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Desalination of Impure Water

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Abstract*—Solar desalination is a process where solar energy is used to distill fresh water from saline, brackish water for drinking purposes, charging of the batteries and medical appliances, etc. In recent years desalination of water has been one of the most important technological work undertaken in many countries. Many areas in Middle East and elsewhere have little or no natural water supplies which can be used for human consumption and, hence, depend heavily on water produced by desalination. Several methods of solar water desalination are known. Many workers indicate that the utilization of solar energy for water desalination is becoming more attractive as the cost of energy is continuously increases. Solar desalination is particularly important for locations where solar intensity is high and there is a scarcity of fresh water. This work gave a cumulative distillate yield of litres for the 10 day test. The Atmospheric temperature fluctuated from 26°C to 30°C during the test period. The distillate water obtained boils at 100°C and freeze at 0°C which correspond to World Health Organization Standard.*

Keywords— Desalination, Distillate, Solar Energy, Impure Water, Boiling Point.

I. INTRODUCTION

Most of our earth surface is covered by water; however, less than 1% of total available water is fresh water which is mostly available in lakes, rivers and underground [1]. Again, about one-third of that potential fresh water can only be used for human needs due to mixed factors. Approximately 1.1 billion people in this world have inadequate access to safe drinking water. The world demand for potable water is increasing steadily with growing population [2]. There are 26 countries do not have enough water to maintain agriculture and economic developments. At least 80% of arid and semiarid countries have serious periodic droughts. A third of Africans and most of Middle-East people live without enough water (Bouchekima, 2003) [3]. The population growth - coupled with industrialization and urbanization results in an increasing demand for water. In India, the scarcity of desalinated water is severe in coastal areas, especially in the remote coastal areas. Renewable energy based desalination plants can solve this fresh water production problem without causing any fossil energy depletion, hydrocarbon pollution and environmental degradation [4]. In spite of the limitations of being a dilute source and intermittent in nature, solar energy has the potential for meeting and supplementing various energy requirements. Solar energy systems; being modular in nature can be installed in any capacity. Different methods of desalination have been used in several countries to resolve the crisis of drinking water. A variety of desalination technologies has been developed over the years on the basis of thermal distillation, membrane separation, freezing, electrodialysis, etc. (Howe, 1974; Buros, 1980; Spiegler and Laird, 1980; Porteous, 1983; Heitmann, 1990; Spiegler and El-Sayed, 1994; Bruggen, 2003) [5]. Commercially, the two most important technologies are based on the multistage flash distillation (MSF) and reverse osmosis (RO) processes. It is viewed that three processes – MSF, RO, and multiple-effect distillation (MED) – will be dominant and competitive in the future (Rautenbach, 1992; Rautenbach *et al*., 1995) [6]. For instance, in 1999 approximately 78% of the world's seawater desalination capacity was made up of MSF plants while RO represented 10% (Wangnick, 1998) [7]. Solar distillation is a process where solar energy is used to produce fresh water from saline or brackish water for drinking, domestic and other purposes. There are several distillation methods developed for water desalination technology which differ in simplicity, cost and applications. In the last decades, many researchers have been conducted to minimize the cost of this process, and several methods have been developed. Among these methods, solar distillation appears as one of the best practical and the most economical, especially for mass production of fresh water from high saline water like seawater (Saidur *et al.*, 2011)[8]. High energy cost of the evaporation process contributes most of the running expenditure in various distillation methods. The advantage of solar energy based small desalination plant is the requirement of small quantities of energy which is mostly collected from the sun [9]. This should be the most economical solution to provide potable water to villagers residing at remote areas where proper infrastructure is lacking. Solar distillation looks very attractive as it utilizes the free source of energy – the heat from the sun. Solar water distillation has begun over a century ago. In 1872, a solar plant with capacity around 4000 m^2 has been

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built in Chile and successfully ran for many years. In addition, the small plastic solar stills have been employed to provide potable water for life rafts floating in the ocean during World War II. Thus, the use of solar energy with water distillers has a long history and the technology is well improved and field tested throughout the world. Solar stills can serve the purpose of basic drinking water requirements of man. For countries like India, the domestic solar still is a viable safe water technology (Avvannavar *et al.*, 2008). India, being a tropical country is blessed with plenty of sunshine. The average daily solar radiation varies between 4 and 7 kWh/m^2 for different parts of the country. There are on an average 250–300 clear sunny days in a year, thus it receives about 5000 trillion kWh of solar energy in a year (Arjunan *et al.*, 2009) [10]. From its operational feasibility and associated costs, it can be inferred that solar still technology is quite capable to provide desalinated water to households in rural India. The fresh water crisis is already evident in many parts of India in varied scale and intensity at different times of the year. Also, the demand for fresh water increases with the growth of its population. The conventional desalination technologies are expensive for the production of small amount of fresh water. Also, use of conventional energy sources is costly and not always eco-friendly. Solar distillation is most attractive and simplest technique among other distillation processes especially for small-scale units located at places where sufficient solar energy is available.

II. MATERIAL AND METHODS

Materials

The water used in this work was collected from water pond located at Ezea in Ebonyi State, Nigeria. The pond is made of brackish water which contains salt and other dissolve mineral. It expected that the water has to under go a lot of chemical treatment before it will be safe for drinking. But some of the chemical treatments are expensive and the rural dweller cannot afford them.

Method.

Procedure for the Experiment.

The 15 liters brackish water was poured into a container having sieve on it to remove some material that might block solar still tap during discharge. The sieved water was then poured into distillation basin [11]. The set up was exposed to the sun to receive the sun radiation, Ofili and Ugwuoke *et al* (2016) [12]. The essence of exposing it to sun is that the solar radiation provides the energy which will heat the absorber basin painted black. The water in the basin will receive energy and increase in temperature. As the temperature of the water rises, vapor evaporates to the glass and condenses; it then trickles down from the sliding glass cover to the storage basin, where the pure water is collected.

pH Determination

Water reaction is usually expressed as concentration of hydrogen ion. When pH=7, water reaction is neutral; if pH is > or < 7 then the reaction change in the alkaline or acid direction, respectively [12]. In natural waters, the concentration of hydrogen ions depends on the dissociation and hydrolysis of the combination occurring in it. The table used for determination of the pH value of the water used in the experiment is shown below. The pH meter was used for the determination of hydrogen ion and the value of pH of the water obtained was 6.9.

Table.1: PH Value Ugwuoke et al (2016) 13

Water Type	Water Characteristic	pH
Acid	Water of Volcanize Exhalation	>2
Acid	Mine Water	3-4
Acid	Swamps	4-6
Acid	Ground Waters	5-7
Alkaline	Rivers	7.8-7.8
Alkaline	Fresh Lakes	7.3-9.2
Alkaline	Ocean	7.8-8.3
Alkaline	Salt (Soda) Lakes	Up to 10.5

Determination of Chemical Properties of the Water

Color of Water: The water color was determined by measurement of optical density (absorbance) on a spectrometer which has various wavelength of light passage. This works with the principle that the wavelength that was maximally absorbed by water is the characteristic of its colors [13]. The water that was used for the investigation was first filtered to eliminate possible turbidity. The value of the optical density is a measure of color intensity. In this experiment the 575-590 wavelength was maximally absorbed by the water.

Physical Properties of Water

Boiling Point of Water: 2 liters of water was used to determine the boiling point of water. The 2 liters of water was poured inside electric kettle with specification (Panasonic Automatic Electric Kettle, model NC-430, AC 220/240V, 2.0-2.4KW,9-10A,50-60Hz) of 4.3- liter capacity [12]. The kettle was plug and monitored for about 15 minutes. The temperature of the water was determined to be 106°C. The rise in the boiling point of water above 100°C was due to the impurities in it

III. RESULTS AND DISCUSSIONS

The experiment was done for a period of 10 days. The result obtained was not steady in other words the distillate produce for the period of 10 days varied. This was due to variation in solar radiation for the period the experiment was conducted [14]. It was observed that maximum

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distillate produced was 4.4 litres on day 7. On day 1 of the experiment 1.7 litres of water was obtained, this might be as a result of poor weather condition on that day as well as other factors. Ugwuoke et al recorded a maximum distillate of 2.3 litres on day 5 [14].Tiwari and Tiwari (2005) found a daily yield of up to 1.714 kgm^{-2} in their study [15]. Also Tenthani (2012) collected 2.549 kgm^{-2} average of distilled water daily with the improved solar still they performed experiment with in Malawi [16]. The experiment was performed at National Centre for Energy Research and Development, University of Nigeria, Nsukka. The average Insolation at Nsukka is 450W/m^2.

Table 1: Volume of distillate Water produced for a period of 10 days.

Time (Days)	Volume of Distillate produced (Litres)
1	**1.7**
2	**2.8**
3	**2.5**
4	**3.1**
5	**1.6**
6	**3.5**
7	**4.4**
8	**3.9**
9	**1.7**
10	**3.6**

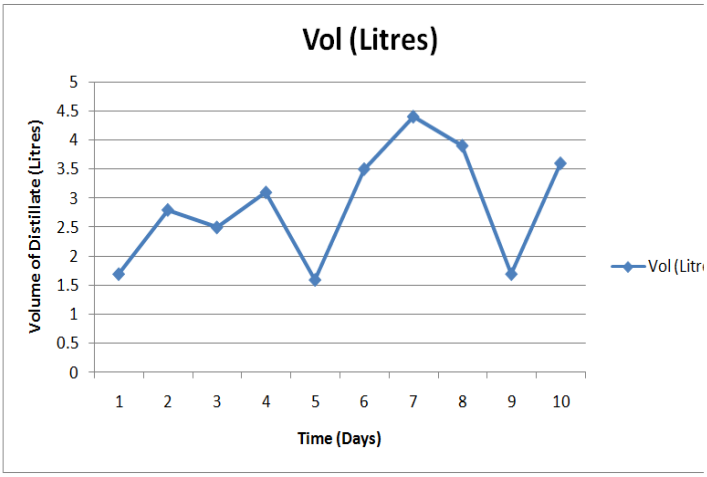

Fig.1: Volume of distillate (Litres) Versus Time (Days).

Table.2: Maximum Atmospheric Temperature for a period of 10 days.

Time (Days)	Maximum Atmospheric Temp (°C)
1	26
2	29
3	27
4	29
5	26
6	28
7	30
8	29
9	27
10	29

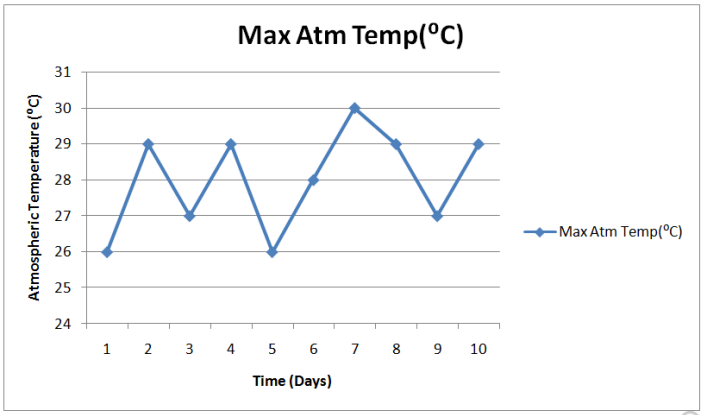

Fig.2: Maximum Atmospheric Temperature (°C) Time (Days).

IV. CONCLUSION

Clean water is essential for socio-economic development. Nevertheless, there is limited access to water that meets standard limits of water quality, especially in the African region. The quality of water can be improved through desalination.

Conventional techniques for desalination are available but they require a large input of energy, mostly from fossil fuels that contribute to environmental degradation. Consequently, there is need to use sustainable energy sources, with solar energy being one of the most promising alternatives. A conventional solar still (CSS) is widely exploited but it has low efficiency. Thus, numerous modelling and design attempts have been made to improve its performance. This work centred on proving quality drinking water to small household, Ocean divers and rural dwellers. The maximum distillate produced during the experiment was 4.4 litres.

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