Development of Basin Solar Still

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Abstract: The basin solar still was developed by adding a magnetic treatment unit, its energy 0.12 Tesla and two layer of glass provided with water between them. The study was conducted by testing the device by using magnetic water and double glass provided with water, non-magnetic water and double glass cover, magnetic water and single glass cover, non-magnetic water and single glass cover and control treatment (without additions). Intensity of incidence solar radiation in Pune province during the month of April, Temperature in the basin solar still, glass cover surface, ambient, pH, water electric conductivity, productivity, density, physical and chemical properties were measured. Theoretical productivity and efficiency were calculated. The results showed that the average of solar radiation intensity is 889.55 W/m². Temperature of basin solar still, glass cover surface and ambient increased with increasing solar radiation intensity. The maximum of temperature in the basin water of solar still is 56.61°C at using magnetic water and single glass cover which has best performance compared with other treatments and having pH 7.03, and its productivity improved by 50% compared with conventional.

Index Terms: Solar Still, Basin, Magnetic Water, Glass

I. INTRODUCTION

Water is life in all its forms. All living organisms contain water the body of a human being is composed of approximately 60% of water, a fish of 80%, plant between 80 and 90%. Water is necessary for the chemical reactions that occur in living cells and is also in the middle of this water that these cells are formed. Water is essential to sustainable food production as well as all living ecosystem, human development is based entirely on the hydrological cycle (Chaouachi, 2011). Solar desalination is one of the cheapest methods for distilled water production. Solar still is widely used in the solar desalination. The yield of the single basin solar still is very less compared to that of other conventional Desalination methods (Tanaka et al., 2000). Single basin solar still is a popular solar device used for converting available brackish or waste water. Because of its lower productivity, it’s not popularly used. A number of works are under taken to improve the productivity of the still.

The still productivity and efficiency depend on parameters like location, solar radiation intensity, atmospheric temperature-basin water depth, glass cover material, thickness and it’s inclination, wind velocity and the heat capacity of the still (Tiwari et al., 1995; 1998; Singw et al., 1995; Ghoneyem and Ileri, 1997; Tiwari and Madhuri, 1985; El-Sebaii, 2000; Yousef and Abu-Arab, 2004; Tripathi and Tiwari, 2006). Akash et al. (1998) and Tiwari and Tiwari (2007) were carried out to determine the still efficiency, the efficiency was ranged from 15-25%. Moreover, a parameter study was performed Al-Hinai et al. (2002) on a conventional double-sloped single basin solar still under climate conditions of the sultanate of Oman at the Gulf region, this study showed that under optimum design condition, the still trends to give an average annual solar yield of approximately 4 l/m²-day. Nafey et al. (2000) stated that using black gravel of 20-30 mm size improve the productivity by 19% at the condition of 20 l/m² brine volume and 15° glass cover angle. Also Velmurugan et al. (2008) added pebbles in the solar still and found that the Productivity increased by 20% than the conventional solar still. Productivity of solar still was increased with increase of absorber area. Fins are integrated with solar still to increase the absorber plate area (Velmurugan and Srithar, 2011). The aim of the present paper is to development of basin solar still by adding magnetic treatment unit and double glass content here.

II. MATERIALS AND METHODS

Water magnetic unit is used to producing magnetic water and double glass cover provided with water was added to the solar still. Apparatus consist of basin area of the still is 0.24 m² manufactured using iron steel of 18 gauge thickness. The bottom and sides of the basin are insulted by 2.5 cm thick foam surrounded by wooden frame of 2 cm thickness. Trough made of aluminum which used to collecting distilled water that put in the forward the basin which have 0.25 in. diameter aluminum pipe which connected with plastic pipe to output distilled
water. The basin is containing of porosity black stones, the purpose of black stones to absorbance solar radiation and heating of basin water, as well as increasing the evaporation. Tank is made of stainless steel 314 and connected behind the solar still. Magnetic treatment unit was connected under tank that consists of two static magnets their intensity is 0.12 Tesla and the plastic pipe put between them to producing magnetic water. Using magnetic water to producing low surface tension of water which increases the evaporation then increasing of productivity. Balance tank was setup beside of the solar still to control on water level in the basin. Aluminum foil was putted in the inner wall of basin to reflect sun rays on the water basin. Double glass cover inclined 30 degree was provided with water is put between glasses to increasing of condensation. Solar radiation intensity was measured by Pyrometer type Kipp-Zonen Model CM11 is used for measuring solar radiation data. Through this instrument most of the available data on solar radiation are obtained. A pyrometer produces voltages from the thermopile detectors that are a function of the incident radiation. Temperatures of basin water and glass cover are measured by thermocouples type cu-constantan. Ambient temperature is measured by a thermometer. pH is measured according to APHA (1995). Electrical Conductivity (EC) was measured, according to Chapman and Pratt (1962). pH, Total Dissolved Solid (TDS) were measured by water analysis kit and manual methods. Calcium and magnesium hardness of water was estimated by complex osmotic titration method (Prajapati and Roal, 2004). Chloride contents were determined volumetrically by silver nitrate titration method using potassium chromate as an indicator. It was calculated in terms of ppm (Mitra and Gupta, 1999). Productivity (l/m².day): the collection of output distilled water from distiller at limit time has been measured then productivity is calculated from the following:

\[
\text{Productivity} = \frac{\text{Mass loss rate}}{\text{Unit area}} = \frac{(\text{Vapor Pressure} - \text{Ambient Partial Pressure}) \times \sqrt{\frac{\text{Molecular Weight}}{2\pi R T}}}{2.303 R}
\]

The Vapor Pressure of a liquid at a given temperature is a characteristic property of that liquid. Vapor pressure of a liquid is intimately connected to boiling point. Vapor Pressures are influenced by Temperature logarithmically and this relationship is defined with the Clausius Clapyron Equation:

\[
\log \frac{P_2}{P_1} = \frac{\Delta H}{2.303 R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right)
\]

Where:
- \( R \) = universal gas law constant = 8.31 J/mol-K
- \( P_1 \) and \( P_2 \) = vapor pressure at \( T_1 \) and \( T_2 \)
- \( T_1 \) and \( T_2 \) = Kelvin Temperature at the initial state and final state.

But reducing operating temperature will come at the cost of lower rated of evaporation and consequently lower rated of condensation leading to slower distillation. So now the problem boils down to increasing the rated of evaporation at lower temperature.

Constructing a solar water distiller using available utensils like plastic for casing, aluminum for absorption of heat, glass and the thermocol for insulation. Got the temperature of water up to 60 degrees and 1000 ml of distilled water in 4 hours.

Figure 1: Schematic diagram of basin solar still with magnetic water and double glass.

1. Tank
2. Plastic Pipe
3. Magnetic treatment unit
4. Static magnet
5. Porosity black stones
6. Balance tank
7. Float
8. Basin water
9. Plastic pipe
10. Basin
11. Wooden frame
12. Trough
13. Pipe
14. Reflector
15. Inner glass cover
16. Outer glass cover
17. Water

III. RESULTS AND DISCUSSION

The experimental work was carried out in Pune. The theoretical and practical solar radiation intensity during day hours is shown in Fig. 3. The maximum and minimum of practical solar radiation intensity average was 1084.33 and 602.40 W/m² respectively in April in clear days. The theoretical solar radiation intensity was higher than the practical solar radiation intensity in the morning and after hour of 15.00 but the theoretical solar radiation intensity was lower than the practical solar radiation intensity at day hours from 11.30 to 15.00. The variation between the practical and theoretical solar radiation intensity is caused by to the theoretical values was depended on the apparent extraterrestrial solar radiation, extinction coefficient and diffused solar radiation coefficient are calculated for United State American cities by meteorological stations. Conditions of these cities are differ from Pune city conditions, these factors led to the variation between the theoretical and practical data, as well as present light dust in Pune weather is led to reducing the solar radiation intensity in some times. These results are agreed with (Al-Hilphy, 2006; Al-Hilphy 2010). Average practical solar radiation intensity in April 2013 is 889.55 W/m².

Fig.4. Temperature of ambient, basin water and glass cover during day hours in April 2013 at using single glass cover and without magnetic water.

Figures 2-5 illustrated the change in the temperature of ambient, glass cover and basin water during day hours with and without magnetic treatment unit and single or double glass cover. Results showed that the temperature of ambient, glass cover and basin water are increased with increasing day hours up to maximum value at 15:30 pm (except ambient temperature at 15.00 pm) and then it decreases at using magnetic water and double glass cover (Fig. 3). This is because increasing of solar radiation intensity with day hours at 10:00 am to 12:00 noon and this may be attributed to the increase of the absorbency of the solar energy entering the still by water.

IV. CONCLUSION

A basin solar still was fabricated and tested. The optimized modified desalination system was magnetic water and single glass cover. The efficiency was calculated as 32.55% which is comparable with stills being worldwide. The productivity of the basin solar still is augmented by adding magnetic water and single glass cover and improved by 50% compared with conventional treatment. Also it is found that quality of distilled water using magnetic water and single glass cover is better than other treatments.

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