Improving the yield of a solar still with the aid of an evacuated tube

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Abstract. Solar distilling process is a viable way to supplying clean freshwater to remote populations with low water condition and sufficient sunshine. Because, water purified in a simple solar still yields less, and hence, it would not be widely utilized or traded. The effectiveness of a traditional solar still is highly dependent on the quantity of energy received by the solar still's bottom surface. Thus, expanding either the absorption capacity of the basin surface or the rate of energy transfer to the saline water would then result in an enhancement in potable water yield levels. Through the coupling of an evacuated glass tube (EGT), an effort has been made to increase the evaporative heat transfer and solar still heat transfer effectiveness in this study. Further, the current research analysis compares the performance of the ordinary (Plain-Still) and evacuated tube linked solar stills (EGT-Still) at a fixed water level of 2.0 cm. The findings demonstrated that integrating an evacuated tube with the traditional solar still increased the solar still's productivity by 13.73%.

Keywords: solar still; evacuated tube; productivity; potable water; saline water.

1. Introduction

Drinkable water is required for sustaining life and is vital for the maintenance of a healthy ecosystem. Annually, as a consequence of urban development, the demand for potable water increases [1]. Regardless of the fact that presence of water occupies maximum portion of the earth, the majority of accessible water is unfit for human consumption due to salinity as well as contamination [2, 3]. Purification of such water is accomplished by a number of processes, includes screen distillation and filtration. Energy from the sun is one among the potential technologies for obtaining drinkable water and minimizing the amount of distilling operations, when used straightforwardly through adequate thermal collecting arrangements [4, 5].
Solar desalining mechanism is indeed an approach for obtaining drinkable water that is less expensive than other types of saline water treatment methods [6, 7]. Sun distilling method using solar distillation devices is the more economical and ecologically friendly mean of delivering drinkable water in arid as well as remote places. Solar distilling devices operate on the alternative evaporating and condensing theories, and generally comprising water storing base and a transparent cover that allows sunshine to flow through, while boosting the water evaporation [8, 9]. The vapor state of water, then form condensates on the rear of the transparent cover and is recovered as required. But at the other end, solar distilling basins are notorious for its limited productivity when comparing to other distilling approaches [10, 11]. This is primarily due to the reduced temperature within the enclosures that are caused by decreased energy reception and perceived intermittence level.

The collecting sheet that acts as a high solar absorbing medium and gives the required energies to the liquid is indeed a critical element, adding greatly to the production of a solar distilling device [12, 13]. High thermal conductivity plates coated in black color had frequently been generally used to maximize energy collection. Solar distilling arrangements have been modified in numerous ways to boost their production, according to previous researches [14, 15]. The investigators tried a variety of absorber architectures, including stepping type, fin-accompanied absorption plates, heat recovery substances including phase changing materials (PCMs), steel scraps, sand, pebbles, stones, and gravels. Further, the research papers had been reported incorporating various absorption patterns, including one-sided or dual-sided slope, spherical, and prismatic-shaped translucent covers [16, 17, 18].

Mohit Bhargya [19] investigated a variety of arrangements for optimizing vaporization and cooling of water vapours. Interior reflectors were used to increase energy absorption, as well as an evacuated pipe solar collectors, and exterior condensing arrangement. Various combinations had been employed to enhance the efficiency of solar stills. The investigational findings indicated that the solar still in unification with an evacuated chamber, an interior mirror, and an outside condensing arrangement. Concurrently, the enhanced arrangement’s performance had been assessed along with the normal still. The boosted yield of the still was noticed to be around 2300 ml per square metre, with an efficiency of around 34%. Also, other active methods had been investigated using a pumping arrangement, which necessitated an outside source of energy [20, 21].

In this present work, a fresh attempt is endeavored to enhance the yield of the traditional solar still by integrating it with an evacuated glass tube collector. The two still having similar design configuration were used. Among them, one still was the traditional type and another was coupled with an evacuated glass tube (EGT). The experimentation was carried out concurrently and the outcomes were compared.

2. Experimentation set-up
Two different conventional solar stills have been used in the trials, every one having a base constructed from a 0.8 mm thickness galvanized steel sheet covering a surface area of 1.5 m². The reservoir was 70 mm tall across all the edges. Then, the bottom of both the stills were set in a supporting structure made of wood and was isolated using a 25 mm thickness insulating material to keep the gathered energy contained inside the still and to minimize the loss of energy [22, 23]. Among the two conventional stills, one was used without any further modification and named as Plain-Still as illustrated in Figure 1. Another was coupled with an EGT and labeled as EGT-Still, which is shown in Figure 2. The EGT was 180 cm length with the standard diameter. Both the stills had been topped using a 2 mm glass wall having 97% transmittance and sloped at 24° towards south to collect the greatest solar energy attainable year round [24, 25].
3. Methodology
The trials were taken place in April 2021 in the subtropical environment of South India. Two stills were evaluated: one without an evacuated glass tube (Plain-Still) and another still with an EGT (EGT-Still). To acquire reliable findings, the testing had been performed concurrently with both the stills with the identical area to verify that the two stills operated under the same ecological circumstances. Every hour from the commencement of 8 a.m. to the completion of the examination at 6 p.m., temperature data were recorded using 11 J-type temperature sensors and a digital recorder. Hourly measurements of solar irradiance and generated clean water had been also made with an electronic solar metre and a metered container [26, 27]. The thermodynamic
effectiveness the solar stills was tested in real environmental conditions at a fixed water depth of 2.0 cm.

4. Results and discussion

![Figure 3. Solar irradiation during investigations.](image)

![Figure 4. Temperature of the atmosphere during investigations.](image)

The investigations were accompanied during the day time from forenoon to evening hours during April 2021. The examinations were repeatedly conducted for a week of time in order to ensure the
correctness of the data. Then, the data from a representative day was accounted for further investigations.

![Figure 5. Water temperature during investigations.](image)

The fluctuations of solar irradiance during the assessment are depicted in Figure 3 and the temperature of the atmosphere across the investigational periods is depicted in Figure 4. In April 2021, solar insolation was definitely essential to run experimental test. Solar irradiation gradually climbed throughout the early hours and declined in the sunset, averaging around 690 W/m² during the course of the study. The temperature of atmosphere was roughly 24°C in the morning time and climbed to 34°C by the noon, attributable to the assessment period's direct solar irradiation and breezes.

Figure 5 illustrates the temp. of the water in the solar still base for various configurations and a consistent depth of water in the still. The pattern of changes in temperature finding concurs in both circumstances. Nevertheless, solar combined with EGT resulted in a larger increase in the temperature of saltwater. Amongst the two separate settings, it was reported that the still with the coupled EGT exhibited the biggest increase in salty water temperature. The water temperature in Plain-Still remained relatively low all through the trial. At 2.0 cm water depth of salty water, the EGT-Still attained a highest temperature of 86°C, which was 14°C higher than the Plain-Still at the same depth.

On the testing days, Figure 6 displays the aggregate water production of the two distinct instances with the solar stills for a constant 2.0 cm depth of water. The capacity for water collection increased steadily till early afternoon, at which point it accelerated drastically till early evening. Following then, the collection efficiency has not been very impressive in both the stills. The largest quantity of water gathered was calculated for the still scenarios using the EGT, which was associated with a rise in the quantity of evaporative cooling in the still. It was easily discernible that the EGT-Still gathered 4640 ml of water continuously for a water depth of 2.0 cm, which is 560 ml more than the still without EGT (Plain-Still). Overall water extraction was increased by 13.73%, when the still was combined with the EGT. The aforementioned results revealed that integrating evacuated glass tubes boosted the total energy collecting rates, hence greatly enhancing the solar still's output and water producing capability.
6. Water collection during the investigations.

5. Conclusion
Two basic conventional solar stills had been developed with varying architectures; one remained as traditional still (Plain-Still), while the other included a connected EGT (EGT-Still). Both of them have been investigated consecutively for a constant water depth of 2.0 cm. When combined with an EGT, the solar still achieved an exceptional water temperature of 86°C, which was 14°C larger than the normal solar still. The production of the EGT-coupled solar had always been reported to be 4640 ml per day, which was found to be 560 ml more than the Plain-Still, implying that its productivity had been increased by 13.73% with the addition of EGT.

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