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COMPARATIVE PERFORMANCE ANALYSIS OF SOLAR STILL WITH AND WITHOUT BASIN LINE WITH BLACK POLYTHENE FILM

[1]Hassan Ibrahim Igoh and *[2]Nicholas Akhaze Musa

[1]Department of Mechanical Engineering Technology, Isa Mustapha Agwai I Polytechnic Lafia, Nasarawa State
[2]Department of Mechanical Engineering, Federal University of Technology Minna, Niger State

*Corresponding authors' email: Madonick1@yahoo.com

ABSTRACT

Since a solar still's optimal performance is crucial, improvements to both its component designs and environmental factors have received attention. Thus, the focus of this study was the solar still basin. First, a black polythene film was used to line the basin of a planned solar still. The yield of this method was assessed, and then the black polythene film was taken out of the basin and another assessment was made. Hourly measurements of the ambient, glass, basin, and solar intensity as well as the distilled water were made in each case. The experiments' results showed that the temperature of the environment, the glass, and the water in the solar still's basin all increased in tandem with the sun's intensity. The solar still's production rose by 9.1 % per day on average when 0.15 mm black polythene film was used to line the basin. The study confirms that using black polythene film into solar still designs provides a workable and effective way to increase potable water production rates.

Keywords: Solar still, Glass cover, Water depth, Basin, Yield

INTRODUCTION

A solar still is an affordable apparatus that uses sun radiation to turn salty or polluted water into drinkable water. In places where there is a water shortage and a chance of contracting diseases that are spread by water, it is essential (Vikrant and Sandip, 2021). Solar still productivity is influenced by various factors such as climatic conditions, water depth, glass cover thickness, cover angle, coated material, and salinity (Mouhoumed, *et al*, 2022). Solar radiation intensity directly influences production, with daily output increasing proportionally. Ambient temperature and wind speed also affect performance (Dsilva *et al.*, 2016). Misra et al. (2021) found a 35% increase in distillate with increased wind velocity. Mouhoumed et al. (2022) discovered that daily distillate production from a single slope solar still in Djibouti increases with higher wind speeds. The study of Ogunseye and Oladepo (2022) shows seasonal impacts of harmattan can affect productivity and Alwan et al (2020) analysis of modified solar data in Russia reveals environmental factors impact heat and mass transfer.

Basin water depth significantly impacts solar still yield and efficiency. Smaller depths improve efficiency for short durations, while more depth may be necessary to prevent drying out over longer periods, as noted by Hossein et al(2014) and Dsilva et al(2016). Misra et al (2021) found distillate water flow highest at 20 mm water depth, while Roshdy et al. (2021) found that increasing gap distance from 37 mm to 17 cm boosts solar still production by 70% in the Aswan climate. Diab et al (2022) found that optimal disc rotation speed (1.5 rpm) and water depth of 5 cm increased vertical distiller thermal productivity and performance.

Manokar et al. (2020) found that with insulation, freshwater production from a pyramid solar still increased by 3.72 kg/m^2 with water depths of 1 to 3.5 cm. Danjuma et al. (2018) found higher yields at different water depths. Narayanan et al. (2020) concluded that lowering basin water depth increases evaporation rates, thereby increasing production.

Glass cover is a popular material for solar still construction, as its performance and efficiency are significantly influenced by the temperature difference between water and the cover. Studies by Panchal (2016) have shown that thicknesses of 4 mm, 5 mm, and 6 mm increase distillate output. Awad (2019) found that transparent tent solar stills produce 6% more water per square meter per day. Edeoja et al. (2015) revealed in their examination of five solar stills with different glass cover thicknesses that two-sheet stills produced more water than glass-covered stills. Khechekhouche et al. (2021) improved the glass thickness of a standard solar still (CSS) in El Oued, Algeria, resulting in distilled water with energy efficiencies of 30.71, 19.02, and 11.44%. Srivastava et al. (2017) found minimal temperature difference in traditional basin-type solar stills. Sivakumar et al. (2022) found that desalination still effectiveness is affected by glass thickness, with 4mm glass thickness producing 48% more fresh water.

A review of pertinent literature on optimizing solar still yield indicates that, in contrast to climate, water depth, and glass cover, the solar still basin has gotten little to no attention. Therefore, the goal of this research is to increase the water yield of the solar still by concentrating on the solar still basin. Thus, the purpose of this study is to compare the performance of solar still that has a basin lined with black polythene film versus the one that does not.

MATERIALS AND METHODS

Materials and Equipment

The materials and equipment utilized in this research include; Solar still developed by Hassan (2023), Solar Dual Transmission Meter with model number, XM1400 manufactured by 44 Tool, Plan city, Ohio, USA, and Hand held non-contact infrared thermometer, model no . TM380 manufactured by Sibeir Electronic Technology Co. Ltd Xian Shaanxi China. Others include Eutech Instrument Stol point Digital pH meter with Model no. PH 700.Manufactured by Victory lab. Technologies, Munddka, New Delhi, a stop watch, 60 litres of sample water from Edege community as well as a Graduated cylinder and Five litres jerry can

Method

Thirty litres of raw water were put into the basin of the developed solar still that was kept outside as shown in plate 1.

Plate 1: Experimental set-up for the Hassan(2023) developed solar still with the basin lined with black polythene film

Hourly measurements were taken of the ambient temperature, the glass temperature, the basin temperature, the temperature of the water in the basin, the solar intensity, and the amount of distilled water. After the aforementioned performance analysis of the solar still, the black polythene film that was initially used to line the basin was removed and solar still was coupled back. Thirty litres of raw water were also put into the basin of the solar still and kept outside as shown in Plate 2.

Plate 2: Experimental set-up for the solar still with the basin not lined with black polythene film.

Hourly measurements were also taken of the ambient temperature, the glass temperature, the basin temperature, the temperature of the water in the basin, the solar intensity, and the amount of distilled water. Comparison of the measured and evaluated parameters of solar still with basin lined with black Polyethene film and with basin not lined with black polythene film are shown in Table 1.

RESULTS AND DISCUSSION

Table 1: Parameters of solar still with basin lined with black Polythene film and with basin not lined with black polythene film

D	Average parameters of solar still with basin not lined with black polythene film					Average parameters of solar still with basin lined with black polythene film					
	Ta_1	Tg_1	Tb_1	I_1	Y_1	Ta_2	Tg_2	Tb_2	I_2	Y_2	%WY
1	35.2	43	45.1	230.5	0.217	34.5	41	47.5	226.6	0.242	11.52
2	40	46.2	48.7	191	0.193	37.4	45.4	50.4	179	0.210	8.81
3	41.5	49.4	50.2	203	0.331	40.8	50.1	52.7	161	0.35	5.74
4	35.1	41	42.4	332	0.239	33.7	40	43.7	350	0.26	8.79
5	43.6	51	52.7	170.2	0.209	42	49.8	55.6	173.9	0.231	10.53

Key: D represents the day number, Ta, Tg, Tb, I ,Y and WY represent the average ambient temperature (^{0}C), glass temperature(^{0}C), basin temperature(^{0}C) of the solar still, average solar intensities(N/m^2), water yield(Litres) and percentage increase in water yield of the solar still with basin lined with black polythene film in days 1,2,3,4 and 5. Subscripts 1 and 2 denote solar still with basin not lined with black polythene film and the one lined with black polythene film respectively.

Table 1 shows that, for solar still lined with black polyethene film and those without, the ambient temperatures range over the course of five days from 34.5°C to 42°C and from 35.2°C to 43.6°C respectively. The glass temperature of the solar still with the black polythene film lining runs from 40°C to 50.1°C, while the glass temperature of the solar still without the film ranges from 41°C to 51°C, as can also be seen in the previously mentioned table. The solar still with black polythene film has a basin temperature range of 43.7°C to 55.6°C, while the solar still without black polythene film has a range of 42.4°C to 52.7°C.

Table 1 makes it clear that the glass and basin temperatures increased as the ambient temperature increased in days 1, 2, 3, decreased in day 4 and increased in day 5 with the solar still when the basin was lined with black polythene film and when the black polythene film was removed from the basin. Solar intensity increased in day 1, dropped in day 2 and increased in day 3, day 4 and dropped in day 5 when the solar still was lined with black polythene film.

As evident in Table 1, for solar still lined with black polyethene film, the solar intensity ranges from 161 to 350 N/m^2, while for solar still without such film, it ranges from 170.2 to 332 N/m^2.

Solar intensity increased in day 1, dropped in day 2 day 3 increased in day 4 and dropped in day 5 when the black polythene film lining was removed from the basin. The yield dropped in day 2, increased in day 3 and dropped in day 4 and 5 for both cases of the basin.

The yield for a solar still with black polythene film ranges from 0.210 to 0.350 liters per day, while the yield for a solar still without black polythene film ranges from 0.193 to 0.331 liters per day as shown in Table 1. Moreso that the yield of solar still is higher irrespective of the day with the basin lined with black polythene film than without the basin of the solar still being lined with black polyethene film. This is attributed to the heat absorbing and storage by the black polythene film. The percentage increase in the yield of the solar still as a result of the lining of the basin with black polythene film was 11.52, 8.81, 5.74, 8.79 and 10.53% for day 1, 2, 3, 4 and 5 respectively. The average percentage daily yield increase was found to be 9.1%. This percentage increase is 4% shy away from 13.1% increase obtained by Riahi et al(2021) that investigated the productivity enhancement of a solar still with transparent polythene film cover and cylindrical hollow fins for heat storage. They however considered the cover of the solar still while the basin of the solar still was considered in this study.

CONCLUSION

A comparison of solar stills with and without a black polythene film-lined basin shows that adding this alteration significantly improves performance measures. Several important factors were measured and assessed during the study period, including the ambient temperature, glass temperature, basin temperature, sun intensity, water yield, and the % increase in water yield.

Results repeatedly demonstrate that solar still with a basin lined with black polythene film maintained higher temperatures than those without the film, leading to higher yields of potable water. This finding highlights the efficacy of black polythene film in improving solar energy absorption within the still, thereby raising the overall efficiency in freshwater production. The film's capacity to absorb and retain solar radiation effectively raises the temperature within the basin, speeding up the evaporation process and, as a result, increasing the yield of potable water. According to the study, adding black polythene film to solar still designs is a useful and effective way to increase water production rates in areas with restricted access to potable water.

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