Experimental study on performance of single slope solar still integrated with sand troughs

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A R T I C L E I N F O

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A B S T R A C T

In this paper, a new method of incorporating sand troughs is proposed to enhance the performance of a single slope solar still performance with 1.5 m^2 aperture area. Experiments are performed in clear days of the sky for 1 cm, 2 cm, and 3 cm of water levels at the basin. The maximum yield is obtained for 1 cm water level at 2 PM for both the cases of solar still with and without sand troughs are 0.453 L/m^2 and 0.2 L/m^2, respectively. Solar still gives better yield with low depth of water level even at less solar radiation. The water level and use of sand troughs increased the evaporation rate and yield of the solar still. The still with sand troughs exhibits the maximum daily productivity rise of 71.4% for 1 cm water level when saline water is used. For 12 years of still life, the annual cost of produced pure water in modified still with sand troughs is calculated as ₹0.801 per litre. Water level plays a major role in the productivity of the solar stills. The efficiency of solar still with Sand troughs at 1 cm water depth is obtained as 65.08% whereas still without S.T at 1 cm water depth is limited to 37.9%.

Introduction

Getting enough drinking water every day is essential to lead a healthy life. Rapid population growth and industrial development are the prime reasons for the drinking water crisis in the developing country like India. Due to global warming and unpredictable climatic changes, the natural water resources like rivers, lakes, ponds and underground water belts are getting depleted at faster rate [1]. The domestic and industrial waste discharged into these water resources make them unpotable. Hence, a need arises to identify an economical and improved technology to convert this unpotable brackish water into pure drinking water in order to satisfy the drinking water needs of the people living in remote regions with less access to the drinking water. There are several methods employed for desalinating brackish water and salt water which includes, flash distillation, membrane distillation, multi-effect distillation, reverse osmosis, capacitive deionization, ion exchange, vapor compression, and electrodialysis. Out of the above mentioned techniques, solar desalination is a sustainable, simple and cheapest technology to convert impure water into pure drinking water which utilizes only the thermal energy received from the sun [2–4].

It is a major challenge to provide quality drinking water in the interior villages, terrain areas, distant places in arid and semi-arid countries where potable water is scarce. The service personnel deployed in difficult stations like desert region, high altitude regions and coastal regions are devoid of potable water for drinking purpose. Various techniques are available to purify the water, however most of the techniques require electricity which makes it infeasible to employ in the areas where the sources of electric power generation and distribution are limited. Hence, the purification of water through renewable energy technologies seems to be the most feasible solution. From the past two decades, extensive research is being carried out on the

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Nomenclature

T_{go}	Glass outlet temperature (°C)
T_{gi}	Glass inlet temperature in (°C)
T_{ev}	Evaporation temperature (°C)
T_{water}	Temperature of water (°C)
T_{basin}	Temperature of basin (°C)
T_a	Atmospheric temperature (°C)
M_w	Hourly distillate output (kg)
L	Latent heat of vaporization (kJ/kg)
I	Daily average radiation (W/m^2)
A	Area of glass cover (m^2)
T_v	Vapor temperature (°C)
η	Efficiency of solar still (%)
$S.T$	Sand troughs
CRF	Capital recovery factor
AC	Annual cost (Rs)
SFF	Sinking fund factor
ASV	Annual salvage value
AMC	Annual maintenance cost (Rs)
TAC	Total annual cost (Rs)
ACY	Annual cost of yield (Rs/L)

development of an efficient solar desalination method. In this regard, water desalination using single slope solar still has proven to be cost efficient because of its straightforward design and simplicity of manufacturing. Despite the advantage of simplicity in construction, single slope solar still is not as efficient as the conventional desalination techniques [5]. As a result, many techniques have been incorporated in to the solar still by various researchers to increase the yield of the solar still. Among all the approaches, increasing the still's productivity by adding an extra evaporating surface has taken the lead due to its simplicity and low cost [6]. Pal et al. [7] to improve the execution of the double slope solar still, jute and black cotton wicks were used. By incorporating wicks, a significant improvement in yield was obtained and at 2 cm water deepest part, the daily productivity of the still with jute and black cotton wick was observed as 3.52 and 4.50 L/m^2 respectively. Kaushal et al. [8] employed floating wick in the solar still and reported 12% enhancement in productivity in differentiation with standard still. Sellami et al. [9] provided black sponge sheets over the base of the still. It was observed that the still with 5 mm and 10 mm thick sponge sheets has enriched the productivity by 57.7% and 23% respectively. On the other hand, the productivity of the still was reduced by 29.95% when sponge thickness was increased to 15 mm. Sharon et al. [10] analyzed efficacy of a tilting solar still with wick. It was noted that the everyday productivity of the changed still was enhanced by 19.76% when compared with the normal still. Haddad et al. [11] modified the conventional still by introducing vertical rotating wick. From his considerations it was concluded that the modified still's daily production was enriched to 7.17 kg/m^2 in summer and 5.03 kg/m^2 in winter.

Panchal et al. [12] employed sandstones with solar power and marble pieces as storage of vigor material and found that the alambic's productivity was increased by 14 % and 30 %, respectively. Kabeel et al. [13] carried out experimental investigations and found that the solar still's effectiveness was increased by using sand as a heat storage medium covered in jute fabric, and the daily output of distillate increased to 5.9 kg/m^2. Shanmugan et al. [14] used four types of basin liners and suggested that fin with cotton wick is preferable. Agarwal et al. [15] employed V-shaped floating wicks made with jute as heat absorption material to increase the still's production. The daily output of the still was 3.23 kg/m^2 and 6.20 kg/m^2 during summer and winter with the efficiencies of 56.62% and 47.75%, respectively.

Rashidi et al. [16] incorporated reticular porous media to the still and obtained an enhancement of 17.35% in the solar still's daily production. Modi et al. [17] modified the still by introducing black cotton wick and jute. When compared to the still-in-use black cotton wick, the productivity of the still-in-use little pile of jute fabric was improved by 18.03 % and 21.46 % at 1 cm and 2 cm water depths, respectively.

In the last decade, many researchers [18–20] have used phase change material (PCM) as energy storage material for solar applications to improve their performance [21]. Amir Abdollahpour, Roghayeh Ghasempour et al. [22] a transcritical carbon dioxide power cycle's thermodynamic and economic analysis is combined with a solar thermal subsystem and an LNG subsystem. The Copper-Therminol VP1 nanofluid is utilised in the solar thermal subsystem, which comprises of parabolic trough collectors and a thermal storage tank. The TOPSIS decision-making technique is used to find the best point. Under ideal conditions, the system is capable of producing power with an exergy efficiency of 8.53 percent and a product cost rate of 2.09 million dollars per year. Mohammad HosseinAhmadi et al. [23] due to their changed properties, hybrid nanofluids have various advantages over regular nanofluids. According to the findings of the reviewed studies, the increased thermal characteristics of the convective fluid are the most essential factor in improving the performance of nanofluidic solar energy systems. Ammar H. Elsheikha et al. [24] the freshwater yield of a stepped solar still and a traditional one is forecasted using a long short-term memory (LSTM) neural network model in this study. When compared to a traditional solar still, the yield of the stepped solar still is increased by roughly 128 percent. For the traditional and stepped solar stills, the coefficient of determination of the predicted outcomes is strong, at 0.97 and 0.99, respectively. Bagher Mokhtari Shahdost et al. [25] due to rising greenhouse gas emissions and high energy prices, it is now more important than ever to utilise renewable energy sources in many industrial applications. The highest quantity of fuel that can be saved using solar energy for the examined furnace is 1,996,000 m3 per year, which is roughly 23.8 percent of the furnace's fuel consumption and is responsible for 3557.7 tonnes of CO2 emissions per year in the best-case scenario. Finally, the cost of utilising a solar heat exchanger before a furnace is calculated for various sizes of solar farms, taking into account various fuel prices and mortgage rates. Ammar H. Elsheikh et al. [26] solar energy systems (SESs) are one of the most important alternatives to traditional fossil fuels because of its capacity to transform solar energy directly into heat and electricity with no negative environmental consequences such as greenhouse gas emissions. The goal of this review paper is to look into the latest developments in nanofluid applications in solar energy systems, such as solar collectors (SCs), photovoltaic/thermal (PV/T) systems, solar thermoelectric devices, solar water heaters, solar-geothermal combined cooling heating and power system (CCHP), evaporative cooling for greenhouses, and water desalination. Sadeghzadeh M et al. [27] the thermal efficiency of a flat plate solar collector is predicted using Multilayer Perceptron Artificial Neural Network (MLPANN) mode, Radial Basis Function Artificial Neural Network (RBFANN), and Elman Back Propagation Neural Network (Elamn BPANN) in the current study. A two-step process is employed to prepare TiO2 (20 nm)/water nanofluids, which are then used in the planned solar system. Pourkiaei SM et al. [28] the bulk of existing water is saline, thus it's critical to create efficient and dependable methods and technologies for desalinating it. Solar energy can be used in desalination systems to provide essential heat or generate power through the use of PV modules. Nazari MA, Maleki A, et al. [29] for thermal energy storage and performance enhancement, Phase Change Materials (PCMs) have been used in a variety of solar energy systems. Improved heat transfer from PCMs results in shorter charge and discharge times, making them more appealing as storage units. Dispersion of nanoscale conductive solid materials is a feasible way to improve their thermal properties.

From these studies, it can be stated that incorporating PCM has some limitations like leakage issues and low thermal conductivity and cost. So, in order to reduce the complexity, enhancing evaporation rate by

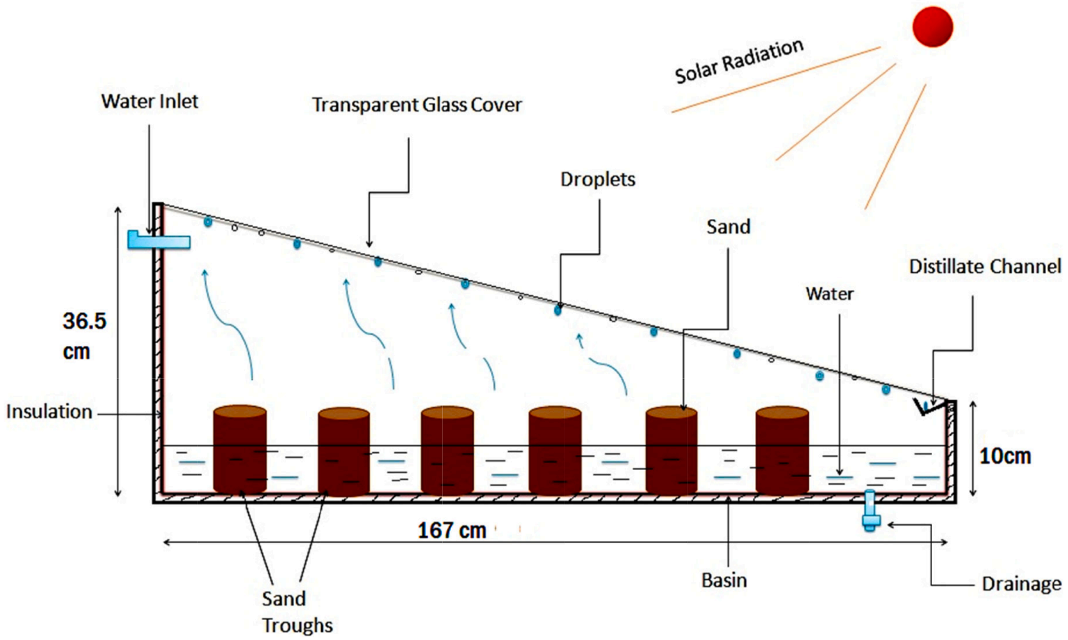

Fig. 1. Schematic line diagram of experimental set up.

adding additional heat absorbing materials such as sand troughs are used in the present work.

From the above-mentioned works, it can be understood that various authors have employed several techniques for increasing the efficacy of solar stills. In the current project, a new technique is proposed and the conventional solar still is modified by incorporating sand trough in the basin to transform the given saline water to fresh water. Sand troughs avail the maximum energy inside the still by providing an additional evaporative surface. The water in the basin rises through the sand, due to the capillarity effect and thus the sand troughs are expected to absorb the heat from the vapor particles available between transparent glass and basin. Furthermore, sand troughs are inexpensive and readily accessible on the market. Upon considering all the above features, sand troughs are chosen to improve the productivity of the solar still. The primary aim of this study is to carry out experimental analysis of the solar still with sand troughs different levels of water depth of 1 cm, 2 cm, and 3 cm at the basin.

To demonstrate the prime benefits of the newly proposed technique (incorporation of sand troughs), increase in the productivity is compared with the previously published works. A detailed cost exploration is also presented to realize the cost significance of the proposed technique.

Assumptions. Basic assumptions in the modeling of the desalination system take account of negligible temperature stratification within the evaporator basin. Temperatures are supposed to be uniform within each still component, while they are time dependent.

Experimental methods and material

Experimental setup

Fig. 1 shows a schematic line diagram of an experimental setup of a solar still with sand troughs. Two solar stills with same geometrical features and dimensions are manufactured and examined under same working conditions. The basins are manufactured with galvanized iron sheet and coated with mat finish black to engage more amount of emission. The aperture area of the still is 1.67 m × 0.9 m, the back wall elevation is 0.36 m, and the stature of front wall is 0.1 m. The slope provided to the glass cover is 16.5° which is equivalent to the latitude of

Fig. 2. Schematic view of experimental setup.

Koneru Lakshmaiah Education Foundation (KLEF) (altitude of 25 m, Longitude: 80.6225° E, Latitude:16.4419° N-above sea level), Vijayawada, Andhra Pradesh, India. Six number of sand troughs are fabricated and are placed in the solar stills. The outer shell of sand trough made of mud pot material with an inner diameter of 0.075 m and fine sand particles with uniform size were filled in the troughs to enhance the evaporation rate inside the still. The height of the troughs is adjusted in such a way that front troughs of height 0.085 m and back troughs with height of 0.17 m to maintain the distance between troughs and glass cover as 0.03 m. If the distance between the sand trough and the glass is very small, then the difference in temperature between water and glass will be low which further reduces the productivity. Upon considering this, the distance between trough and glass is taken as 0. 03 m. The basin was insulated with 0.01 m layer of plywood and 0.01 m layer of glass wool to escape heat loss to the atmosphere from the still. Six number of K type thermocouples were used in the each solar still to record the temperatures of outside glass (Tgo), inside glass (Tgi), basin liner (Tb), vapor (Tv), water (Tw) and ambient (Ta) for every 30 min. Solar radiation was measured in W/m^2 using a solar power meter. Fig. 2 shows

Table 1
Specifications of measuring instruments used in the study.

Device Name	Type	Accuracy
Data logger	Eight channel heatcon 8003/USB	±1 °C
Thermocouple	K-Type (a positive chrome wire and a negative alumel wire combination). It can measure up to 150 °C	±0.01 °C
Solar power meter	TES-1333	$\pm 5W/m^2$

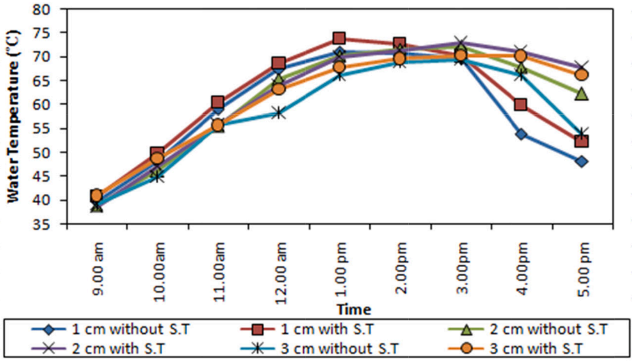

Fig. 3. Hourly water temperature variation of both conventional solar still and the solar still with sand trough at different water depths.

photographic view of the experimental setup. Table 1 shows the dimensions of the devices employed in the current study.

Experimental procedure

The experiments were conducted from 9.00 AM to 5.00 PM during clear days of the sky to avail the complete incident radiation of the Sun. In order to find the effect of the sand trough introduced into the basin of the solar still, the experiments are performed in two solar stills with same geometrical features simultaneously in which one is integrated with troughs, and another is without troughs. Sand trough is fabricated with an outer shell of earth and red mud and interior is filled with normal sand. Total basin area is 1.5 m^2 and sand troughs occupied 1.35% of the total water basin area. Further, in the first still, 0.5 cm layer of sand was used in the basin for the stability of sand troughs, and also to enhance the still by storing excess sensible heat in one trough. In the second still, experiments have been carried out without troughs and sanded normal water is poured in the basin at three different water levels 1 cm, 2 cm and 3 cm. Clean water is collected, and the yield is measured on hourly basis.

Uncertainty analysis

Table 1 shows the uncertainty of several measuring equipment. The root sum square approach can be used to calculate the uncertainty in measuring the still's efficiency using the following equation:

$$\delta\eta = \sqrt{\left(\frac{\partial\eta}{\partial M_w}\times\delta M_w\right)^2 + \left(\frac{\partial\eta}{\partial L}\times\delta L\right)^2 + \left(\frac{\partial\eta}{\partial A}\times\delta A\right)^2 + \left(\frac{\partial\eta}{\partial I}\times\delta I\right)^2} \quad (1)$$

Using the above equation, the uncertainty in measuring efficiency is calculated to be 3%

Results and discussions

Comparison of hourly water and vapor temperatures

At various specified water depth levels, Fig. 3 depicts the hourly water temperature change of both the traditional solar still and the solar still with sand trough. Due to the low thermal inertia of the lower water depth of basin water, the water temperature is higher when a lower depth of water is used, i.e., 1 cm depth. The highest temperature of the water is noted as 73.7 °C at 1:00 PM at 1 cm water depth. When 1 cm water depth is employed, higher temperature is achieved quickly as the amount of water is less and the water level is further reduced because of water extraction by sand troughs. The maximum temperature of water in the basin in the case of higher water level depth is shifted to 3:00 PM. Till the evening, this high temperature is retained at high water depth which implies the reduction in day-time productivity of still.

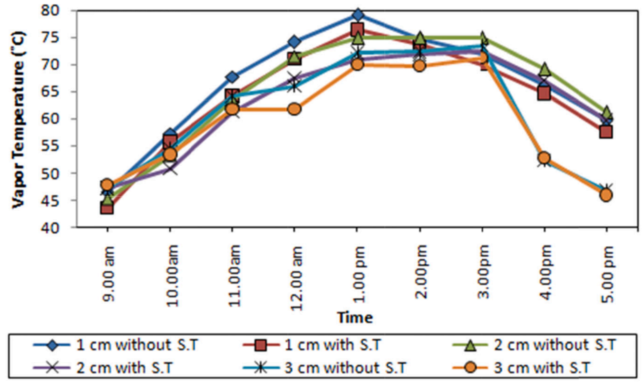

Fig. 4. Hourly vapor temperature variation with respect to time at different water depths using with and without sand troughs.

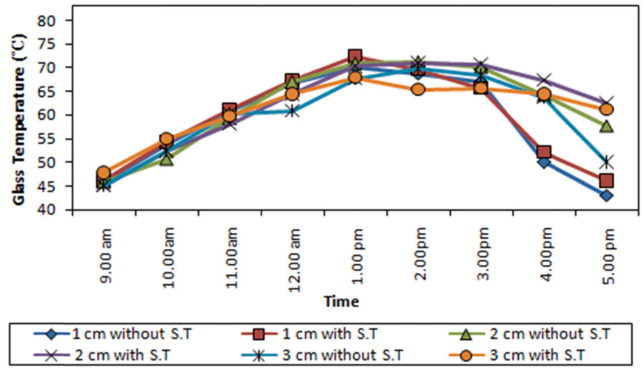

Fig. 5. Hourly glass temperature variation with respect to time at different water depth of solar still using with and without sand troughs.

Fig. 4 illustrates the hourly vapor temperature variation of both conventional solar still and the solar still with sand trough at different considered water depth levels. It is observed that the solar still for conventional still at 1 cm water depth has the highest vapor temperature when compared with other cases and noted as 74 °C. It is found that the vapor temperature of the still with sand troughs is lower than the conventional still at all considered water depths. This is due to the extraction of heat in the vapor region by the sand troughs. It is also observed that vapor temperature is increased with respect to time till 1:00 PM in the case of 1 cm water depth and 3:00 PM for higher water depth and later on the temperature started decreasing. The vapor temperature for higher water depths such as 2 cm and 3 cm decreased due to the increase in thermal inertia of the water for the higher water depth which further resulted in increase in time to achieve maximum vapor temperature and shifted to 3:00PM for 2 and 3 cm water depths.

By comparing Figs. 3 and 4, it is clearly seen that the water temperature in the basin is lesser than the vapor temperature for all the considered cases of experimentation. The reason behind this is the radiation loss from the surface of the water and aggregation of the latent

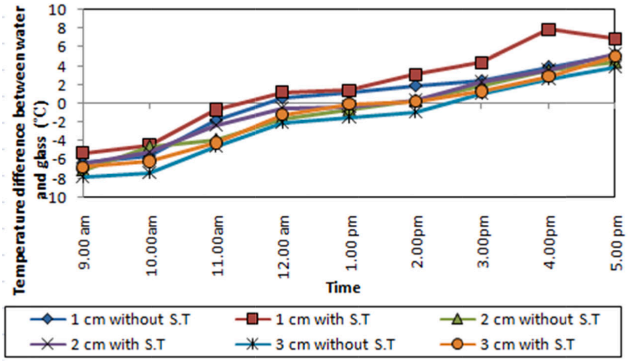

Fig. 6. Variation of temperature difference between glass and water temperatures with time.

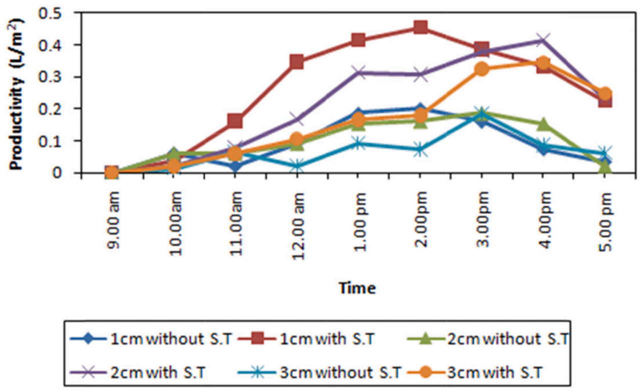

Fig. 7. Variation of productivity of solar still with and without sand troughs for different water levels.

heat released by the glass in the process of condensation.

Variation in glass temperature and difference between glass and water temperatures

Fig. 5 presents the hourly glass temperature variation of both conformist solar still and the solar still with sand trough at altered considered water depth levels. From Fig. 5, it is clear that the glass temperature of the still using sand trough is higher in comparison to the still without troughs. From the previous discussion, it is apparent that in the event of a still with sand trough, the basin water temperature rises. The increased temperature of the water resulted in a strong radiation effect from the water to the glass. Due to this effect, the glass temperature is observed to be higher for the still using sand trough when compared with conventional still.

The effect of sand troughs on the temperature difference between basin water and the solar still's glass inner cover temperature in all circumstances is depicted in Fig. 6. When comparing a still with a sand trough to a normal still, the temperature difference between basin water and glass inner cover temperature is greater. Due to the addition of extra evaporative surface i.e., sand troughs to the still, the water temperature increased which resulted in enhanced glass temperature and finally led to an increment in the temperature difference between basin water and glass. It is also noted that the temperature difference is very low during morning hours and gradually raised till 1:00 PM and later on the temperature difference between water and glass has been raised rapidly. From Fig. 5 it is clear that the glass temperature of the still with sand troughs is more in morning hours and gradually decreased in the afternoon hours. Because of this, higher difference in temperature between glass and water is observed in the afternoon session. With the

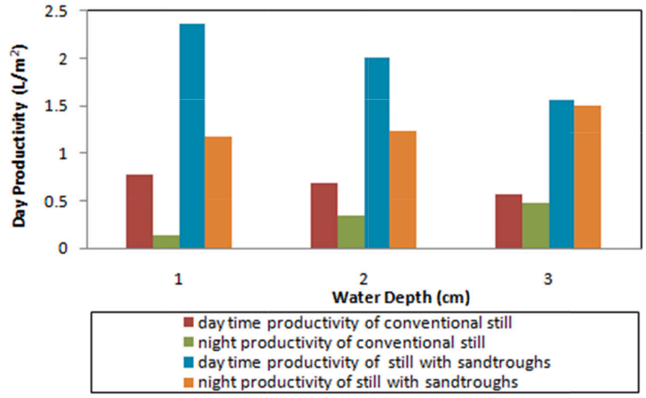

Fig. 8. Day and night productivity of solar still with and without sand troughs at different water depths.

increase in water depth temperature difference between the basin water and inner glass cover increased due to increase in amount of water which delayed the condensation process.

Comparison of yield

To analyze the performance (yield) of solar still, the distilled water is collected and measured on hourly basis. Fig. 7 shows the variation in the yield rate of solar still with and without sand troughs for the water levels of 1 cm, 2 cm and 3 cm. It is noticed that the yield rate decreased with the increase in depth of the water due to the increase in amount of water which requires higher time to achieve higher temperature of water. From the figure, it can be noticed that the highest yield rate is gained by using sand troughs with less depth of water level. This is due to enhanced evaporation because of smaller amount of water. Hence it can be said that the water level affects the evaporation rate and yield of the solar still. As sand troughs increased the rate of evaporation further near to the glass surface in the solar still, employing sand troughs increased the yield of the still. The maximum yield for the cases with and without sand troughs is 453.3 L/m^2 and 186.6 L/m^2, respectively.

Fig. 8 shows the day and night productivity of the solar still with and without sand troughs at different water depths. It can be observed that the productivity of the still at nighttime is increased with the increase in water depth. On the other hand, the productivity of the still at daytime is higher at lower water depth. With the increase in water depth, mass of water rises which further increases the amount of heat absorption during daytime. This results in maintaining water in the basin at high temperature during nighttime for longer periods which resulted in enhanced nighttime productivity.

Comparison of still efficiency

The solar still's thermal efficiency is calculated according to Tiwari et al. [30] using the following equation

$$\eta_{still} = \frac{\sum M_w \times L}{\sum I \times A \times 3600} \quad (2)$$

where

$$L = [2.4935 \times 106(1 - 9.4779 \times 10 - 4T_v + 1.3132 \times 10 - 7T_v^2 - 4.974 \times 10 - 9T_v^3 \quad (3)$$

It is to be noted that the Eq. (3) is valid for vapor temperature $T_v < 70^{\circ}$C.

The efficiencies of solar still with sand trough and without sand trough are depicted in Fig. 9. The still with sand troughs at 1 cm water depth exhibited higher efficiency around 12:00 to 3.00 PM and the value of the efficiency curve varies from zero to maximum of 65.08% around

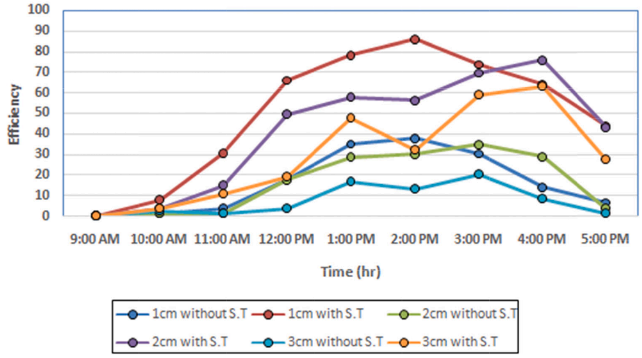

Fig. 9. Variation of efficiencies of still with and without sand troughs at different levels of water.

2.00 PM. The still without sand trough at 1 cm water depth achieved higher value of 37.9% after 2.00 PM. On the other hand, still without sand trough at 3 cm water depth showed least promising performance and the peak value is attained after 2.00 PM. The still with sand trough at 2 and 3 cm water depths showed mediocre performance. Efficiency of the still incorporated with sand roughs significantly increased when the level of water is less. This is due to quick rise of basin water temperature which led to increase in daily productivity and efficiency.

Comparison with previously published works

The results obtained in this study are compared with the existing data available in the literature in terms of maximum productivity and is presented in Table 2. The daily productivity of the solar still with the newly proposed method of incorporating sand troughs is increased by 246.07% when compared with the conventional still. From Table 2, it is very clear that productivity of the modified solar still is more even though it has low solar radiation.

Economic analysis

The main purpose of the current work is to provide efficient water purification technique with low investment cost, which is feasible for remote and economically backward areas. Table 3 specifies the cost of materials used in the present study. For the operation of solar still, solar energy is considered as a prime input source of energy which contributes no cost to input energy. So, the total cost of the still depends on maintenance cost, installation cost and operation costs. The cost analysis of the present work is performed by using the empirical relations developed by Tiwari et al. [32,33]. Table 4 provides information about annual cost of yield for solar still with sand troughs and the calculation procedure is explained below.

Let F be the initial investment of the still with a life of n years at i interest rate per year. The following are the equations that are required for economic analysis.

The capital recovery factor (CRF) is given as

$$CRF = \frac{i(1+i^n)}{(1+i)^n - 1} \tag{4}$$

The annual cost (AC) is calculated using Eqn 5

$$AC = CRF \times F \tag{5}$$

The sinking fund factor (SFF) is obtained by using Eqn 6

$$SFF = \frac{i}{(1+i)^n - 1} \tag{6}$$

The annual salvage value (ASV) is represented by

$$ASV = SFF \times S \tag{7}$$

where S is the salvage value of the still and represented by 20% of F

The annual maintenance cost (AMC) is calculated as 15% of AC and found to be Rs 198.69

The total annual cost (TAC) is calculated as

$$TAC = AC + AMC - ASV \tag{8}$$

The annual cost of yield per liter is calculated as

$$\frac{ACY}{l} = \frac{TAC}{Q} \tag{9}$$

where Q is the annual yield per liter of solar still.

Conclusions

Solar still is a promising distillation technique which requires lot of

Table 3
Material cost for solar still with sand troughs.

Name of the material	Cost (Rs)
Glass cover	726
Galvanized Iron	1100
Plywood	850
Glass wool for insulation	125
Thermocol Sheet	300
Sand trough	126
PVC pipe and water tank	968
Fabrication cost	2000
Transportation	700
Paint bottles	589
Total cost	7484

Table 4
Annual cost of yield for solar still with sand troughs.

Particular	Value
CRF	0.176
AC	Rs 1324.6
SFF	0.078
ASV	Rs 116.75
AMC	Rs 198.69
TAC	Rs 1406.54
ACY	Rs 0.801/L

Table 2
Comparisons of present work with previous works.

Author	Modification incorporated in solar still	Location	Maximum solar radiation (W/m^2)	Daily Productivity (L/m^2)	Increase in daily productivity using modified solar still (%)
Sellami et al [10]	Bain is covered with polurethene foam	Algeria	820	4.8	58
Haddad et al [12]	Rotating wick	Algeria	950	5.03	51
Arun Kumar et al. [31]	Porous absorber with double wrap insulation	India	857	3.1	63.1
Current Work	Cylindrical shaped Sand troughs	India	550	3.53	71.64

investigations to improve the amount of freshwater production. This work presented an attempt to improve the solar still productivity by proposing a novel set up using sand troughs. The main outcomes of this present work are summarized as follows:

- The performance and productivity of the conventional solar still and the still with sand troughs were investigated for three different depths of normal and saline water of 1 cm, 2 cm and 3 cm.
- Yield rate increases with decrease in depth of the water at the basin, and also use of sand troughs increases the yield rate to appreciable extent. The highest yield rate can be obtained by using sand troughs with less depth of water level. The maximum yield is obtained for 1 cm water level at 2:00 PM. The maximum yields of case with and without sand troughs are 0.453 L/m^2 and 0.2 L/m^2 respectively. This is due to enhanced evaporation because of the deficiency in the thickness of the water layer.
- Water level affects the evaporation rate and yield of the solar still. Solar still produced better yield on the experiment of still with 1 cm water level with troughs even though radiation is less than the data of experiment of still with 2 cm water level without troughs. Because sand troughs increase the evaporation rate further near to the glass surface in the solar still.
- The daily productivity of the solar still decreases with increase in water level at the basin. The still with sand troughs gives maximum productivity rise of 71.64% for 1 cm water level.
- The efficiency of solar still with S.T at 1 cm water depth is obtained as 65.08% whereas still without S.T at 1 cm water depth is limited to 37.9%. There by the increase in efficiency of still with S. T was 71.7%. Yield and efficiency of the still incorporated with S.T significantly increased when the level of water in the basin increases.
- For 12 years still life, annual cost of produced pure water in modified still with sand troughs is found as 0.801/L.

Author statement

All authors have equal contribution.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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