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SOLAR DISTILLATION OF CONTAMINATED WATER IN NIGER DELTA REGION OF NIGERIA

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ABSTRACT

The Niger Delta region is a densely populated oil producing area of Nigeria with a history of devastating oil pollution that has made provision of drinking water a major challenge. The study investigated the adoption of solar distillation as a simple low cost technique for potable water provision in this region. A simple single basin still was constructed with provisions for introduction of feed water, removal of distillate and disposal of feed water. The unit was exposed to radiation in an open space and fed with raw water collected from Nembe water creek (Rivers State) and Nworie stream (Imo State). Day time and night time outputs (distillate) were measured and recorded. Ambient, insulator and contaminated water pool temperature were also measured. The raw water and distillate were subjected to physiochemical and bacteriological analysis and results comparatively analyzed to assess the capacity of the unit in reducing the contamination level. The experimental still of area $4m^2$ *yielded an output of 1.5l/day. The area could be increased proportionately to meet drinking water requirements of households. The physiochemical and bacteriological tests showed marked improvement in the water quality. The distilled water satisfied physiochemical limits recommended by WHO, the E-coli level though significantly reduced was however above WHO recommended level. Further studies are recommended to specify minimum hygienic conditions with regard to collection and storage of distillates to ensure that no secondary contamination occurs during the process.*

Key Words : Solar, distillation, Niger Delta, Still, evaporation.

1 INTRODUCTION

There is a growing concern worldwide that water is increasingly becoming an extremely scarce natural resource (IFAD, 1992; Petty et al, 1994). Numerous countries including Nigeria are facing serious crises in that their expanding populations have access to adequate clean water (Khadka et al, 1999, Nigam et al, 1997). There are two angles to the water problem in Nigeria; one relates to the poor quality of available water owing largely to pollution, the prevalence of fluoride, arsenic, and iron deposits in underground water aquifers. The other relates to scarcity of water- a phenomenon which has led to the scramble for water all over Nigeria; and forced people to dig deeper into the ground in search of water thereby lowering the groundwater level and exposing the earth to erosion, leaching and other ecological problems ((Agarwal and Narain , 1999).

The Niger Delta is a densely populated area in southern Nigeria. The delta is an oil rich region, and has been the Centre of international controversy over devastating oil population. The area is exposed to oil population and environmental degradation and has for long suffered from neglect and poor infrastructural development (Omofonmwan and Odia, 2009). Niger Delta is the south most physiographic region of Nigeria protruding into the gulf of Guinea and extruding from Benin River in the West Bony river in the East. The area lies slightly north of the equator within the tropics. Minimum temperature ranges between 25^0c while maximum temperature between 29^0c and32^0c. These temperature ranges would surely cause high evaporation.

Pure drinking water can be produced with energy from the sun in a process known as water distillation. It is an inexpensive low-tool alternative for pure drinking water Distillation takes advantage of the principle that chemicals vaporize at different temperature. Most potential chemical contaminants in drinking water have vaporization points higher than temperature. When untreated water is heated in a solar –distillate, pure water vaporizes first.

Distillation takes advantage of the principle that chemicals vaporize at different temperatures. Most potential chemical contaminants in drinking water have vaporization points higher than water. When untreated water is heated in a solar distiller, pure water vaporizes first, leaving contaminants behind A simple solar distiller removes salts, heavy metals and bacteria, as well as arsenic and many other contaminants (Anderson, 2002).

Malik et al (1982) concluded that only total area is required to estimate still production, while Farid and Hamad (1993) showed that still efficiency depends also on how much of the total radiation is diffused. The development of a rugged-design high-efficiency multistage solar still was studied and analyzed (Goff et al 1991). The unit was a stack of 6 rectangular cells, each 4cm thick.

2 MATERIALS AND METHODS

An experimental simple single basin still was constructed (Fig 1). The unit composed of a contaminated water pool with associated radiation absorbent liner, a supporting structure and a glass cover. Provision was made for introduction of feed water, removal of distillate and disposal of bottom dust or feed water. Continuous flow was obtained by producing a gentle gradient on the base and allowing the feed to truckle in.

The basin was constructed of aluminum sheets. Putty plug was used to seal the joints of sheets already fixed. The basin was tested for leakage. Wooden casing combined with coconuts fibers were used for insulation. Finally a glass having same dimension with the top perimeter of the basin was placed to cover the top of the basin.

The unit was exposed to radiation in an exposed area and fed with contaminated water from Nembe water creek in Rivers State and Nworie Stream in Imo State (Fig 2). The raw water and the distillate are subjected physiochemical analysis using a photometer apparatus and applying the appropriate reagent for the various parameters.

The following parameters were determined, temperature, odour, colour, turbidity, pH, total dissolved solid (TDS), Chlorine, alkalinity, hardness, calcium and magnesium. Also nitrate, fluoride, iron and chloride concentrations determined. Bacteriological analysis focused on facial coliform analysis and the technique used was the membrane filter technique which involved filtration of water sample (100ml) under vacuum through a sterile membrane filter. The filter pore character was small enough to completely retain coliform bacteria placed on a medium and incubated at 37^0c for 4hrs. Colonies develop after the incubation period. The results were comparatively analyzed based on WHO standards for drinking water.

Ambient insulator and contaminated water pool temperatures were measured at 2hrs intervals daily and the average values recorded. Output data were obtained by exposing the solar sill to the sunshine and measuring the output using a graduated cylinder. Readings were taken both at daytime and night. Daytime output data were recorded at sunset. This was done for a period of 3 months (August - October).

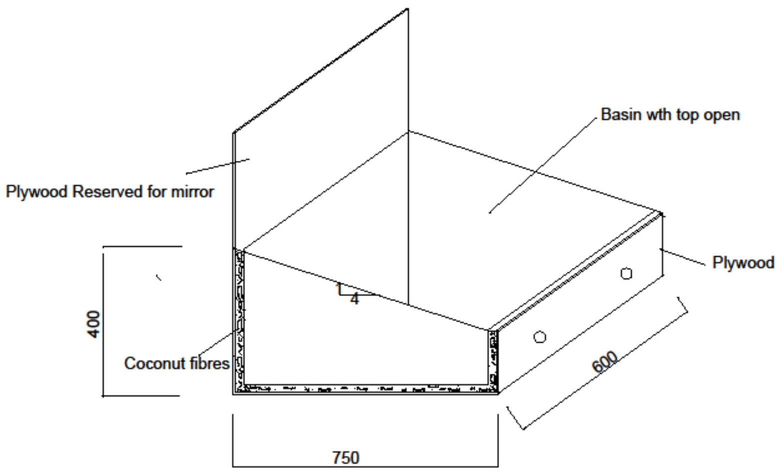

Fig 1 Cross Section of the Solar Still under Construction

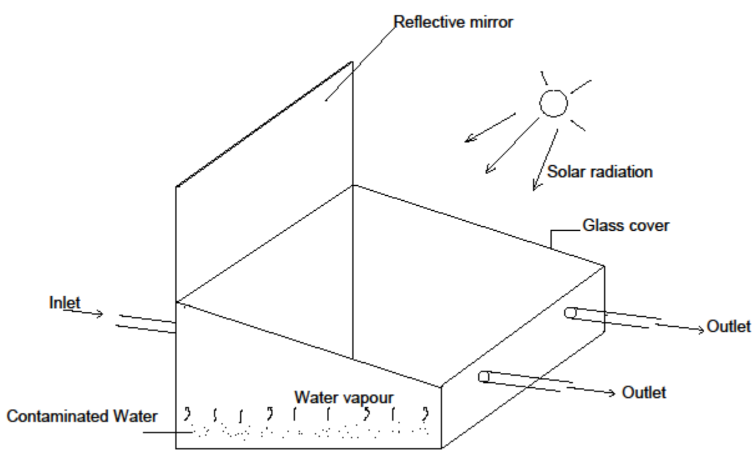

Fig 2 Operation of Solar Still

3 RESULTS PRESENTATION AND ANALYSIS

Table 1 presents ambient insulation and contaminated water pool minimum and maximum temperature readings for the months of August, September and October.

Results show that the highest daily output obtained during the experiment was 1.516litres while the lowest was 0.466litres. This difference in output could be attributed to fluctuations of radiation.

The efficiency the solar basin in the output and daily solar radiation was calculated using equation (i)

$$Q = 1.6(E.A.G) \qquad 1$$

Where Q = Daily output of distilled water L/day

E = Overall efficiency of system

G = Average daily solar reading

A = Aperture of the sill (Plane area m^2)

Therefore: $$E = Q/[1.6(A.G)] \qquad 2$$

$$E = 1.516/[1.6(0.4635\,X4)]$$

$$E = 0.51 \; = 51\%$$

The result showed that, during period of strong sunshine, the output covered 1.5l/day. Though this could be increased in proportion to increase the area of still, A 10 m^2 still size would be adequate for a household of 5 persons; this could be increased with improved efficiency of the system.

Tables 2 show results of physiochemical and bacteriological tests on the raw water samples and distilled water. The test results revealed significant improvement in the quality of the samples from the two different sources. For instance the TDS for water sample from Nembe creek was reduced from 20mg/l to 5mg/l. Also the chloride content was completely eliminated in the distilled water.

The bacteriological test also showed marked reduction in the presence of E-coli (from too numerous to count (TNT) to 9 counts for the Nembe creek sample while that of Nworie River was reduced from 21 counts to 4 counts. The values are however still above WHO recommendations which is 0 – 2 CFU/100-coliform backers. This is in contrast to results of precious studies that stated that the output of solar still is free from any contaminant. Secondary contamination could have occ as a result of mode of handling It is possible that safe and hygienic handling of the effluent was not given adequate attention during the tests.

CONCLUSION AND RECOMMENDATIONS:

Solar water distillation could be initiated in the riverine communities as a means of seeking solution to the problem of drinking water need. However despite the fact that larger household water needs could not be met by increasing the still area appropriately, the quality of distilled water must be ascertained. This is view of the fact that though the distilled water quality satisfied the physiochemical limits recommended by WHO the E-coli level could not be reduced to acceptable limits. It is possible that minimum safe and hygienic conditions were not given adequate attention in collecting handling of the distilled water.

It is therefore necessary that solar still and distillation plants are not only considered at the design and performance level but also minimum hygienic specifications must be defined to ensure that there is no secondary contamination of the distillate.

Table 1 Temperature Readings

Month	Ambient temperature (°C)		Insulator Temperature (°C)		Contaminated Water pool	
	min	max	min	max	min	max
August	25.1	29.71	37.5	42.35	48.25	55.13
September	25.0	29.71	38.53	41.54	42.39	50.59
October	28.9	31.0	38.79	41.97	45.98	51.31

Table 2 Water Quality Test Results (Nembe Creek)

Parameter	Unit	Raw Water	Distilled Water	WHO Standard
Temperature	^oC	38	26	20-30
Odour		Objectionable	Unobjectionable	Unobjectionable
Colour	ptco	<10	<10	15
Turbidity	FTU	<5	<5	50
pH		6.0	6.6	6.5-8.5
Total dissolved Solid (TDS)	mg/l	20	5	250
Chlorine	mg/l	<0.01	<0.01	100
Alkalinity (Ca_2CO_3)	mg/l	8	0	
Total Hardness	mg/l	0	0	250
Nitrate	mg/l	0.12	0.03	40
Flouride	mg/l	0	0	8.0
Iron	mg/l	0	0	0.3
Chloride	mg/l	20	0	1
E-coli	CFU/100ml	TNT	9counts	0-2

Table 3 Water Quality Test Results (NwaorieRiver)

Parameter	Unit	Raw Water	Distilled Water	WHO Standard
Temperature	^oC	28	26	20-30
Odour		Objectionable	Unobjectionable	Unobjectionable
Colour	ptco	<10	<10	15
Turbidity	FTU	<5	<5	50
pH		6.7	7.4	6.5-8.5
Total dissolved Solid (TDS)	mg/l	0.5	0.5	250
Chlorine	mg/l	0.01	< 0.01	100
Alkalinity (Ca_2CO_3)	mg/l	0.8	0	
Total Hardness	mg/l	0	0	250
Nitrate	mg/l	0.043	0.09	40
Flouride	mg/l	0	0	8.0
Iron	mg/l	0.04	0	0.3
Chloride	mg/l	8	0	1
E-coli	CFU/100ml	21 counts	4 counts	0-2

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