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Experimental Investigation of Single Slope Passive Solar Still Using Different Heat Storage Material

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Abstract

Energy and water are necessity of mankind that influences and sustainable development of any nation. Today, the production of fresh drinking water is a serious problem worldwide. Quantity of fresh water is very less which shows need of conversion of impure water into fresh water. For effective and economic conversion of impure water into pure water, such type of energy source required which is readily available in supreme amount. Distillation is a well-known thermal process for water purification and most importantly water desalination. There are many ways and techniques for solar distillation. This paper represents experimental results of passive solar stills with Al & SS 410 as a heat storage material. Both still have same basin dimension of 75 × 75 cm^2. A comparison study between the still with material and without material was carried out to evaluate the distillation and effective parameters under the same climate conditions for different nine days with different height of water in still (1cm, 2cm and 3cm). Effect of material on distilled output was increased by 24 % and 29% with SS 410 &Al respectively during height of water in still is 1 cm. But when height of water is followed by 2 cm and 3 cm distilled output does not increase with scrap material. So, maximum productivity obtained with 1 cm height of water in still.

Keywords: Solar Still; Yield; Heat Storage Material; Solar Desalination; Passive Still.

1. Introduction

Solar desalination is a technique to desalinate water using solar energy by some arrangements such that, the refining of salt water to recoup versatile water is expert by uncovering slender layers of the salt water to sunlight based radiation and gathering the water vapor delivered on a straightforward cover such that it can be gathered in accepting troughs. Sunlight based refining is a procedure where sun oriented vitality is utilized to deliver crisp water from saline or salty water for drinking, local and different purposes.

For nations like India, the local sun powered still is a suitable safe water innovation. The normal day by day sun oriented radiation fluctuates in the vicinity of 4 and 7 kWh/m^2 for various parts of the nation. There are on a normal 250–300 clear sunny days in a year, consequently it gets around 5000 trillion kWh of sun oriented vitality in a year. From its operational attainability and related costs, it can be gathered that sun based still innovation is very competent to give desalinated water to family units in provincial India. [1]

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2. Effect of Heat Storage Material

The efficiency of Solar still can be increment by utilizing heat stockpiling material in bowl or in development mass of sun oriented still. Heat capacity material builds the absorptivity of sun powered flux and subsequently increment the yield in day time as well as in night.

Charcoal particle acts as a good absorber medium which produces 15% more yield. The blend of paraffin wax, paraffin oil and water included with Al turnings utilized as an uncommon stage change material builds the profitability to the greatest estimation of 851 ml/m2h. By the addition of 10 kg of sand as sensible heat storage medium the daily productivity and efficiency are increased by 10.8%. [2] In this experiment authors are Magnesium Sulfate Heptahydrate ($MgSO_4$ $7H_2O$), Sodium Sulphate (Na_2S $7H_2O$) used as phase change material & Titanium oxide is a nano-material used as a storage material. Among these energy storage materials Magnesium Sulfate Heptahydrate ($MgSO_47H_2O$) enhances the productivity of solar still distillation. [3]

Ravi Gugulothu and others el al [4] are obtained experimental results of a single basin solar still in the presence of different phase change materials are Potasium dichromate ($K_2Cr_2O_7$), Magnesium Sulfate Heptahydrate ($MgSO_47H_2O$) and sodium Acetate (CH_3COONa) are used.

Among these phase change materials Magnesium Sulfate Heptahydrate ($MgSO_27H_2O$) gives better productivity of potable water.

Bilal A. Akash and othrs el al [5] are concentrate the impact of utilizing diverse retaining materials in a solar still, and in this way upgrade the yield of water. In this experiment an absorbing black rubber mat, black ink and black dye are used to increase the daily water productivity by 38%, 45% and 60% respectively. From that black dye was the best absorbing material used in terms of water productivity. M. Hassen Sellami and othrs el al [6] are done experiment to expand the yield of ordinary solar still, Portland concrete has been utilized as a part of two structures: splashed powder and glue layer. As a result they found that using the cement as powder is more effective than using it as an adhesive layer. Out of 50, 100 and 150 g of powder cement/m2 of absorber area they found that the best result recorded is by adding 150 g of powder cement with an improvement of 51.14% compared with conventional still. H.S. Deshmukh, S.B. Thombre el al [7] have experimentally study, performance of a single slope single basin solar still have been analyzed with sand and servo therm medium oil (heat transfer oil) as passive storage material beneath the basin liner. With this experiment authors found that the units with passive storage such as sand and SM oil give higher overnight productivity.

Hossein Taghvaei and other el al [8] one of the most important operating parameters which affects the performance and efficiency of active solar stills is brine depth. H.N. Singh, G. N. Tiwari el al [9] On the basis of the results and discussion, they were concluding for greatest yearly yield: The yearly yield is at its most extreme when the gathering glass cover slant is equivalent to the latitude of the place.

3. Experimental Setup and Procedure

Figure 1 demonstrates the setup produced using 3mm thick Acrylic Sheet. Two single incline single slop passive solar still were outline and experiment done at university road, Rajkot, Gujarat. Both still have 75 × 75 cm^2 same basin area. The basin liner was made watertight by body bind and Flex Quick. A black surface was used at inner side of still to assimilate more solar radiation. All stills were secured by 3mm thick straightforward toughened glass lean approx. 22.5^0 with level as 23^0 is the latitude of Rajkot, Gujarat.

Both still are fitted with the RTD and six channel temperature indicator for the measurement of basin temperature, inner glass temperature and outer glass temperature. Solar Radiation was measured by Solar Power Meter. Transparent Beaker was also used to measure distilled output.

Experiments were started from morning 7.00 O'clock to evening 6.00 O'clock continues for various height of water e.g. 1cm, 2cm and 3cm. All the measurement data like temperature, yield output, radiation etc. were taken in the interval of 1 hour.

4. Result and Discussion

The performance analysis of two different Solar Stills, one having SS 410 or Aluminum and second without material during first two practical session. During third session of practical still 1 with Al & still 2 with SS 410 are compared for distilled output comparison. The Figures shows the hourly variation of various temperatures for all three depth of water, e.g. 1 cm, 2 cm and 3 cm.

Figure 1. Experimental Setup

Figure 2, figure 3 and figure 4 show the Hourly variation (Hrs.) of distilled output (ml). It is clear from the graph that distilled output increases from 7AM – 2PM, becomes maximum between 1 PM – 3 PM and then starts decreasing gradually. The result of the experiment explained in below graph.

From the experiment it is confirmed that the productivity of the distilled output is varied with the variation of the basin linear temperature (T_1 for still 1 and T_4 for still 2), inner glass temperature (T_2 for still 1 and T_5 for still 2) and outer glass temperature (T_3 for still 1 and T_6 for still 2). The variation of the all temperature for the different height of water is shown in below fig. 4 and fig. 5. Temperature will be increases up to 2 PM then after it will be gradually decreases with the decreasing of solar radiation falling on it. Also temperature will decrease with increase of the height of water in the still. It is highest in 1 cm water height in still as shown in figure 5 to figure 10. Solar radiation will maximum between 12 PM to 2 PM. Here productivity obtained maximum with the 1 cm of water. Al is gives better productivity compare to SS 410. For 2 cm and 3 cm it will not give good result.

Different graphs plotted as per reading for different conditions are shown in below figures:

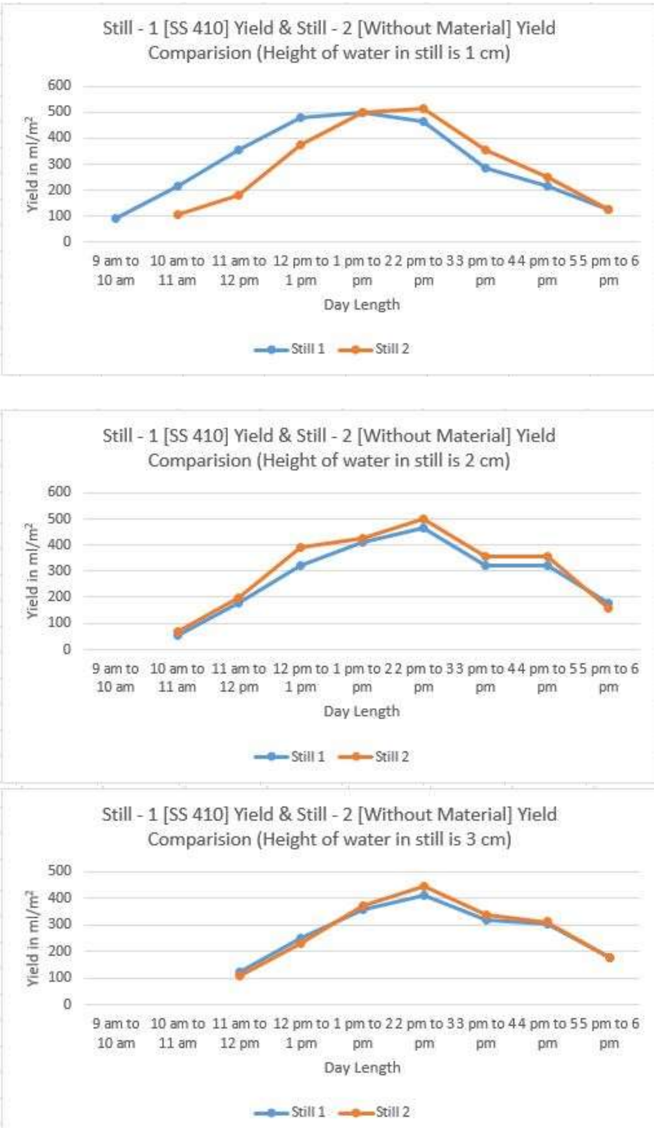
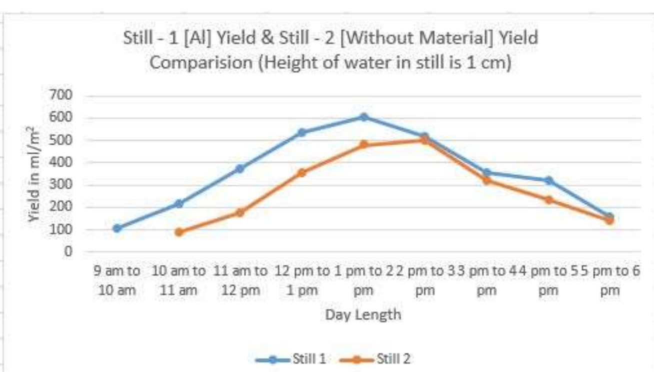


Figure 2. Variation of Hourly Yield Production in stills (SS 410 & without material) for 1cm, 2cm and 3cm height of Water in still



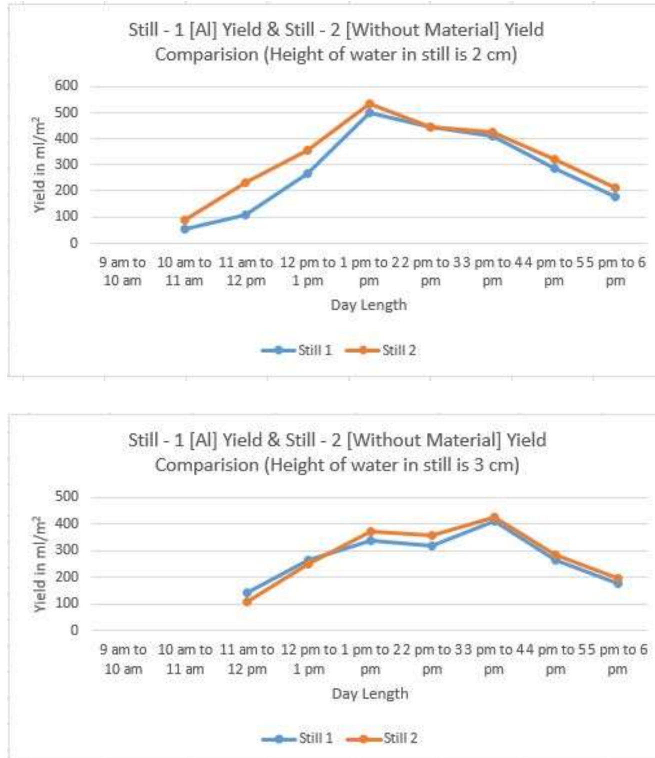
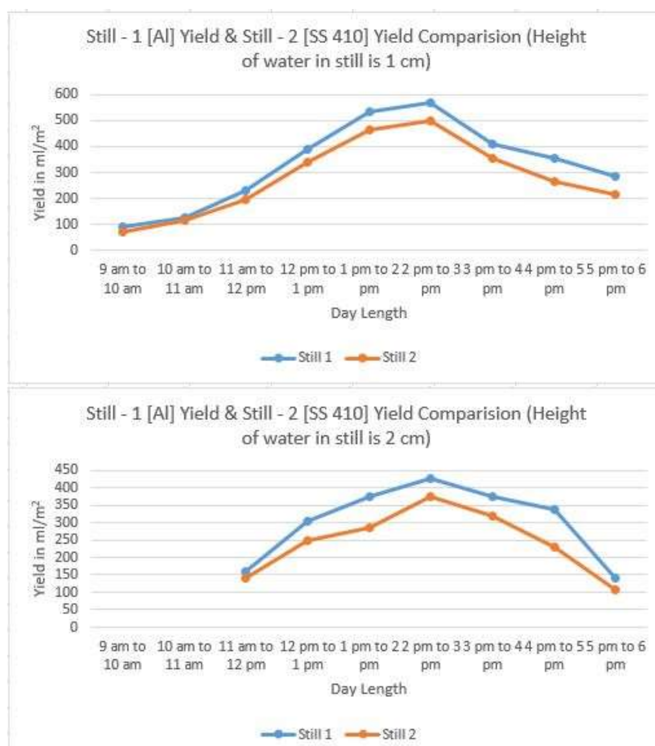


Figure 3. Variation of Hourly Yield Production in stills (Al & without material) for 1cm, 2cm and 3cm height of Water in still



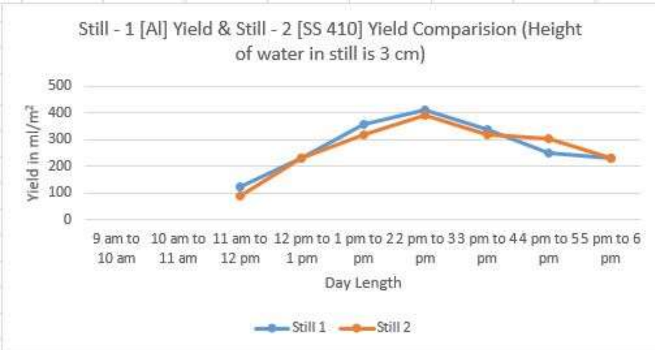


Figure 4. Variation of Hourly Yield Production in stills (Al & SS 410) for 1cm, 2cm and 3cm height of Water in still

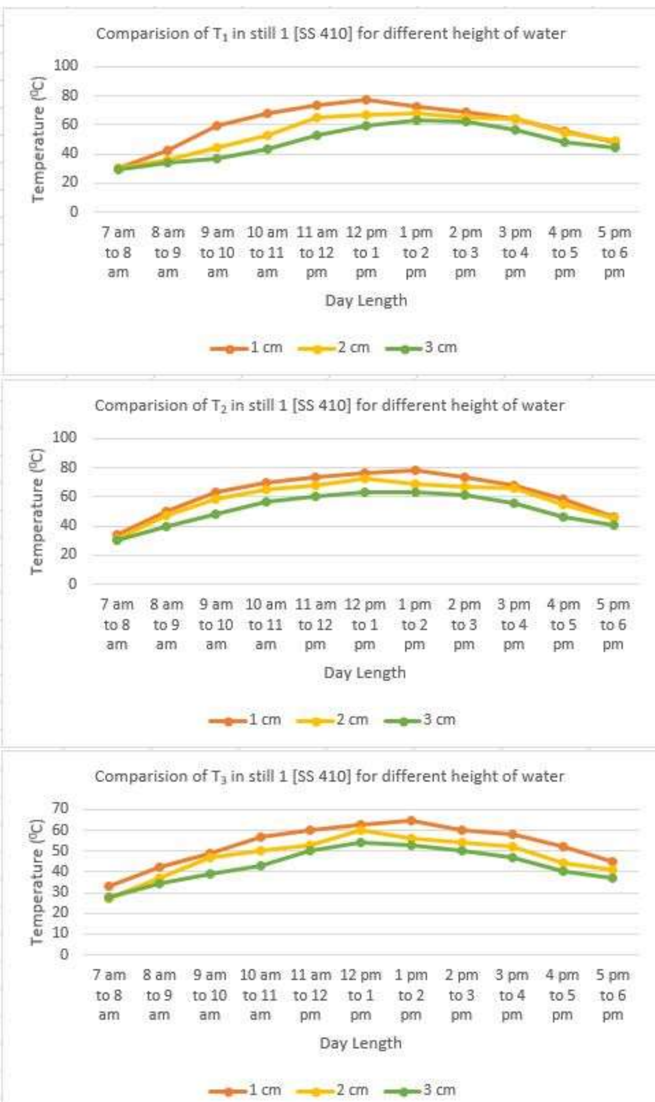


Figure 5. Variation of temperature in stills (SS 410) for 1cm, 2cm and 3cm height of Water in still

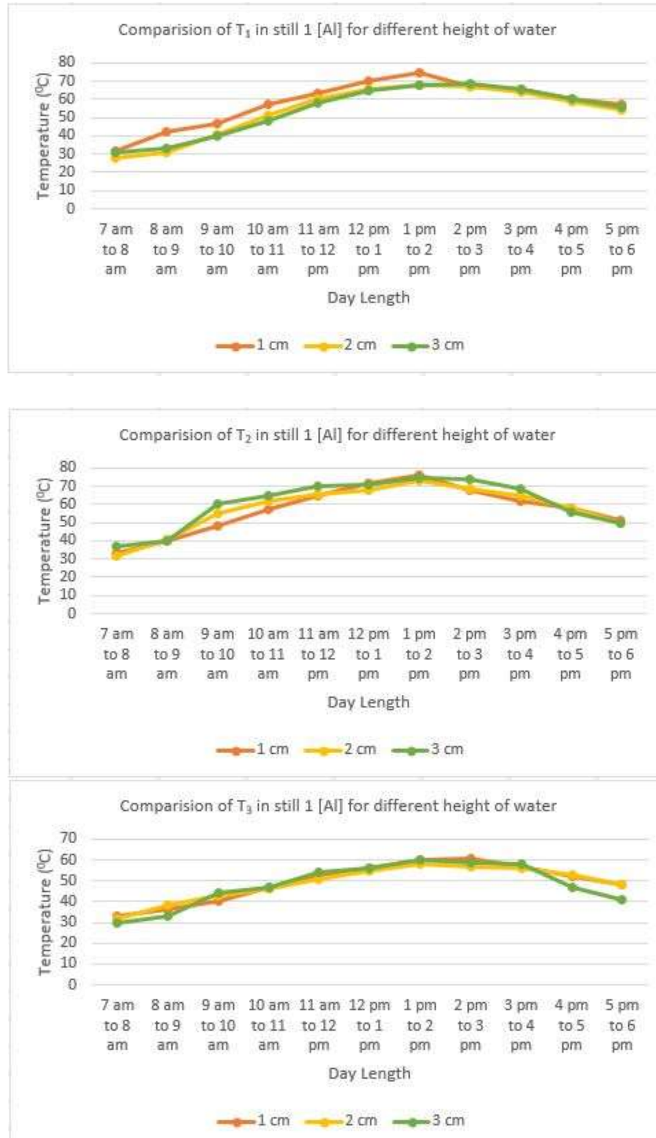
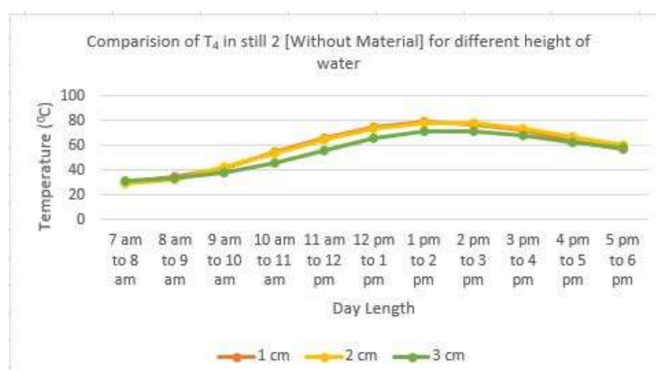


Figure 6. Variation of temperature in stills (Al) for 1cm, 2cm and 3cm height of Water in still



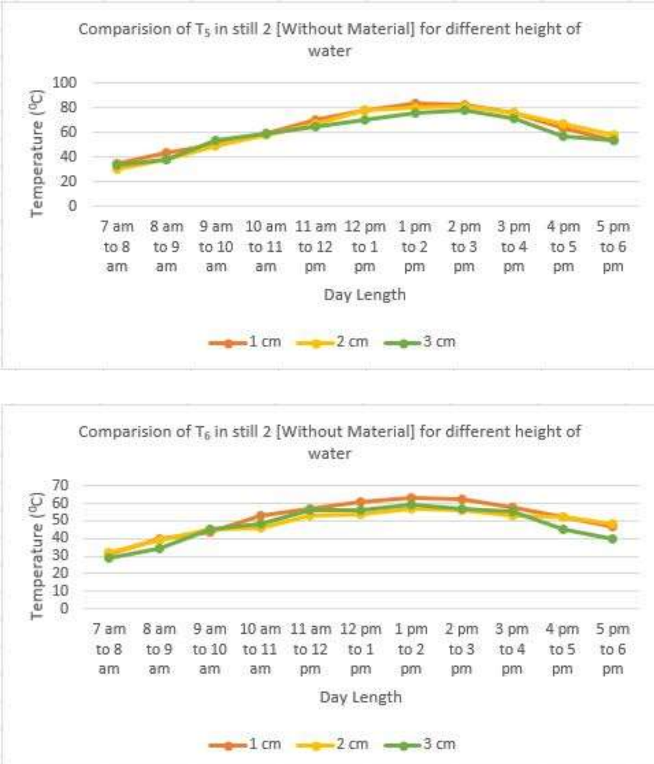
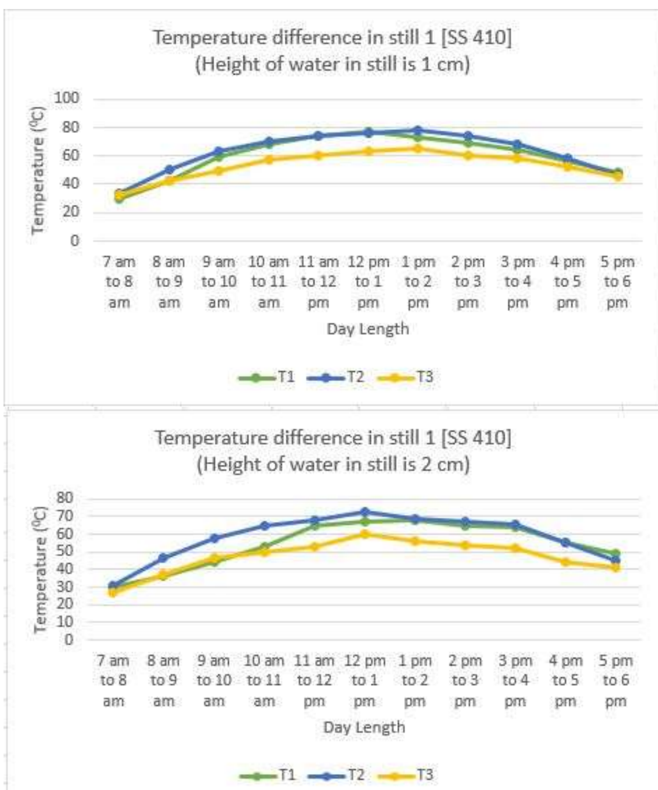


Figure 7. Variation of temperature in stills (Without material) for 1cm, 2cm and 3cm height of Water



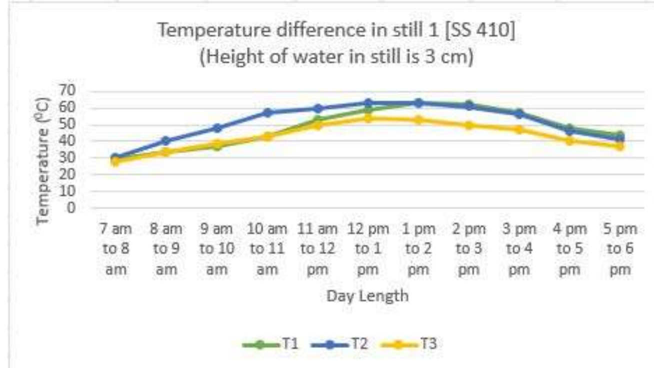


Figure 8. Temperature difference in stills (SS 410) for 1cm, 2cm and 3cm height of Water

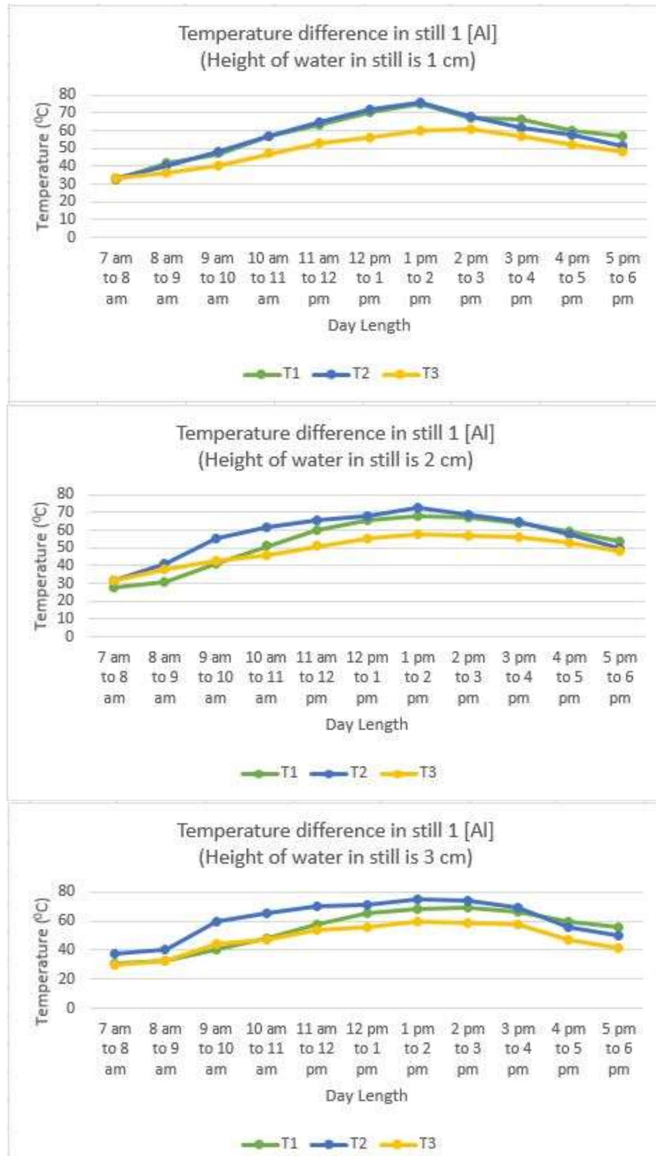


Figure 9. Temperature difference in stills (Al) for 1cm, 2cm and 3cm height of Water

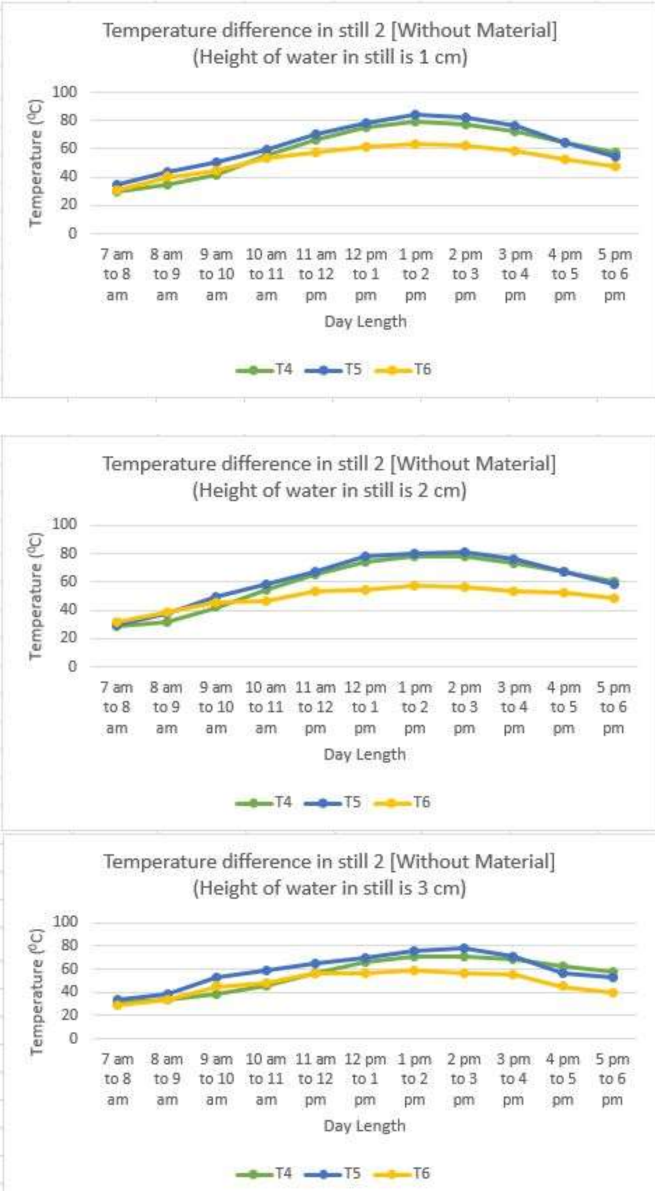


Figure 10. Temperature difference in stills (Without material) for 1cm, 2cm and 3cm height of Water

4. Conclusions

Two identical Solar Stills were constructed, one having any metal scrape as a heat storage material (Aluminium OR SS 410), second without material to evaluate the effect of storage material on the distilled output. The following conclusions can be made from this experiment:

- Height of water in still increases (from 1 cm to 3 cm) distilled output is decreases.
- For 1 cm height of water in still distilled output is maximum with heat storage material in still, for 2 cm & 3 cm height of water in still distilled output is decreases respectively in still with material compare to without material.
- For best distilled output Aluminium scrape is used as storage material with 1 cm height of water in still is maximum suited.

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