Effect of Design Parameters on Productivity of Various Passive Solar Stills

Ajay Kumar Kaviti, Anil Kumar and Om Prakash

Abstract Fresh water and shortage of conventional energy are two major problems of the world. Water is the basic necessity for sustenance of all living entities. Human beings are considered most refined living entities. They need clean and fresh water for their sustenance at less consumption of conventional energy or by consumption of renewable energy. In this perspective, many non-renewable and renewable techniques have been developed for the purification of brackish or saline water. Among many water purification techniques, domestic solar still is most attractive and sustainable method to cater the need of fresh drinkable water in distant areas at a reasonable cost. Any amount of effort to improve the yield from solar stills by considering various design parameters is worth to discuss. In the last three decades, so many design parameters are considered to improve the productivity of fresh water. Various designs and design parameters used by researchers to improve the productivity of solar stills were reviewed in this chapter for passive solar stills.

Keywords Solar stills · Desalination · Design parameters · Productivity

1 Introduction

Water is one of the most essential and basic requirements for the sustenance of all living entities like human beings, animals, birds and trees. Freshwater availability is less than 1%, and it is decreasing day by day due to pollution and increasing industrial revolution and increase in unwanted population [1]. In today's world,

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majority of the health problems are due to inadequate clean drinking water. Mostly, women spent 200 million hours every day to collect water from distant places. On an average, 3.575 million people lost their lives every year in the entire world due to unclean-water-related diseases. The basic medical facilities are meagre in villages in the under-developed and developing countries. Most of the countryside people are still not sufficiently educated about consequences of drinking saline water [2]. There are numerous ways to change saline water to drinkable water. Advance desalination techniques like thermal vapour compression, multi-stage flash desalination, vapour compression, reverse osmosis, electrodialysis and activated carbon filtration are used to provide clean potable water for rural and urban people. However, people living in secluded areas need affordable technologies [3]. Solar still is considered as a suitable and appropriate alternative renewable energy technique to provide the clean water to remote areas at low cost. Solar stills were first used by Arab alchemists, and this was followed by its utilization by other scientists and academicians; among them, Della Porta (1589), Lavoisier (1862) and Mauchot (1869) are considered most prominent. The first conventional solar still plant was designed by Charles Wilson (1872), a Swedish engineer, for mining community in Las Salinas in Northern Chile. Solar still is easy to fabricate by easily accessible materials with bare minimum maintenance and operational needs and very friendly to the nature [4]. Clean and free energy and friendly to the environment are the main advantages of solar stills. But, they are not extensively used due to low productivity of fresh water in comparison with other advanced distillation techniques [5, 6]. This makes the solar stills highly uneconomical. Thus, it becomes necessary to get better productivity and thermal efficiency of solar desalination systems. There are several researches have been done to improve the productivity of solar still by considering various factors like climatic, design and operational conditions [7–9]. Climatic conditions are mostly dependent on Mother Nature. So, lot of emphasis was given so many researchers on design and operational parameters to improve the productivity. Kalidasa Murugavel et al. [10] reviewed the progress in improving the effectiveness of the single-basin solar still. Velmurugan and Srithar [11] compiled the various parameters affecting the performance of solar stills. Kabeel and El-Agouz [12] elaborated on recent research and progress in solar stills. Kaushal and Varun [13] explained about various types of solar stills. Sampathkumar et al. [2] reviewed in detail about active solar desalination. Xiao et al. [14] focused on the solar stills suitable for brine desalination. Sivakumar and Ganapathy Sundaram [15] reviewed techniques to improve solar still efficiency. Muftah et al. [16] reviewed factors affecting basin-type solar still productivity. Yadav and Sudhakar [17] reviewed the domestic designs of solar stills. So far various design parameters are reviewed by various researchers in a broad manner, the present work aims to review of various design parameters for passive solar stills and their effects on performance.

2 Design Parameters of Solar Stills

Various design parameters used to enhance the efficiency of the solar still. Depending upon the applied design parameter to enhance the still is classified as passive- and active-type solar still. In passive-type solar stills, simple modifications are to be made like different shapes of still designs, cover plate optimization, basin optimization, and addition of some material inside the basin. In active-type solar stills, some additional energy is supplied to the basin through an external mode like collectors, concentrators, solar pond and PV/T system to increase the rate of evaporation in turn improves its effectiveness. But, this chapter is focused on passive solar stills only.

3 Design Parameters for Passive Solar Still

Passive stills used at domestic level are popular because of its simplicity in fabrication at reasonable cost. Because of its less efficiency and lower distillate production rate of potable water, there is so much scope to research to improve the productivity of the still. Various design parameters like different shapes of still designs, optimization of cover, optimization of basin, energy absorption and storing materials are considered by various researchers throughout the globe.

3.1 Different Cover Shapes of Solar Still Designs

Basic shapes of solar stills are developed in the beginning based on the ease and convenience. Later, lot of improvements and modifications have been made in the shapes to get better efficiency.

3.1.1 Single-Basin Single-Slope and Double-Slope Solar Still

Single-basin solar still is preferable for the places where latitude is higher than 20°. Single-slope stills with south-facing cover are used for north latitude places and north-facing cover are used for south latitude places [18]. Double-slope solar stills are preferred for lower latitudes, so that both sides of still receive the sun rays.

Cooper [19] discussed the efficiency of single-basin single-slope solar still in terms of component efficiency by considering various factors. He indicates that an efficiency of about 60% is the upper limit, and in practical it is highly unlikely to attain the single-basin solar still efficiency more than 50%. Farid and Hamad [20] constructed a single-basin single-slope solar still with a basin area of 1.5 m^2 (1.5 m × 1.0 m) from 1-mm GI sheet. The glass of 6 mm thickness was inclined at angle of 11°, and rubber gasket is used to prevent any amount of vapour leak to the atmosphere. Schematic diagram is shown in Fig. 1.

Aboul-Enein et al. [21] designed a single-slope solar still of basin area 1 m^2 with 15° inclined top glass cover with deep basin. Single-basin single-slope solar still was fabricated using 4-mm FRP. Base area is 0.73 m × 0.73 m, and glass cover is sealed with gasket at angle of 10° [22]. Elango et al. [23] fabricated two single-basin single-slope solar stills using 0.01-m GI sheet with basin area 0.5 m × 0.5 m with a 30° inclination of window glass cover. The schematic diagram is shown in Fig. 2. Samee et al. [9] fabricated a simple single-basin solar still with basin area 0.54 m^2 using 18-mm-thick galvanized iron sheet. Schematic and actually fabricated solar still is shown in Fig. 3.

Rubio et al. [24] performed experiments on double-slope single-basin solar still with dimensions of 3.64 m × 2.42 m at the Northwest Biological Research Center at latitude of 24.15°. Glass covers of 5 mm thickness are mounted at an angle of 45° as shown in Fig. 4. Zeroual et al. [25] fabricated an aluminium rectangular basin with dimensions 0.90 m × 0.70 m × 0.03 m. An inverted-V-glass cover with tilt angle of 10° mounted over the rectangular basin. Basin thickness is 3 mm, and window glass of 4 mm thickness was considered for cover glass. Two identical still prototypes are

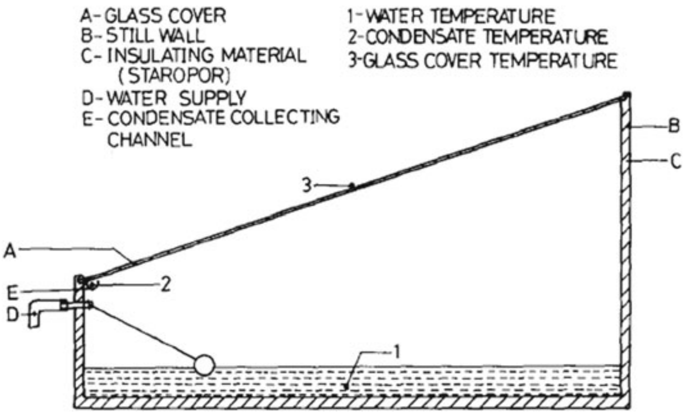


Fig. 1 Single-basin single-slope solar still [20]

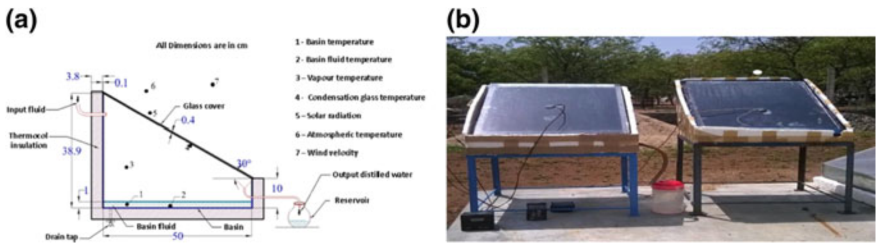


Fig. 2 **a** Schematic and **b** actual diagrams of single-basin single-slope solar still [23]

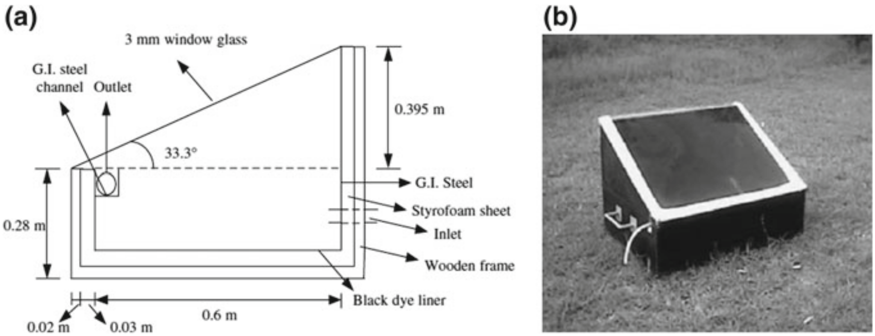


Fig. 3 Single-basin single-slope solar still; **a** schematic, **b** fabrication set-up [9]

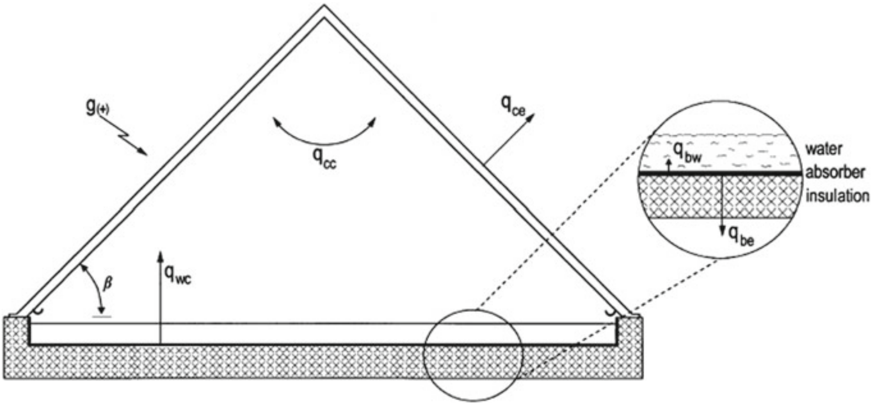


Fig. 4 Side view of single-basin double-slope solar still with main heat flow [24]

shown in Fig. 5. Kalidasa Murugavel et al. [26] constructed a double-slope single-basin solar still as shown in Fig. 6. The size of the basin is 2.08 m × 0.84 m × 0.075 m and outside basin of 2.3 m × 1 m × 0.25 m is made of mild steel. Two glasses of 4 mm thickness is inclined at 30° to the horizontal using wooden frame. Bechki et al. [27] developed a double-slope single-basin solar still. The still was fabricated with 5-mm-thick sheet of waterproof moulded fibre with basin dimensions of 1.00 m × 1.00 m × 0.25 m. An inverted-V-glass roof, tilted at 10° is mounted over the rectangular basin. Cross-sectional view of experimental set-up is shown in Fig. 7.

3.1.2 Spherical and Hemispherical Solar Stills

Dhiman [28] presented a mathematical model to predict the thermal performance of a spherical solar still. He modified the heat and mass transfer relationships empirically and validated them experimentally. The schematic is shown in Fig. 8. The still is

Fig. 5 Two identical single-basin double-slope solar stills [25]

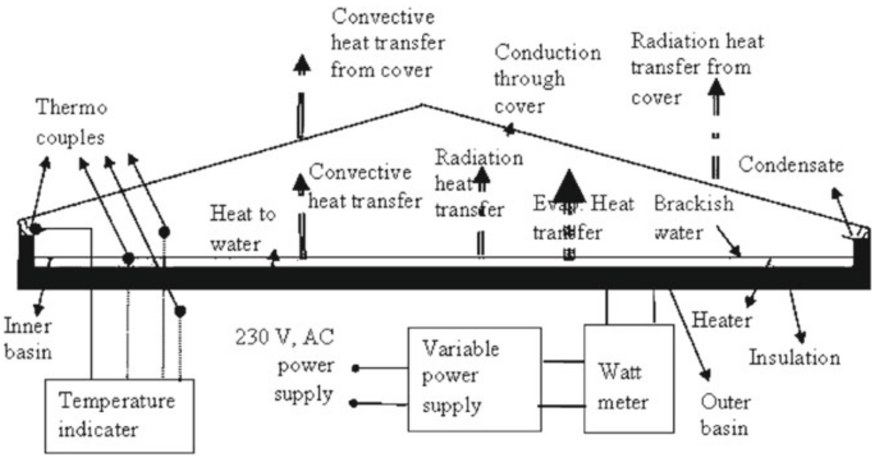


Fig. 6 Single-basin double-slope simulation solar still [26]

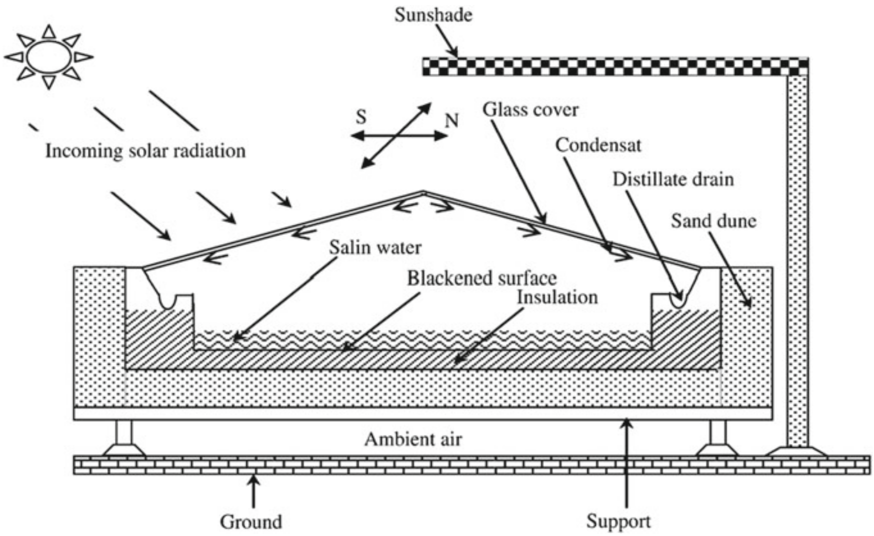


Fig. 7 Cross-sectional view of single-basin double-slope solar still [27]

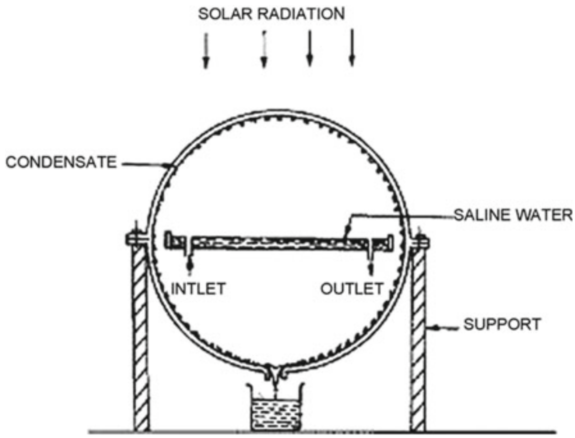


Fig. 8 Spherical solar still [28]

fabricated by a spherical glass cover, and a blackened metallic plate is horizontally placed at its centre. It was observed that efficiency of this still is 30% higher than other conventional stills.

Solar still with a hemispherical shape top cover with diameter of 0.95 and 0.10 m height is constructed from transparent acrylic sheet of 3 mm thickness. The square cross-section outer box was made with a 4-mm-thick wood with 1.10 m × 1.10 m × 0.25 m dimensions. Saw dust and glass wool were used for insulation on bottom and sides of the basin, respectively, and efficiency found to be increased from 34 to 42% [29]. Schematic and experimental set-up are shown in Fig. 9. Ismail Basel [30]

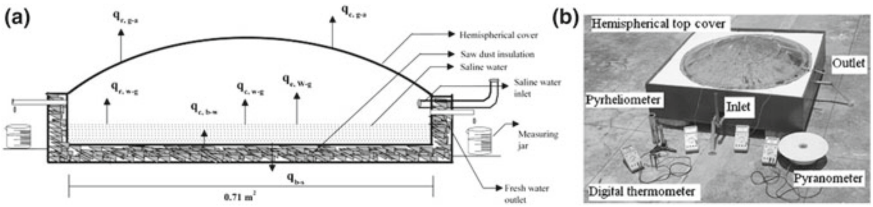


Fig. 9 Hemispherical still; **a** schematic, **b** experimental set-up [29]

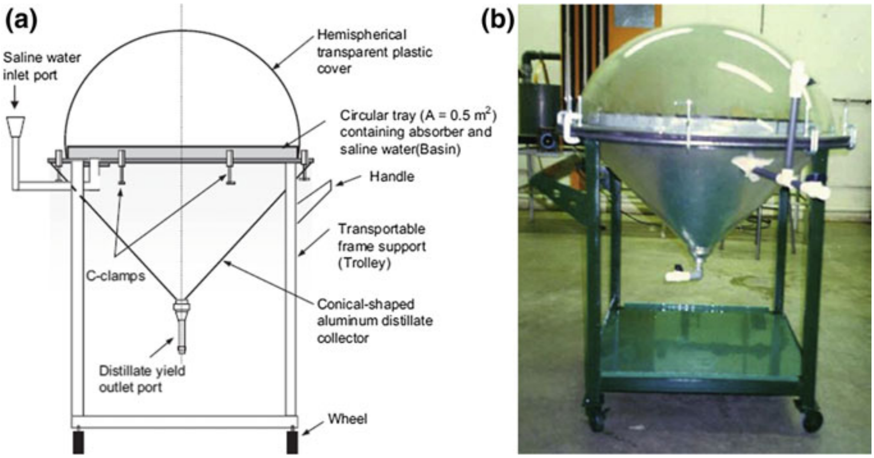


Fig. 10 **a** Schematic and **b** picture view of hemispherical solar still [30]

developed a simple transportable hemispherical solar still as shown in Fig. 10. The main components of still are circular basin, absorber plate of 0.5 m^2 surface area and conical-shaped distillate collector which are all made with 4-mm-thick aluminium sheet. Hemispherical shape top cover located on the top was made with transparent plastic with 0.9 absorptivity and 0.8 transmissivity.

3.1.3 Pyramidal and Rectangular Solar Still

Fath et al. [31] presented analytical as well as thermal and economic comparisons between pyramid and single-slope solar still. Base area of both stills is 1.235 m × 1.235 m, and inclination angle of pyramid is varied and identified that 50° pyramid angle gives best productivity. Diagrammatic sketch is shown in Fig. 11. Taamneh and Taamneh [32] designed and fabricated pyramid-shaped solar still to increase the surface area of condensation. Metallic container with black plate as base is used as basin and four glass faces of 6 mm thickness with 0.88 relative transmissivity used to transmit solar radiation. Photographic view is shown in Fig. 12. Kabeel [33] developed a pyramid-quadratic-shaped solar still. The square cross-section of base and height of the pyramid are 100 cm × 100 cm and 160 cm, respectively. Whole structure of the still is built of aluminium and triangular faces are made of 5-mm-thick glass. Rubber is used in between frame and glass faces to overcome vapour leak, and 15-mm-thick insulation provided below the base. Schematic and photographic views are shown in Fig. 13. Kabeel [34] designed and constructed concave wick surface pyramid solar still as shown in Fig. 14. The basin is made in concave shape from galvanized steel with a square aperture of 1.2 m × 1.2 m. Depth of the basin is 30 mm at the centre. Insulation of the basin is done by 5-mm-thick layer of glass wool.

Satyamurthy et al. [35] constructed domestic triangular pyramid solar still and investigated its performance. The still consists of triangular base which is painted with a black colour and was kept inside the wooden box. A piece of glass barrier was set inside surface of the glass cover to provide the deflection of condensate to come back into the collection channel. Saw dust was used below the basin for insulation and line and photographic view are shown in Fig. 15.

Eze and Ojike [36] carried out the performance comparison between a pyramid-shaped and a rectangular-shaped solar still as shown in Fig. 16. The glass cover of rectangular still is inclined to the horizontal at an angle of 22° in north–south direction. They concluded that water temperature is more for rectangular still in comparison with pyramid still. Hence, rectangular still efficiency is 8% more than pyramid still.

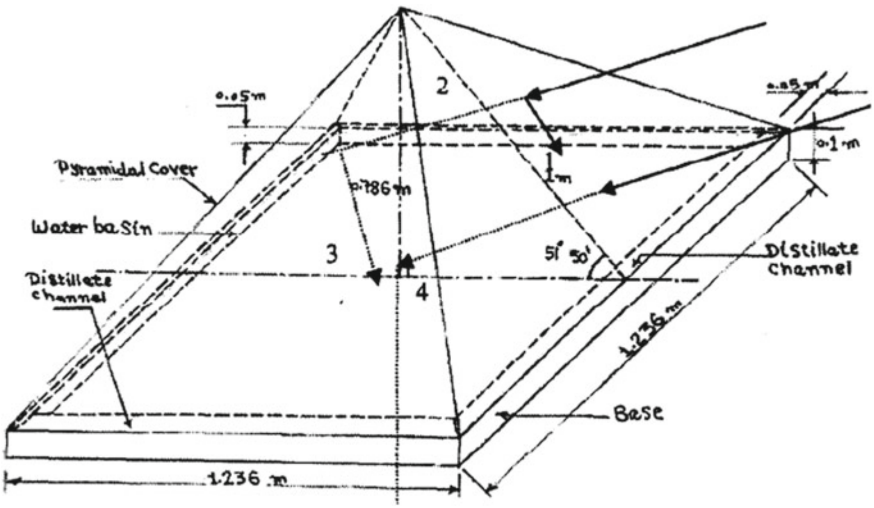


Fig. 11 Diagrammatic sketch of pyramid solar still [31]

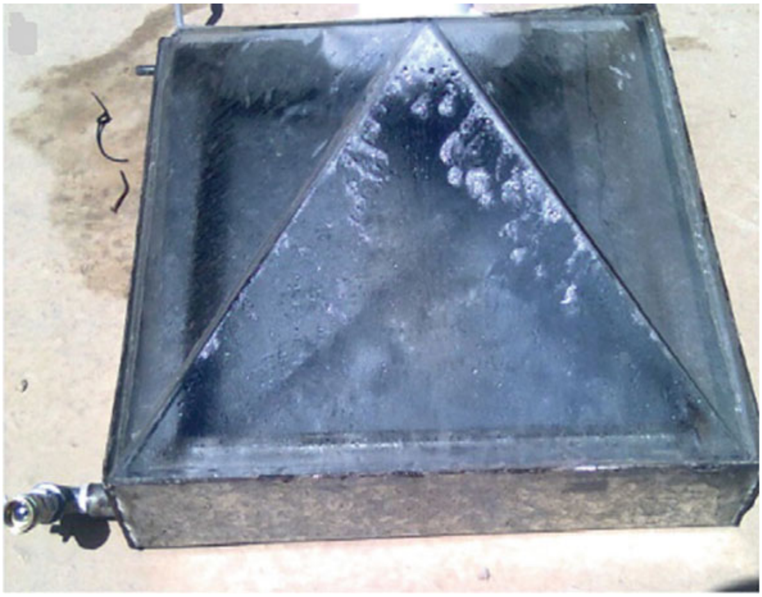


Fig. 12 Pyramid solar still [32]

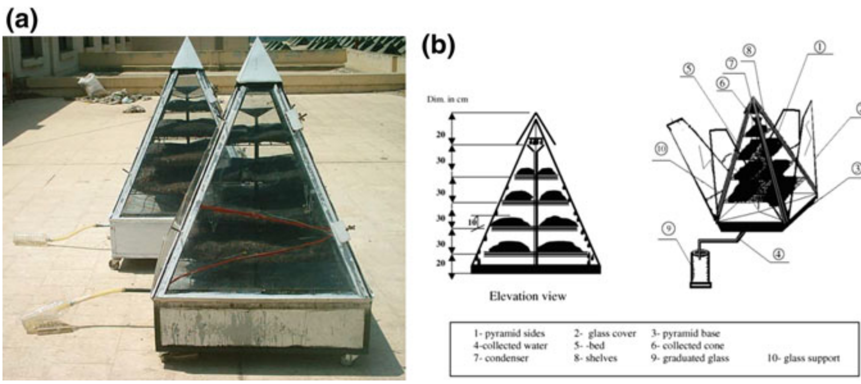


Fig. 13 **a** Schematic view and **b** photographic view of solar glass pyramid still [33]

Fig. 14 Actual view of concave wick surface pyramid solar still [34]

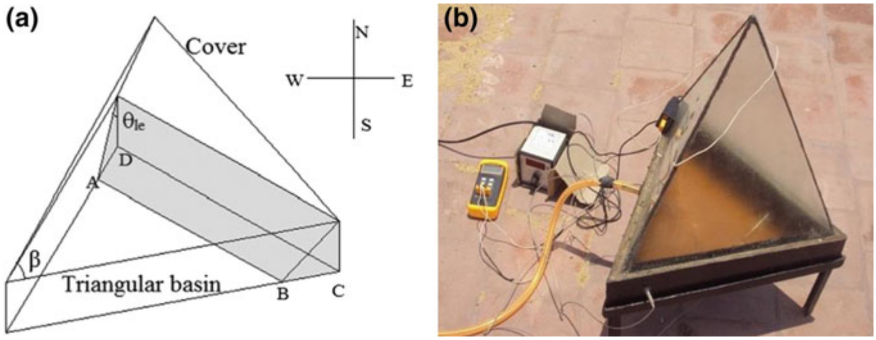


Fig. 15 **a** Schematic and **b** photographic view of triangular pyramid solar still [35]

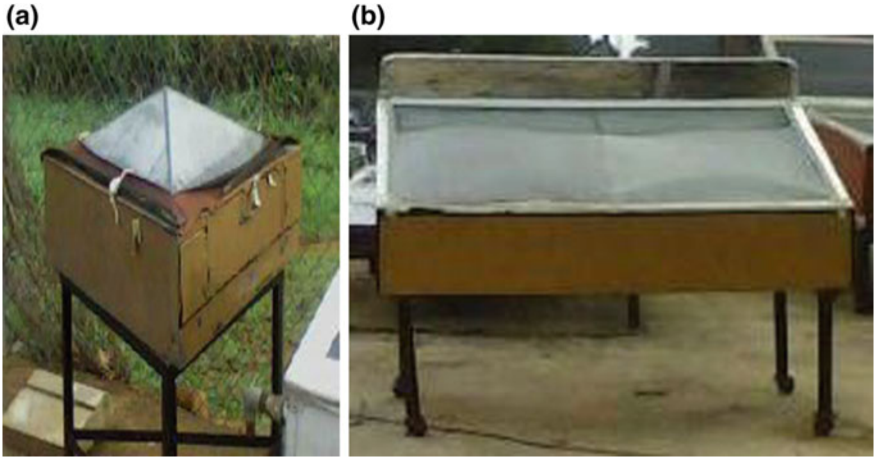


Fig. 16 **a** Pyramid still, **b** rectangular still [36]

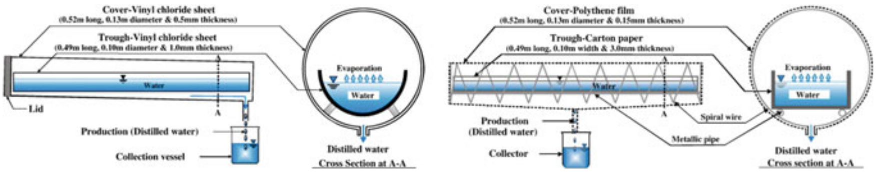


Fig. 17 Schematic diagram of old and new tubular still [37]

3.1.4 Tubular and Triangular Still

Ahsan et al. [37] carried out experimental observations on tubular solar stills as shown in Fig. 17. A comparison study was done between a new tubular and an old solar still made of Vinyl chloride sheet and polythene film. It was observed that polythene film solar still was more economical.

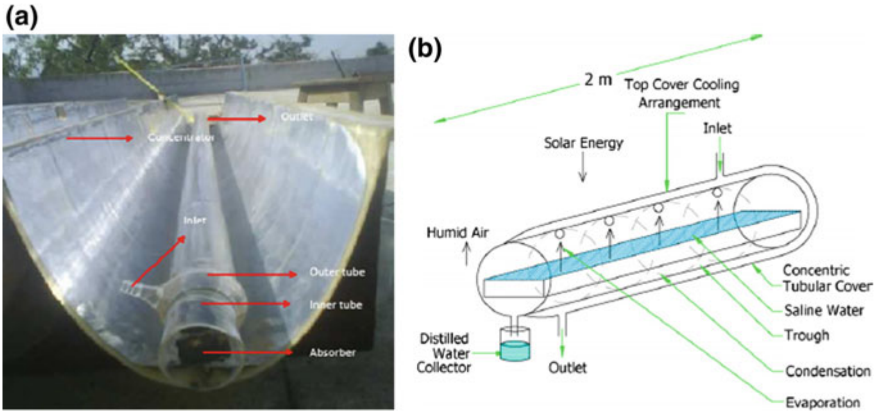


Fig. 18 **a** Schematic and **b** photographic view of concentric tubular solar still [38]

Arunkumar et al. [38] designed and fabricated a 2-m concentric tubular solar still with a rectangular basin as shown in Fig. 18. The inner circular tube diameter is 0.045 m, and outer circular tube diameter is 0.05 m. Tubes are positioned in such a way that 5 mm gap is maintained so that air and water flow to cool the outer surface of the inner circular tube. A rectangular basin of 2 m $\times$ 0.03 m $\times$ 0.025 m is used to collect the water, and constant water level is maintained by graduated tube.

Zheng et al. [39] designed and constructed multi-effect tubular desalination device as shown in Fig. 19. The multi-effect tubular solar still consists of four stainless steel tubes of different sizes. The length and diameter of first effect tubular shell are 1950 and 114 mm, respectively, with 1900 mm basin length and 100 mm width. The length and diameter of second effect tubular shell are 2000 and 168 mm, respectively, with 1950 mm basin length and 124 mm width. The condensation area of the two-effect tubular solar still is 0.698 and 1.055 m^2, respectively, and its evaporation area is 0.19 and 0.242 m^2, respectively.

Ahsan et al. [40] designed and developed a triangular solar still as shown in Fig. 20. This solar still was made with locally available cheap, lightweight materials. PVC pipe of 15 mm diameter is used for frame of the still. Perspex of 3 mm thick, polythene of 0.15-mm-thick material was used for trough and cover, respectively. Nylon rope of 50 m and transparent scotch tape of 2 m were used to seal the solar still to avoid the escape of evaporation. Experiments were conducted for various depths of water, and it was observed 1.6 and 1.55 kg/m^2/day production of water for 1.5 and 2.5 cm of water depth every day.

3.1.5 Other Shapes of Still

Tayeb [41] fabricated the four solar stills with flat, semisphere, bilayer semisphere and arch glass covers, as shown in Fig. 21 for an absorption area of 0.24 m^2 and a

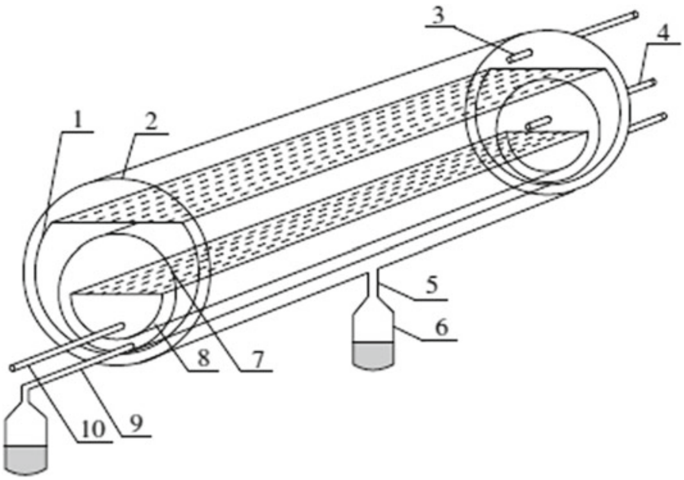


Fig. 19 Structure diagram of tubular solar still [39]

Fig. 20 Schematic and photographic view of triangular solar still [40]

condensation area of 0.267 m^2. It was observed that on peak summer, the highest productivity was approximately 1.25 kg/m^2/day for inclined flat glass cover and lowest productivity was approximately 0.83 kg/m^2/day for arch cover. The solar still with a semisphere cover, a bilayer semisphere cover productivity was observed intermittent.

Suneesh et al. [42] developed a V-type solar still as shown in Fig. 22. A rectangular basin of 2 m × 0.75 m × 0.05 m is made, and inward slope of the glass cover was maintained in such a way that it makes V-shape. The glass cover was sealed with chemical adhesive to prevent from any leakage. The productivity of water was observed 3.3, 4.3, and 4.6 l/m^2/day for no CGTCC, with CGTCC and CGTCC and air, respectively.

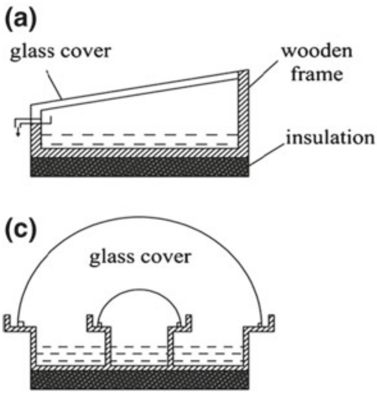


Fig. 21 Solar stills with different shapes of glass cover [41]

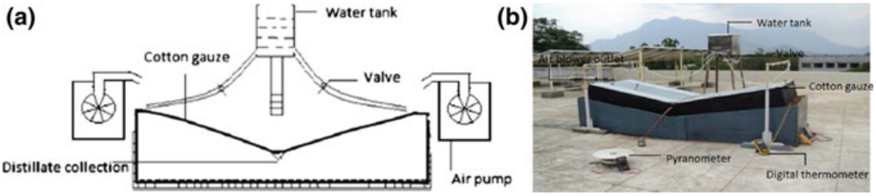


Fig. 22 **a** Schematic view, **b** photographic view of V-type solar still [42]

3.2 Basin Design Parameters

The most important role of the basin design is to absorb the maximum radiation with least reflectance and conduction loss to the surroundings. It acts like reservoir of energy [4]. Temperature gradient between inside glass and water is driving force for the natural convection of air and the water inside the still. The evaporation rate also depends on area and depth of water in the basin of still [43]. Thus, type of material used for basin, depth of water in basin, energy-storing materials in the basin, increasing evaporation area of the basin, etc. are important design parameters to improve the productivity of pure water.

3.2.1 Different Basin Materials

Basin material is supposed to absorb solar radiation and must be watertight. The material should be strong enough to resist high temperatures in case of no water condition of still. There is lot of research is going on to identify the better basin materials. In general, solar radiation first enters solar still transparent cover which is captivated by water and basin liner. So, it is essential that liner should have a moderately high absorbance of radiation [44]. Commonly used materials for fabrication of basin liners are plastic or metal and sometimes wood, asbestos cement, masonry bricks and concrete [45]. Plastics of various grades are used, and some plastics are cheaper in comparison with others which are expensive [46]. Among the metals, copper, aluminium and steel are most commonly used metals because of their high thermal conductivity [47]. Thermal conductivity of aluminium is almost half of the copper, and steel is one-fourth of aluminium, however, copper and aluminium are more expensive in comparison with steel. Phadatare and Verma [48] used Plexiglas to fabricate the solar still as shown in Fig. 23. All four sides and bottom of the still are made of 3-mm-thick black Plexiglas, and top cover is made of same thickness transparent Plexiglas. It was observed that maximum distillate of 2.1 l/m^2/day is obtained at water depth of 2 cm in the basin. The maximum efficiency of the still was observed as 34%, and results indicated that productivity of still decreased with increase in depth of basin water.

Elango and Kalidasa Murugavel [49] designed and fabricated single- and double-basin double-slope solar stills with same basin area with glass as basin material are shown in Figs. 24 and 25. They conducted experiments on both the stills by varying the water depth from 1 to 5 cm under both un-insulated and insulated conditions. It was observed that insulated stills are more productive in comparison with un-insulated. It was further identified that double-basin insulated and un-insulated stills are 8.12 and 17.38% more productive than single-basin still.

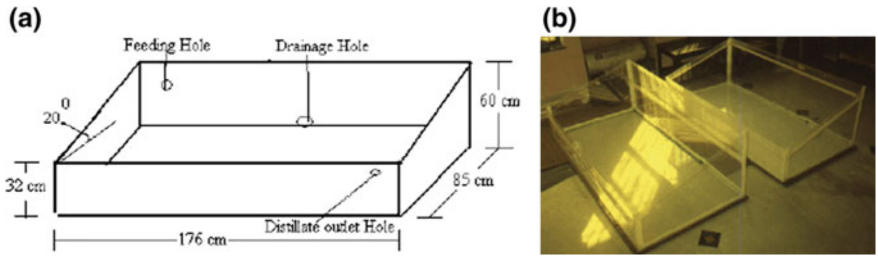


Fig. 23 **a** Line diagram, **b** solar still boxes made of Plexiglas [48]

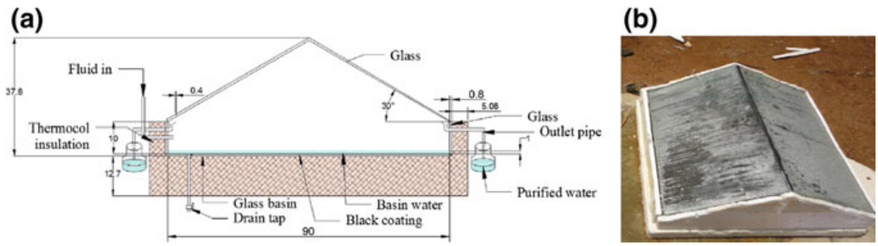


Fig. 24 **a** Schematic, **b** experimental view of single-basin double-slope glass solar still [49]

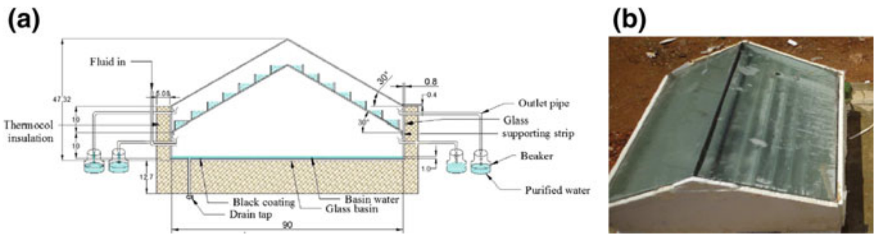


Fig. 25 **a** Schematic, **b** experimental view of double-basin double-slope glass solar still [49]

3.2.2 Water Depth in the Basin

Depth of water in the basin has a significant effect on the distillate production. It was observed from various investigations that depth of water (Figs. 26 and 27) in the basin is inversely proportional to the productivity of the solar still [50–52].

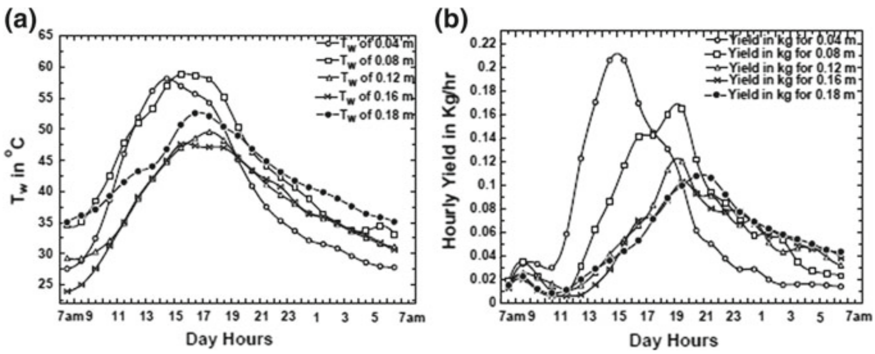
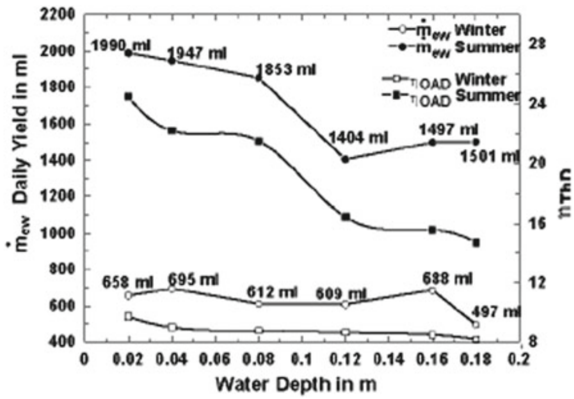


Fig. 26 **a** Variation of water temperature, **b** variation of hourly yield for various depths of water in the basin [50]

Fig. 27 Variation daily yield and thermal distillation efficiency in summer and winter seasons for different depths of water [52]



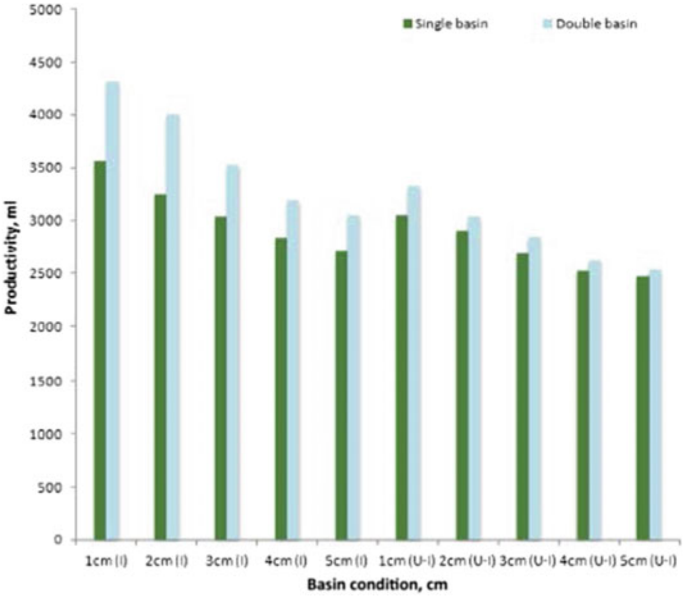


Fig. 28 Variation in production rate of single- and double-basin stills with depth of water [49]

Aboul Enein et al. [21] performed tests on a deep single-basin solar still. It was observed that productivity of the still decreases with increase in depth of water in daytime and vice versa in the night time. Rajmanickam and Ragupathy [53] conducted experiments on both single- and double-slope solar stills with same basin area for various water depths (1, 2.5, 5 and 7.5 cm). The maximum water productivity was 3.07 and 2.34 l/m^2/day for double- and single-slope stills, respectively. It was furthered observed that water productivity is inversely proportional to water depth.

Ahsan et al. [40] evaluated the productivity of water for 1.5, 2.5 and 5 cm depths of water and concluded that productivity of water decreases with increase in depth of water. Figure 28 shows the comparison of water productivity of single- and double-basin solar stills. It is clear that insulated stills are more productive than un-insulated stills, and both stills are evaluated for water depths of 1, 2, 3, 4, 5 cm [49]. Sangeeta and Tiwari [54] studied the effect of water depth on the productivity of an inverted absorber double-basin solar still. Maximum performance of still was observed for the least depth of water in lowest still. Productivity of water increases with decrease in depth of water.

Hossein et al. [55] investigated the long-term effect of water depth on solar still, and results indicate that productivity of water increases with increase of water depth. Thus, higher water depth is suggested for practical uses of solar stills (more than two days) as shown in Fig. 29. Influence of water depth on evaporation is carried out in a plastic solar still. Depth of water is varied from 20 to 120 mm in the intervals of 20 mm, and it was found that maximum productivity is obtained at 20-mm water depth

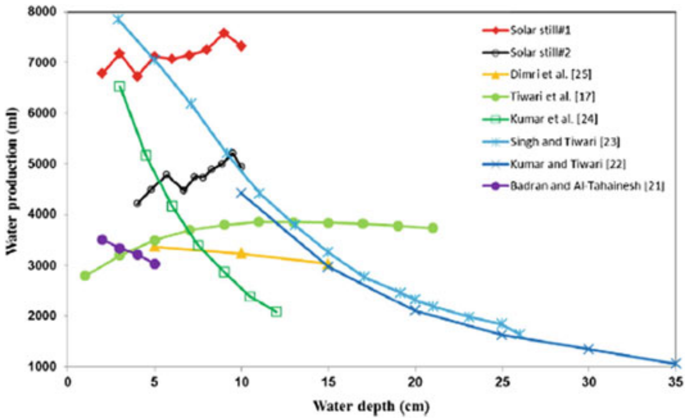


Fig. 29 Water production versus water depth with previous researchers [54]

[48]. Kalidasa Murugavel and Srithar [56], Kalidasa Murugavel et al. [57] carried out experiments considering mass of water in single-basin double-slope solar still, and maximum water productivity was observed at minimum mass of water.

3.2.3 Enhancing the Absorption Rate of Basin Water

On an average, 11% of solar radiation reflects back without any use. So, different researchers find different ways to increase the absorption coefficient of basin water in order to minimize the radiation losses [4]. Anil Kumar [58] adopted the simple technique of adding dyes with water. He used three kinds of dyes (black napthylamine, red carmoisine and dark green) at various concentrations. It was observed that black dye with 172.5 ppm concentration solution attained the highest distillate output.

Elango et al. [23] used the water nanofluids like Aluminium Oxide (Al_2O_3), Zinc Oxide (ZnO), Iron Oxide (Fe_2O_3) and Tin Oxide (SnO_2) at different concentrations. Two stills were fabricated with same basin area and tested with water and nanofluids simultaneously. The amount of production rate of distillate was observed in the order of Aluminium Oxide (Al_2O_3) > Zinc Oxide (ZnO) > Tin Oxide (SnO_2) > water (Fig. 30). Kabeel et al. [59] carried out a design modification of single-basin solar still to improve the productivity using nanofluids and integrating an external condenser. They used solid particles of aluminium oxide in water and observed the superior evaporation rate of water in comparison with conventional saline water. The results showed that 53.2 and 116% improvement in water productivity using external condenser and combination of nanofluids along with external condenser, respectively. Patel et al. [60] used various semiconducting oxides (CuO, PbO_2 and MNO_2) as photocatalysts to enhance the overall efficiency and production rate of distillate water as well. The amount of production rate of distillate was observed in the order of CuO > PbO_2 > MnO_2 > DWP (Fig. 31).

Bilal et al. [61] used different types of absorbing materials in the basin to increase the absorption rate of the water in a double-slope solar still. They used three kinds of materials (Black rubber, black ink and black dye) and found 38, 45 and 60% daily productivity of water, respectively (Fig. 32). Zurigat and Abu-Arabi [62] modelled the conventional and regenerative solar desalination units and studied the effect of

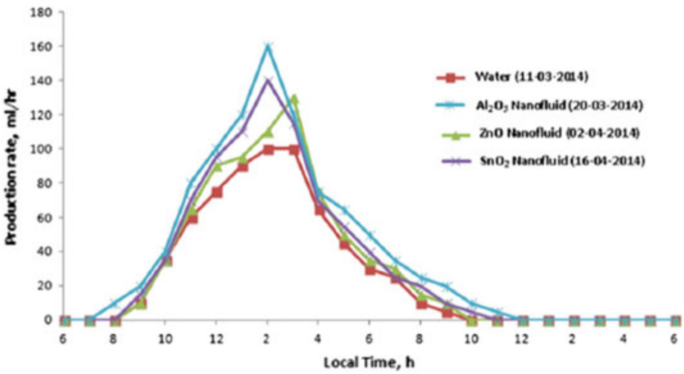
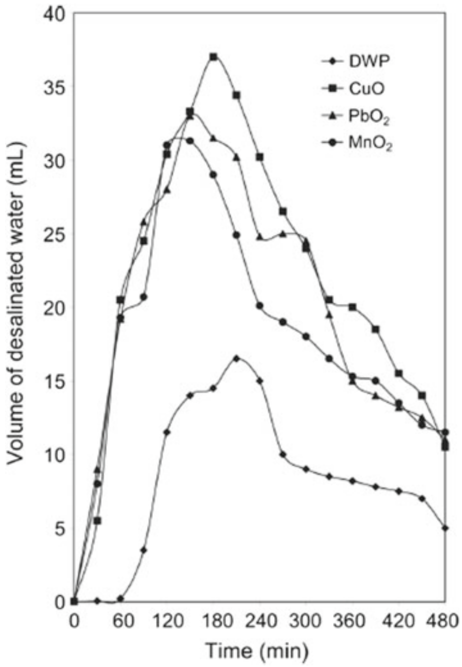


Fig. 30 Rate of production versus nanofluids [23]

Fig. 31 Production rate of distillate water versus semiconducting oxides [60]



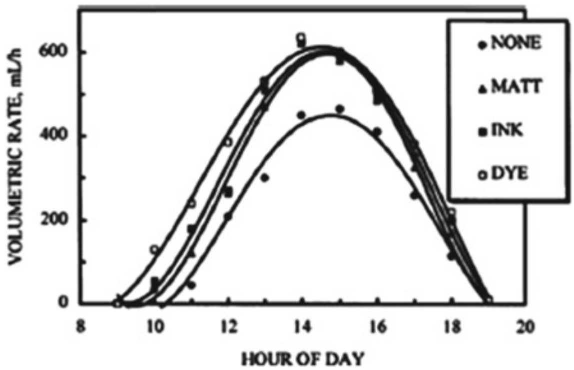


Fig. 32 Water productivity versus hours of the day for different absorbing materials [61]

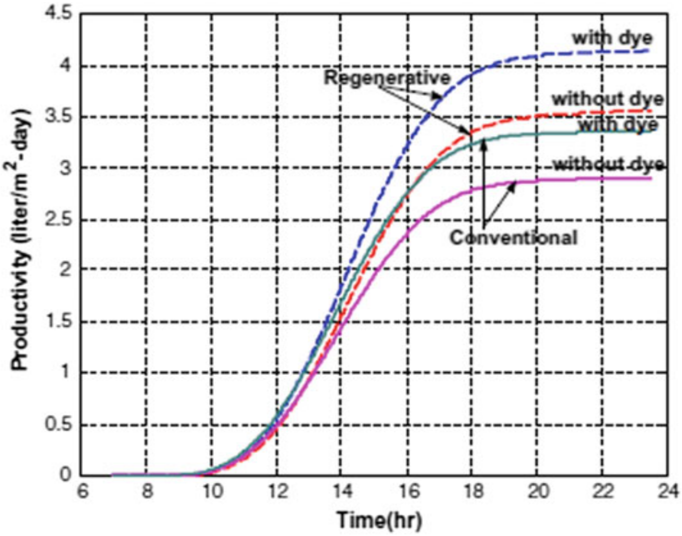


Fig. 33 Water productivity with and without dye [62]

dye on the water productivity. It was observed that addition of dye improves the water productivity of conventional and regenerative by 16 and 17%, respectively (Fig. 33). Different absorbing materials like dissolved salts ($K_2Cr_2O_7$, $KMnO_4$), violet dye and charcoal were used to enhance the absorptivity of water for solar radiation. It was found that violet dye obtained the maximum efficiency 19.1% (Fig. 34), and this increase is much significant and amounts 29% greater than water efficiency [63].

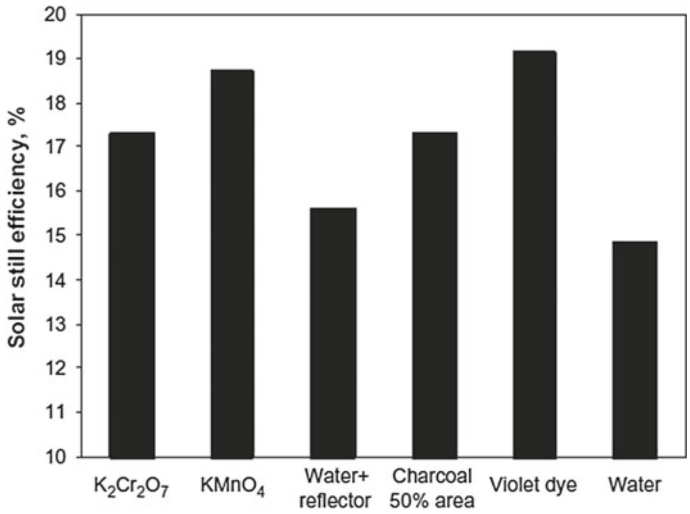


Fig. 34 Solar still efficiency vs absorbing materials [63]

3.2.4 Energy Absorption and Storing Materials to Increase Absorption Rate of Still Basin

Absorption rate of still can be improved either by using absorbing materials or energy-storing materials along with water in the basin. Commonly used energy absorption materials are charcoal, sponge, jute cloth, cotton cloth, matt and gravel, rubber and glass are some of the energy-storing materials.

Srivastava Pankaj et al. [64] used ordinary black colour jute cloth in single-slope solar still. It helped in increasing basin water temperature and in turn in higher productivity of distillate. Tiris et al. [65] used charcoal, blackened rock-bed and black paint as absorbing materials in single-basin solar still. They observed that charcoal is more efficient in comparison with rest and efficiency of charcoal is 20% more than black paint and 20–90% more than blackened rock-bed. Depth of water is also an influencing parameter in addition to absorbing material, especially in summer.

Abu-Hijle and Rababa'h [66] used sponge cubes in solar still. It was observed that sponge cubes helped in major improvement in productivity of solar still in comparison with conventional solar still.

3.2.5 Inclination and Thickness for Glass Cover

Singh and Tiwari et al. [67] observed that direction and orientation of glasscover depend on the latitude of the geometrical location. The glass cover with same inclination as latitude has maximum possibility of receiving sunrays very close to normal throughout the year. Kumar et al. [68] conducted similar kind of test at latitude

28.36°N by varying the inclination of glass cover and observed that 30° inclination produced highest yielding. Akash et al. [69] performed experiments by tilting the glass cover above and below latitude 31.57°N. They observed that tilting angle same as latitude was 63% more efficient in comparison with other inclinations. Optimum thickness of glass cover helps in enhancing the heat transfer rate. Mink et al. [70] conducted experiments by varying the thickness of glass cover in single-slope solar still. It was observed that productivity of 3-mm-thick glass cover was 16.5% more than 6-mm-thick glass cover.

3.2.6 Insulation

The thickness of the insulation also plays a role in reducing heat loss through bottom and side walls. Farid and Hamad [20] performed experiments on a single-basin double-slope solar still with mild steel plate. The basin is lined with concrete, to reduce the heat loss through the bottom surface. Al-Karaghouli and Alnaser conducted experiments on solar still with and without insulation of the basin. Daily productivity of distillate was 2.46, 2.84 kg/m^2, respectively, for without and with insulation in the month of June.

4 Conclusions

Various designs of solar stills are reviewed with special focus on different shapes of top glass cover and basin design parameters. It is evident from researchers' work that there is no clear-cut possibility to optimize the design as yielding of different solar stills is different. However, this study will pave a path to researchers to come up with new optimum designs which can have better performance.

It is also observed that surface of the solar collector is vital in enhancing the productivity of the solar still. This is where different designs of top glass cover help for absorbing the maximum possible radiation.

It is also observed that basin material, depth of water and energy-absorbing material, inclination of glass cover plate and insulation play an important role in enhancing the performance of the solar still. None of the researchers considered all the influencing parameters to study the performance. Hence, there is a lot of scope for improvement in performance of the solar stills in near future.

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