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A Review of a New Advance Technique for Energy Consumption Management by Using Active Solar Still (Nano and PCM Material)

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Abstract - This review aims to provide a comprehensive analysis of active solar stills, a promising technology for sustainable water purification. Active solar stills utilize external energy sources and the sun's energy to evaporate and condense water, thereby removing impurities and producing clean drinking water. However, existing reviews on active solar stills have certain limitations. This review addresses these limitations through consistent experimental setups and meta-analyses. Additionally, the review takes a holistic approach, considering not only productivity and efficiency but also practicality, maintenance requirements, and economic feasibility. The use of phase change material (PCM) in solar stills is a potential approach to entrap the heat and reduce the losses. The review provides practical guidelines and recommendations for optimizing the performance and feasibility of active solar stills. By integrating these novel aspects, this review offers valuable insights to advance the understanding, implementation, and adoption of active solar stills as a sustainable water purification solution.

Keywords: Active Solar Stills, Solar Desalination, Productivity, Efficiency, Nano Materials, Phase Change Materials.

1. Introduction

The world's population is growing, and the demand for freshwater is increasing. At the same time, many parts of the world are facing water scarcity due to climate change, pollution, and over-extraction of groundwater. Desalination is a potential solution to this problem, as it can provide a reliable source of fresh water in areas where freshwater is scarce.

The day, when water runs out, has occurred in many worldwide cities, particularly Cape Town, Beijing, and Chennai. seventeen countries, home to a fifth of the world's population, are reportedly experiencing "severe water stress," based on the World Resources Institute's (WRI) Aqueduct Water Risk Atlas, whose statistics we have provided below. [1]

Solar desalination is the process of using solar energy to remove salt from seawater or brackish water to produce fresh water. It is a sustainable and environmentally friendly way to produce fresh

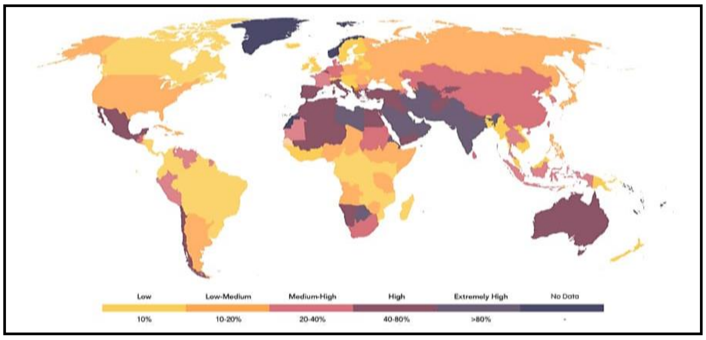

Fig 1 Global Water Stress (World Resources Institute, 2021)

water, and it is particularly well-suited for use in areas with limited access to fresh water.

There are two main types of solar desalination systems: passive solar stills and active solar stills. Passive solar stills rely solely on solar energy to evaporate the water, while active solar stills use external energy sources to enhance the evaporation and condensation processes.

Active solar stills are typically more efficient than passive solar stills, and they can produce fresh water at a faster rate. This is because they use external energy sources to heat the water, which causes it to evaporate more quickly.

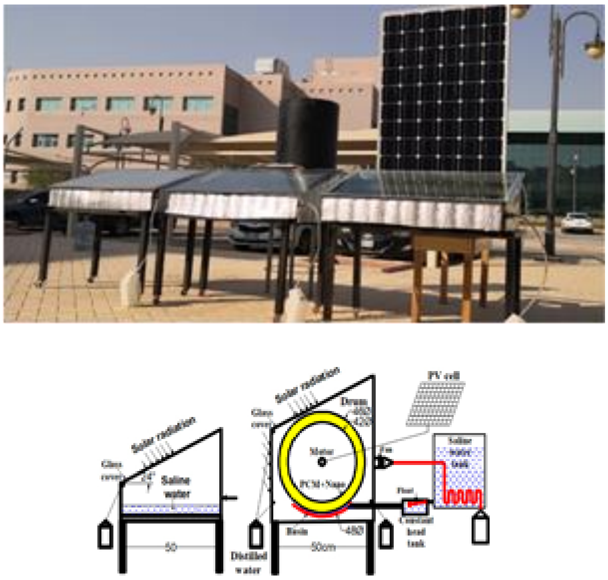

Fig 2 Picture Of Tested Solar Stills [2]
(a). Reference Solar Still (b). Trays Solar Still (c). Finned Trays Solar Still

There are many different types of active solar stills, but they all share some common features. The

basic components of an active solar still include a basin of water, a solar collector, a condenser, and a heat exchanger. The solar collector heats the water in the basin, which causes it to evaporate. The vapor then condenses on the condenser, and the condensate is collected in a reservoir.

The heat exchanger can be used to transfer heat from the solar collector to the basin, which can help to improve the efficiency of the still. Active solar stills can be powered by a variety of sources, including solar photovoltaic (PV) panels, solar thermal collectors, and waste heat.

The advantages of active solar stills over passive solar stills include:

- Higher productivity
- Faster production rate
- Better performance in cold climates
- Reduced dependence on solar radiation

The challenges that need to be addressed to improve the performance of active solar stills include:

- The cost of the system
- The efficiency of the heat exchanger
- The durability of the components

The future potential of active solar stills for providing fresh water in areas with limited access to water is significant. As the demand for freshwater continues to grow, active solar stills could play an important role in providing a sustainable and environmentally friendly source of fresh water.

2. Literature Reviews on Solar Stills:

2.1 Reviews of Active SS with PCM and Nano Materials

As shown in Figure 2, examined three solar stills (one conventional and two TSS) with cuo. The glass cover was used as an area of condensing for all SSs with a 240-degree tilt angle. The daily water output of the FTSS was enhanced by 196% above the CSS. The diameters of the trays and finned absorbers can be optimized by theoretical research.

Alqsair et al. boosted the effectiveness of drum solar stills (DSS) by applying PSC, as demonstrated in Figure 3. The opening width as well as the rim angle were 150 cm and 400 cm, respectively, as per the design. When using NC, PSC, and an external condenser in DSS, peak output increased by around 32% with an effectiveness of 72%. [3]

Fig 3 An Image of The Experimental Setup (DSS with PSC and without PSC) [3]

Parsa et al.'s recommended system contain five elements: photovoltaic modules, two SSs, phase change modules, turbulators, and thermal modules in the town of Tehran. The PVs were oriented to the south and inclined 35° with the horizon. Fig. 4 displays the proposed setup during tests. A topic that merits investigation is comparing the same experiment for solar stills at various geometries to determine the best geometry in thermoelectric-based systems. [4]

Abdelgaied, Abdulla, et al. evaluated a stepped solar distiller, demonstrating three effective hybrid alterations, comprising PCMs below the steps, inside mirrors, and absorber surfaces wrapped with CuO nanoparticles. The updated stepwise solar distiller increased the estimated daily energy efficiency to 7.96%, an increase of 187.4%. [5]

Abdelgaied, Attia, et al. researched three MHSS instances and matched them to THSS: (0.3 wt%) According to reports, the hemispherical distillers' overall daily efficiency varied between 35.52%, 45.45%, 56.46%, and 63.61% depending on the four scenarios that were studied (THSS, MHSS/PCM, MHSS/CuO-water nanofluid, and MHSS/PCM + CuO-water nanofluid). The thermo-economic performances of the four cases under analysis were compared and evaluated. It is testable using various nanoparticles and modifications. [6]

Felemban et al. has tested the influence of employing three unique absorber liners: a convex plate absorber, a stepped absorber, and an absorber with a corrugated cover over it. Their performances were studied and compared with those of a typical solar distiller. The dish distiller with a corrugated absorber, wicks, and energy storage substance produced more, with a 69.5% boost in thermal efficiency and an increase in production of roughly 183%. [7]

The efficiency of tabular solar using phase-change material, parabolic solar concentrator (PSC), rotational drum (TDSS), and nanoparticle coating In this research, different operational elements were explored by them. The relationship between PSC and PCM was originally examined in TDSS. The CSS achieved a thermal performance of roughly 32 to 34%. At 0.3 rpm, the greatest TDSS thermal efficiency utilizing PCM was 63.8%. After a few years, rotation may be impacted by erosion. [8]

Sharshir et al. has examined two pyramid-shaped solar stills, one standard and another customized by wick materials, reflectors, freezing of the glass cover, and the inclusion of nano-TiO_2 particles. The daily thermal efficiency for five custom-constructed pyramid solar tests that were still being examined was 83.8% for MPSS-Case 5 and 37.87% for TSS, respectively. The cost per liter for MPSS-Case 5 was 0.021 dollars, which is around 52.38% less expensive than the cost for TSS. [9]

Abdullah et al. conducted a study on three solar stills with copper oxide: CSS, FTSS, and CTSS, to contrast their performance (Fig 5). A glass plate of three millimeters in thickness was applied as the condensing layer for all solar stills having an angle of inclination of 24, which is the latitude of Al Kharj, KSA. [10]

Younes et al. have developed four sorts of solar stills: a flat wick solar still (FWSS), a corrugated wick solar still (CWSS), a half barrel wick solar still (BWSS), as well as a standard sun still. The improved evaporation area for CWSS and BWSS

Fig. 4. Experimental Setup of Two Single Basin Square Pyramids Shape Solar Stills[4]

originates from modifications in absorber

Fig. 5. Pictorial View of Tested Solar Stills [10] (a)**. Conventional Solar Still (b). Trays Solar Still (c). Corrugated Trays Solar Still**

Tafavogh and Zahedi designed a mechanism to distribute clean water, heat, and power. The proposed HRES has been formed of a ground-based heat pump together with a microalgal culture pond to create microalgae biomass, a parabolic trough catcher and solar still prefilter photovoltaic panels to provide heat, electricity, and water needed to include n-octadecane with a polymer shell via miniemulsion polymerization and transform bio-oil into biodiesel, and a wind turbine as well as a proton exchange On a 67.1% production efficiency, encapsulating was applied to create the nanocapsules. However, while CO production increased, NOx emissions decreased. [12]

In the study of [13], the PCM fulfilled the role of a latent heat storage medium inside the inner tube of the evacuated tube. The PTC featured a 3 m length, an 80° rim tilt, and a 0.9 m aperture width. the daily production for the standard solar system, which continues to use oil as its working fluid at flow rates of 1.5, 1.0, and 0.54 L/min, as well as its system efficiency of 28%, 13.7%, and 26%.Mahmoud et al. have designed a solar still with an incorporated two-effect humidifying desalination

unit (SS-HDH). Regarding transient performance, the influences of solar concentration ratios (CR)

and then also partial solar thermal energy storage were explored. According to the statistics, with h = 0.2 m and CR = 2, the largest water output without PCM remained at 11.6 L/m^2 per day. The cost of configuration. For CSS and CWSS utilizing PCM, the *efficiency and anticipated cost per liter were 35%-0.028$ and 54.5%-0.023$, respectively. The effectiveness has grown as a result of new designs. [11]*

operation and maintenance is significant due to the extensive setup. [14]

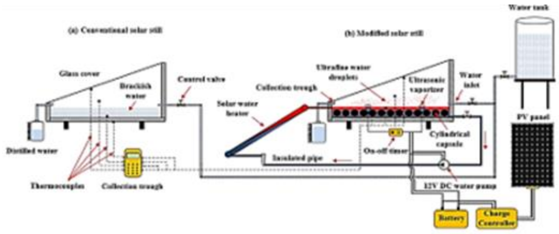

Fig. 6. Layout Of Experimental Setup (a) Conventional SS (b) Modified SS [17]

Bhargva & Yadav have fitted a heat exchanger (HE) alongside an inner reflector (IR), and an outside condenser enhances the performance of this ETC even more. The SS (HE+IR+condenser) features a massive yield of 2259 ml along with an efficiency of 33.4%, depending on the testing findings. For better outcomes, it can be done at various depths. [15].

2.2 Reviews of Active SS with PCM and Without Nano Materials

To enhance production, [16] developed PCM chambers, erected them and connected them to a stepped solar still. Case I included a single-step solar still; Case II contained a stepped solar still with PCM; Case III contained a stepped solar still with an external condenser and PCM; and Case IV contained a single-step solar still. Single-stepped solar still had a 28.21% efficiency.Abed et al. constructed an experimental setup that fundamentally includes a typical solar still, a solar water heater, PCM power storage caps, a high-frequency ultrasonic vaporizer, PVs, a feeding water tank, a water reservoir, a water pump, and a control system as shown in Fig. 6. A 0.004 m single glass cover was applied as a still transparent covering, situated at an inclination angle of 35° with the horizon in Baghdad, Iraq. The larger the setup, the more room is needed to install it. [17].

Tuly et al. has investigated an active customized solar still (SS) with a double slope that takes into account the impacts of an external condenser, a stiff rectangular fin, paraffin wax, and black cotton fabric. Three double-slope SSs' performance is examined utilizing five separate instances (modified, finned, and conventional). The maximal productivities for modified, finned, and standard SSs are found to be 3.07, 2.70, and 2.46 L/m^2, respectively. Although PCM is expensive and EC manufacturing costs are rather high, fin and wick materials function as inexpensive heat transfer mediums. [18].

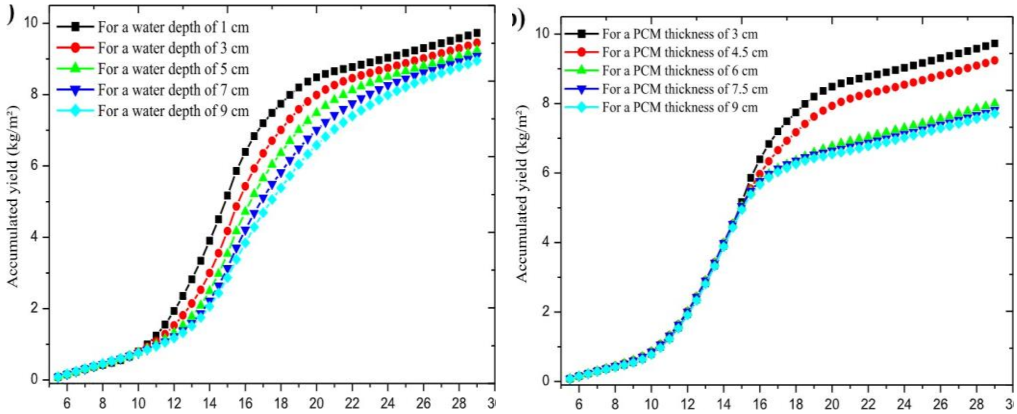

Fig. 7 Effect of Water Depth and PCM Thickness Accumulated Productivity [21]

Arunkumar et al. have experimentally evaluated the effectiveness of a single-slope solar still paired with a composite parabolic concentrator-concentric tubular solar (CPC-CTSS). In the present experiment, the distillation productivity was 3.23 L/m2/day, resulting in a yield efficiency of 76.78%, and the gross distillate output totaled 6.46 L/day. [19]

Phase change material (PCM) was employed to connect a self-powered dual-cover solar still to a solar collector, and its performance was studied by [20] The three types of tests that were conducted with the glass cover refrigerated were the solar still alone (SS), the solar still coupled to an external solar collector (SSC), and the solar including PCM and being attached to an external collector. Production climbed by roughly 340% when the SS system unit added the outside solar collector. If the glass cover is effectively cooled, more improvement may be feasible.

Khairat Dawood et al. have analyzed one study, a solar still with a stepped slope works better with an outside solar dish. 250, 350, 450, & 550 mL/min were the 4 flow rates of water flowing. The combination of PCM and sand accordingly enhances daily production by 51% & 31% at water spray mass flow rates of 250 & 550 mL/min. [22]

R et al. have constructed a method by installing an evacuated tube thermosyphon heat pipe and experimented with enhancing the productivity of a regular solar still that provides fresh water. Two additional solar stills were built and tested at the same time, one with a three-evacuated tube thermosyphon and the other without any evacuated tube thermosyphon. Heat input is raised by 84.5% when an added source of heat is an evacuated tube heat pipe. The customized solar still created 215.7% additional fresh water jointly than the traditional sun. [23] Fresh water production is still good when the evacuated heat pipe is connected directly to the solar panel.

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Fig. 8 Photograph for the Proposed Solar Still and The Conventional Solar Still [27]

Ganesan et al. have suggested a research project to boost the performance of PV/T solar stills. To promote vapour turbulence, a DC-powered blower was inserted inside a solar still with a single slope. In the solar still, a nickel-chromium (NiCr) heater has been added to accelerate the generation of filtered water. With higher overall thermal and electrical performances of around 12.5% & 11.5%, respectively, the suggested PV/T solar system still offers exceptional performance [24].

Benhammou & Sahli have studied, A single-slope solar still with a unique heat storage system that consists of a dual-glass solar collector with a latent heat storage component. For each sample period, the fraction of melted PCM was calculated using this model. The new configuration's diurnal, nocturnal, & daily levels of productivity grew by 44%, 635%, & 63%, respectively, over the conventional still. [21] The tilt angle must remain constant throughout the year for solar uses.

Ghadamgahi et al., have reported an investigation focusing on a paraffin wax-powered, five-stage solar still. Additionally, the quantity of fluid produced at flow rates of 0.7, 1.3 & 1.8 L/min using and without PCMs was investigated. revealed that 70% of the total water came from the first step's water generation. [25]

To evaluate the performance of a modified solar still, [26] tested three different scenarios: a solar still with glass cooling (SC), a solar still linked to an external collector (SCC), and a solar with phase-change material. Sodium thiosulfate pentahydrate, paraffin wax, and sodium acetate trihydrate were all used as PCMs. Productivity climbed in the SC, SCC, and SCCP units from 1 to 2.14, 1 to 6.65, and 1 to 7.5 ml/min, respectively, when the coolant mass flow rate was adjusted from 0 to 10 kg/s. The total cost of PCM materials is expensive.

The integrated desalination system propped by [27] consists of a single solar still, PV module, ½ hp centrifugal pump, and an evacuated solar collector shown in Fig. 8. A 5 mm glass sheet was placed at an inclination angle of 30° with the ground at Alexandria, Egypt. The maximum reported yield was around 7.45 kg per day.

Amarloo and Shafii have done a study in which the possibility of applying radiative cooling to solar still was investigated. An integrated collector was employed for the operations of solar radiation absorption and infrared radiation emission in radiative cooling. The day yield and efficiency were raised to 2.805 kg/m^2 and 30.7%, respectively, by employing nocturnal radiative freezing to preserve coolness in the PCM condenser. (Radiative cooling has a limited cooling capability; hence, using an air condenser in addition to the PCM condenser is required. [28]

Elbar and Hassan have created a single-acting solar cell still connected to a photovoltaic (PV) module. Their daily productivity is increased by around 11.7% when they have a PCM unit with a still and PV, while their daily yields are raised by 19.4% when they have a FAC with CSS, PV, and PCM. More research can be done with a method that uses salty water to cool the PV. [29]

Kumbhar and Sonage have made attempts to enhance the design of stills by incorporating reflectors and phase change material (PCM). According to experiments, the solar still's efficiency rose to 42%, and its distillate production rate reached 4 liters. [30]

Mazraeh et al. has created a novel solar still system that incorporates phase change materials, evacuated tube collectors, and semitransparent photovoltaics. The maximum diurnal energy and exercise efficiencies were reported for water depths of 0.03 m and 10 tubes with PCM, respectively. These values were 17.93% and 6.95%. [31] Although the presence of PCM increases energy efficiency, it has little impact on exercise efficiency.

Al-harahsheh et al. have examined a solar still furnished with PCM and connected to a solar collector that was employed to undertake an experimental inquiry on the desalination of water. The effects of hot water circulation rate of flow, freezing flow rate, and basin water level were examined regarding the generation of fresh water. The generator could create 4300 ml/day, or roughly 40% of that amount generated after sunset. [32]

Different thermal models are implemented to investigate the impact of height shifts, and experimental data are utilized to support those models. [33] have been utilized. Four stirrers in research to produce turbulence in saline water. The performance of the solar was still 33.76% without any adjustments; however, it is 58.63% when paraffin wax and a stirrer are applied. The saltwater is stirred using a solar PV panel-powered motor setup as part of ongoing trials on the solar still.

Faegh and Shafii have studied whether phase transition materials may be exploited to store the latent heat of condensed vapor in solar stills. The system includes two evacuated tube collectors, a saline water basin, a phase change material tank, a fan, and 20 thermosiphon heat pipes. The yield increases by 86% and reaches 6.555 kg/m^2 per day, with 50% effectiveness compared to the system lacking PCM. [34]

Kabeel & Abdelgaied have researched experimentally to determine the performance of a focal pipe-equipped cylindrical parabolic concentrator linked to a solar still with an oil heat exchanger and PCM. While the regular solar panel still has a value of 46%, the improved solar panel remains at a daily efficiency of around 25.73%. The cost of setup is considerable. [35]

Kabeel et al. have provided A modified solar still incorporating phase change material that is connected to a solar air collector became the object of investigation. The altered still and the normal still are compared. The two-stage customized solar still with PCM generates 108% more freshwater than the normal still on average. [36]

Arunkumar et al. have offered a suggestion for a solar still that employs a parabolic concentrator (PC) as well as a storage tank to assure consistent water circulation. There were four separate working modes applied in the studies: PC-solar without top cover cooling, PC-solar with top cover cooling, PC-solar merged with phase change material (PCM), and PC-solar merged PCM with cooling. Different water flow rates were employed throughout the studies. [37] Additionally, it has been determined that nanofluids can be used in solar parabolic trough collectors to warm water for greater water evaporation.

Arunkumar et al. has enhanced the concentrator-linked hemispherical basin solar still's effectiveness and distillate output. One single-slope solar still without the PCM impact and a single-slope solar still with the PCM effect have both been the subject of investigation. Experimental studies reveal that the impact of heat storage in the concentrator-coupled hemispherical basin solar system still enhances production by 26%. [38]

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Table 1 Summary of Active SS with PCM and Nano Materials

Author(s) Location (Latitude, Longitude)	Construction Type	Use Of PCM	Use Of Nano materials	Basin Area (m^2)	Glass Angle	Glass Thickness	Maximum Productivity (L/ M^2/D) or Efficiency (%)	Occurrence /Remark
A.s. Abdullah et al. [2] Saudi Arabia.	Trays Solar Still	Paraffin Wax	Copper Oxide	0.5 m^2	24 °	3 mm	4.5 l/ m^2/d	Solar Stills With IR at 2 Cm Water Depth
Alqsair et al. [3] Saudi Arabia.	Drum Solar Still	Paraffin Wax	Silver (Ag)	0.5 m^2		3 mm	8.8 l/ m^2/d	The Aperture Width and The Rim Angle Were 150 Cm And 40°
Parsa et al. [4] Tehran, Iran	Pyramid Solar Still	Paraffin Wax	Silver Nanoparticle	0.25 m^2	35 °	4 mm	10-12 l/ m^2/d	TEHM System has Higher Performance Than TECM-System
Abdelgaied et al. [5] Tanta city, Egypt (30.47◦ N Latitude & 31◦ E Longitude)	Stepped Solar Stills	Paraffin Wax	Cuo Nanoparticles	1.08 m^2	30.47 °	3 mm	9.79 l/ m^2/d	Depth Of The Basin Saltwater for Both Distillers Is 2 Cm
Abdelgaied M. et al. [6] (33◦27′N, 7◦11′E), Algeria.	Hemispherical Solar Still	Paraffin Wax	Cuo Nanoparticles	0.11 m^2	36◦ - 39◦	3 mm	8.65 l/ m^2/d	The Basin Water Depth In All Stills was Set At 1.0 Cm
Felemban et al. [7] Saudi Arabia.	Dish Solar Still	Paraffin Wax	Tio2 Nanoparticles	70-cm diameter and 45-cm height	-	3 mm	8.150 l/ m^2/d and 69.5%	Different Water Depths (1.0, 2.0, 3.0, 4.0, And 5.0 Cm) were Investigated
Essa et al. [8] Saudi Arabia.	Tubular Solar Still	Paraffin Wax	Cuo			essa et al. [8] saudi arabia.	tubular solar still	Paraffin Wax

Sharshir et al. [9] Egypt (30.570◦E and 31.070◦N)	Pyramid Solar Still	-	Nano-Tio2 Particles	0.64 m2	-	3.5 mm	7 l/ m²/d	The Tio2 Nps (30 Nm Size) Were Mixed With The Saline Water With a Concentration Of 1.5 Wt%.
Abdullah et al. [10] Al Kharj ,KSA	Trays Solar Still	Paraffin Wax	Cuo Nanoparticles	1 m²	24°	3 mm	6- 7 l/ m²/d	2 Cm Basin Water Depth for Basin and Trays.
Younes et al. [11] Al Kharj, KSA	Wick Solar Stills	Paraffin Wax	Cuo Nanoparticles	0.5 m²	24°	3 mm	54.50%	Fiberglass
Tafavogh M. et al. [12] Iran	Solar Still Desalination	Paraffin Wax	Mgo Nanoparticles	71 m³	-	2 mm	67.10%	Depth of Water 2 To 5 Cm
Khairat Dawood et al. [13] Egypt (30◦35′N 32◦16′E)	Conventional Single-Slope Solar Still	Paraffin Wax	Cuo Nanoparticles	1 m²	-	3 mm	11.14 l/ m²/d	The Effect Of The Saline Water Depths Of 1.5 And 3 Cm was Investigated.
Mahmoud et al. [14] Egypt	Integrated Solar Still	Paraffin-18 Wax, Paraffin Wax-56, Potassium , And Glaubers Salt (Na2so4 - 10 H2	Cuo Nanoparticles	4.4 m²	30°	-	11.6 l/ m²/d	Water Temperature Below Caco3 Scale Deposits Of 70 °C
Bhargva & Yadav [15] NIT Kurukshetra, India (29.9490° N ,76.8173° E)	Single-Slope Solar Still	Paraffin Wax	Aluminum Oxide	0.36 m²	29.9°	4 mm	6.28 l/ m²/d	The Water Depth of 6 Cm Is Maintained

Table 2 Summary of Active SS with PCM

Author(s) Location (Latitude, Longitude)	Construction Type	Use Of PCM	Use Of Nano materials	Basin Area (m²)	Glass Angle	Glass Thickness	Maximum Productivity(l/ m2/d) or Efficiency (%)	Occurrence /Remarks
Adibi Toosi et al. [16] Iran (36.26 °N and 59.61 °E)	Stepped Solar Still	Stearic Acid	-	60 cm x 8 cm x 3.5 cm	36.26 °	3 mm	56.6%.	3 Cm Depth of Basin Water Has Been Kept Constant For Both Still
Tuly et al. [18] Bangladesh (88.6241 °E, 24.3636 °N)	Double Slope Solar Still	Paraffin Wax.	-	0.5 m^2	25 °	3.5 mm	39.74%	The Constant Water Level of 3 Cm Was Kept In The Absorber Plates
Arunkumar T. et al. [19] India	Tubular Solar Still	Paraffin Wax	-	2 m^2	11°	4 mm	3.23 l/m²/d with 76.78%	6 Copper Balls Got Fabricated with 28 Mm Diameter & Covered With Black Paint
Al-Harahsheh et al. [20] Jordan	Active Solar Still	Sodium Thiosulfate Pentahydrate (Stp), Sodium Acetate Trihydrate (Sat) And Paraffin Wax	-	0.83 m^2	35°	6 mm	9.7 l/ m²/d	Exterior Solar Collector & Stainless Steel Pipes to The Solar Still Enhanced The Production by 3.2 Times.
Khairat Dawood et al. [22] Egypt (30° 35' N, 32° 16' E)	Stepped Solar Still	Paraffin Wax	-	1.0 m^2	30 °	5 mm	13 l/ m²/d	-
Vijay R. et al. [23] India (11°18'45.8''N,	Conventional Solar Still	Paraffin Wax	-	0.5 × 0.5 m^2	15°	4 mm	4 l/ m²/d	The Heat Pipe Was Connected at A 45° Angle to The Horizontal Surface.

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77°42'57.8'' E)								
Ganesan et al. [24] India	Conventional Solar Still	Glauber Salt	-	1 m × 0.65 m	10°	3 mm	5.8 kg/m²	Constant Water Depth Of 1 Cm
A. H. Abed et al. [17] Iraq (33.309253° N, 44.45 °E.)	Single-Slop Solar Still	Paraffin Wax	-	0.5 m²	35 °	4 mm	7.255 l/m²/d and 39.3%	Hfu Vaporizer Modules Were Employed In This Investigation To Atomize The Water Basin & Create Ultrafine Droplets Of Water (Fog).
Benhammou & Sahli [21] Algeria (27.53°N, 0.17 °W)	Sloped Solar Still	Paraffin Wax	-	0.35 m²	30 °	4 mm	9.870 kg/m²	The Water Depth, 3—9 Cm
Ghadamgahi M. et al. [25] Iran (52.5 °E , 35.7 °N)	Five-Stage Solar Still	Paraffin Wax	-	0.25 m²	35 °	1 mm	4.9 l/ m²/d	This Water Content Was Attained at a Speed Of 1.3 L/Min
Abu-Arabi et al. [26] Jordan	Modified Solar Still	Paraffin Wax	-	1.3 m²	-	3.4 mm	6.3 l/ m²/d	-
Shehata et al. [27] Egypt	Single Solar Still	Paraffin Wax	-	1 m²	30°	5 mm	7.45 l/ m²/d	Water Depths of 25 And 35 Mm
Amarloo & Shafii [28] Iran (51.35°E,35.70°N)	Conventional Solar Still	Paraffin Wax	-	78 cm × 56 cm	18°	1 mm	2.805 l/m²/day	The Polyethylene Foam Having a Thickness Of 5 Cm was Utilized for Thermal Insulation
Elbar & Hassan [29] Egypt (Longitude/ Latitude: E 029° 42′/N 30° 55′)	Single Acting Solar Still	Paraffin Wax	-	1 m²	31°	4 mm	32.86%	Three Tiny Channels Were Welded Along Both Internal Sides of The Stills Glass Panels At An Angle of 5° Downward Inclination

Kumbhar & Sonage [30] India	Double Slope Solar Still	Paraffin Wax	-	0.65 m²	23°	4 mm	6-6.5 l/m²/day	Brackish Water (High Contents of Sodium Carbonates – 40% Soap Solution) Used
Mazraeh et al. [31] Iran	Single Slope Solar Still	Paraffin Wax	-	1 m²	45°	4 mm	4.55 kg/m²·day	Water Depth of 0.03 M,0.07, And 0.12 M
Al-harahsheh et al. [32] Jordan	Single Basin Solar Still	Sodium Thiosulfate Penta Hydrate	-	1 m²	35°	4 mm	4300 ml/(m². day)	Three Water Levels were Investigated; 5, 8, And 10 Cm
Arunkumar et al. [39] Coimbatore (11° North, 77° East), India	Single Slope Solar Still	Paraffin Wax	-	0.25 m²	11°	4 mm	7346 ml/m²/day	Fill The Pss Basin Up to a Depth Of 3 Cm.
Rajaseenivasan et al. [33] India (9.9252° N)	Conventional Solar Still	Paraffin Wax	-	0.64 m²	10°	-	5.23 kg/m²day	A Saline Water Depth of 1 Cm Is Maintained In The Basin
Faegh & Shafii [34] Iran(latitude:42.35,longitude:35.51)	Simple Solar Still	Paraffin Wax	-	0.04 m²	35.5°	1 mm	6.555 kg/m²day	Saline Water Basin, a Tank, a Fan, and also Twenty Thermosiphon Heat Pipes
Kabeel & Abdelgaied [35] Egypt (Latitude 30.47°N and longitude 31°E)	Developed Solar Still	Paraffin Wax	-	0.72 m²	30.47°	3 mm	10.77 l/m²day	Same Water Depth of 2 Cm
Kabeel et al. [36] Egypt	Modified Solar Still	Paraffin Wax	-	0.6 m × 1.2 m	30.47°	4 mm	9.36 l/m²/day	The Depth of The Saline Water Remains Constant at 2 Cm During The Experiments

Arunkumar et al. [37] Coimbatore ,India	PC-Solar Still	Paraffin Wax	-	0.25 m × 0.25 m	11 °	2 mm	3.5 l/day	To Improve Production Further, PCM-Loaded Balls Are Added to The Basin
Arunkumar et al. [38] India (Latitude 11°)	Hemispherical Basin Solar Still	Paraffin Wax	-	-	23.18 °	-	4460 ml/m²/day	-

Summary

This section presents a summary of various solar technologies still employing phase change materials and nanomaterials that have been reviewed. The summary contains information about the solar still types, altitudes of location, PCM, nanomaterials, specifications of basins and glass, productivity, and remarks.

Conclusion

The proposed review, considering the limitations mentioned earlier, can address several important problems related to solar stills. Based on the findings of the review, practical guidelines, and recommendations can be formulated to optimize the performance, maintenance, and economic feasibility of solar stills. These guidelines can be beneficial for researchers, engineers, policymakers, and individuals interested in implementing solar still systems.

By advancing the understanding of active solar stills, this review contributes to the promotion of sustainable water purification technologies and their adoption in regions facing water scarcity challenges.

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