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COMPARATIVE PERFORMANCE OF ALUMINIUM COPPER
AND IRON SOLAR STILLS

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ABSTRACT

Three different metal sheets have been used in the fabrication of three different single sloping solar stills of the same surface geometry.The metals were galvanized iron, aluminium and copper. This paper presents the performance of the different stills operating under the same environmental conditions. The observed distillate yields was greatest for copper, then aluminium and lastly, iron still. The differences in the yields is attributed to the differences in the thermal conductivities of the metals. The equivalent local costs for the fabrication of the copper, aluminium and iron stills are respectively $160, $95 and $60. Taking the long run costs into consideration, the copper still is prefered because of its availabilty, durability, weldability and relatively higher conductivity of $380Wm^{-1}K^{-1}$ value.

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1 Introduction.

The use of solar stills in the production of distilled water is one of the oldest application of solar energy. As far back as the end of the last century a desalination plant was built at Las Salinas(Chile) with a production of $20m^2$ per day during the summer[1]. The plant was operated by energy from the sun which is free and without pollution. The plant itself is called the solar still.

A solar still is a sun operated apparatus which produces distilled water from brackish or saline water. It basically consists of a thermally insulated tray with a blackened bottom and a glass cover. Usually the tray is drawn out to form a gutter in which the condensate collects and runs into a container through plastic pipes. The present day technology on solar still is on the choice of material and design. Researchers working in this field have come up with a lot of demonstrated ideas in this regard. Various designs of solar stills have been constructed and tested for distillation of brackish water[2].

In Nigeria and many other countries, the single and double sloping solar stills are being built. Dioha and Gulma[3], Folayan and Ajayi[5] working independently at Birnin-kebbi and Zaria respectively observed that the single sloping type is more efficient. Earlier on, Sodha, Kumer and Tiwari[5] reported that adding a black dye increases efficiency by increasing the absorbable solar radiation but noted that the choice of dye is very important since in solution they behave like the coloids.

Hence insulator-dyes like the carbon black or ground charcoal tend to float on the surface thereby limiting the radiation availiable to the distilling solution. Chendo and Schmitter[6], Ipanyi[7], respectively reported that using glass cover and orienting the still to correspond to the latitude of the location improves efficiency.

2 Rational And Design Technicalities

The focus of this paper is on the perfomance of the stills. The volume of the distillate produced after a given time will serve as the index for perfomance for the stills. This definition is consedered appropriate for this study since the stills are operating uder the same conditions.
The metals used in this study are the most three locally available but in differing quantities and costs. The relative prevailing costs are in the ratio of 6:3:2, for copper, aluminium and iron respectively. On the whole the metals are availaible in the Nigerian market.

Various designs of solar stills exist in the world today but the authors have opted to work with single sloping design for the reasons adduced above. Added to these, single sloping design is easier to fabricate and cheap because a single sloping solar still can almost produce twice the distillate of a double sloping still of twice its surface area.
The panel works were done with each of the three metals in equal proportions. Each of the stills consists of two parts; a tray made of the particular metal and a plain glass pane. The inner side of the trays were painted black and each housed in a wooden box sloped at an angle of 12.5° which corresponds to the latitude of the study location. The plain glass covers were held in place with rubber gaskets.

The inlet is on the dorsal sides of the stills. The distillate drops into canals drawn at an angle of slope by the extention of the trays.From the canals the distillate builds up and runs into a collecting plastic vessel through a pvc pipe. In the welding of the stills, argon gas welding was used for putting together aluminium still becase of its low melting point temperature. Iron and copper stills can be made electric and gas welding respectively.

3 Results

The parameters measured are the tempreture and the volumes of the distillates. Allowance for optimum yield of the stills to be recorded was ensured by taking measurements over a two week period and then finding the mean of the brightest days. The average volume measurements of 20th and 24th of of March were used as the reference data as they were the days with the brightest and the most crear days. The respective temperatures of the stills were measured under the same conditions using thermocouples.

Tbe peak temperatures were recorded between 11.00am and 1.00pm. Before 9a.m., the temperature difference was not appreciable. The copper solar still attained the highest temperature of $85^{\circ}C$ followed by the aluminium and then iron with temperatures of $81^{\circ}C$ and $76^{\circ}C$ respectively. The comparative results of the three stills are as shown in fig.1 and the cummulative distillate yields are shown in fig.2. The volumes of distillates recorded over a 10-hour period are respectively $3.92, 3.42, 2.83m^3$.

4 Solar Still Management

The management of solar stills generally concerns the purity of the distillate produced. For desalination purposes solar stills are made in such a way that rust and corrosion is reduced to the barest minimum. Corrosion costs the industrialized societies millions of dollars each year, not only because of the need to protect iron and steel objects but also due to the expense involved in replacing rusted articles.

Since copper and aluminium hardly corrode, stills made of any of these materials are recommended for locations where humidity is high while iron stills should be for dryer environments. However, painting incorporating the use of lead(iv) oxide or zinc(iv) as protective priming coats can prevent rusting on a short term. Aluminium stills should not be used with alkaline solutions since alkalinity destroys the stability of aluminium oxide which serves as a protective film at the joining point with other metals.

The location of this study is very ideal for solar still operation. There is clear sky most of the months of the year. The ambient temperature hardly falls below$29^{\circ}C$ while the peak temperatures of $46^{\circ}C$ are common. However, occasional bursts of very high winds do occur but are not generally sustained. The solar still must therefore be cleaned of loose sand deposits on the glass pane to ensure the radiation is not undully interrupted. Also the cover of the stills should not fit eactly to the metal container to allow for the expansion in the instance of of the prevailing high temperature. Using rubber gaskets as stated above easily solves this problem.

5 Comparative Costs Of The Stills

Knowledge of the cost of each of the stills is very important for any good selection to be made of the stills. Copper still is of high quality and durable but it is very expensive to obtain relative to others. The relative costs are as shown above for the present study and location.

In the short term, galvanised iron still appears to be more attractive if only the cost is taken into consideration. This initial advantage is grossly overtaken when the cost of corrosion is considered. Corrosion sets in the iron still in less than a year, reducing the efficiency and purity of the distillate.
On the other hand, the copper still requires no running cost and in the long run becomes more cost effective. A life span of at least fifteen years is expected of a copper still. The performance of the still is generally better. Aluminium still is also good if ardent effort is made to monitor the PH of the medium.

6 Conclusions

The paper has compared the performance of three the identical stills fabricated with different metals of copper, aluminium and and iron, using the distillate outputs as the parameters. Copper still gave the highest yield but is expensive. However the study shows that the use of the copper sheet in place of aluminium and iron is more economical in the long run. This is in response to the global quest to enhance the performance of stills for better yields.

Selective coating, colouration or dying of the brackish water are some of these efforts. It is worth noting that if these measures are adopted in the copper still, a lot more improvement will be made. Using alloy of any of the metals can also improve yield.

7 Acknowledgements

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1. Cu_d , Al_d and Fe_d; are the distillates in litre per metre squared for copper, aluminium and iron stills respectively.
2. T_{ab}, T_c, T_a and T_i; are respectively the ambient temperature; the copper, aluminium, aluminium and iron stills' temperatures in degree centigrade.
3. *Fig*.1 : Variation of the stills' temperatures with local time.
4. *Fig*.2 : Variation of the stills' the distillate yields for the stills with local time.

8 REFERENCES

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Table 1:

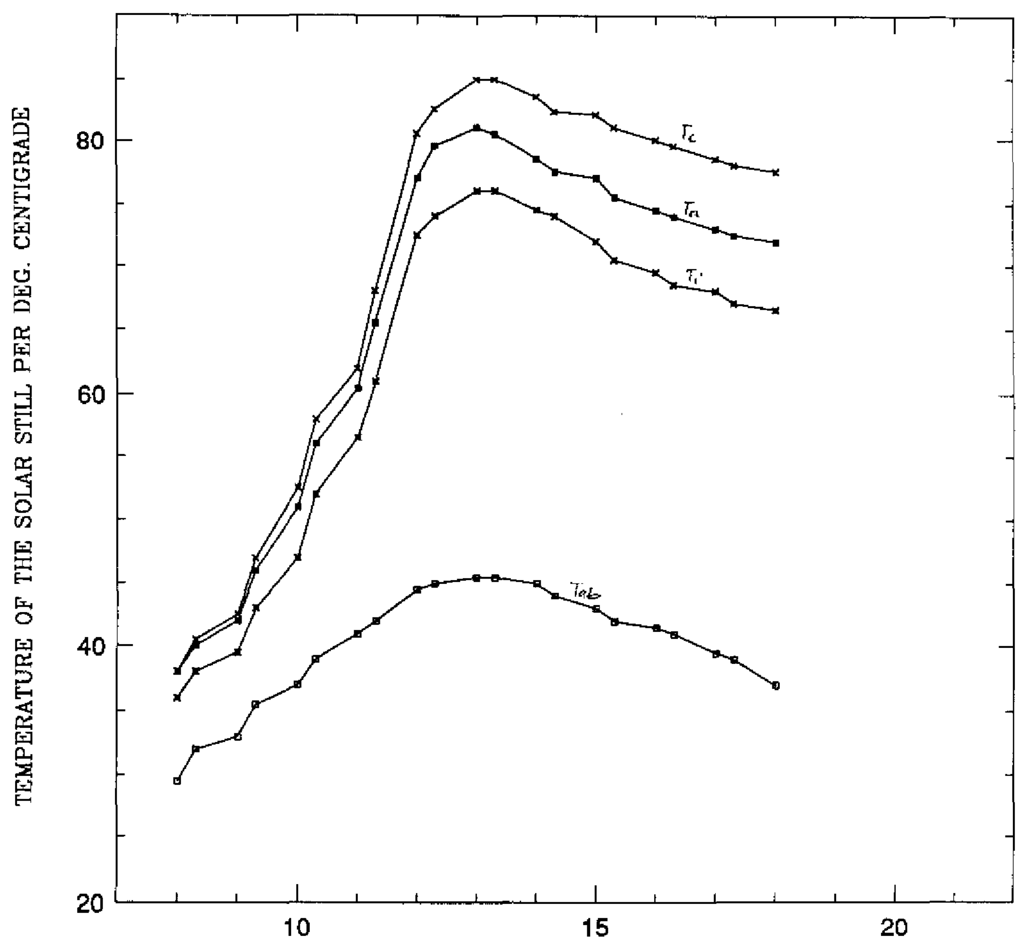
Comparative Results Of The Stills Operating Tempperetures Betweem 8.00am and 6.00pm on 24th March 1990 At Birnin-Kebbi Lat. 12.5° *N.*

local time	$T^o_{ab}C$	T^o_cC	T^o_aC	T^o_iC
8.00am	29.50	38.00	38.00	36.00
8.30am	32.00	40.50	40.00	38.00
9.00am	33.00	42.50	42.00	39.50
9.30am	35.50	47.00	46.00	43.00
10.00am	37.00	52.50	51.00	47.00
10.30am	39.00	58.00	56.00	52.00
11.00am	41.00	62 00	60.50	56.50
11.30am	42.00	68.00	65.50	61.00
12.00noon	44.50	80.50	77.00	72.50
12.30pm	45.00	82.50	79.50	74.00
1.00pm	45.50	85.00	81.00	76.00
1.30pm	45.50	85.00	80.50	76.00
2.00pm	45.00	83.50	78.50	74.50
2.30pm	44.00	82.25	77.50	74.00
3.00pm	43.00	82.00	77.00	72.00
3.30pm	42.00	81.00	75.50	70.50
4.00pm	41.50	80.00	74.50	69.50
4.00pm	41.00	79.50	74.00	68.50
5.00pm	39.50	78.50	73.00	68.00
5.30pm	39.00	78.00	72.50	67.00
6.00pm	37 00	77.50	72.00	66.50

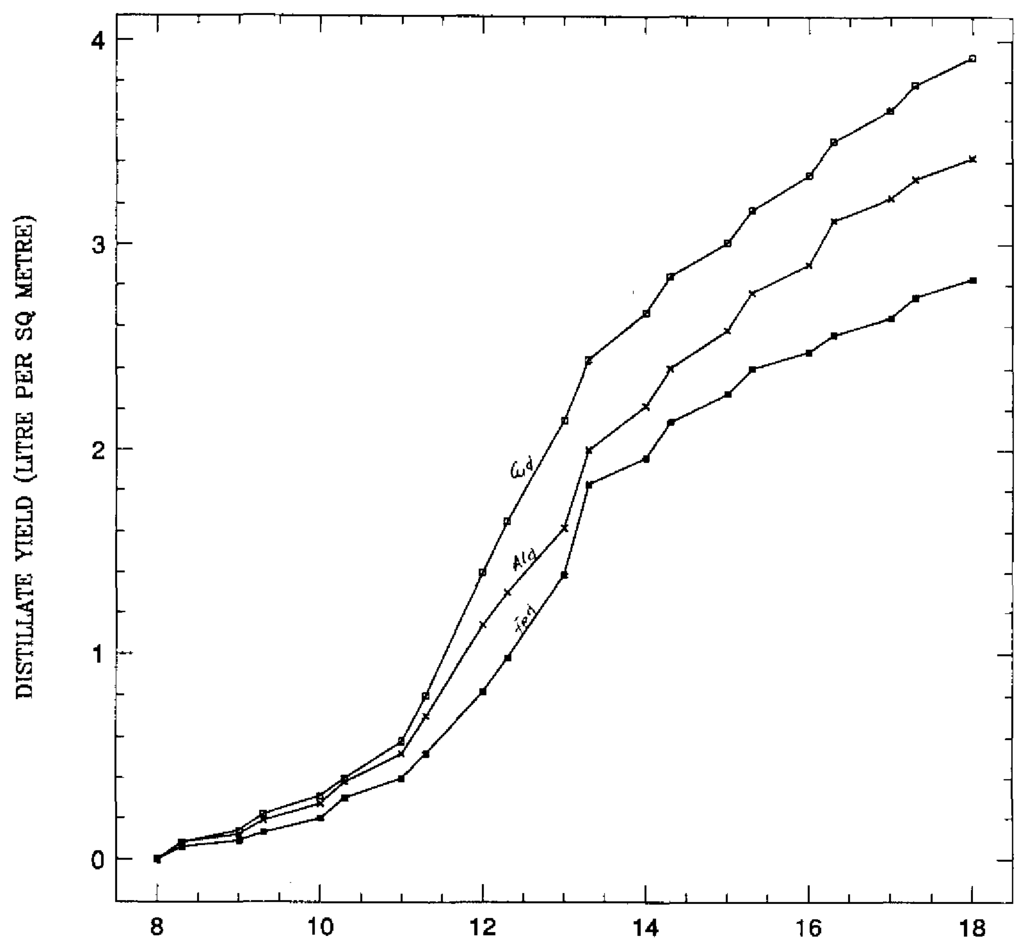
Table 2:

Half-hourly cummulative productivity of the stills per day on 24-3-89 at Birnin-Kebbi Lat. 12.5° *N*

Local Time	Cu_dM^{-2}	Al_dM^{-2}	Fe_dM^{-2}
8.00am	0.00	0.00	0.00
8.30am	0.08	0.08	0.06
9.00am	0.14	0.12	0.09
9.30am	0.22	0.19	0.13
10.00am	0.31	0.27	0.20
10.30am	0.40	0.38	0.30
11.00am	0.58	0.52	0.40
11.30am	0.80	0.70	0.52
12.noon	1.40	1.14	0.82
12.30pm	1.65	1.30	0.98
1.00pm	2.15	1.62	1.39
1.30pm	2.44	2.00	1.83
2.00pm	2.66	2.22	1.96
2.30pm	2.84	2.40	2.14
3.00pm	3.01	2.58	2.28
3.30pm	3.17	2.76	2.40
4.00pm	3.34	2.90	2.48
4.30pm	3.50	3.12	2.56
5.00pm	3.65	3.23	2.64
5.30pm	3.78	3.32	2.74
6.00pm	3.92	3.42	2.83



LOCAL TIME (HOURS) FIG. 1



LOCAL TIME (HOURS) FIG. 2