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Solar Distillation of Water for Rural Household in India

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Abstract: ***With exponentially increasing population and rapid industrialization the available freshwater is becoming more polluted and scarce day by day. The effect of consuming this polluted water can be seen more severely in rural areas as most of the rural households do not have access to clean and purified water as compared to their urban counterparts.A major part of population living in rural areas of developing countries don't have privilege to useelectric water purifiers and alternatives of RO purifiers are expensive and requireskilledlabor to maintain and operate these units. A solar still is system that uses the energy of the sun to purify water.it is able to supply pure water for drinking and cooking, even in areas where there are no other sources of energy, while still being friendly to the environment.Peoples living near open cast mining sites such as in Jharkhand and other parts of India are facing huge problems related to polluted water. A person needs pure water for at least drinking purposes. Ouraim is to fulfill this mere necessity of individuals and make their lives a little better then now. Solution of these problems lies in use of renewable and non-conventional energy sources [1]. this study shows the basic principles of distillation by solar energy, types of solar still systems, and the developments in solar still systems.***

Keywords: Freshwater, RO purifiers, renewable and nonrenewable energy source

1. Introduction

This system is a distillation system which can be small or large. It can be designed either to serve the needs of a single family, producing up to 3 gallons of drinking water in a day on average, or to produce much greater amounts for an entire neighborhood or village. In some parts of the world, scarcity of fresh water is partially overcome by covering shallow salt water basins with glass in greenhouse-like structures. These solar energy-distilling plants are relatively inexpensive, low technology systems, especially useful where the need for small plants exists.Increasing water temperature and the area of water in contact with the air can accelerate the rate of evaporation.

A wide, shallow black painted pan makes an ideal vessel for the water. It should probably be baked in the sun for a while before it is used in order to free the paint of any volatile toxicants, which might otherwise evaporate and condense along with the drinking water. The pan is painted black (or some other dark color) to maximize the amount of solar energy absorbed. It should also be wide and shallow to increase the surface area, assuming the availability of a substance with good solar absorbing properties and durability in heated salt water.With care in design and operation, the solar still should, therefore, be capable of producing good drinking water free of cancer-causing pollutants and other harmful substances, water that is colorless, odorless and, unfortunately, tasteless. When the minerals common to drinking water are removed, taste goes, too. One flavor recommendation is to add small amounts of minerals or salts to the distilled water, since the minerals found in water may be healthful. Hanson et al. (2004) studied distilled water quality on a single-basin solar still. They reported the performance of a single-basin solar still for the removal of a selected group of inorganic bacteriological and organic contaminants in laboratory environment and actual field environment.

2. Methodology

The design methodology of the project involves designing a solar still as per the output **requirements.** The solar still is designed for an estimated **output of around** 2 **liters**.

2.1 Design Calculations

The calculation of the base area of the solar still is the most essential part as it is vital to know the area needed for desired amount of solar radiations to be incident in order to produce the required output [2]. With a desired output of 2 liters of water, the amount of solar energy required(Q_{req}) can be calculated as follows [3]:

$$M_W = \frac{Q_{req}}{L_V}$$

WhereM_w=Mass of water required and,
L_V=Latent heat of vapourisation.

Therefore,

$$2 = \frac{Q_{req}}{2260}$$

$$Q_{req} = 4520\ KJ$$

Now,
In order to obtain the quantity of incident solar energy (Q_{inc}), we are required to analyze the data of the average amount of solar energy incident in Ranchi. The average solar energy received in Ranchi throughout the year is $5.15 kWhr/m^2/day$.

Therefore,

$$Q_{inc} = \frac{5.15 \times 1000}{24} W/_{m^2}$$
$$= 214.58\ ^{W}/_{m^2}$$

Commercial glass transmits at least 80% of light rays incident on it. Therefore,

$$Q_{inc} = 214.58 \times 0.8\ ^{W}/_{m^2}$$
$$= 171.66\ ^{W}/_{m^2}$$

Suppose a period of 8 hours per day of incident solar energy,

$$Q_{inc} = 171.66 \times 8 \times 3600\ ^{J}/_{m^2}$$
$$= 4943.81\ ^{KJ}/_{m^2}$$

Thus,

$$Area\ of\ base\ required = \frac{Q_{req}}{Q_{inc}}$$
$$= \frac{4520}{4943.81} m^2$$
$$= 0.914\ m^2$$

Thus, let us consider area of base as 1 m^2 .

3. Manufacturing

The body of the solar still comprises of a triangular structure mounted over a cuboidal base. Commercial plywood is used to forge the entire setup [4]. As per calculations, the dimensions of the base are taken as 1200 mm × 900 mm for a 1.08 m^2 base area, considering the typical sizes of plywood available. The entire setup is a wooden frame of thickness 50 mm to ensure robustness and durability.

The triangular section is designed using trigonometric calculations. The total height of the frame is considered 620 mm.

The base of the frame is taken as 900 mm and, the angle of inclination of glass as 30° [5], the height of the triangular frame is calculated as 520 mm.

The triangular sidewalls of the frame are accordingly given dimensions. Fig. 1 shows the produced setup of the solar still and fig. 2 shows the working model of the same.

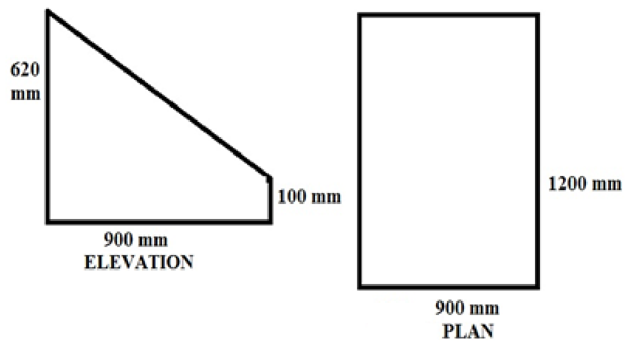

Figure 1: Dimension of solar still.

- Length of still = 900mm
- Breadth of still = 1200 mm
- Total height of still = 620 mm
- Height of basin = 100 mm
- Angle of inclination = 30°

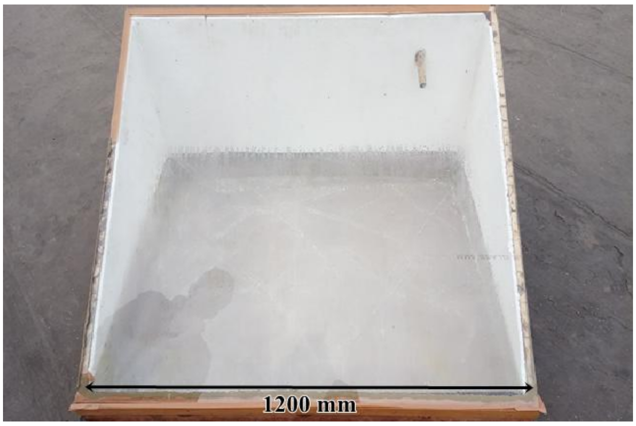

Figure 2: Working model of solar still

4. Results and Discussions

Testing was conducted on the solar still in the month of December and January. The volume of water initially filled was 16 liters and the output was noted.The observations and readings recorded are as follows:
Testing time: 8 hours.

Table 1: Observations when input was 16 liters

Days	Volume Of Water Input (Litre)	Volume Of Water Output (Litre)
1	16	0.7
2	16	0.6
3	16	0.7
4	16	0.7
5	16	0.8
6	16	0.6
7	16	0.5
8	16	0.9
9	16	0.8
10	16	0.7
	AVG.	0.7

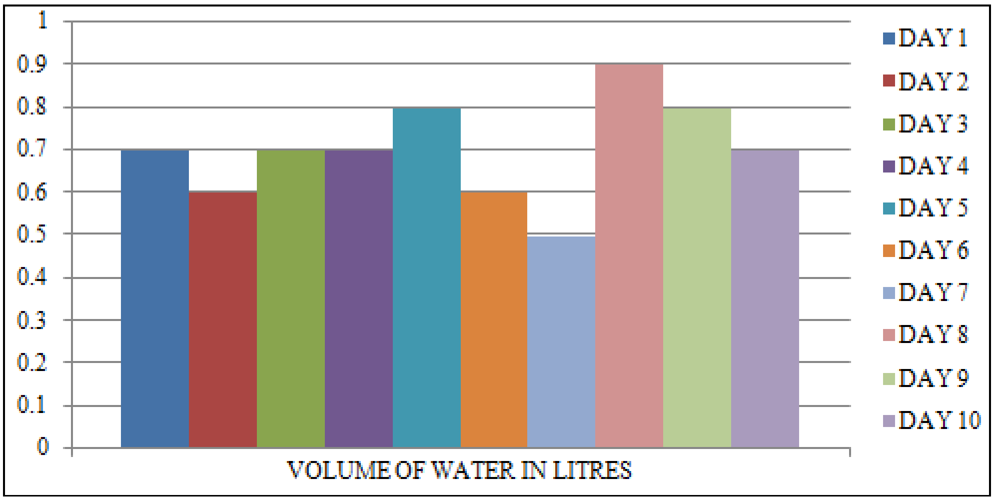

Table 2: Test for water quality.

Water Quality Parameters	*Initial Reading*	*Final Reading*	*Standard Reading*
Total Hardness	110PPM	22PPM	<200PPM
Flouride	0.0mg/l	0.0 mg/l	<1.5mg/l
Chloride	75mg/l	20mg/l	200mg/l
PH	8	6.5	6-8.5
TDS	110PPM	28PPM	<500mg/l
E.Conductivity	84µs/cm	72.72µs/cm	<250µs/cm

5. Conclusion and Application

The setup was installed and it was tested continuously for 10 days in the month of December and January. In India, during the said months, the time is of peak winter and this it was observed that output varies considerably for an input of 16 liters because of the heat received by the Sun. The output we got is tabulated in table 1 and a graph has been provided for the same.

The distilled water was successfully tested for various parameters, the initial and final reading for the same are mentionedin table 2.The total value involved in the manufacturing of the solar still is Rs. 9000. This water can be used for drinking purpose, in laboratories and in lead-acid batteries.

References

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