A Comprehensive Review: High-Efficient Productivity Solar Stills

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***Abstract*:** As global freshwater scarcity continues to escalate, the development of efficient and sustainable technologies for freshwater generation is of paramount importance. Solar stills, driven by solar energy, have emerged as a viable output for providing clean and uncontaminated water in arid and remote regions. However, conventional solar stills often abidebyefficiency and low productivity, limiting their widespread adoption. To process fresh water, solar desalination is one of the choicesfor any sort of polluted water (contaminated, brackish, and seawater) in anacceptable method. Through condensation and evaporation methods using solar energy to cleanse the water asimple solar still mechanismis used. In broad, the traditional solar still productivity is about 02 to 05 liters per square meter per day. However, for a human being, this amount is not sufficient to lead asufficient life. Hence alteration is required to better the yield of the clean water (more than 05 liters per square meter per day). In this study, an effort has been made to classify variousdesigns of solar still only based on their production of more than 05 liters per square meter per day. Here, in order to draw conclusions that are relevant, we identify these effective, stills withhigh productivity,and talk about innovative adaptation and processes of heat transmission. Forthcoming investigators who seek to focus solely on effective solar stills with high productivity in order to increase yield can use this thorough review as a reference manual.

Keywords: *Solar collectors, Solar still, solar desalination, Water, Efficacy, Productivity*

1. Introduction/ Preface work

For all biological treatment water is required and it is the prime source of existence on Earth. Owing to its plentiful environment and biophysical properties, water has a constituting result on cosmic and earthbound distilling [1]. Survival beyond water is highly impossible as on Earth it is the most essential fluid [2, 3]. A sufficient amount of water can be brought from an efficient solar desalination system to humanity for water shortage [4, 5]. For a healthy life nowadays it has become more challenging to get better grade water. The solar desalinationmechanism is the assured processof producingpure water in a viable way [6, 7].Based on their alteration [8, 9], the sources can be indirect (using solar ponds, flat plate and, evacuated tube collectors, etc.) or direct sources (sun). Traditional solar still with effectual alteration plays a crucial role in producing more clean water and it can be possible by using a mechanism for heat utilization of source of heat to the basin water [10, 11].

Al-Garni [12] experimented to increase the effectiveness of SSSS with a solar using an external cooling and water heating system. The glass cover at the top was cooled using an external fan that circulated air at speeds between 9 and 7 m/s and around 78 °C of hot water can be achieved with this adjustment. According to the findings, the maximum and minimum productivity of around 8.741 l/m^2 and 2.40 l/m^2 of a water heater with and without SSSS was produced. Alaudeen et al. [13] have carried out studies withSingle Slope Solar Stills (SSSS) using glass as the basin substance. The upper section of the glass basin served as the evaporation zone, and the lower section served as the heating zone. Sponges, sand, corrugated material, paraffin wax, ethylene glycol (EG), and zinc nitrate were used as heat-storage components and were positioned between the two glass sections. According to the study, the corrugated sheets with glass basin solar still had better productivity than other storage components, with a maximal output of roughly 2.62 kg/m^2. In the basin, a honeycomb structure with SSSS was used in studies by Arshad et al. [14] to enhance the source of the heat transfer mechanism. This change improved the yield to 2.6 l/m^2 per day by raising the temperature of water basins up to 5°C. Ayoub et al. [15] improved the heat transfer rate using a revolving drum inner side of the basin. With and without a drum two similar solar stills were invented. Drum with solar still maximizes the water evaporation surface area and the yield of freshwater improves comparatively to without a rotating drum in SSSS. To increase the heat consumption at night, Aybar et al. [16] experimented with an SSSS using different thicknesses for the cubes of sponge inside the basin. According to the study, a reduction in sponge thickness leads to an increase in solar cell productivity.

Generally, solar still productivity depends on divergentterminologieslikethe radiation of solar [17–20], the difference of temperature in water-glass [21–25], depth of water [26–31], wind [32–34], insulation [35], and ambiance temperature [36, 37]. The solar still design has a profound effect on the aforementioned productivity-influencing criteria. The numerous active and passivedesigns of solar stills with productivity levels greater than 5 l/m^2 per day are thoroughly analyzed in this paper, and the innovative mechanism underlying productivity augmentation is explained. The review's contribution to future research is crucial. Researchers can readily concentrate on the most effective strategies based on the review's findings. This ought to make it easier for the innovations to be commercialized.

2. High-productivity efficient Solar Stills

2.1. Solar pond accompanied by solar still

2.1.1. Double basin

Experimental research on the traditional solar and converted double basin solar stills for increasing productivity was conducted by Gnanaraj et al. [38]. The bottom and upper basins have dimensions of 0.100 m by 0.140 m and 0.100 m by 0.100 m, respectively. Per day productivityof 6247 ml/m^2 was produced a by tiny solar pond and reflector coupled FPC accompanied to the solar still double basin. This productivity was found low comparedwith other solar still.

2.1.2. Shallow solar pond with single basin slope solar still

An exergy study was carried out by Ranjan and Kaushik [39] through a solar still and solar pond combination. The 1 m^2 surface area of solar stillswas specified and the theoretical productivity per day wasfound 16.79 l/m^2. El-Sebaii et al. [40] conducted an experimental analysis of the thermal endurance of an SSSS paired with a Shallow Solar Pond (SSP) with a one m^2 surface area. The flow rate of mass was 1.10^3 kg/s on the basis of SSSS area and the productivity was found 5.019 kg/m^2 per day. By changing the flow rate, productivity was investigated in research. El-Sebaii et al. [41] carried out experimentation using the SSP and SSSS combination. In the closed cycle operation, investigated different six flow rates (0.10, 0.004, 0.003, 0.002, and 0.004kg/s). Higher and maximum yield was produced at 0.005 kg/s flow rate with SSP-integrated SSSS than that without the SSSS.

2.2. Humidification and dehumidification (H&DH) techniques with solar still

2.2.1. Various effect of H&DH system integrated with solar still

The numerous effects of solar still incorporated with an H&DH system were theoretically examined by Fath et al. [42]. To reduce condensation, the dehumidifier and humidifier components were utilized to improve the distiller's circulation of fresh water. At 0.2 kg/s of air-flow rate, per day highest9.85 kg/m^2 production was obtained.

2.2.2. H&DH system coupled with conventional solar still

Investigating a solar still using an H&DH system byGhazy and Fath [43]. The solar still's surface area was one square meter.In comparisonwith the traditional solar stillsper day the highest yield of 4.2 l/m^2, this solar still produced roughly per day's largest yield of 6.5 l/m^2.

2.3. Heat storage with solar still

Sensible heat/latent heat energy storage methods with Phase Change Material (PCM) can be used to store heat [44–47]. A substance that releases heat is referred to as an energy storage medium (latent heat) when it does not change its phase. Both of these methods have been employed by researchers in sun still applications to keep the water at the proper temperature and produce distilled water at night.

2.3.1. Latent heat energy storage with solar still

2.3.1.1. PCM with tubular solar still

Solar still with a coaxialcircular tube supported by a composite parabolic concentrator was experimentally examined by Arunkumar et al. [48]. PCM with and without, the per day productivity of the composite parabolic concentrator coaxial circular tube solar still was found respectively 5.789 $l/m^2$and 5.329 l/m^2.

2.3.1.2. PCM with solar still

In solar stills, Kabeel and Abdelgaied [49] and Kabeel et al. [50] conducted studies of injected hot air with PCM, respectively. In the latter, the air was heated with a double-pass using a solar air heater and it was then delivered using insulated pipes into the solar still. The SSSS had a size of 0.6 m by 1.2 m. Paraffin wax served as the PCM. Surface area of 0.612 m^2, copper served as the absorber material of solar stills. Heat transfer was accelerated by hot air bubbles. In comparison to standard solar still, which produced per day of 4.5 l/m^2, the combination of solar air heater and SSSS with PCM respectively produced 9.36 and 7.54 l/m2 per day.

Solar still, Faegh and Shafii [51] experienced using a collector of evacuated tubes for heat pipes and loaded PCM with an external integrated condenser. The basin had a 0.40 m^2 area. They discovered and together produced a per day output of 6.65 kg/m^2using evacuated heat pipes, heat pipes, and PCM with external condenser.

2.3.1.3. Nanoparticle-enhanced PCM with solar still

Enhanced paraffin PCM of nanoparticles in solar stills was explored experimentally and numerically by Rufuss et al. [52, 53]. A pair of 0.50 m2 solar stills that are identical to one another were built. The nanoparticle concentration was 0.3 weight percent. The solar still's distillate per day yield was respectively 3.96 l/m^2 and 5.29 l/m^2, without and with the use of nanoparticle PCM (NPCM) [54].

2.3.1.4. PCM with weir-kind solar still

Dashtban and Tabrizi[55] conducted an analysis on a solar still cascade stepped with a weir-kindthat contained an energy storage medium such as Paraffin Wax (PW). The absorber plates' total surface area was 0.72 m^2. PW energy storage medium with and without, the solar still escorted step produced respectively per day of 6.69 kg/m^2 per day and 5.09 kg/m^2. The thermal efficiency was found 47% and 64% respectively with and without PCM.

2.3.2. Latent heat storage materials with solar still

In applications of solar still, investigators used latent heat storage materials (LHSMs) [56, 57] and studied the behavior of productivity. These SHSMs include marbles, sponges, fins, pebbles, wick, charcoal, iron scrap, black cotton cloth, corrugated absorber, clay pots, jute wick, black gravel granite, and mild steel pieces.

2.3.2.1. Sponges with solar still

Experimental testing of the SSSS along with steps in the basin was done by Ensafisoroor et al.[58]. To improve the solar still's ability to transfer heat through evaporation, sponge cubes were also placed in the basin. The stepped solar still per day productivity with CSS and sponge was respectively 4.78 l/m^2 and 5.34 l/m^2, according to their research.

2.3.2.2. Fins solar still

Although fins were utilized as an LHSM to retain heat, their primary function is to expand the region where heat may be transferred. Fins, however, can serve as anLHSM and anapproach to speed up heat transfer when placed as a distinct inner basin material. The porous fin with an absorber in single-basin solar still was studied by Srivastava and Agraval [59]. Around 2.0 kg/m^2 per day productivity difference was found.

In an experiment, fins, jute fabric, a flat plate collector basin (FPCB), and black gravel were combined with the solar still by Rajaseenivasan et al. [60]. The FPCB had a surface area of 1 m^2. To expand the FPCB's evaporation surface area, additional materials like black gravel and jute cloth were employed. They found that the FPCB produced per day of 5.79 kg/m^2 of energy when jute and black gravel absorber were combined, compared to 3.62 kg/m^2 from traditional solar per day.

2.3.2.3. Iron scraps, marbles, and pebbles with solar still

With each type of material in the basin— black stones, white marbles, pebbles, iron scraps, and calcium stones—Shanmugan et al. [61] experimental investigation conducted of the solar still. The dimensions (1.3 m by 1.3 m by 0.3 m) used for an artificial solar still. They discovered the solar still basin per day production of 5.81 kg/m^2 with calcium stones.

2.3.2.4. Wick with solar still

The vertical rotating black wick in the SSSS was experimented by Haddad et al. [62]. The solar still's basin measured 0.36 m^2. A motor (DC) powered by solar energy was used to revolve the black wick, which was placed on the belt. The wick is always kept moist by the 0.0033 rev/s of rotation. The per day maximum yield from the vertical solar panel revolvingwick was still 5.08 kg/m^2 in the winter and 7.19 kg/m^2 in the summer.Thote et al. [63] experimented and improved the water purification performance using wick.

2.3.2.5. Different absorbing materials with solar still

The double & single basin solar stills with various absorbency materials were experimentally tested by Rajaseenivasan et al. [64]. To boost the evaporative transmission of heat inside the basin, they employed jute cloth, cotton pieces, black cotton cloth, pieces of mild steel, and clay pots. The pieces of mild-steel components in the solar still system with double basin produced the highest per day productivity of 5.62 l/m^2.

2.3.2.6. Wick and wire mesh solar still

Under the climatic circumstances of Cyprus, Agboola and Egelioglu [65] compared experimentally two similar types of inclined water desalination solar systems. Investigations were done into the impact of wick material and mesh of wire on the absorber panel. With a spraying technique, wick and mesh of wire on the absorber panelrespectively per day produced 6.41 kg/m^2 and 3.03 kg/m^2.

2.3.3. Latent and sensible heat energy material storage (the combined effect) along with solar still

A modified traditional solar still depicted in Fig. 1, being studied by Rajaseenivasan et al. [66]. In the solar still's basin, paraffin wax and charcoal absorbers were employed. For boosting evaporation a PV-powered stirrer was also utilized in the basin to stir up the water. They discovered that per day greatest yield was 5.32 kg/m^2 when PCM, CSS, and stirrer were combined.

2.4. Solar stills with multi-effect

2.4.1. Vacuum tube collectors with multi-effect solar still

The solar still with multi-effect assisted by heat pipe (vacuum tube)was used by Xiong et al. [67] in the study (Fig. 2). The multi-stage solar still's basins are heated by the collectors with vacuum tubes, which take in solar energy. Water heated in supplementary stacked chambers of vaporized water condenses and continuously releases latent heat. The multi-stage solar system with vacuum tubes still produced per day 9.61 kg/m^2.

Experiments were carried out in a solar still with a stacked-tray multi-stage by Chen et al. [68]. The trays were 0.75 mm thick by 0.40 m by 0.55 m in size stainless steel plates. The supplementary stacked chambers in the distiller efficiently used the latent heat delivered by the lowest basin. This system's overall productivity was estimated to be 8.1 kg/m^2 per day. Four alternative steps of a solar still with multi-effect were examined by Estahbanati et al. [69]. The chamber's horizontal evaporation area was 0.46 m^2. The solar still's tray and heat exchanger (HE) construction employed copper and aluminum, respectively. In order to transport heat to the bottom basin of the solar still from the HE, the oil served as a fluid of heat transfer in the HE. When the vapor condenses, the existing heat is transferred to the tray above. When used for a whole day, the clean water produced the largest of 23.79 kg by solar still.

In an integrated evacuated collector and multi-stage solar still, Shatat and Mahkamov [70] conducted trials. The rectangular still with multi-stage has a length of 1200 mm and a width of 400 mm. Freshwater of 10 kg was still produced every day by the multistage solar system.

Experimental research on the evacuated tubular collectors combined with SSSS was conducted by Panchal et al. [71, 72]. A 1.5 m long, array of 14 concentric pipes of diameters 54 mm (outer) and 47 mm (inner)was created. The system produced 5 kilograms per day per square meter. Solar collectors with evacuated tubes were inserted into the solar still of the lower basin. The clean water of 20 liters per day was produced by the evacuated collector's double-effect solar distillation system.

2.4.2. Wicks with plenty-effect solar still

The compound solar still with plenty-effect diffusion powered by waste heat and heat energy of solarwas experimentally examined by Park et al. [73]. 18.06 kg/m^2 per day were produced by the compoundsolar still with plenty-effect.

2.4.3. Heat pump coupled with multi-effect solar still

A multi-effect evacuated solar still was investigated by Ahmed et al. [74]. To boost the evaporation rate inside the chamber, a solar collector was combined with the multi-phase unit's lower basin, and a vacuum of solar-powered was utilized to remove the non-condensate gases from every stage. At a vacuum pressure of 0.5 bars per day, 14.2 kg/m^2 productivity was found bythis mechanism.

2.4.4. Fresnel lens integrated with differentsolar still

The trials were carried out by Younas et al. [75] in solar still (multi-stage) integrated with a Fresnel lens and determined that the Fresnel lens and multi-stage still had a productivity of 5 kilograms per square meter per day.

2.4.5. FPC integrated with multi-stage solar still

An experimental test conducted on solar still with a multi-phase connected to a solar collector by Abed et al. [76]. The solar still and collectors were integrated using a HE coil. The largest per day 5 l/m^{2}yield produced. Using an FPC the effectiveness of a multi-stage solar purification system was examined by Reddy et al. [77]. The FPC had 1 m^2 of surface area. The daily 28.04 kg/m^2 production was found by this purificationsystem.

2.5. Unconventional shapes and designs with stills

By transforming the entire mechanism of the standard solar stills into non-traditional structures including tubular, cascade, inclined, pyramid, and hemispherical [30, 41], these sorts of sun stills possess many distinct configurations. But the way that these stills function is the same as how CSS functions.

2.5.1. Solar still with a hemispherical shape

In an experimental study, Ismail [78] examined the solar still with a hemispherical shape. The aluminum absorber plate had a 0.50 m^2 surface area. At 12 mm water depth, this still produces per day 5.75 l/m^2 of maximum output and has a daily efficiency of 33%.

2.5.2. Solar still with a tubular shape

The solar still tubular shape (SST) was experimentally researched by Ahsan et al. [79]. The outer tube measured 0.52 m (length), 0.13 meters (diameter), and 0.15 millimeters (thickness). The tubular shape of SST resisted the other unusually solar stills shaped and contributed to the per day low production of 5 kg/m^2.

2.5.3. Solar still along with a cascaded shape

Two important characteristics of this kind of solar still are its slanted form with a basin stepped and its single condensate route for extracting the distillate yield. The cascaded still solar was analytically examined by Ziabari et al. [80]. The still's basin measured 1.16 m^2. They regularly provide water to the basin to avoid any dry places. Additionally, a mathematical model was created and tested using the outcomes of the experiment. The redesigned cascaded solar still had a per day 6.7 l/m^2 average productivity.

2.5.4. Tilted solar still

Experimental and theoretical analysis of atilted solar still weir-type with double and single coating arrangements was conducted by Sadineni et al. [81]. The absorber plate has measurements of 0.57 m by 1.7 m and found the per day productivity of 5.6 l/m^{2}and 2.3 l/m^2 respectively for single and doublecoating.

2.5.5. Pyramid still coupled with inclined still

A solar still of a pyramid in shape connected to baffles with a tilted solar still was theoretically examined by Kumar et al. [82]. The solar still's productivity is increased by the slanted structure with baffles, which expands its heat transfer area. Analysis was done on eight distinct masses of water basins, weighing from 20 kg to 100 kg. With a water mass of 20 kg, the 7.06 l/m^2 of the highest productivity was attained.

2.6. Unifiedsolar stills with a single slope, brine changes, and container heat transfer augmentation methods.

2.6.1. Collector with solar still

A cover cooling of solar still with triple basin (SSTB) aided by a collector of the parabolic shape (CPS) was experimentally explored by Srithar et al. [83] for the improvement of freshwater (Fig. 3). Fins, charcoal absorbers, and river sand were employed in the channel to speed up the rate of heat transfer inside the distiller. The SSTB had an interior size of 0.36 m by 0.3 m and 0.33 m in height. For heat loss from the top glass cover the pumping system with airflow rates of 20, 25, 30, 35, and 40 m/s was run by a solar photovoltaic (PV) panel.The four separate operations that were performed. According to the scientists, the SSTB-CPS and top cover cooling combination produced per day of a maximum production of 16.94 kg/m^2.

Sampathkumar and Senthilkumar [84] combined a collector of evacuated pipe (CEP) integrated with a solar still. The SSSS and CEP combination for the enhancement of freshwater has been experimentally tested by the authors. Four methods were used to carry out the procedure: SSSS coupled with CEP for the operation of 12 to 17 hours, operation of24 hours, 8 to 12 morning hours, and for 60°C water. The SSSS and CEP combination for the enhancement of freshwater has been experimentally tested by the authors.

2.6.2. Parabolic concentrator assisted to solar still

The test was conducted byGorjian et al. [85] on a parabolic-shaped solar still for seawater purification. The reflector has a 2.0 m^2 aperture and a 0.693 m focal length. The analysis showed that even after seven hours of operation, the system produced per day 5.15 kg/m^{2}of the largest production.

Experimental research on the parallel pipe solar still-composite parabolic concentrator (PPSS-CPC) combined with SSSS for freshwater enhancement was conducted by Arunkumar et al. [86]. The CPC and SSSS have respective areas of 2 m^2 and 0.25 m^2. On the CPC's line focus, five parallelpipe arrangements were created and installed. The hot water was connected to the SSSS. The distiller's warm-up time was shortened and evaporation was improved by the hot water. The overall experimental finding showed that 6.4 l/m^2 of CPC-PPSS-SSSS were produced daily from the still.

APPSS-CPC coupled with a solar still pyramid in shape(SSP) and SSSS was used by Arunkumar et al. [87]. The CPC's collecting area was 2 m^2. An SSSS and an SSP were directly linked with the warmed water from the PPSS-CPC. The productivity of PPSS-CPC with SSSS and SSP from the solar still was estimated by the authors respectively per day of 6461 ml and 7769 ml. A CPC combined with a channel-type solar still was modeled by Pearce and Denkenberger [88]. The 16 l/m^2outcome showed that roughly three times per day the height of the reflector is 2.5 times the still width. Additionally, the CPCs have considerable financial privilegesin producing purified water.

2.6.3. Air blower with solar still

Experimental research on the SSSS with a blower (warm air) to increase the productivity of the system was done by Joy et al. [89]. The findings revealed that the SSSS at the solar basin with air blower injection continued to produce per day of 4.9 l/m^2.

2.6.4. Integrated with reflectors solar still

Solar still inverted absorber for saltwater was tried by Dev et al. [90]. An arc reflector and a typical solar still (TSS) make up a solar still inverted absorber. Diverse depths were used to evaluate seawater samples inside the still and had 1 m^2 of surface area. The inverted absorber solar still per day produced 6.302 kg/m^2 for the area of still.

Experimental research combined with a cycle of refrigeration for inverted type solar still was conducted by Wahab and Al-Hatmi [91]. The mechanism had a constructed size of 400 mm by 200 mm. To heat water in the basin, this mechanism was positioned at the reflector mirror's focal point. The refrigeration cycle in the still had the major benefit to the basin by adding heat and removing it from the external surface of condensation. As a result, per day 10 l/m^2 of a largest productivity was produced at 35 °C.

Experimental research on the straightforward basin-kind of solar still with external and internal reflector mirror was conducted by Khalifa and Ibrahim [92]. The solar still's basin was intended to be 1.0 m^2. The thickness of 4 mm of reflector mirrors for external and internal were used. The per day highest productivity of 6.70 l/$m^2$was produce by the solar still without any reflector.

2.6.5. Nanoparticles and brine with solar still

A wick-kind of solar still containing nanoparticles of Al2O3 and Cu2O mixes with brine inside the basin was experimentally evaluated by Omara et al. [17] and constructed area of 0.5 m^2 consider for each solar stills. The experiment was conducted at three distinct water depths: 3 cm, 2 cm, and 1 cm. The output results show that the use of Al2O3 and Cu2O nanoparticles, a vacuum (exhaust fan), and a wick still with reflectors all enhanced the yield. While the still-containing Cu2O nanoparticles only produced per day 7.360 l/m^2, the 7.570 l/m^2 produced by Al2O3. Kabeel et al. [93] incorporated a still with Al2O3 nanoparticles in the brine and an outlet fan driven by a motor attached by PV panels. This is the mechanism underlying the productivity improvement. Additionally, it has been noted that the fan accelerates condensation by sweeping non-condensable vaporthrow away from the solar still. The solar still's stated per day production was 8.390 l/m^2 and 7.920 l/m^2 with and without running the fan.

2.6.6. Finned basin with solar still

The surface area maximized by fins, which enhances the heat transmission from the source to the sink. El-Naggar et al.[94] investigated the productivity-enhancing SSSS with a finned basin is shown in Fig. 4. As a result, maximum per day 5 kg/m^2 produced by the finned basin with solar still and indicated higher productivity of the traditional solar still.

El-Sebaii and Shalaby's [95] inspectedthe productivity using a SSSS with v-corrugated. The corrugated solar still's basin measured 0.437 m^2. The area of heat transfer magnified when the number of "v" expanded. As a result, the corrugated solar still's highest daily productivity was 8.679 kg/m^2. This productivity is implied to be greater than that of the reflectors with inverted solar still [90], unitestill effect [92], and the pyramid-shaped solar still with composite parabolic concentrator [85].

2.6.7. PV basin with solar still

PV channel basin in the SSSS (Fig. 5) was studied by Manokar et al. [96, 97]. In addition to producing electricity, the PV panel served as a medium for the basin to absorb energy. The per day 7.3 kg/m^2 maximum outcome produced with this structure.

2.6.8. Heat pump meshed with solar still

Halima et al. [98] done the theoretical analysis of the heat pump-integrated SSSS in the basin. They observed that heat pump-assisted distillation produced 13.5 kg/m^2 of productivity per day.

2.6.9. Condenser and solar chimney integrated with solar still

Condenser and solar still along with solar chimney with the reinforced plastic of fiberglass (RPFG) was experimentally tested by Refalo et al. [99]. The solar still had an area of 0.897 m2. It produced 5.12 l/m^2 per day of yield, correlated to 4.7 l/m^2 per day for the solar still conventional. This study suggests that even if a chimney and a condenser are used for heating and cooling at the same time, the productivity improvement was not as significant as with other treatments.

2.7. Solar stills with step-type

2.7.1. Absorbing materials and air heaters with stepped solar still

Abdullah [100] conducted tests in an aluminum-filled, stepped solar still with an integrated solar gas heater. The solar still with stepped had areaof 0.5 m^2. The pre-heated air raised the temperatureof water and improved the efficacy of the mechanism. As a result, the solar gas heater augmented stepped type of solar still had a highestper day productivity of 6.3 l/m^2 as opposed to the per day traditional solar still's 3.4 l/m^2.

2.7.2. Top cover cooling with stepped solar still

The impact of flow rate, cover glass length cover, and film thickness of water cooling (top cover), on the output of a solar still with stepped was theoretically examined by El-Samadony and Kabeel [101]. They discovered that a cooling film thickness between 0.00025 and 0.00055 m, a volumetric flow between 0.00004 and 0.000085 m3/s, and a top cover length between 2 to 2.8 m had the highest per day productivity of 5.58 kg/m^2.

2.7.3. The integrated effect on stepped type solar still

Omara et al. [102] looked into how well internal mirror performed in a stepped type of solar still with an Egyptian climate. It produced per day 6.350 l/m2 with 1.16 m^{2}an absorber area, which was more than in the absence of internal mirrors. The stepped solar still with exterior mirrors for production of freshwater, depicted in Fig. 6, was experimentally examined by Maiti et al. [103]. The distiller's productivity increased per day to 5.07 l/m2. However, Muftah et al. [104] integrated absorber material and condensing unit to further increase output. With different modifications, including the inclusion of external and internal reflectors, an external condenser cooling unit, and absorber materials, the author conducted experiments in a stepped kind of solar still. 1.16 m^2 was the size of the absorber plate used for the structure. As a result, the adjusted stepped solar system maintained its maximum 8.9 kg/m^2 daily production.

2.7.4. Different absorber plates with stepped solar still

The absorber plate was altered, and productivity was evaluated by Hansen and Murugavel [105]. According to the trial findings, the tilted solar still with a fin absorber produced 5.210 l/m^2 per day the purified water.

2.8. Solar still with a double slope

Investigates in a solar still with double slope (SSDS) coupled with an FPC have been carried out by Mord et al. [106]. The both side coefficients of heat transfer were computed using a heat model that was created and illustrated in Fig. 7. Utilizing irregular cooling with 1 cm water depth in a basin, per day highest productivity of 10.06 l/ m^2 was attained.

2.8.1. Air heater with solar still

Riahi et al. [107] coupledgas heater and SSDS driven by PV. Six photovoltaic panels connected to four batteries, each with a 150 Ah capacity, powered the heater in the basin. The solar sill had dimensions of 1 m by 0.60 m by 0.60 m. The production with this mechanism produced per day an average of 5.7 kg/m^2, also the cost would be prohibitive.

2.8.2. Integrated with absorber materials solar still with a double slope

Experimental research was done by Pal et al. [108] on the SSDS using a wick of black cotton and jute to produce clean water. The SSDS covered a 2 m^2 area. The greatest productivity of the cotton black wick in 2 cm of water was 9.012 l/m^2 per day and that was higher than the productivity of the jute cloth wick in 2 cm of water (7040 ml/m2 per day). The SSDSsingle basin with a rubber black mat inside the basin was experimented by Akash et al. [109]. During the trial per day 7 l/m^2 largest output was attained.

2.8.3. Condenser unit with double slope solar still

Experimental research was conducted on the condenser unit and integrated SSDS by Zeroual et al. [110]. The water in the basin measured 0.9 by 0.70 by 0.03 meters. The daily output was 6.26 l/m2.

In conclusion, incorporating an FPC and chilling the glass cover at the same time will enable double-slope solar still to operate at its highest productivity of roughly per day 10.6 l/m^2. This solar still's synergistic behavior of simultaneously water pre-heating and chilling ofcover glass was discussed in section 2.6.Table 1 displays the analysis findings of effective designs of solar still and their production capacity.

Fig. 1. PV-powered stirrer with SSSS [65]

Fig. 2. Vacuum tubes with multi-effect solar still

Fig. 3. Pictorial view of the PDC-TBSS [82]

Fig. 4. Finned basin with SSSS [93]

Fig. 5. PV panel in the basin with SSSS [95]

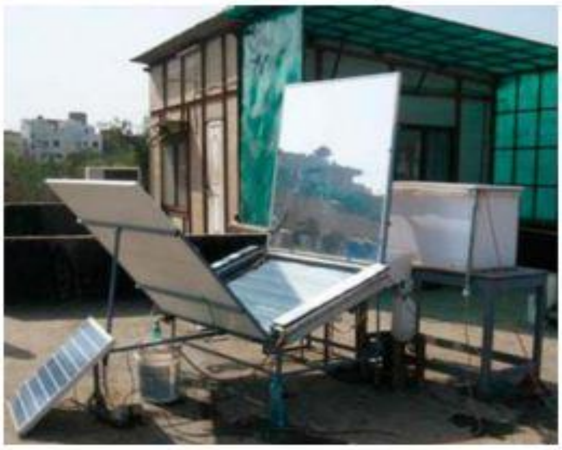

Fig. 6. Reflectors with stepped solar still [101]

Fig. 7. DSSS view [105]

3. Conclusion

This article provides a study of effective designs of large productivity of solar still and itsstructure. To improve the basin heat transfer, a variety of passive and active sources of heat, including even plate collectors, evacuated pipe collectors, concentrators, fluid heaters, and mirrorforexternal - internal, were used. Steel bits, PCM, NPCM, and pebbles were used as heat storage components. To boost production, different materials including clay pots, cotton &jute cloths, and wicks are employed. The following are the main conclusions from this review:

3.1 The bottom basin's temperature rise as a result of the concentrator's intense radiation. The solar channel with triple basin coupled with the concentrator of parabolic shape produced per day 17.04 kg/m^2 of freshwater.

3.2 The use of PCMs in solar channel at night produced pure water. Per day productivity was 7.64, 7.8, and 9.63 kg/m^2 observed utilization of PCM in solar channel.

3.3 The productivity of freshwater improves with multi-stage solar desalination. The water in the top trays warmed by the sensible heat of the vapor produced in the first stage. The per day largestcapacity18.05 kg/m^2, 23.79 kg/m^2 , 19.98 kg/m^2, and 10.87 kg/m^2 were produced respectively for different effect of desalination system coupled with SSSS was, the active solar still, the ETC with solar still, and with Fresnel lens coupled with solar still.

3.4The freshwater productivity was 7.98, 8.99, and 6.4 kg/m^2 per day, respectively observed for the solar channel with various material (wick, rubber and cooling cover) used. The rate of condensation in the solar channel is increased by cooling the glass shield. By including a wick inside the solar channel, surface tension and the area of evaporationimproved. The rubber mats improved productivity by raising the temperature of water inside the basin.

3.5 Daily 13.49 kg/m^2 were produced by the SSSS when it was combined with the heat pump. The increase temperature of basin water for greater productivity was mostly due to the heat pump.

3.6 Maximum 16.64 kg/m^2 daily production produced from the SSSS and solar reservoir. The freshwater productivity was increased by the heat extracted from the solar reservoir, which was directly related to solar channel elevated the temperature of water.

Table 1: Designs and Productivity of Solar Still

Sr. No.	Design of Solar Still	Production per day	Unit	Area/ Dimension	Appliance/ Mechanism	Country	Author
1	Nanofluid Al2O3 with SSSS	7.6	l / m^2	1 m^2	Due to nanoparticles inside the basin, maximized the conductivity of the fluid.	Egipt	Omara et al. [17]
2	Nanofluid Cu2O with SSSS	7.4	ml/ m^2	1 m^2		Egipt	Omara et al. [17]
3	Integrated reflectors with FPC and solar reservoir with double basin solar channel	6.249	l / m^2	0.14 x 1 m^2	Additional heat source for a reflector, solar pond, absorbing materials, and FPC.	India	Gnanaraj et al. [38]
4	Solar pond with SSSS integrated	16.76	l / m^2	1 m^2	Heat is extracted from SSP and used in solar still with a single basin.	India	Ranjan and Kaushik [39]
5	SSSS-SSP	6.68	kg/ m^2	1 m^2	Heat is extracted from SSP and used in solar channel with a single basin.	Egypt	El-Sebaii et al. [41]
6	PCM with TCM	7.77	l / m^2	2 m^2	Radiation reflected by the CPC.	India	Arunkumar and Kabeel [48]
7	PW and CuO mixture with SSSS	5.28	kg/ m^2	050 m^2	Due to the nanoparticles and storage of energy material inside the basin, the thermal conductivity of the fluid increased.	India	Rufuss et al. [52-54]
8	Steps and sponges with	5.37	l / m^2	1 m^2	Glass temperature reduced by the sponge	North	Ensafisoroor et al.

	SSSS				and increases the temperature difference.	Cyprus	[58]
9	Porous fin absorber with SSSS	7.5	kg/ m^2	0.50 m^2	Fins enhanced the basin water heat.	India	Srivastava and Agrawal [59]
10	Solar still with flat plate collector basin	5.82	kg/ m^2	0.65 m^2	Fins enhanced the rate of heat transfer.	India	Rajaseeni vasan et al. [60]
11	Solar still inclination	6.41	kg/ m^2	1 m^2	Inclination of angle towards the sun is efficient.	Turkey	Agboola and Egelioglu [65]
12	PV-stirrer and absorber and energy storage material with SSSS	5.23	kg/ m^2	0.8 x 0.8 m^2	0.45 m to 0.15 m range of basin height shows more productivity.	India	Rajaseeni vasan et al. [66]
13	Solar still with multi-effect	9.61	kg/ m^2	1.7 m^2	Basin temperature increased by vacuum tubes.	China	Xiong et al. [67]
14	Solar still with active multi-effect	23.8	kg / m^2	0.47 m^2	Released latent heat by vapor and heated the water in the upper chamber.	Iran	Estahbana ti et al. [69]
15	Evacuated glass tubes with double-effect solar still	20	l / m^2	1 m^2	Released latent heat by vapor and heated the water in the upper chamber.	India	Panchal [72]
16	SSSS-Hybrid MED	18.02	kg/ m^2	0.77 m^2	Released latent heat by vapor and heated the water in the upper chamber.	Korea	Park et al. [73]
17	Point focus Fresnel lens with multi-stage solar still	10.9	kg/ m^2	2.2 m^2	Fresnel lens enhanced the heat of basin water. Released latent heat by vapor and heated the water in the upper chamber.	UAE	Younas et al. [75]
18	Collector (Solar) with	5	l / m^2	0.45 m^2	Solar energy collectors enhanced the heat of	India	Abed et al. [76]

	multi-stage solar channel				basin water. Released latent heat by vapor and water heated in the top chamber.		
19	Solar purification system with multi-stage with FPC	28.04	kg/ m^2	1 m^2	FPC enhanced the heat of basin water. Released latent heat by vapor and water heated in the top chamber.	India	Reddy et al. [77]
20	PDC-TBSS	16.94	kg/ m^2	0.3 x 0.36 x 0.33 m^3	Lower basin temperature increased due to more radiation through the concentrator.	India	Srithar et al. [83]
21	Air blower with SSSS	5	kg/ m^2	1 m^2	Heat enhancement of basin water.	India	Joy et al. [89]
22	Solar channel with inverted absorber	6.302	kg/ m^2	1 m^2	Incoming solar radiation directs the reflector profile to the absorber at the lower basin.	Oman	Dev et al. [90]
23	Solar channel with v-ridged single basin	8.679	l / m^2	1 m^2	vees are responsible for productivity.	Egypt	El-Sebaii and Shalaby [94]
24	PV panels with inclined solar still	7.3	kg/ m^2	1.81 x 0.92 m^2	Iinclination of the angle towards the sun was efficient.	India	Manokar et al. [97]
25	Solar chimney and condensers with SSSS	5.1	l / m^2	1 m^2	Enhance the convective heat inside the distiller by the chimney.	Malta, Europe	Refalo et al. [99]
26	Air heater with stepped solar still	6.3	l / m^2	0.50 m^2	Maximum temperature variation between glass and water due to hot air injected.	Egypt	Abdullah [100]
27	Reflectors and condenser with stepped solar still	7.27	l / m^2	1.01 m^2	Increase distillate water production by condenser.	India	Maiti et al. [103]
28	Internal mirror with solar still	8.9	kg/ m^2	1 m^2	Condensation and absorption process improved by the	Malaysia	Muftah et al. [104]

					arrangement.		
29	Flat, grooved, and fin-shaped absorber with SSSS	5.2	l / m^2	1.3 m^2	Area of heat transfer is increased by the absorber in the solar still.	India	Hansen and Murugavel [105]
30	PV-powered heaters with traditional solar channel	5.7	kg/ m^2	0.405 m^2	Heat enhancement in basin water.	Perak	Raahi et al. [107]
31	Solar channel with dual slope multi-wick	9.0	l/ m^2	2 m^2	Enhanced the surface tension and area of evaporation by the wick.	India	Pal et al. [108]
32	Cooled condenser with dual slope solar channel	6.26	l / m^2	0.9 x 0.7 m^2	Improves the productivity and temperature variance amide glass and water due to glass cooling	Algeria	Zeroul et al. [110]

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