Energy Reviews*, Volume 15, Issue 6, August 2011, pp. 3029–3033.
25. Mohamed F.M., Auatf S.J, Yaseen. H.M., Mohamad A.K., “Design and Study of Portable Solar Dish Concentrator”, *International Journal of Recent Research and Review*, Vol. III, September 2012, ISSN 2277 – 8322.
26. Garcia R.F., Carril J.C., DeMiguel C. and Gomez J.R., “An efficient parabolic dish engine based on Rankine cycle, *International Conference on Renewable Energies and Power Quality*” (ICREPQ’2012), Santiago de Compostela (Spain).
27. Mohammed I.L., “Design and Development of a Parabolic Dish Solar Water Heater, *International Journal of Engineering Research and Applications*” pp. 2248-9622.