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ORIGINAL ARTICLE

Distillation of Water by Solar Energy

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ABSTRACT

Only 1% of Earth's water is in a fresh, liquid state, and nearly all of this is polluted by both diseases and toxic chemicals. For this reason, purification of water supplies is extremely important. There is always a scarcity of clean and pure drinking water in many developing countries. Water from various sources is often brackish (i.e. contain dissolved salts) and/or contains harmful bacteria and therefore, cannot be used for drinking purpose. Many parts of India, particularly, rural areas, coastal areas and many urban areas too, have a major drinking water problem. Contaminated drinking water is one of the reasons of major health hazards responsible for almost 90 % of the health problems in rural areas. Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy, especially when other sources in the country have depleted. Solar water distillation is a very old technology. Distillation is one of the many processes that can be used for water purification and can use any heating source. Solar distillation is a relatively simple treatment of brackish (i.e. contain dissolved salts) water supplies. Solar energy is a low tech option. In this process, water is evaporated; using the energy of the sun then the vapour condenses as pure water. This process removes salts and other impurities. It is recommended that drinking water has 100 to 1000 mg/l of salt to maintain electrolyte levels and for taste. In the following study, an attempt is made to design a pilot scale solar distillation unit. The initial and final proper properties like TDS, Hardness, Turbidity and MPN are useful to determine the potability and commercial use of water for small laboratories as distilled water. The application of such water if utilized for production of rose water can be then commercially enhanced.

***Key Words**: Renewable energy, brackish, solar water distillation, potability, water purification.*

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INTRODUCTION

Water is the biggest crisis facing India in terms of spread and severity. There are many villages either with scarce water supply or without any source of water. Water source being open dug well, the quality of water is poor; dirty, saline and has turbidity. At some villages water from tube wells is too saline or brackish especially in the coastal regions. Even animals particularly cow gets indigestion after drinking this water, so the villagers add water from the dug well. Where groundwater is used intensively for irrigation and industrial purposes, a variety of land and water-based human activities are causing pollution of this precious resource. Non-point pollution caused by fertilizers and pesticides used in agriculture, often dispersed over large areas, is a great threat to fresh groundwater ecosystems.(9) Contaminated drinking water is one of the reasons of major health hazards responsible for almost 90 % of the health problems in rural areas. Conventional boiling distillation consumes three kilowatts of energy for every gallon of water; while filtration and deionizing systems are even more expensive to purchase and use and will not totally purify the water by removing all contaminants. This poses a challenge to the rural population to keep themselves safe from the myriad diseases caused due to contaminated water. Distillation is one of many processes available for water purification, and sunlight is one of several forms of heat energy that can be used to power this process. It is least costly method of 99.9% true purification of most types of contaminated water especially in developing nations where fuel is scarce or too expensive. Solar distillation is a relatively simple treatment of brackish (i.e. contain dissolved salts) water supplies (3). Solar energy is a low tech option. In this process, water is evaporated; using the energy of the sun then the vapour condenses as pure water. This process removes salts and other impurities. Solar water distillation is a very old technology. An early large-scale solar still was built in 1872 to supply a mining community in Chile with drinking water (6).

Present study, aims to find the effectiveness of the simplest model developed in this study for the process of Solar Distillation. The physico-chemical and bacteriological parameters such as TDS, Hardness,

Turbidity, MPN were analysed in the sample water and the distillate obtained after the Solar Distillation. The objective of this paper is to evaluate the characteristic of the distillate to determine if it can be used for portable purposes.

MATERIALS AND METHODS

Construction of the working model.

Materials

This study tries to develop the simplest solar still with the materials available at any rural home. It includes:

1. a basin or trough to hold water, preferable metallic tin, or aluminum, (the basin used in this study is aluminum basin of 25 X 25 X 6 inches) (Fig 1.1)
2. black colour, (CFC free, with no Lead)
3. a container to collect distillate, (Fig 1.2)
4. a clean transparent plastic sheet, (Fig 1.3)
5. Additional insulation may be provided with newspaper and glue. A stone may be placed to weigh the sheet towards the collector. The plastic sheet is secured to the basin by cello tape.

Working

Water to be distilled is added to the basin. The entire assembly was left in the sun for a period of 6 hours. (Fig 1.4) The transparent plastic sheet allows the solar radiation to pass into the still, which is mostly absorbed by the blackened base. This blackened base facilitates to improve absorption of the sunrays. The water begins to heat up and the moisture content of the air trapped between the water surface and the plastic sheet cover increases. The heated water vapour evaporates from the basin and condenses on the transparent plastic sheet cover. In this process, the salts and microbes that were in the original water are left behind. Condensed water trickles down the plastic cover to an interior collection container. Feed water should be added each day that roughly exceeds the distillate production to provide proper flushing of the basin water and to clean out excess salts left behind during the evaporation process. The distillate thus obtained was evaluated for the various portability parameters.

Sampling

In all four samples of water were tested. Two of which are Ground water samples and remaining two are 1% and 3 % salt solutions. Groundwater samples were collected from the bore wells.

Procedure

The analysis was done of the samples as well as the distillate as prescribed by APHA (8) ,S.K.Maiti (2) and P.K. Gupta (4) methods. All the samples were analysed for physico-chemical, bacteriological parameters such as TDS, Hardness, Turbidity and MPN, to test the portability of the distillate. TDS (Total Dissolved Solids) was estimated by Gravimetric method. Hardness was estimated by EDTA titration. Turbidity was measured by Nephelometry with Formazin suspension as the primary standard reference suspension of 400 NTU. Bacteriological analysis for Coliforms was carried out by Most Probable Number using Double and Single strength Mac Conkey Broth, a selective enrichment media for *E.coli*. And inoculating it with serial dilutions of the water sample and distillate.

RESULTS

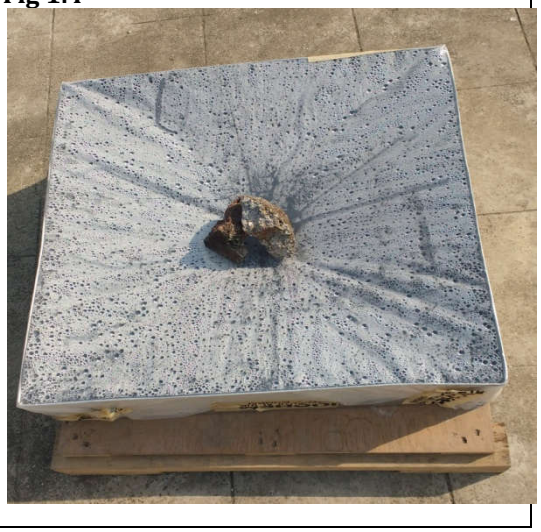
List of Figures

Fig 1.1

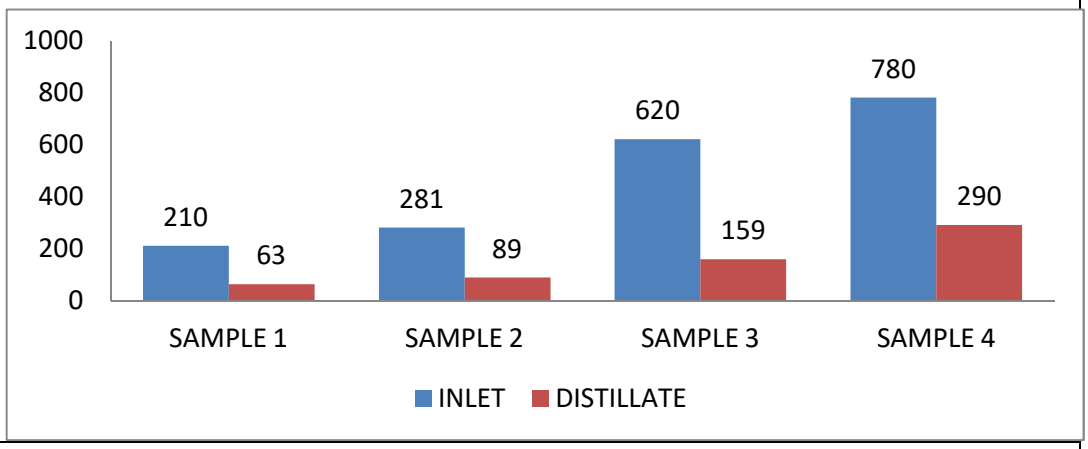
Fig 1.2

Fig 1.3

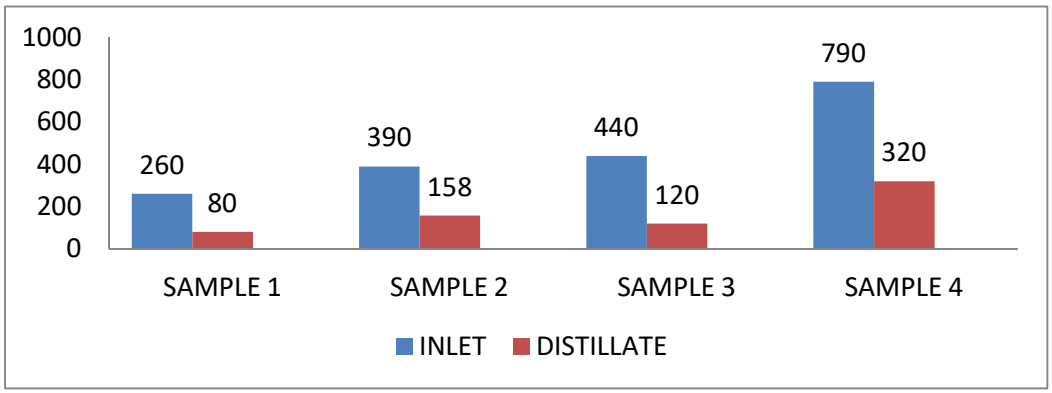
Fig 1.4



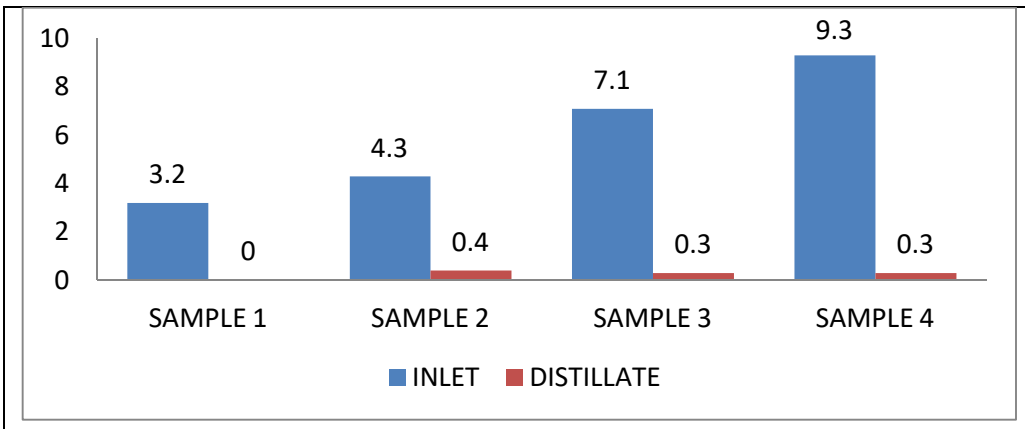
Graph1.1: TDS mg/l



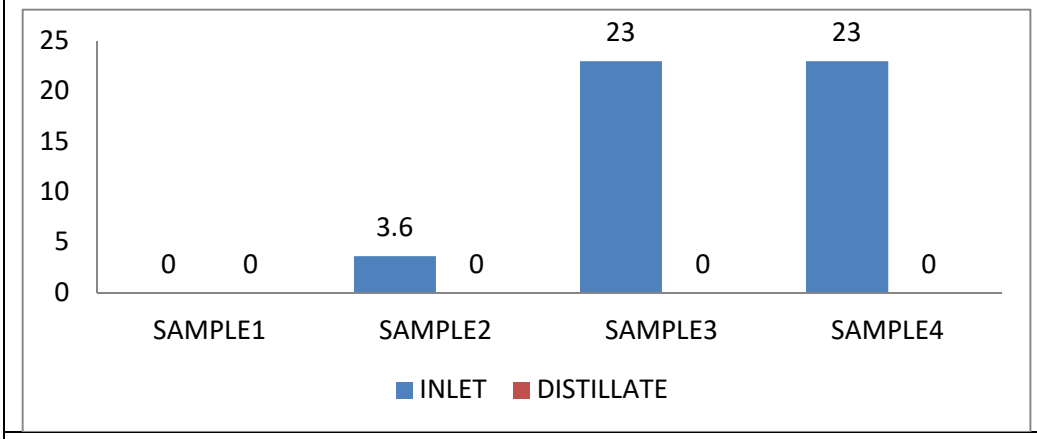
Graph1.2: Hardness mg/l



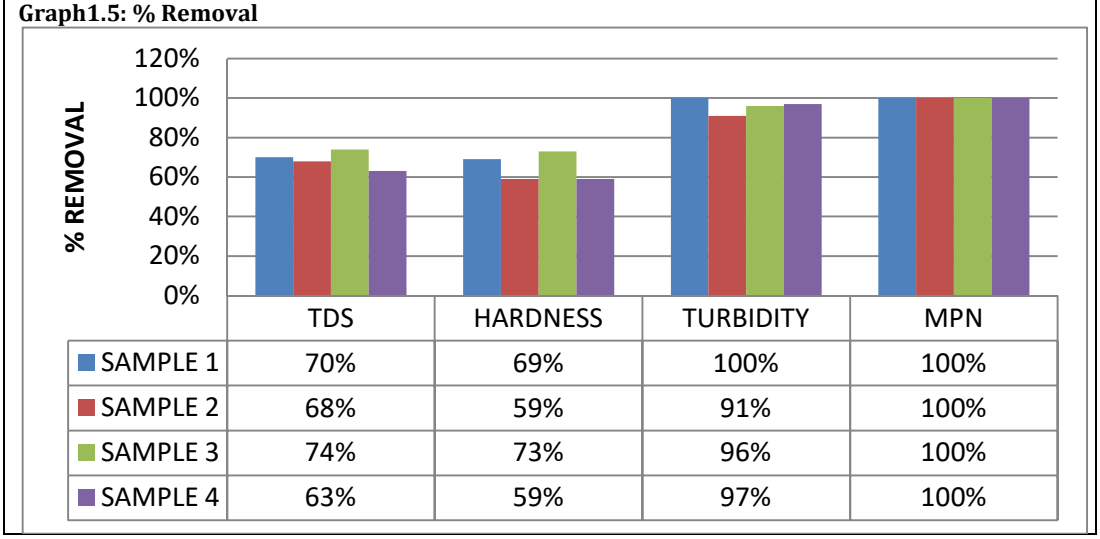
Graph1.3: Turbidity NTU



Graph1.4: MPN coliforms/100 ml



Graph1.5: % Removal



	TDS	HARDNESS	TURBIDITY	MPN
SAMPLE 1	70%	69%	100%	100%
SAMPLE 2	68%	59%	91%	100%
SAMPLE 3	74%	73%	96%	100%
SAMPLE 4	63%	59%	97%	100%

DISCUSSION

TDS

The TDS for the inlet samples was found vary from 210 to 780 mg/l. The removal of TDS in the distillate is between 60 – 75% (Graph 1.1) with sample 3 shows the maximum removal of 74%. (Graph 1.5) The desirable limit for TDS is 500mg/l & permissible limit is 2000mg/l as per Drinking Water Standards of BIS (1)

Hardness

The Hardness for inlet samples ranged from 260 to 790 mg/l. The removal of Hardness in the distillate is between 60 – 75% (Graph1.2).Sample 3 shows the maximum removal of 73%. (Graph 1.5) The desirable limit for Hardness is 300mg/l & permissible limit is 600mg/l as per Drinking Water Standards of BIS (1)

Turbidity

The turbidity of inlet samples was between 3.2 to 9.3 NTU. The removal of Turbidity in the distillate is 90-100 %. (Graph 1.3) sample 1 shows 100% removal. (Graph 1.5) The desirable limit for Turbidity is 5 NTU & permissible limit is 10 NTU as per Drinking Water Standards of BIS (1)

MPN

The coliforms present in the inlet samples were 3.2 to 23 coliforms/100ml. The removal of coliforms in the distillate is 100%. (Graph 1.4, 1.5) Guidelines as per Drinking Water Standards of BIS (1) for all water intended for drinking No coliforms must be detected in any100ml of water sample.

CONCLUSION

The average output of distillate for inlet volume 4liters has been 150ml with 6 hours of solar exposure. The quantity of distillate varies with the variation in temperature, light intensity, duration of solar exposure etc. The distillate obtained from the solar still has parameters such as TDS, Hardness, Turbidity, MPN within the desirable limit given for portable water by BIS. Thus it can be used in rural areas for drinking purpose as contaminated drinking water is one of the reasons of major health hazards responsible for almost 90 % of the health problems in rural areas. The model is simple and uses the materials easily available at any rural home. It requires no scientific expertise for operation. Thus the model is a viable economic substitute for expensive water filtration devices. This study will help in the decision-making process for the use of solar distillation to be easier, better, faster, and effective for providing portable water to the rural population. It is step towards achieving the Sustainable Development Goals of: Clean Water and Sanitation, Affordable and Clean Energy, Good Health and Wellbeing. Solar distillation is attractive as a renewably powered means of providing portable water at both large and small scales.(5) It is relatively simple operation & maintenance, no high tech exchange parts like batteries, filters or membranes.(7) Simple production facilitates independent drinking water supply for individual families. Hybrid designs - There are a number of ways in which solar stills can usefully be combined with another function of technology. Three examples are given: Rainwater collection. By adding an external gutter, the still cover can be used for rainwater collection to supplement the solar still output. Greenhouse-solar still. The roof of a greenhouse can be used as the cover of a still. Supplementary heating. Waste heat from an engine or the condenser of a refrigerator can be used as an additional energy input.

ACKNOWLEDGEMENT

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