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Experimental Investigation of Single Slope Solar Still Using Black and White Wall

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***Abstract*:- The aim of this study is to design a water system that can purify water from almost any source such as rivers, lakes and underground reservoirs. The direct use of water from these sources is dangerous because the salt is present in the water and therefore the need for new water for a cheap, portable system and relies solely on renewable solar energy. Our research objective is to properly generate clean drinking water from the conversion of solar energy. One of the many methods that can be used to purify water is drinking drinks. As heat and sunlight can be a source of energy, this includes the installation of energy. It is known as Solar Water Distillation when solar energy is used for this reason. Solar Distillation is an attractive process for producing drinking water using free solar energy. This energy is used directly on evaporation within a device commonly referred to as 'solar still'. In this research work analyze the heat and mass transfer in the improved solar still. And Comparison between different location Temperatures (Basin Temperature, Ambient Temperature, Water Temperature, Glass Temperature, Vapor Temperature).**

Keywords: Solar still, desalination, Temperature, Solar Energy

1. INTRODUCTION

Global demand for fresh water is increasingly challenging since most sources of water are contaminated.
Industrial waste, sewage and pollution from farming. In certain parts of the world, the result is an inadequate supply of water. A solar still is a precious device that can be used for drinking water purposes to purify brackish water and salt water. But the key downside is that solar output is still poor.
In the proposed work, efforts are being made to build and evaluate an improved solar system and to combine it with an auxiliary unit consisting of a sediment filter and a solar-powered UV disinfectant unit in order to obtain a solar-powered water treatment system. This unit is intended to cater to the average family's need for consumable water, preferably in rural areas where open space is plentiful.
The higher rate of growth in the world's population and industries has contributed to a major rise in demand for fresh water. A small demand can be met by the natural supply and this leads to acute fresh water shortages. Therefore, the extensive treatment of salt and polluted water into filtered water is a concern.

2. LITERATURE REVIEW

Drinking water is still a big problem in dried and remote areas. Single basin solar still is a solution for this problem. This type of solar still is capable of producing clean potable water from available salty or waste water throughout the year. Single slope still is suitable at higher latitude place.

Water and energy are two types inseparable items that govern our lives and promote civilization. Looking to the history of mankind one finds that water and civilization were also two inseparable entities. It is not a coincidence that all great civilizations were developed and flourished near large bodies of water. Rivers, seas, oases and oceans have attracted mankind to their coasts because water is the source of life. The supply of hygienic potable water is one of the major problem faced in underdeveloped and in some developed countries. Since transportation of drinking water from far-off regions is usually not economically feasible / desirable, desalination of available brackish water has been considered as an alternative approach.

Several researchers have studied the effects of various designs, operational and climatic parameters. Many designs and modifications of the solar still have been proposed in literature.

Omar O. Bad ran et. al. [2] Evaluating thermal performance of a single slope solar still.In this study, several conclusions can be obtained as follows; (a) the increase in either ambient temperature and/or the solar intensity can lead to an increase the solar productivity, (b) as the water depth decreases from (3.5 cm) to (2 cm), the productivity increases by (25.7 %), (c) The maximum efficiency occurs in early afternoon due to the high solar radiation at this time, (d) the overall heat loss coefficient increases until it reaches the maximum in the afternoon due to higher solar intensity and ambient temperature, and finally, (e) the proposed mathematical model gave good match with experimental results. Future work can be carried out using this model to enhance the design of single solar stills.

Anil kumar Tiwari et. al. studied [3] Effect of Cover Inclination and Water Depth on Performance of a Solar Still for Indian Climatic Conditions. The study leads to the following conclusions.

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1. There is significant variation in convective heat transfer coefficient for different inclinations of condensing covers and different water depths. This will be useful in choosing passive solar still designs for specific applications, regions, and seasonal performance requirements.

2. Overall, 45 deg and 15 deg inclinations of the condensing cover result in maximal annual yields of similar order of magnitude. However, specific summer or winter peak performances are optimized when choosing a condensing cover inclination of 15 deg or 45 deg, respectively.

3. Lowest possible water depth produces maximum yield and efficiency throughout the entire year.

P.Vishwanath Kumar et. al. studied [4] Solar stills system design as freshwater demand is growing day by day in the present times of rapid grow distilling the saline water throughout the world. Many solar stills have been studied in detail in this review covering all the aspects of design specifications. Also the effect of design and operating parameters on the distillate productivity of various stills has been presented. The following are the conclusions that were noted from this detailed review:

In single effect passive basin stills, distillate output increases from 34%to42%bycovercoolingbycovercooling.Alsothe productivity depends on solar radiation and ambient conditions i.e., on clear and cloudy days. Particularly on sunny days, productivity was more for still with inclined flat glass cover compared to semi-sphere, bi layers hemisphere and an arch coverwithvaluesof1.25kg/m2/d, 1.1kg/m2/d, 1.2kg/m2/d and 0.83kg/m2/d respectively. Whereas on winter days, productivityincreasesby70–100%byusingreflectors.

Kuldeep H.Nayi et. al. studied [7] Pyramid solar still. The study leads to the following conclusions. Pyramid solar still is one of the outcomes of such a development. The present paper reviews the development in the field of pyramid solar still as well as the various techniques to improve the performance of still. From the review on research carried out by the various researchers, it has been found that pyramid solar still is more efficient and economical in compare to conventional single slope single basin still. Thus, the review paper will assist the researchers to understand the fundamentals of pyramid solar still with the need, developments and challenges in pyramid solar still to improve its thermal performance and to make it more and more economic.

Swellam W. Sharshir et. al. [8] In this article, a review of factors affecting solar still production (climatic conditions, operations and design parameters) and enhancement techniques (wicks, internal and external condensers, internal and external reflectors, phase change materials, Stepped solar still and a new method improved the solar still yield by using nanoparticles) has been argued. Using sponge cubes in the basin water caused a significant enhancement in solar still production (up to 273%) whereas using cuprous oxide nanoparticles increased the distilled yield by 133.64% and 93.87% with and without the fan respectively.

Ravishankar Sathyamurthy et. al. [9] Concludes that the geometry in the solar still significantly influences the yield of fresh water. Following conclusions are made:

(1) The highest yield stills are the stepped with reflectors and weir cascaded solar stills, but their cost remains high.

(2) A method for improving the yield of conventional solar still is increasing the surface area of water by adding specified dimensions of sensible heat energy storage in the basin .

(3) A new shape of a triangular basin single slope solar still increases the contact area of water with solar radiance by reducing the shadowing effect from the side walls during morning and evening hours.

(4) For the triangular pyramid solar still, cooling water may be circulated through the side walls, which takes away the heat which is returned as feed water into the basin.

Ali.F.Muftah, K.Sopian et. al. [10] study involved the enhancement of a stepped solar still by integrating superior design concepts into one design. The energy-balance analysis of the proposed stepped still prior to and post modification has been conducted. The performance of the proposed stepped solar still was detailed under multiple evaluation parameters. The daily productivity of the stepped solar still post modification increased from 6.9 kg/m2 to 8.9 kg/m2. Based on the results obtained from the thermal evaluation parameters and statistical test, the proposed design significantly enhanced the thermal performance of the stepped solar still.

3. METHODOLOGY AND EXPERIMENTATION

Impure water is filled inside an airtight insulated basin covered with a transparent glass in the basin style still solar. The rays are transmitted from the cover to the absorber surface at the bottom when the silos are exposed to the light, thereby heating the water. Then the hot water heats the air inside, leaving it unsaturated. The water evaporates and saturates the air that surrounds it. which is being circulated inside the still due to the temperature difference between the water surface and the cover lower surface.

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Solar units of the single basin type are produced with certain design parameters and tested under field conditions. The basin was made of wooden block with a 1.0 m x 0.8 m base, which was positioned for support on the metal stand. In order to minimize the heat loss to the atmosphere, 5 cm thick insulation (glass wool) was provided between the wooden box and the basin. In order to increase the absorptive of the basin surface, it is painted black . Glass of 3 mm thickness covers the single slope still with an inclination with horizontal.

Fig. 1 Experimental Setup of solar distillation system

A pyranometer was used to measure the insolation on the still. Temperatures of the following locations were recorded by means of digital type thermometer, a) at basin liner, b) inner and outer surface of glazing, c) water in basin and d) surrounding air. The accuracy of this thermometer is of the order of ±0.1 degree centigrade for the range of temperatures measured. The distillate output was measured by means of a measuring Cylinder, at half hour interval.

All the observations & readings on experimental setups are taken in the month of May -Jne .The time duration for observations of solar still is from 9:00 AM to 5:00 PM for experimental setups of arrangement of only Black Coating with reflector arrangement.

Table 1 Simulation parameters of inclined solar still

S.No.	Parameters	Symbol	Values and units
1	Mass of Solar Still	M_s	20 kg
2	Area of base	A_b	1 m^2
3	Specific heat of material	C_b	510 J/kg K
4	Absorptivity of material	α_b	0.95
5	Mass of glass	M_g	2.7 kg/m^2
6	Area of glass surface	A_g	1 m^2
7	Specific heat of glass	C_g	750 J/kg K
8	Absorptivity of glass	α_g	0.05
9	Transmissivity of glass	t_g	0.88
10	Emissivity of glass	ε_w	0.97
11	Mass of basin water	M_w	10.8 kg
12	Area of basin water surface	A_w	0.95 m^2
13	Specific heat of water	C_b	4185 J/kg K
14	Absorptivity of water	α_w	0.05
15	Emissivity of water	ε_w	0.95
16	Latent heat of vaporization for water	L_w	2430.7 KJ/kg
17	Convection heat transfer Coefficient	$h_{c(b-w)}$	135 W/m^2K
18	Overall heat loss coefficient from bottom	U_b	14 W/m^2K
19	Stefan-Boltzmann constant	σ	$5.67x10^{-8}$ W/m^2K^4
20	Thermal conductivity of absorber plate	K_b	50.2 W/mK
21	Thickness of absorber plate	tk_b	0.003 m

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Table 2 Controllable parameters used in mathematical modeling of proposed solar still configurations.

S.No	Type of Proposed solar stills	Controllable parameters with units					
		A_w	A_b	A_g	M_w	M_b	M_r
		M^2	M^2	M^2	Kg	Kg/m^2	kg/s
2.	Inclined still with Base Black Color	0.85	1	1	6.1	9.6	0.00083
3.	Conventional basin still	0.27	0.3	0.3	4	2.34	-

4. RESULTS AND DISCUSSIONS

Organization of this chapter is intended to present the outcome of the experiments carried out in black coated stills and white coated still for their performance. Line diagrams, are used in various sections to present the test results. This paves the way for the easy understanding of the work and to improve the performance of the still.

Black Coated Still

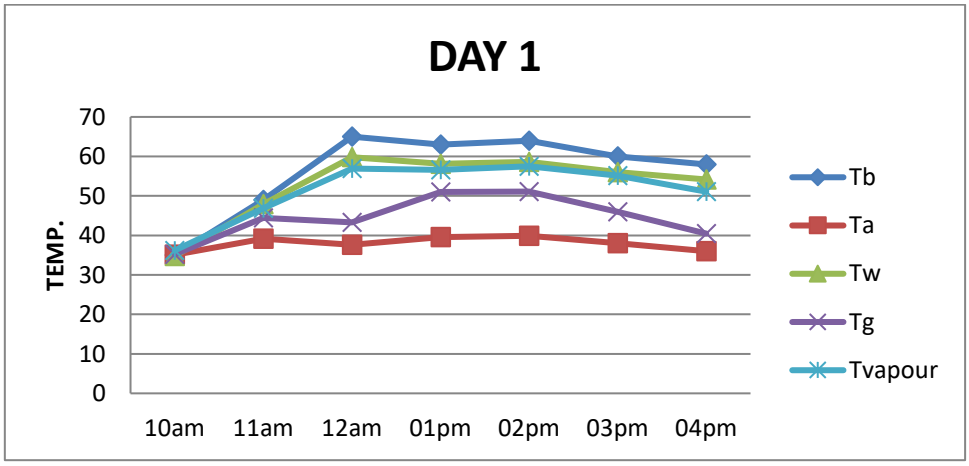

Fig. 2 (a) Comparison between different location Temperatures (Basin Temperature, Ambient Temperature, Water Temperature, Glass Temperature, Vapor Temperature)

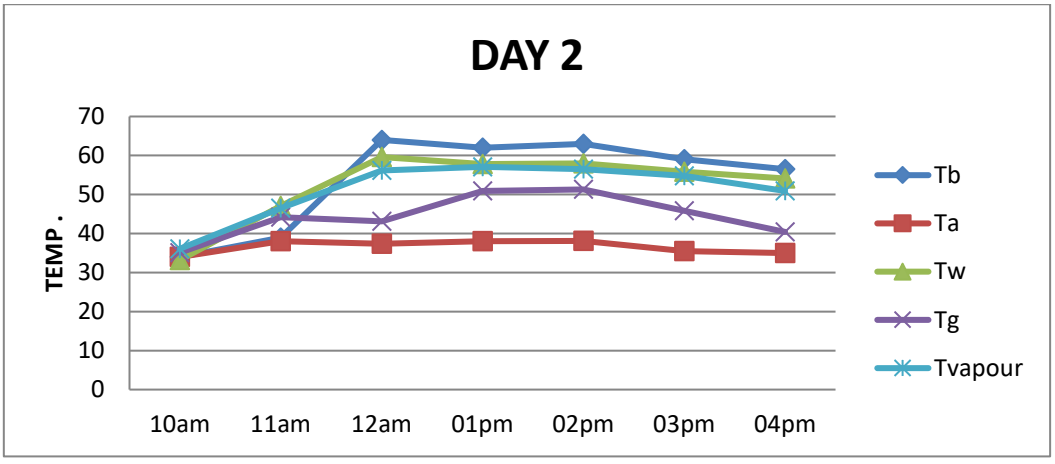

Fig. 2 (b) Comparison between different location Temperatures (Basin Temperature, Ambient Temperature, Water Temperature, Glass Temperature, Vapor Temperature)

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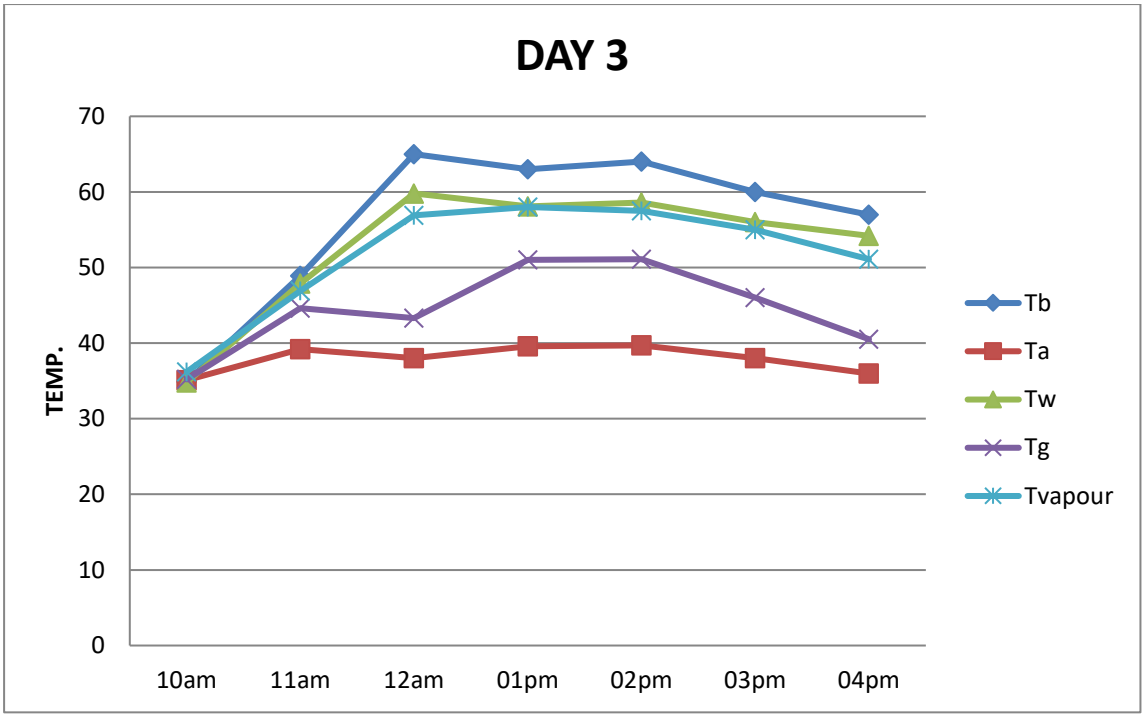

Fig. 2 (c) Comparison between different location Temperatures (Basin Temperature, Ambient Temperature, Water Temperature, Glass Temperature, Vapor Temperature)

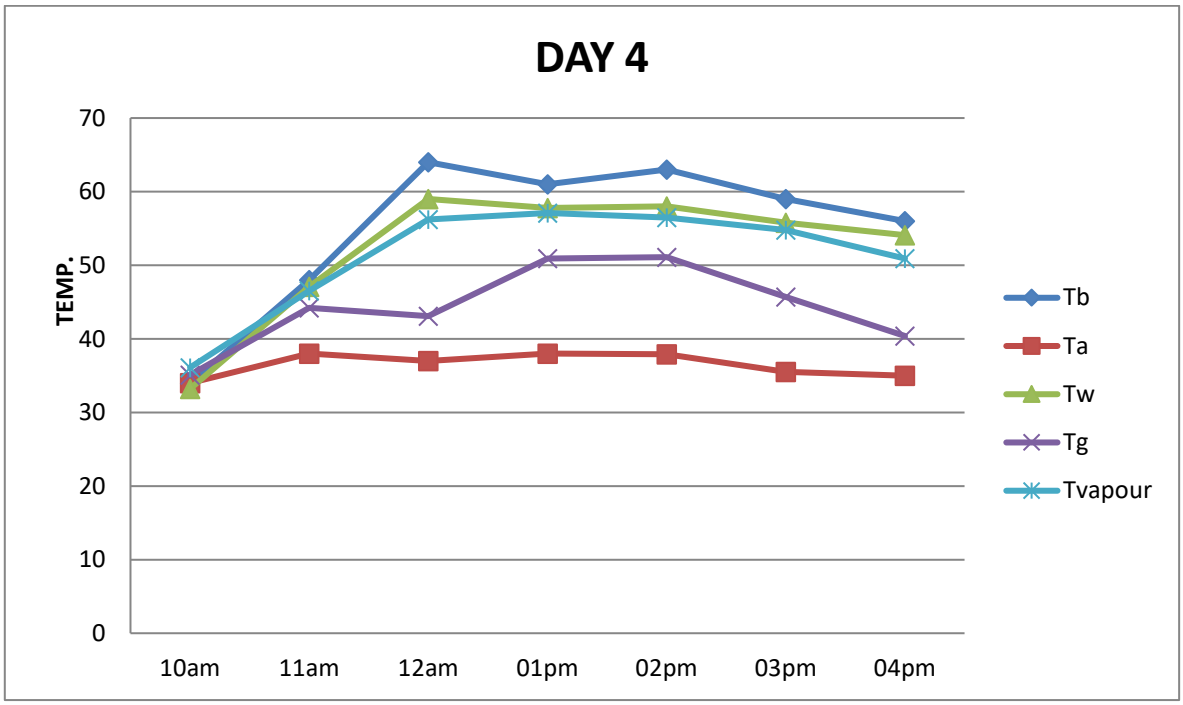

Fig. 2 (d) Comparison between different location Temperatures (Basin Temperature, Ambient Temperature, Water Temperature, Glass Temperature, Vapor Temperature

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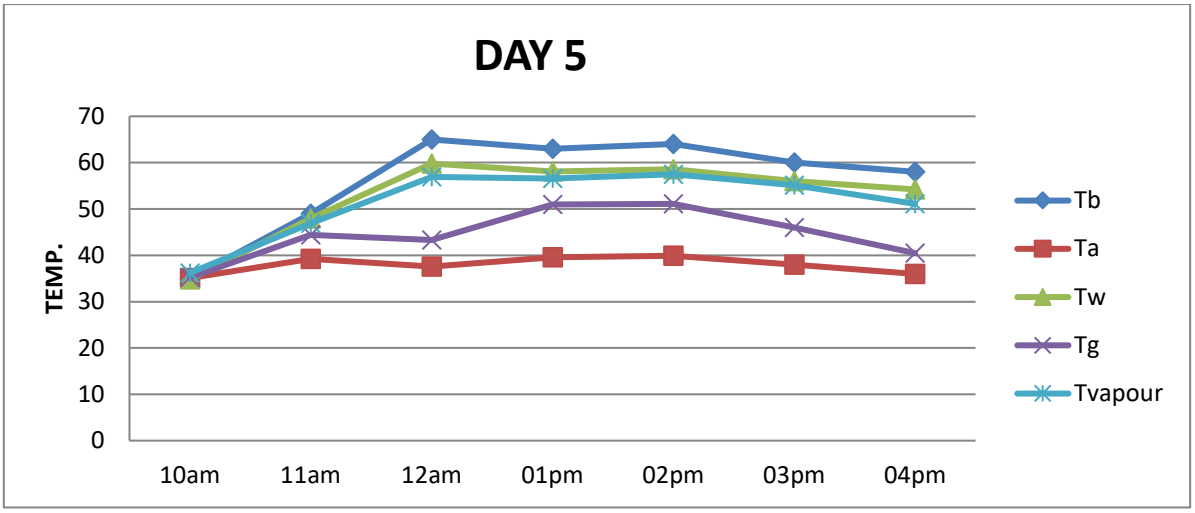

Fig. 2 (e) Comparison between different location Temperatures (Basin Temperature, Ambient Temperature, Water Temperature, Glass Temperature, Vapor Temperature)

Above diagram shows, the performance of the proposed basin solar still is verified under different evaluation parameters. These parameters are saline water temperature, glass cover temperature. The values of the evaluation parameters prior to and post modification are obtained under clear sky day conditions.

Comparison of Time Vs Output

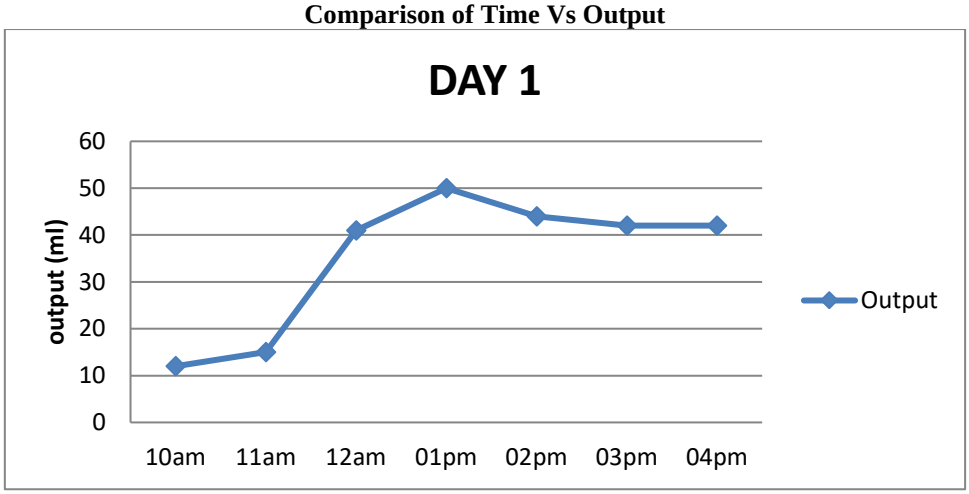

Fig. 3 (a) Variation of Output vs. Time Day 1

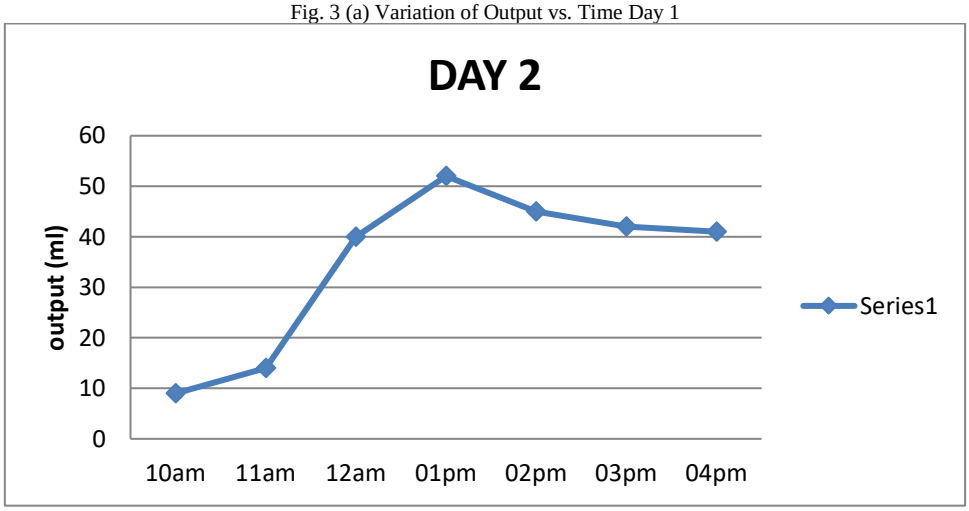

Fig. 3 (b) Variation of Output vs. Time Day 2

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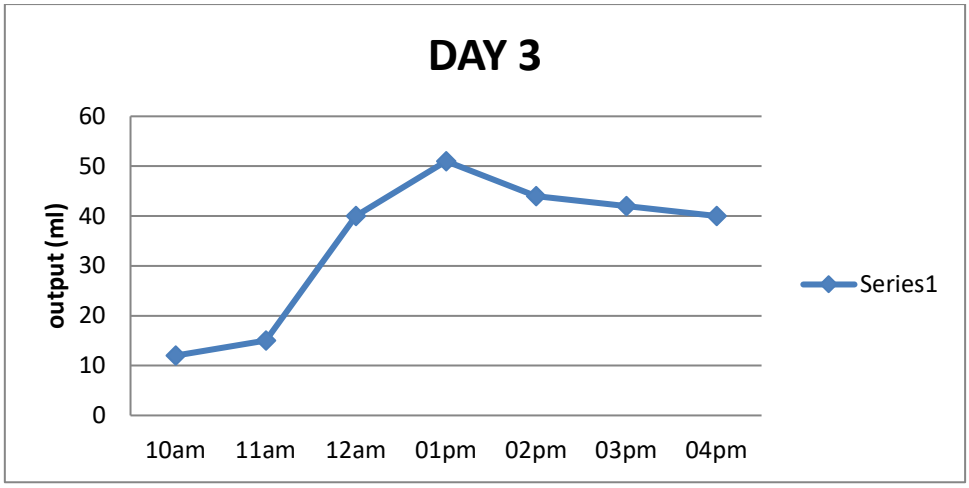

Fig. 3 (c) Variation of Output vs. Time Day 3

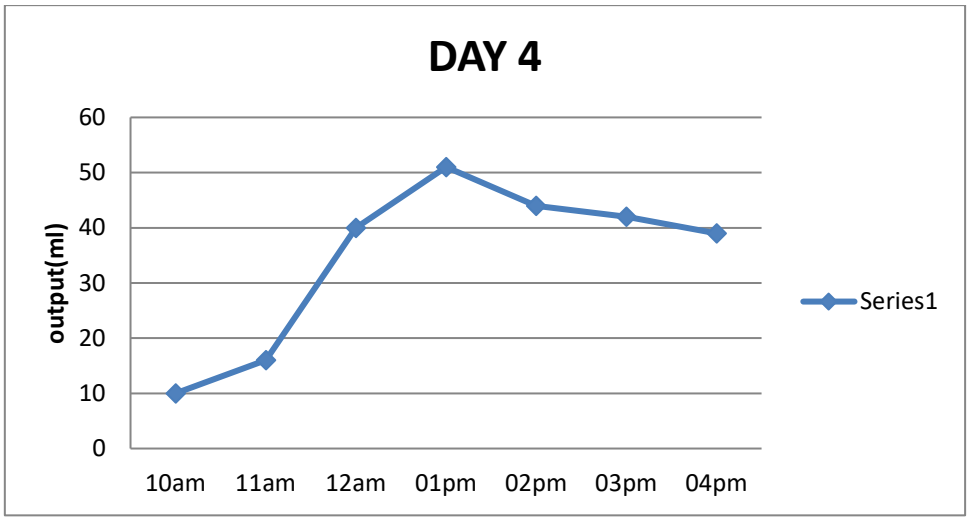

Fig. 3 (d) Variation of Output vs. Time Day 4

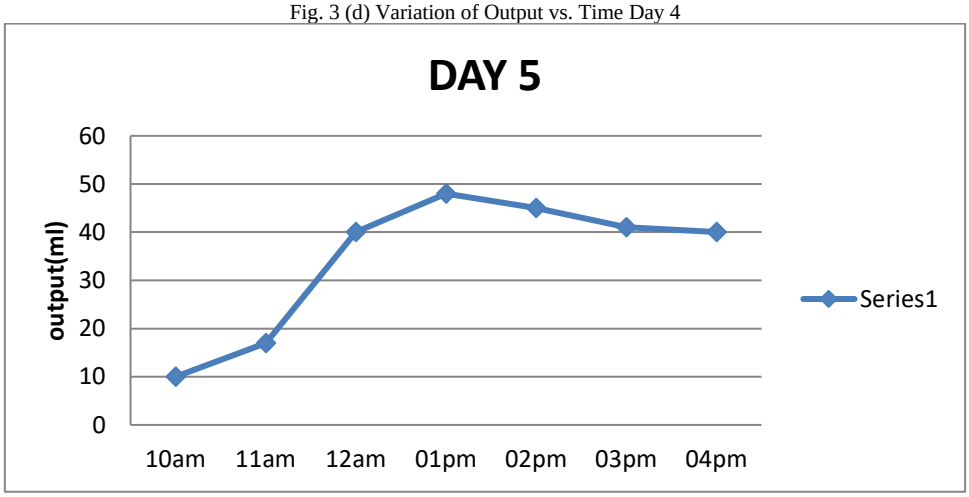

Fig. 3 (e) Variation of Output vs. Time Day 5

As shown in the figure the maximum output is achieved with time of the day and reaches its maximum at about 1 pm.

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5. CONCLUSION

From this experimental Inquiry (shown in Fig. 3 a-e). We may infer that in the time from 12:00 am to 02:00 pm, the rise in temperature and thus the production is maximum. The saline water we given was 05 liters and we got 2.30 liters per square meter of purified water for experimental setups at the end of the experiment, as described earlier. An efficient use of solar energy can reduce the need for the use of expensive conventional sources of energy and meet energy saving requirements.

The improved thermal performance of the manufactured solar with an improved evaporation rate and faster condensation was achieved due to the appreciable contribution of design parameters and operation.

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