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PERFORMANCE ENHANCEMENT OF SOLAR STILL WITH PARABOLIC TROUGH COLLECTOR ALONG WITH ENERGY STORAGE MATERIAL: A REVIEW

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Abstract

A solar still is an easy-to-use device that turns brackish water into potable water. Due to low distillate output, the improvement in solar still (SS) yield is considered to be quite important . It is also regarded as a simple desalination device, technology and expert work are not required. The yield of solar still can be significantly increased with higher water temperatures, so many researchers have utilized different solar collectors to improve the yield. The parabolic trough collector (PTC) is a trendsetting innovation that provides high-temperature water to the solar still to improve the yield. This review paper presents the findings of studies on parabolic trough collector conducted by various researchers. The paper's conclusion covered the PTC's upcoming collaboration with the SS. The PTC is an essential solar collector that can boost production in a desalination system and has a promising future, according to the study's findings.

Keywords: Solar still, Parabolic through the collector, Distillate output, Yield

Abbreviations :

SS – Solar Stil
PTC - parabolic trough collector
FPC – Flat plate collector
ETC – Evecuted tube collector
PCM – Phase change material
CSS – Convntional solar still
MSS – Modified solar still
TBSS- Triple basin solar still

TWSS - Twin Wedge Solar Still

Introduction

Drinkable water is one of the fundamental components that human civilization depends on to survive and to ensure that all body cells receive vital nutrients. Oceans and seas contain unusually saline water, making up around 97% of the water resources on Earth's surface. (Sathyamurthy et al., 2015, 2017a; Panchal et al., 2020; Kateshia and Lakhera, 2021) Many communities in the developing world face a major challenge of Access of Drinkable water. Due to rapid population growth and industrialization growth so people are now concerning the quality and accessibility of drinkable water. (Shannon et al., 2008; Arunkumar et al., 2015) There are different processes like electro dialysis, multi-stage dissipation, and more, yet they include a lot of cost for producing fewer amounts of Drinkable water.(Sathyamurthy et al., 2016) The main sources for getting drinking water to date are rivers, lakes, springs, etc.; on the other hand, the sea and ocean have a lot of water, but we do not consider that source drinkable water.(Mevada et al., 2020) The growing demand for freshwater resources create an urgent need to create an independent system to meet the need for Drinkable water. Water shortage is projected to turn into a more significant determinant of food shortage than land shortage, as indicated by the view held by the UN (UNDP, 2007). In water and power alarm locales, the appropriate main technique to acquire Drinkable water from different wastewater sources is the solar distillation process. (Manokar et al., 2018) It operates on the basic principle of condensation and evaporation in the presence of the sun's ultimate solar radiation water can be purified. This process is known as solar distillation, and the device is called solar still. solar desalination process is the best solution to resolve the existing requirement for freshwater. (Belessiotis et al., 2016; Mevada et al., 2020). India receives a good amount of solar energy per square metre, is close to the centre of the globe, and enjoys 250 to 300 days with clear skies annually. India naturally has a large amount of solar energy potential. India naturally has a large amount of solar energy potential. Solar still is the main component of solar desalination systems. Due to less production output of still approximately 2-4 lit/day it's not widely popular for industrial as well as household appliances. (Nougriaya et al., 2021)

Still, productivity mainly depends on two parameters: the first is high water temperature and the second is lower glass cover temperature production (Panchal et al., 2021) improvements in high and low glass cover temperature will also increase the production of distillate.(Sathyamurthy et al., 2017b; Mevada et al., 2020; Narayanan et al., 2020 ; Panchal et al., 2021) The different researcher proposes several ways to improve the distillate output, but they are still working on improving the productivity with different ideas. Researchers mainly work with Parabolic trough collectors, Different energy storage materials, Use the condenser, Evacuated tu be, Flat plate collectors, use phase change material, and many other methods to enhance the efficiency of solar stills.(Kabeel and El-Agouz, 2011; Vigneswaran et al., 2019; Mevada et al., 2022) This review study discusses variations in the rate of evaporation in active solar still caused by the effects of various techniques and characteristics.

Modern and inventive solar still designs experimented including the inverted Absorber type, Concave Wick type , Single Basin Double Slope type, spherical , hemispherical , tubular , pyramid, Twin Wedge type and many more. Additionally, some researchers used experimental works incorporating different active components, such coupling solar flat plate collectors, evacuated tubes, sun concentrators, spiral tube collectors, and parabolic trough collectors.In order to increase solar energy's output hybrid solar stills have also been created and are being researched by a number of academics.(Jeevadason et al., 2022)

The following research gaps were identified after reviewing several efforts on improving solar still performance.

- Lower efficiency of solar stills.
- Variable yield as a result of the inherent reliance on solar energy.
- Lack of control over the saline water's evaporation rate.

The following goals were developed to address the drawbacks of the current system in light of the research gaps that were identified.

- To create a solar system that can yet provide a higher yield.
- To ensure reliable productivity from the solar stills.
- To create a novel design called SS combined with PTC to address the ongoing problem of reduced and erratic productivity of solar stills.

A review study's primary objective is to assess and compare the productivity of single-basin solar stills with Parabolic troughs with PCM, heat storage material carried out by various researchers and suggest potential future paths.

Significance of Evaporation Rate

The rate at which wastewater is converted into drinking water is directly proportional to the rate at which water evaporates. The evaporation rate mainly depends on Solar radiation availability and basin water temperature. In Active or Passive Solar Still, the evaporation rate is improved by an increase in basin water temperature. The following methods improve basin water temperature.

- Concentrator or a Collector to generate hot water that is fed into a still basin.
- Utilized the different Energy storage materials

Table 1: Short Review of solar still Integrated with different collector

Sr. No.	**Testing Place**	**Integration Method with CSS**	**Type of Study**	**Results achieved using still**	**Author Name**
(1)	Ghaziabad, India	Flat Plate collector	Experiment	24% higher production rate is achieved in daily output.	(Rai and Tiwari, 1983)
(2)	Madurai, India	Flat Plate collector	Experiment	60% higher output is achieved in daily output using energy storage material with FPCB.	(Rajaseenivasan et al., 2014)
(3)	Andhrapradesh, India	Flat Plate collector	Experiment	1 FPC, 2 FPC, and 3 FPC connected in series. 41% more output gets using 2FPC compared to FPC and 89% more output gets using 3FPC compared to FPC	(Raju and Lalitha Narayana, 2018)
(4)	Ghaziabad, India	FPC	Experiment	51% productivity is increased using natural circulation in double slope solar still.	(Dwivedi and Tiwari, 2010)
(5)	Egypt	Flat Plate collector with temperature-controlled glass cover	Experiment	Performance evaluation of integrated solar stills, active and passive stills, and FPC. In terms of daily output, a greater production rate of 57% is obtained. 3 mm thick glass is utilised with a 5-minute on/off cycle.	(Morad et al., 2015)
(6)	Coimbatore, India	CSS with collector and Concentrator	Experiment	The high temp was achieved using a Concentrator compared to a collector.	(Singh et al., 1996)
(7)	Egypt	PTC, Heat exchanger	Experiment	28% higher production rate is achieved in daily output.	(Abdel-Rehim and Lasheen, 2007)
(8)	Egypt	PTC and ETC	Experiment	46% higher production rate is achieved in daily output using a parabolic	(Nabil and Dawood, 2021)

				trough collector with conventional still	
(9)	India	Heat exchanger	Analysis	Due to the still's lower production, a heat exchanger is a tool used to speed up heat transfer and boost distillate productivity.	(Elsheikh et al., 2022)
(10)	Egypt	PTC, Heat exchanger	Experiment	140.4% higher productivity achieved using modified still.	(Kabeel and Abdelgaied, 2017)
(11)	Delhi, India	FPC, ETC	Experiment	Thermal loss is lesser in concentrators compared to FPC.	(Kumar and Sinhat, 1996)
(12)	Coimbatore, India	Compound Parabolic collector	Experiment	When compared to traditional stills, using ccc with solar still results in a 25% increase in productivity.	(Arunkumar et al., 2016)
(13)	Madurai, India	Parabolic dish concentrator	Experiment	90 % higher yield was achieved with a parabolic dish concentrator with TBSS than normal TBSS.	(Srithar et al., 2016)
(14)	Egypt	Parabolic trough collector,	Experiment	combined with sand water and PTC, yield increased 41.96%.	(Fathy et al., 2018)
(15)	Egypt	PTC, ETC, and PCM	Experiment	34 % higher yield was achieved with a depth of basin water of 1.5 cm in MSS compared with conventional still	(Khairat Dawood et al., 2020a)
(16)	India	Parabolic trough collector,	Experiment	Inlet water Temperature increases up to 15 °C using PTC.	(Ranjan et al., 2022)
(17)	Tehran, Iraq	PTC, ETC	Experiment	65.2 percent yield is increased in the Modified setup	(Jafari Mosleh et al., 2015)

Table 2: Characteristics of PCM as Energy storage material

Thermodynamic Characteristics	• High enthalpy • The melting point is in the desired temperature range • High latent heat • High Density

	• Low change of volume during phase change • High thermal conductivity
Chemical Characteristics	• Non-corroded • Non-corroded No chemical decomposition • Non-Toxic • Chemical stability should be high • Non-flammable, non-explosive, and non-poisonous
Material Characteristics	• The unit size is small • Low vapour pressure • Phase equilibrium is favourable
Kinetic Characteristics	• No undercooling throughout the freezing process, • The crystallization rate is sufficient
Economical Characteristics	• Cheap • Large availability

How a solar still and a parabolic trough collector work

Solar still is a simple instrument used for obtaining distillate water from the Brackish water by utilizing the sun's heat energy to evaporate the water leaving the impurities behind it. Vapor collected inside the glass was condensed when the temperature was appreciably lower than that of water and the water vapour and got pure water contained no salts, minerals, or organic impurities. Pure water is mainly used for drinking purposes, different applications in hospitals, automobile batteries, and so on.(Prakash et al., 2022) Productivity is still lower, so using PTC, inlet water temperature is increased, which improves yield. Three major primary components are used: a receiver tube, a Parabolic trough, and a tracking system. So that incident radiation on the receiver tube is focused along the focal line and the sun's movement is tracked. PTC is often oriented north to south. Sunlight focused on the receiver tube through the tracking parabolic aperture as it was laid on the parabolic trough. Due to that, fluid inside the receiver tube is heated, mainly used to increase the solar still's distillate output and used for high-temperature applications in the industry as shown in Figure 1. (Kumar et al., 2016; Prakash et al., 2022)

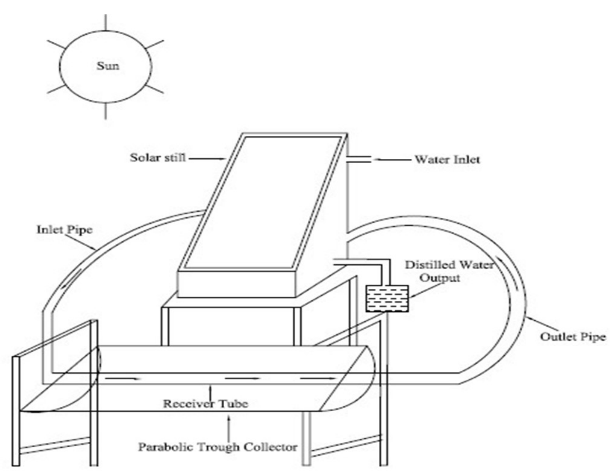

Figure 1: Diagrammatic representation of Parabolic trough collector coupled with Solar still.

Classification of solar distillation

Passive Technique: Conventional still mainly operates with Passive ***Technique; daily production yield is*** relatively low ***due to*** lower temperatures.

Active Technique: The rate of evaporation is increasing in the active mode due to more thermal energy being applied to the basin by different attachments developed by numerous investigators. This raises the solar still output yield. Both the technique are further bifurgated and shown in figure 2.

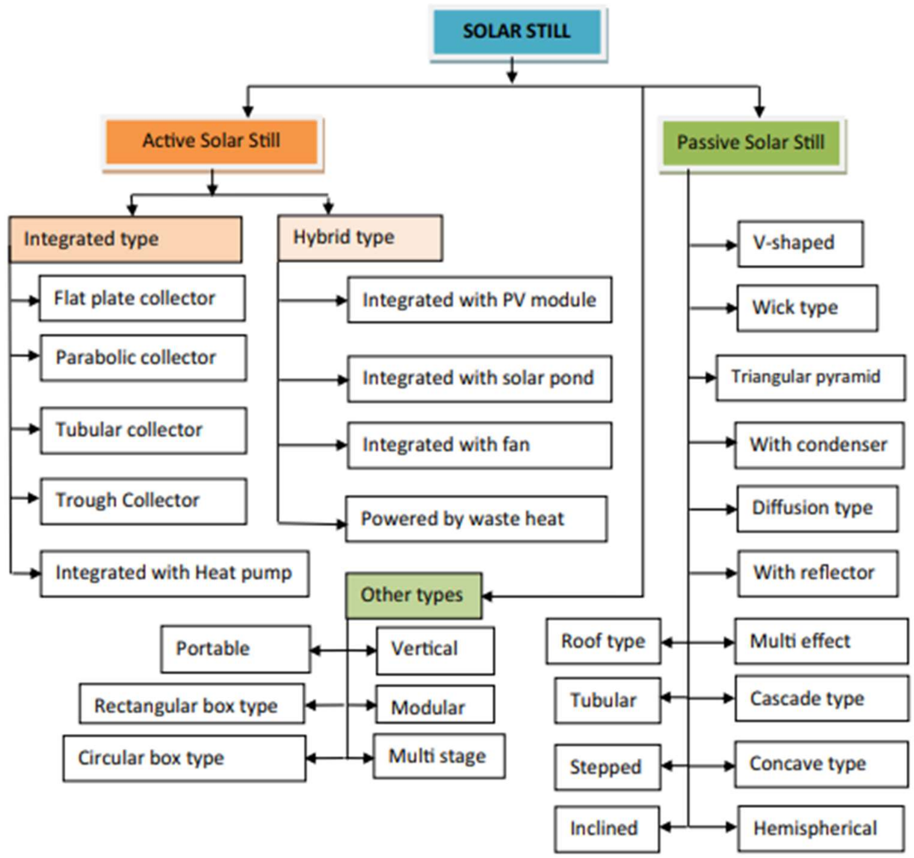

Figure 2: Solar still Classification (Singh et al., 2020)

Improve Solar still performance by various researchers using the Parabolic trough and Different PCM using a basin of still:

(Madiouli et al., 2021) experimented and compared the outcomes for the three cases as shown in figure 3: (1) CSS (2) SS Utilizing PTC (3) SS PTC is used along with Glass balls covered the basin in a thick layer. Due to the heat produced, solar energy from the PTC is transported to a finned piping loop heat exchanger submerged in the still basin. Experiments with 50 mm of salinized water depth were conducted in the winter. The heat transfer rate increased by using a layer of tightly packed glass balls that serves as a media for thermal storage. Investigation reveals that the yield is higher than that of a traditional solar still is 152 percent for instance (3) and 130 percent for case (2). Case (3) achieves the maximum efficiency, which is 14.96 percent, followed by Case (2) with 13.96 percent, and Case (1) with 13.5 percent to show that something is feasible, an economic analysis is also performed on the integration of parabolic trough collectors with a thick layer of glass balls in the still basin.

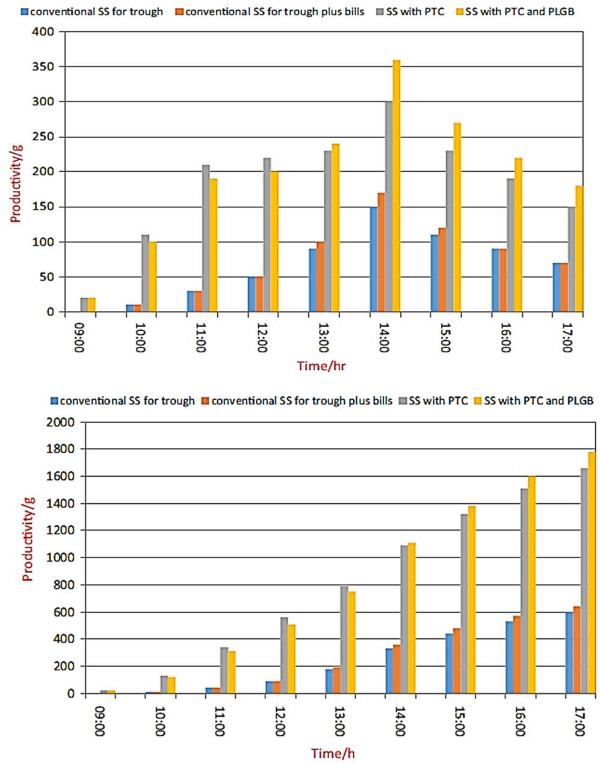

Figure 3: For the solar still systems taken into consideration in this study over the winter, the hourly and cumulative yield of distilled water (Madiouli et al., 2021)

(Madiouli et al., 2020) investigates the efficiency of conventional solar still in combination with parabolic trough collector and flat plate collector, both of which are supported by packaged glass ball layer acting as a kind of energy storage as shown in figure 4. In both the summer and the winter, they conducted experiments with a 50 mm basin water depth. Results indicate that a high production rate of 6.036 kg/m^2/day, or 203% more than in the winter, is attained during the summer season. Additionally, they conducted an economic analysis for a conventional solar still (CSS) that produces one litre of water at a cost 66 percent greater than a developed still. (DSS).

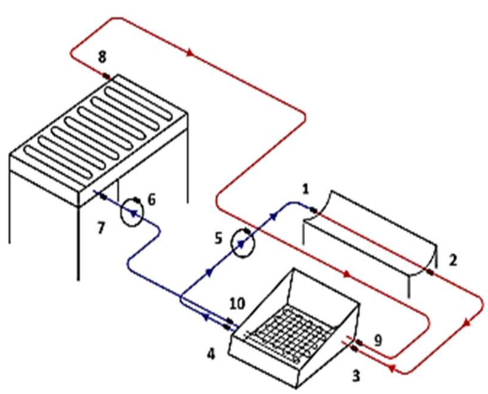

Figure 4: line representation of the test setup (Madiouli et al., 2020)

(Amiri et al., 2021) performed the Energy and Exergy analysis and developed a mathematical model and fresh design for a freestanding PTC collector with built-in SS. They carried out numerous trials to determine productivity. The experimental findings are compared with the mathematical model and the current innovative design model, and there is good agreement between both. The built-in SS with PTC caused seasonal yield changes for them. They concluded that the summer season had a 55 percent higher production of innovative devices than the winter season as shown in figure 5.

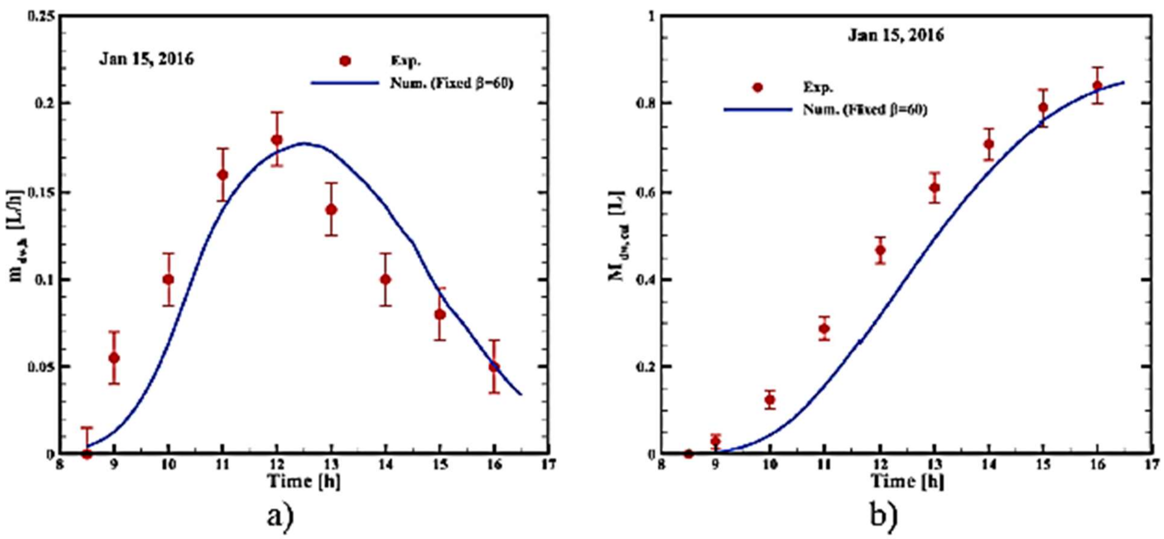

Figure 5: Comparison between the experimental productivity during the validation day and the productivity derived using the thermal model, including a) hourly and b) cumulative freshwater output. (Amiri et al., 2021)

(Upadhyay et al., 2021) The production of warm water for low-temperature applications is the primary goal of the experimental carried out in March 2020 at Godhra. A portable parabolic trough collector is designed and fabricated by the author. In novel design, they do not change the geometry of the parabolic trough, but they easily change the receiver tube, different reflected material, and different heat transfer fluids circulate inside the receiver. The novel design has an automatic as well as a manual tracking system to track the path of sun rays. According to the study, the average experimental PTC with manual tracking efficiency was 11.83 percent, manual tracking with a glass cover was 13.50 percent, and automatic tracking was 14.94 percent.

(Kumar et al., 2020) Examine how PTC performs compared to standard SS in three different water environments in New Delhi. Examine the effectiveness of PTC in comparison to traditional SS given the circumstances in New Delhi, with three separate water depths and flow rate variations. With SS and PTC, they were able to get yields of 4.1 lit/m^2, 3.645 lit/m^2, and 3.2 lit/m^2 in 5 cm, 10 cm, and 15 cm of water, respectively. In comparison to 10 and 15 cm, a yield increase of 22% occurs at a water depth of 5 cm. They also included economic analysis and payback periods for water depths of 5, 10, and 15 cm, respectively, of 246, 253, and 341 days as shown in figure 6. The researcher concluded that this technique is a practical and affordable way to supply rural residents with drinking water.

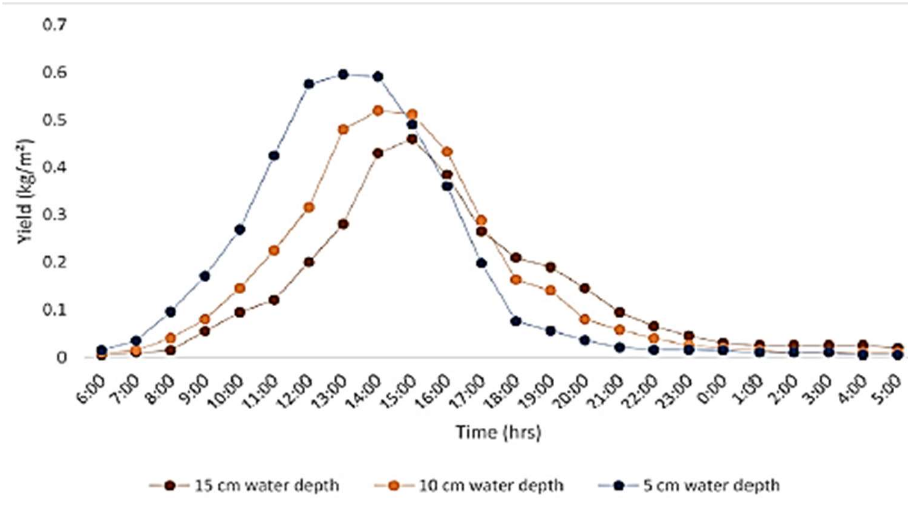

Figure 6: Yield output using different water depth Productivity (Kumar et al., 2020)

(Fathy et al., 2018) An experimental PTC study using conventional SS in Egypt Based on productivity, energy, exergy analysis, and energy payback time, a PTC experimental inquiry using traditional SS in Egypt in a hot and cold climate environment with water mediums is evaluated. The author conducted the test and compared the outcomes for Considerations given to six solar still systems: CSS, PTC with CSS, Steel WM in a basin with CSS, Parabolic trough paired with CSS containing steel WM in a basin, sand in the basin with CSS and PTC integrated with CSS contains sand as shown in figure 7. The results show that using CSS in combination with PTC can provide the maximum amount of freshwater 121% during the summer.

Figure 7: Single slope still in an experimental configuration with PTC (Fathy et al., 2018)

(Fathy et al., 2018) tested the effectiveness of coupling a double-slope solar still with a parabolic trough collector (PTC). The incident solar energy is transferred from the PTC to the solar still via oil pipes attached to a finned-piped loop heat exchanger integrated into the solar still. For two distinct water levels in the basin of 20 and 30 mm, trials are undertaken for three systems: standard solar still, solar still with manually tracked PTC, and solar still with Automatic tracked PTC. The findings indicate that at a saline water level of 20 mm in summer, in comparison to conventional solar stills, the solar still with PTC is 28.1 percent more productive and has a higher basin water temperature. Freshwater productivity for solar still combined with fixed PTC is around 4.03 kg/m^2/day and 8.53 kg/m^2/day in the winter and summer, respectively.

(Subhedar et al., 2019) The performance of conventional single-slope solar still plants (CSP) coupled with parabolic trough collectors as shown in figure 8, was examined using an explored nanofluid (PTC) application. Nanoparticles can be used to improve the thermal properties of a heat transfer fluid. They experimented with water and Al_2O_3/Water nanofluid with 0.05 percent and 0.1 percent volume fractions as the working fluid in the integrated system. The results show that using a still integrated plant greatly enhances the amount of clean water produced. The highest yield was reported at 1741 ml with 0.1 percent volume fraction Al_2O_3/Water nanofluid as the working fluid in a 1 m^2 basin with a 2.5 cm depth of saline water. An integrated solar still system that uses Al_2O_3/water nanofluid shows an increase in yield and thermal efficiency of about 66 and 70 percent, respectively, over CSP.

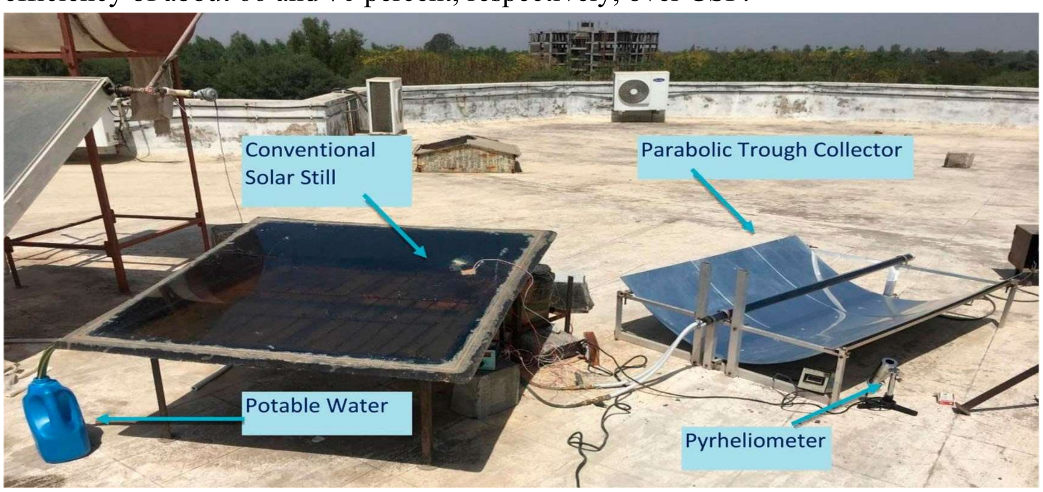

Figure 8: Experimental setup (Subhedar et al., 2019)

(Narayanan et al., 2020) The process of turning saltwater into drinkable water using solar thermal energy is known as solar desalination, and it is the primary use of a solar still. Solar stills' main productivity issue prevents them from being able to meet the rising demand for freshwater. Different researchers have worked for several years on solar still to improve the still yields. From that research, different method is identified by the researcher to raise production. Some techniques used to improve their efficiencies include preheating feed water, forced convection, and various energy storage options.

(Ranjbaran and Norozi, 2019) Examines the efficiency of Iran's hybrid system consisting of a single slope solar still, cascade solar still, and a parabolic trough collector (PTC). Using this hybrid system, authors got a 6 kg/day yield, a better result than the normal conventional still. They conclude that a hybrid solar distillation system improves 41% of total energy.

(Sharshir et al., 2019) Because drinking water is so scarce, desalination using solar energy is crucial for human life. Phase change materials (PCMs) as shown in figure 9, palmitic acid, jute, cubes of sponge, cotton cloth, porous materials, natural rock, sponge sheets, quartzite, coated and uncoated metallic wiry sponges, sand, gravels, and aluminium filling used as thermal energy storage materials all improve the performance of the distillation yield (TESMs). These substances both store and release energy throughout the day. The review claims that using paraffin wax as TEMS enhances SS's thermal performance.

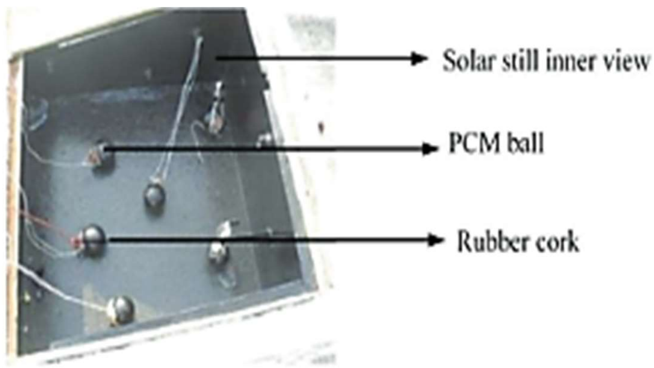

Figure 9: PCM ball with Solar still Setup (Sharshir et al., 2019)

(Jassim Jaber et al., 2021) Wax is primarily employed as a phase transition material in experiments on double-slope solar stills integrated with and without a Parabolic trough to increase the distillation yield. They conclude that PTC with wax as PCM gives 42% more yield than without PTC by performing the 20 mm water depth test. Store the heat is the main ability of phase change material because after sunset, they also improve the performance compared to double basin solar still.

(Kateshia and Lakhera, 2021) performed the experiment, exergy, energy, and life cycle cost analysis on Solar still, Still using PCM with fins and without fin as shown in figure 10. The phase-change substance they utilized was palmitic acid. in different variations of 0, 3.6, 7.34, and 11 kg and water mass 4.9, 9.8, 14.7, and 19.6 kg. They conclude that productivity still is improved by 30% with PCM with fins, compared to 24% with PCM alone.

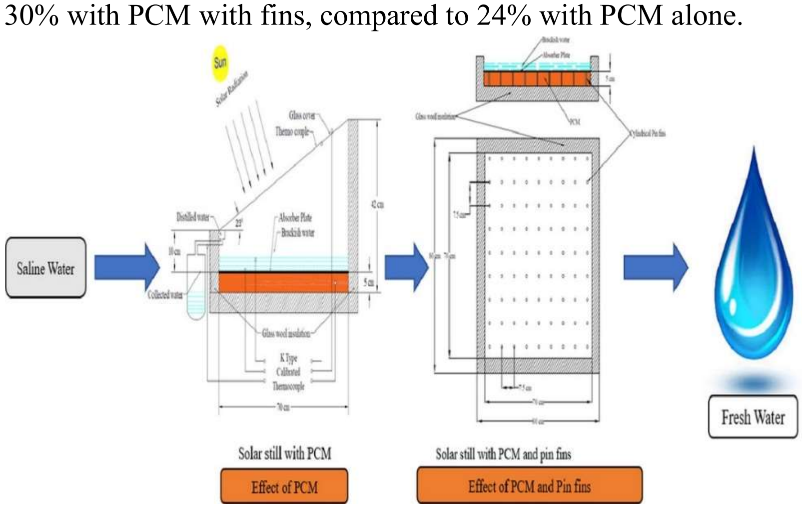

Figure 10: PCM ball with Solar still Setup (Kateshia and Lakhera, 2021)

(Aruldoss et al., 2022, Jeevadason et al. 2022) In this study, Author found the effectiveness of a novel design solar still with a double wedged glass cover design over a concrete material basin. In comparison to a conventional solar still, the Twin Wedge Solar Still (TWSS performance)'s is examined (CSS). The TWSS produced twice as much freshwater (1.3 l/m^2) than the CSS (0.635 l/m^2). TWSS uses 33.94% less energy each day than it should.

Table 3: A brief overview of the materials utilised in solar stills for energy storage

Sr. No.	Publication Year	Using materials for energy storage	Description	Results attained	References
(1)	2021	Paraffin wax as PCM (melting point 52 °C)	A latent heat storage system and built-in condenser were integrated into a basin-type single slope solar still.	Achieved an efficiency 23.7 percentage is solar still where with PCM achieved 48.5% efficiency.	(Khalilmoghadam et al., 2021)
(2)	2020	Paraffin wax combined with Cuprus oxide nanoparticles as PCM	They modified still adding reflector, Nano coating, use cuo nano partials as PCM	Conclusion the output is increased is 5 lit/m^2/day compared with conventional still 2.4 lit/m^2/day.	(Abdullah et al., 2020)
(3)	2020	Paraffin wax and 3 percent graphene oxide nanoparticles are combined to form PCM.	Tubular solar still	Achieved 116% higher efficiency compared with conventional still.	(Kabeel et al., 2020)
(4)	2020	1.5 cm thick and 15 kg Paraffin wax is placed in form of chips under the basin surfaces.	CSS is integrated with PTC and PCM. They perform the test between 1.5 and 3 cm	They concluded that Efficiency increased by a range of 28 to 34%.	(Khairat Dawood et al., 2020b)

			depth of water.		
(5)	2019	Paraffin wax as PCM (melting point 52 °C)	PCM-based pin-finned heat sink integrated with still.	Productivity is lower by 3% during the daytime, but at night, productivity is increased to 46%. Overall efficiency is increased up to 17%	(Yousef et al., 2019)
(6)	2019	Shape-stabilized phase change material (SSPCM) with 1.50 W/m K thermal conductivity	Pyramid-shaped solar still.	Compared to conventional solar without SS PCM, efficiency has increased by 43.3%.	(Cheng et al., 2019)
(7)	2017	Flake graphite nanoparticles	Single slope solar still.	Enhance productivity by 73%.	(Sharshir et al., 2017)
(8)	2017	Paraffin wax (PCM) and CuO (NPCM).	Single slope solar still.	Achieved 3.88 kg/m^2 with PCM and 5.28 kg/m^2 with NPCM during distillation. Increased productivity by 35%.	(Winfred Rufuss et al., 2017)
(9)	2016	PCM as Paraffin wax (melting point of 56 deg. C)	Solar still with a single basin and a V-corrugated absorber.	Distillation gave 3.761 kg/m^2 with PCM against 3.357 kg/m^2 without PCM.	(Shalaby et al., 2016)
(10)	2022	Microcrystalline wax	Single slope solar still.	Results reveal that a solar with PCM that is still employing PTC has superior	(Jaber et al., 2022)

				productivity and temperature than one that is not.	
(11)	2021	Paraffin-CuO	Single slope solar still.	Use of Stearic acid as a PCM below the basin's liner, with 9.005 kg/m^2 of pure water every day. and 4.998 kg/m^2 per day daily has been when PCM was present and when PCM was absent, respectively.	(Yadav et al., 2021)

Summary

Brackish or salted water can be desalinated using solar stills (SS) with no carbon emissions. The output of solar stills is further increased by hybridization. In terms of sustainability, hybridised solar still systems are superior models to transport freshwater to difficult and inaccessible locations at little effects on the environment. The Parabolic trough collector connected to the solar still is a proven method to boost distillate yield since it supplies warm water to the basin. Thus, the following conclusions are drawn from this review paper:

- The high temperature achieved in the PTC compared with Solar still also improved yield and production of distillate output.
- Nanoparticles with fluid integrated with PTC must increase Solar still yield, Heat transfer is increased due to nanoparticles.
- Condenser with PTC increased Solar still yield because of better condensation.
- By increasing the heat transfer coefficient, PTC with a Packed bed increased solar still yield.

Future Scope

The prospects of research work in this field of study that will aid the researchers to proceed in the future direction are summarized herewith. PTC used in many applications, and solar thermal technology is one of them. Following are some potential joint projects that the PTC may undertake in the future.

- Researchers continue to ignore work on the PTC connected to the SS with various energy storage materials. Furthermore, researchers have not looked at the effects of coupled energy storage (latent and sensible heat storage materials).

- Using PTC and condenser is still possible to increase yield and efficiency.
- To improve the yield and efficiency of SS, the PTC and Condenser can still be used with combined storage.
- Newer hybridization models for productivity during the night and during the day.It will be better off with greater efficiency and a lower cost per litre regarding the desalination sector.

REFERENCES

Abdel-Rehim, Z.S. and Lasheen, A. (2007) 'Experimental and theoretical study of a solar desalination system located in Cairo, Egypt', Desalination, 217(1–3), pp. 52–64. Available at: https://doi.org/10.1016/j.desal.2007.01.012.

Abdullah, A.S., Essa, F.A., Bacha, H. ben and Omara, Z.M. (2020) 'Improving the trays solar still performance using reflectors and phase change material with nanoparticles', Journal of Energy Storage, 31. Available at: https://doi.org/10.1016/j.est.2020.101744.

Amiri, H., Aminy, M., Lotfi, M. and Jafarbeglo, B. (2021) 'Energy and exergy analysis of a new solar still composed of parabolic trough collector with built-in solar still', Renewable Energy, 163, pp. 465–479. Available at: https://doi.org/10.1016/j.renene.2020.09.007.

Aruldoss, W.J., S, P. and C, B. (2022) 'Experimental Investigation of a Novel Design Solar Still Desalination System', ECS Transactions, 107(1), pp. 18789–18798. Available at: https://doi.org/10.1149/10701.18789ecst.

Arunkumar, T., Denkenberger, D., Velraj, R., Sathyamurthy, R., Tanaka, H. and Vinothkumar, K. (2015) 'Experimental study on a parabolic concentrator assisted solar desalting system', Energy Conversion and Management, 105, pp. 665–674. Available at: https://doi.org/10.1016/J.ENCONMAN.2015.08.021.

Arunkumar, T., Velraj, R., Denkenberger, D.C. and Sathyamurthy, R. (2016) 'Influence of crescent shaped absorber in water desalting system', Desalination, 398, pp. 208–213. Available at: https://doi.org/10.1016/j.desal.2016.07.039.

Belessiotis, V., Kalogirou, S. and Delyannis, E. (2016) 'Solar Distillation—Solar Stills', Thermal Solar Desalination, pp. 103–190. Available at: https://doi.org/10.1016/B978-0-12-809656-7.00003-9.

Cheng, W.L., Huo, Y.K. and Nian, Y. le (2019) 'Performance of solar still using shape-stabilized PCM: Experimental and theoretical investigation', Desalination, 455, pp. 89–99. Available at: https://doi.org/10.1016/j.desal.2019.01.007.

Dwivedi, V.K. and Tiwari, G.N. (2010) 'Experimental validation of thermal model of a double slope active solar still under natural circulation mode', Desalination, 250(1), pp. 49–55. Available at: https://doi.org/10.1016/j.desal.2009.06.060.

Elsheikh, A.H., Panchal, H.N., Sengottain, S., Alsaleh, N.A. and Ahmadein, M. (2022) 'Applications of Heat Exchanger in Solar Desalination: Current Issues and Future Challenges', Water (Switzerland). MDPI. Available at: https://doi.org/10.3390/w14060852.

Fathy, M., Hassan, H. and Salem Ahmed, M. (2018a) 'Experimental study on the effect of coupling parabolic trough collector with double slope solar still on its performance', Solar Energy, 163, pp. 54–61. Available at: https://doi.org/10.1016/J.SOLENER.2018.01.043.

Fathy, M., Hassan, H. and Salem Ahmed, M. (2018b) 'Experimental study on the effect of coupling parabolic trough collector with double slope solar still on its performance', Solar Energy, 163, pp. 54–61. Available at: https://doi.org/10.1016/j.solener.2018.01.043.

Hasan Ahmed, A., Ibrahim Musa, J. and Mahmoud Ahmed, A. (no date) 'Theoretical Investigation of the Effect of Mass Flowrate on PTC Performance', NTU JOURNAL OF RENEWABLE ENERGY [Preprint].

Jaber, H.J., Rishack, Q.A. and Abed, Q.A. (2022) Investigating the Performance of Solar Still System Integrated with and without Solar Trough Collector Using PCM Basin-An Experimental Study. Available at: http://annalsofrscb.ro.

Jafari Mosleh, H., Mamouri, S.J., Shafii, M.B. and Hakim Sima, A. (2015) 'A new desalination system using a combination of heat pipe, evacuated tube and parabolic trough collector', Energy Conversion and Management, 99, pp. 141–150. Available at: https://doi.org/10.1016/J.ENCONMAN.2015.04.028.

Jassim Jaber, H., A. Rishak, Q. and A. Abed, Q. (2021) 'Using PCM, an Experimental Study on Solar Stills Coupled with and without a Parabolic Trough Solar Collector', Basrah journal of engineering science, 21(2), pp. 45–52. Available at: https://doi.org/10.33971/bjes.21.2.7.

Jeevadason, A.W., Padmini, S. and Bharatiraja, C. (2022) 'Enhancing Freshwater Productivity of Twin Wedge Solar Still by Temperature Control Through Thermoelectric Sensors and Modules', IEEE Sensors Journal, 22(9), pp. 9095–9103. Available at: https://doi.org/10.1109/JSEN.2022.3162311.

Kabeel, A.E. and Abdelgaied, M. (2017) 'Observational study of modified solar still coupled with oil serpentine loop from cylindrical parabolic concentrator and phase changing material under basin', Solar Energy, 144, pp. 71–78. Available at: https://doi.org/10.1016/j.solener.2017.01.007.

Kabeel, A.E. and El-Agouz, S.A. (2011) ‘Review of researches and developments on solar stills’, Desalination, pp. 1–12. Available at: https://doi.org/10.1016/j.desal.2011.03.042.

Kabeel, A.E., Sathyamurthy, R., Manokar, A.M., Sharshir, S.W., Essa, F.A. and Elshiekh, A.H. (2020) ‘Experimental study on tubular solar still using Graphene Oxide Nano particles in Phase Change Material (NPCM’s) for fresh water production’, Journal of Energy Storage, 28. Available at: https://doi.org/10.1016/j.est.2020.101204.

Kateshia, J. and Lakhera, V.J. (2021) ‘Analysis of solar still integrated with phase change material and pin fins as absorbing material’, Journal of Energy Storage, 35. Available at: https://doi.org/10.1016/j.est.2021.102292.

Khairat Dawood, M.M., Nabil, T., Kabeel, A.E., Shehata, A.I., Abdalla, A.M. and Elnaghi, B.E. (2020a) ‘Experimental study of productivity progress for a solar still integrated with parabolic trough collectors with a phase change material in the receiver evacuated tubes and in the still’, Journal of Energy Storage, 32, p. 102007. Available at: https://doi.org/10.1016/J.EST.2020.102007.

Khairat Dawood, M.M., Nabil, T., Kabeel, A.E., Shehata, A.I., Abdalla, A.M. and Elnaghi, B.E. (2020b) ‘Experimental study of productivity progress for a solar still integrated with parabolic trough collectors with a phase change material in the receiver evacuated tubes and in the still’, Journal of Energy Storage, 32. Available at: https://doi.org/10.1016/j.est.2020.102007.

Khalilmoghadam, P., Rajabi-Ghahnavieh, A. and Shafii, M.B. (2021) ‘A novel energy storage system for latent heat recovery in solar still using phase change material and pulsating heat pipe’, Renewable Energy, 163, pp. 2115–2127. Available at: https://doi.org/10.1016/j.renene.2020.10.073.

Kumar, A., Vyas, S. and Nchelatebe Nkwetta, D. (2020) ‘Experimental study of single slope solar still coupled with parabolic trough collector’, Materials Science for Energy Technologies, 3, pp. 700–708. Available at: https://doi.org/10.1016/j.mset.2020.07.005.

Kumar, M.P.N., Manohar, M.T.L., Kumar, M.S.H., Kona, M. and Prasad, R. (2016) Design and Development of Parabolic Trough Solar Concentrator.

Kumar, S. and Sinhat, S. (1996) TRANSIENT MODEL AND COMPARATIVE STUDY OF CONCENTRATOR COUPLED REGENERATIVE SOLAR STILL IN FORCED CIRCULATION MODE, Energy Convers. Mgmr.

Madiouli, J., Lashin, A., Shigidi, I., Badruddin, I.A. and Kessentini, A. (2020) ‘Experimental study and evaluation of single slope solar still combined with flat plate collector, parabolic trough and packed bed’, Solar Energy, 196, pp. 358–366. Available at: https://doi.org/10.1016/j.solener.2019.12.027.

Madiouli, J., Saleel, C.A., Lashin, A., Badruddin, I.A. and Kessentini, A. (2021) 'An experimental analysis of single slope solar still integrated with parabolic trough collector and packed layer of glass balls', Journal of Thermal Analysis and Calorimetry, 146(6), pp. 2655–2665. Available at: https://doi.org/10.1007/s10973-020-10320-x.

Manokar, A.M., Winston, D.P., Kabeel, A.E., Sathyamurthy, R. and Arunkumar, T. (2018) 'Different parameter and technique affecting the rate of evaporation on active solar still -a review', Heat and Mass Transfer/Waerme- und Stoffuebertragung. Springer Verlag, pp. 593–630. Available at: https://doi.org/10.1007/s00231-017-2170-9.

Mevada, D., Panchal, H., Ahmadein, M., Zayed, M.E., Alsaleh, N.A., Djuansjah, J., Moustafa, E.B., Elsheikh, A.H. and Sadasivuni, K.K. (2022) 'Investigation and performance analysis of solar still with energy storage materials: An energy- exergy efficiency analysis', Case Studies in Thermal Engineering, 29, p. 101687. Available at: https://doi.org/10.1016/J.CSITE.2021.101687.

Mevada, D., Panchal, H., Sadasivuni, K. kumar, Israr, M., Suresh, M., Dharaskar, S. and Thakkar, H. (2020) 'Effect of fin configuration parameters on performance of solar still: A review', Groundwater for Sustainable Development, 10, p. 100289. Available at: https://doi.org/10.1016/J.GSD.2019.100289.

Morad, M.M., El-Maghawry, H.A.M. and Wasfy, K.I. (2015) 'Improving the double slope solar still performance by using flat-plate solar collector and cooling glass cover', Desalination, 373, pp. 1–9. Available at: https://doi.org/10.1016/j.desal.2015.06.017.

Nabil, T. and Dawood, M.M.K. (2021) 'Numerical and experimental investigation of parabolic trough collector with focal evacuated tube and different working fluids integrated with single slope solar still', Heat Transfer, 50(3), pp. 2007–2032. Available at: https://doi.org/10.1002/htj.21966.

Narayanan, S.S., Yadav, A. and Khaled, M.N. (2020) 'A concise review on performance improvement of solar stills', SN Applied Sciences. Springer Nature. Available at: https://doi.org/10.1007/s42452-020-2291-5.

Nougriaya, S.K., Chopra, M.K., Gupta, B., Baredar, P. and Parmar, H. (2021) 'Influence of basin water depth and energy storage materials on productivity of solar still: A review', in Materials Today: Proceedings. Elsevier Ltd, pp. 1589–1603. Available at: https://doi.org/10.1016/j.matpr.2020.11.796.

Panchal, H., Mevada, D., Sadasivuni, K.K., Essa, F.A., Shanmugan, S. and Khalid, M. (2020) 'Experimental and water quality analysis of solar stills with vertical and inclined fins', Groundwater for Sustainable Development, 11, p. 100410. Available at: https://doi.org/10.1016/J.GSD.2020.100410.

Panchal, H., Sadasivuni, K.K., Suresh, M., Israr, M. and Sengottain, S. (2021) 'A concise review on Solar still with parabolic trough collector', International Journal of Ambient Energy [Preprint]. Taylor and Francis Ltd. Available at: https://doi.org/10.1080/01430750.2021.1922938.

Prakash, O., Ahmad, A., Kumar, A., Mozammil Hasnain, S.M. and Kumar, G. (2022) 'Comprehensive analysis of design software application in solar distillation units', Materials Science for Energy Technologies, 5, pp. 171–180. Available at: https://doi.org/10.1016/j.mset.2022.01.005.

Rai, S.N. and Tiwari, G.N. (1983) SINGLE BASIN SOLAR STILL COUPLED WITH FLAT PLATE COLLECTOR, Energy Convers. Mgmt.

Rajaseenivasan, T., Nelson Raja, P. and Srithar, K. (2014) 'An experimental investigation on a solar still with an integrated flat plate collector', Desalination, 347, pp. 131–137. Available at: https://doi.org/10.1016/j.desal.2014.05.029.

Raju, V.R. and Lalitha Narayana, R. (2018) 'Effect of flat plate collectors in series on performance of active solar still for Indian coastal climatic condition', Journal of King Saud University - Engineering Sciences, 30(1), pp. 78–85. Available at: https://doi.org/10.1016/J.JKSUES.2015.12.008.

Ranjan, A., Dewang, Y., Raghuwanshi, J. and Sharma, V. (2022) 'Experimental evaluation of solar still coupled with parabolic trough collector', Materials Today: Proceedings, 60, pp. 935–938. Available at: https://doi.org/10.1016/J.MATPR.2021.11.075.

Ranjbaran, A. and Norozi, M. (2019) 'Design and fabrication of a novel hybrid solar distillation system with the ability to brine recycling', International Journal of Heat and Technology, 37(3), pp. 751–760. Available at: https://doi.org/10.18280/ijht.370311.

Sathyamurthy, R., El-Agouz, S.A., Nagarajan, P.K., Subramani, J., Arunkumar, T., Mageshbabu, D., Madhu, B., Bharathwaaj, R. and Prakash, N. (2017a) 'A Review of integrating solar collectors to solar still', Renewable and Sustainable Energy Reviews. Elsevier Ltd, pp. 1069–1097. Available at: https://doi.org/10.1016/j.rser.2016.11.223.

Sathyamurthy, R., El-Agouz, S.A., Nagarajan, P.K., Subramani, J., Arunkumar, T., Mageshbabu, D., Madhu, B., Bharathwaaj, R. and Prakash, N. (2017b) 'A Review of integrating solar collectors to solar still', Renewable and Sustainable Energy Reviews, 77, pp. 1069–1097. Available at: https://doi.org/10.1016/J.RSER.2016.11.223.

Sathyamurthy, R., Harris Samuel, D.G., Nagarajan, P.K. and Arunkumar, T. (2016) 'Geometrical variations in solar stills for improving the fresh water yield—A review', Desalination and Water Treatment, 57(45), pp. 21145–21159. Available at: https://doi.org/10.1080/19443994.2015.1136241.

Sathyamurthy, R., Harris Samuel, D.G., Nagarajan, P.K. and El-Agouz, S.A. (2015) 'A review of different solar still for augmenting fresh water yield', Journal of Environmental Science and Technology, 8(6), pp. 244–265. Available at: https://doi.org/10.3923/jest.2015.244.265.

Shalaby, S.M., El-Bialy, E. and El-Sebaii, A.A. (2016) 'An experimental investigation of a v-corrugated absorber single-basin solar still using PCM', Desalination, 398, pp. 247–255. Available at: https://doi.org/10.1016/j.desal.2016.07.042.

Shannon, M.A., Bohn, P.W., Elimelech, M., Georgiadis, J.G., Marĩas, B.J. and Mayes, A.M. (2008) 'Science and technology for water purification in the coming decades', Nature. Nature Publishing Group, pp. 301–310. Available at: https://doi.org/10.1038/nature06599.

Sharshir, S.W., Elsheikh, A.H., Edreis, E.M.A., Ali, M.K.A., Sathyamurthy, R., Kabeel, A.E., Zang, J. and Yang, N. (2019) 'Improving the solar still performance by using thermal energy storage materials: A review of recent developments', Desalination and Water Treatment, 165, pp. 1–15. Available at: https://doi.org/10.5004/dwt.2019.24362.

Sharshir, S.W., Peng, G., Wu, L., Essa, F.A., Kabeel, A.E. and Yang, N. (2017) 'The effects of flake graphite nanoparticles, phase change material, and film cooling on the solar still performance', Applied Energy, 191, pp. 358–366. Available at: https://doi.org/10.1016/j.apenergy.2017.01.067.

Singh, A.K., Yadav, R.K., Mishra, D., Prasad, R., Gupta, L.K. and Kumar, P. (2020) 'Active solar distillation technology: A wide overview', Desalination. Elsevier B.V. Available at: https://doi.org/10.1016/j.desal.2020.114652.

Singh,'~, S.K., Bhatnagar, V.P. and Tiwari, G.N. (1996) DESIGN PARAMETERS FOR CONCENTRATOR ASSISTED SOLAR DISTILLATION SYSTEM, Energy Convers. M&mt.

Srithar, K., Rajaseenivasan, T., Karthik, N., Periyannan, M. and Gowtham, M. (2016) 'Stand alone triple basin solar desalination system with cover cooling and parabolic dish concentrator', Renewable Energy, 90, pp. 157–165. Available at: https://doi.org/10.1016/j.renene.2015.12.063.

Subhedar, D.G., Chauhan, K. v., Patel, K. and Ramani, B.M. (2019) 'Performance improvement of a conventional single slope single basin passive solar still by integrating with nanofluid-based parabolic trough collector: An experimental study', in Materials Today: Proceedings. Elsevier Ltd, pp. 1478–1481. Available at: https://doi.org/10.1016/j.matpr.2020.02.304.

Upadhyay, B.H., Patel, A.J., Sadasivuni, K.K., Mistry, J.M., Ramana, P. v., Panchal, H., Ponnamma, D. and Essa, F.A. (2021) 'Design, development and techno economic analysis of novel parabolic trough collector for low-temperature water heating applications', Case Studies in Thermal Engineering, 26, p. 100978. Available at: https://doi.org/10.1016/J.CSITE.2021.100978.

Vigneswaran, V.S., Kumaresan, G., Dinakar, B. v., Kamal, K.K. and Velraj, R. (2019) 'Augmenting the productivity of solar still using multiple PCMs as heat energy storage', Journal of Energy Storage, 26. Available at: https://doi.org/10.1016/j.est.2019.101019.

Winfred Rufuss, D.D., Iniyan, S., Suganthi, L. and Pa, D. (2017) 'Nanoparticles Enhanced Phase Change Material (NPCM) as Heat Storage in Solar Still Application for Productivity Enhancement', Energy Procedia, 141, pp. 45–49. Available at: https://doi.org/10.1016/J.EGYPRO.2017.11.009.

Yadav, A., Khalid, M.S., Saini, P. and Kumar, A. (2021) 'Improvement of solar still productivity by using PCM and other enhancement technique- A review', International Journal of Engineering, Science and Technology, 13(1), pp. 98–104. Available at: https://doi.org/10.4314/ijest.v13i1.15s.

Yousef, M.S., Hassan, H., Kodama, S. and Sekiguchi, H. (2019) 'An experimental study on the performance of single slope solar still integrated with a PCM-based pin-finned heat sink', Energy Procedia, 156, pp. 100–104. Available at: https://doi.org/10.1016/J.EGYPRO.2018.11.102.