Design and Evaluation of a Portable Water Distillation System

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Abstract— *The need for quality drinking water these days is on the increase. Many scientists have proved that some tap water and rain water which many people drink are not so good due to impurities and some salt that some of the water contain. This may cause serious health problem. A portable solar water distillation system has been designed in this work to reduce some of the health related problems associated with poor water supplies. The major component of the solar still include (i) Still Basin (ii) Glass cover (iii) Tap (iv) Insulation .The solar still design in this work has a capacity of 10 litres and the maximum of 4.3 litres of water was produced. The maximum atmospheric temperature obtained during experiment was 34^{o}C. The higher the atmospheric temperature the higher the quantity of distillate water obtained.*

Keywords—*Distillation, Atmospheric temperature, Impurities, Distillate, Temperature.*

I. INTRODUCTION

Water and energy are two inseparable items that govern our lives and promote Civilization [1]. Looking into the history of mankind one finds that water and civilization were also two inseparable entities [2]. It is not a coincidence that all great civilizations were developed and flourished near large bodies of water [3]. Rivers, seas, oases and oceans have attracted mankind to their coasts because water is the source of life [4]. The transportation of drinking water from far-off regions is usually not economically feasible/desirable, desalination of available brackish water has been considered as an alternative approach [5]. More than two-third of the earth's surface is covered with water [6]. Most of the available water occurs either as seawater or icebergs in the Polar Regions [7]. About 97% of the earth's water is salty, while the rest is fresh water, of which less than 1% is within human reach [8]. This small percent is still adequate to support life on earth and is replenished through a large scale solar distillation process through what is known as the hydrological cycle [9]. Distillation is one of many Processes that can be used for water purification [10]. Most commercial stills and water purification systems require electrical or other fossil-fuelled power sources [11]. The use of electricity in distillation apparatus, like in fractional distillation, is energy intensive [12]. Air pollution, acid rain, global warming and climate change are but a few of the consequences that are attributed to use of fossil fuels and have been widely investigated [13-14]. Single-basin stills have been much studied and their behaviour is well understood. The efficiency of solar stills which are well-constructed and maintained is about 50% although typical efficiencies can be 25%. Daily output as a function of solar irradiation is greatest in the early evening when the feed water is still hot but when outside temperatures are falling. At very high air temperatures such as over 45ºC, the plate can become too warm and condensation on it can become problematic, leading to loss of efficiency.

II. OPERATIONAL PRINCIPLE

Water to be cleaned is poured into the still to partially fill the basin. The glass cover allows the solar radiation to pass into the still, which is mostly absorbed by the blackened base [15]. This interior surface uses a blackened material 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 glass cover increases. The heated water vapour evaporates from the basin and condenses on the inside of the glass cover. In this process, the salts and microbes that were in the original water are left behind. Condensed water trickles down the inclined glass cover to an interior collection trough and out to a storage bottle

Design Analysis

Assumptions

- Volume of water to be heated, v = 14 litres
- Average heating time, t = 8 hours
- Average Insolation, G = 430 W/m^2
- Ambient temperature, Ta = 26^{o}C
- Water inlet temperature, T_1 = 26^{o}C
- Transmittance of the cover material, ε= 0.9
- Absorbtivity of the absorber plate (coated with black enamel paint), α= 0.83
- Angle of inclination of solar collector = 14 degrees

Measured Parameters/Design Parameters.

- Thermal conductivity of absorber plate, ka = 245 W/mK
- Thermal conductivity of insulating material, km = 0.06 W/mK
- Number of cover material (glazing), n = 1
- Area of the basin = $0.36m^2$
- Area of the collecting surface = $0.362m^2$
- Height of the backside = 0.40m
- Height of the front side = 0.20m

Different Parts Of The System.

Still Basin

This is for keeping of the brackish water or dirty water to be distilled. This is made of mild steel of 3mm thick plate. The volume of the basin is 10 litres. The still basin has dimension of 600mm x 600mm.

Top Cover

This is made of glass cover of transmitivity 0.85. Though other material such as polyethylene could be used for the construction. The dimension of the glass cover is 602 × 602mm.

Tap

Metal tap of 1 inch pipe was used for water passage.

Insulation

This is made of non-conductor such as cotton wool to prevent the heat from going out thereby increasing the quantity of distillate obtained everyday.

III. RESULT AND DISCUSION

The result obtained showed that the portable solar still design could provide a drinking water for an individual for a day. From fig1 below the volume of distillate water obtained from the brackish water used was not steady from day 1 to day 10. This was due to unsteady sun radiation during the experiment. The experiment was performed at National Centre for Energy Research and Development, University of Nigeria, Nsukka. The average Insolation at the centre is $450W/m^2$.

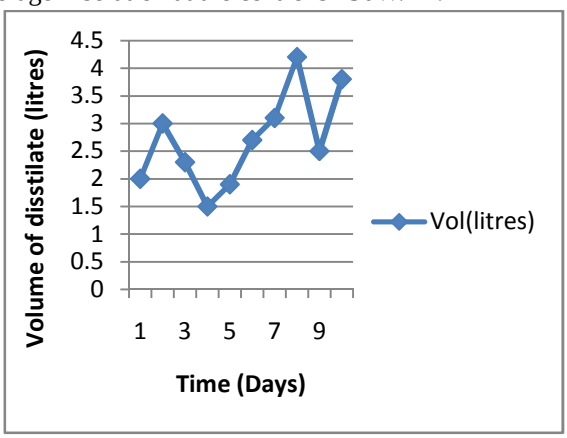

Fig. 1. A graph of volume of distillate (litres) versus time (days)

IV. CONCLUSION.

Unclean water could be made clean by exposing the water in direct solar radiation and allowing the water to evaporate in a well design system called solar water distillation system otherwise known as solar still. The work was able to achieve water purification for an individual for one day. The minimum volume of water obtained from the experiment is 1.5 litres.

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