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Development of Single Slope Solar still for Distillation of Domestic Waste Water

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Abstract –As we you known that we having only 2.5% of all the fresh water in this planet? In this generation safe and fresh water is very important for humans. A water crisis when there is not enough to portable water for our population which is twist into the death and famine due to lake of fresh water in this earth. Due to lack of drinking water every year 1,8 billion peoples affected from it. Today fresh water is very important and delight for the hot-regions like Africa regions and the country having deserts. The most of the sources of the freshwater water in rural areas are terribly polluted due to poor sanitation, industrial effluents, and the water with **Arsenic, Fluoride** water and the lack of waste treatment plants. The various types of technology we having today to eliminating the various types of impurity in freshwater, like reverse osmosis**, ETP plants** (Effluent treatment plant), different types of solar distillation of water. Toady the need of promote appropriate technology like distillation, which are economically and environmentally friendly, as increasing the load or stress on renewable energy using sources like **fossil** fuel, **coal** and etc., technologies which is based on effectively harnessing solar energy prove sustainable. Solar- still distillation is a technology that efficiently harness of natural energy on earth. The solar – still produce safe and clean water from contaminated from arsenic and deferent types of harmful brackish water. the current article shows the silent contribution of **solar-still** distillation and their performance.

Key Words: (Arsenic, Fluoride, ETP plant, Coal, Fossil)

1.INTRODUCTION

Today fresh water is most important and crucial natural resource on this earth. Equitable availability is one of the most supreme environmentally, political and community challenge facing humans nowadays. The increasing demand of freshwater is so scare in the term of quality of water. as using of freshwater pumping from ground and the surface water reservoirs like lake, rivers and others resources. Its essential to development of such an un-conventional method due to increasing the demand of freshwater on various exertion region countries like Africa and deserts area. As we know the sea water is easy and more accessible source than freshwater reservoirs. sea water cannot drinkable but there is various types of technology and method to remove these types of impurities like salt, arsenic fluoride etc from water. Solar desalination is converting saline, arsenic and brackish water into the fresh water. The different types of methods and process like reverse osmosis (RO), electrodialysis (ED), multi-humidification (MED), zero liquid discharge (ZLD) effluent-treatment plant (ETP) it used for large scale operation for water treatment. These types of desalination method used for large-scale industrial or domestic water treatment and more costly than other natural types of distillation methods. The prospectus is to utilize the deferent desalination methods integrated with a sustainable and renewable energy source. A technology that we need to be effective and simple (easy to operate /use) it consumes lees energy and should be self-community among the community.

1.1 REASONS FOR OPTING SOLAR STILL

The solar distillation process is considered as one of the simplest and worldwide adopted techniques or method for converting seawater arsenic, fluoride and other impurities into fresh water. The contains of Arsenic and fluoride water lead to different types of health defect on human health like skin lesions and cancers, problems with blood vessels, high blood pressure, heart disease, nerve effects including numbness and/or pain, and interference with some important. The main advantage of solar distillation is used over the eliminate these impurities from fresh water. One of the main advantages of the distillation process is that it requires heating only up to 60 - 100°C, which can be supplied from solar energy or other cheap fuel like crude oil, fossils fuels. The solar desalination processes such as multi stage flash evaporation, reverse osmosis, electro dialysis, ion-exchange, phase change and solvent extraction are energy intensive, expensive and uneconomical for small quantities of fresh water. Because of the simplicity of the apparatus design, requirement of fresh water, and free thermal energy, work in the field of solar distillation has been in progress for more than one hundred years. These types of desalination method is use or adopted by many countries like India, Australia, Spain and many other countries. There are various categories of solar stills namely basin solar stills, solar collector still, multiple condensing cover still, wick type solar still, vertical solar still etc. of which more than 90 percent of all functioning stills are of the basin type.

1.2 PRINCIPLE OF SOLAR STILL

Today there is big need of find the way to provide fresh water to human population. The easy and effective way is solar distillation, solar distillation simple and effective method to remove harmful factor from water by using nature energy source (solar energy). Solar distillation work on two principles by Condensation& Evaporation, in this distillation process minerals salt & another solid particle do not evaporate Example steel balls and sponge, rock etc. Solar still take some time and energy to convert saline water into water vapour from normal water 20°C to 100°C and partially energy given when the water vapour condenses. Generally, the bottom of solar still is always cover with heat absorbing material or layer and the most and commonly using the black colour material because of black material absorb or trapped and speeds the sunlight in bottom of basin and the topped of still cover with plastic or glass material. This glass is holding the evaporate fresh water, and sliding toward were waters store through PVC pipe and water is collecting from beaker which placed the outlet of still. another impurity (salt, material, rocks etc) is fall down to the bottom of basin. Generally, one solar still produced enough fresh drinkable water for single person.

2. Design & Development of single slope solar still

A basin still basically consists of the following essential components basin, stainless steel sheet, insulation, energy storage material and distillate throughput The basin area of the still is 3ft 2 fabricated using stainless steel sheet of 13mm-gauge thickness. The bottom and sides of the basin are insulated by 15mm cm thick thermocoal sheet, surrounding of stainless steel is covered by using of wooden sheet. By using 14 quantities of c-type clamp for better resting of glass to the frame. Insulation provided around the stainless-steel frame by thermocoal, this is provided proper insulation and reduces heat loss. Total area of still is covered by using wooden sheets 710mm × 600mm×423mm as shown in fig 2.1.

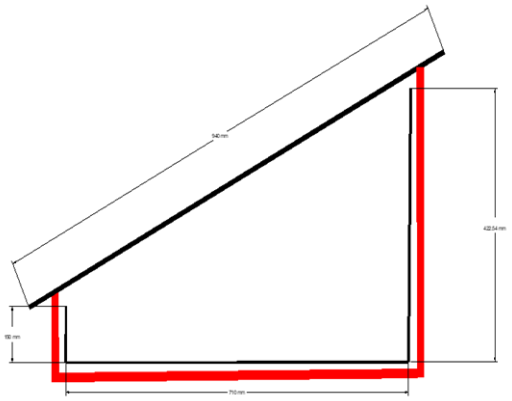

Fig 2.1 schematic diagram of solar still setup

The surface of basin is covered with black paint, because black is store and speeds and absorb the heat radiation. for distillation output one end of still is connected to another end with PVC pipe for better throughout, the main working of though is to collect the evaporate freshwater which is comes from glass by sliding motion (water droplets). Some degree of slope that is 40° of angle. some portion of collecting PVC pipe is extends from setup due to collect the freshwater through Beker. Toughness glass is provided to covered top of experimental setup its permit to sun rays to inside the stiller and rise the temperature of hot water in the still basin .in fig shown the experimental setup of solar still.

Fig 2.2 Experimental setup of solar still setup

3. Distillation output and result

A theoretical and experimental study was conducted at the central Indian location of Nagpur, Maharashtra., India (21.1458° N, 79.0882° E) Examination of the given solar still's performance was caried out through measurements of different parameters for two solar stills contain different amount of energy storage material in each one. In this experimental setup use of energy storage material is Aluminum chips, all experimental measured parameters are performing or record on every single hour from morning 8am to 8 pm during 5 days from 17 April 2022 to 22 April 2022. For both setup is identified as a setup-1(S1) and another is setup -2(S2) both of still's basin is feed by waste water in same depth of level but in (S1) still is fill by waste water and energy storage material and another one still is fill by inlet of waste water. This all activity is performed or tested at JD college of engineering and management, Nagpur, Maharashtra -441501. The measured parameters concerning the distillation process are the hourly distillated amount of water for both of model. All temperatures are measured by using of PT-100 sensor this sensor comes from category of Resistance Temperature Detectors or RTDs. All wind and other details have been determined from the recorded official weather data for Nagpur city. Table 1 is shown all output of distillated freshwater this all performance in month of April 2022.

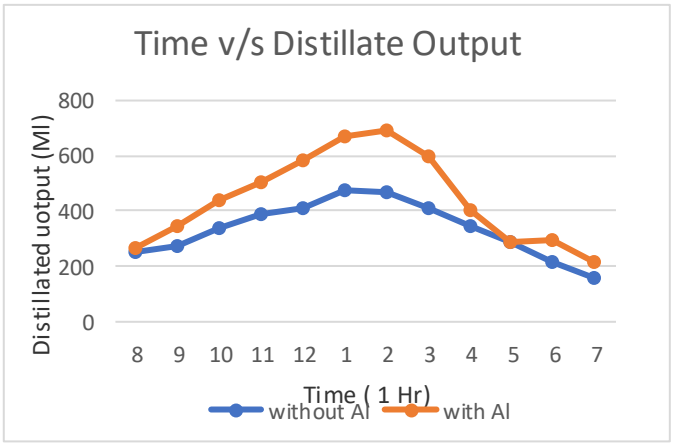

Chart: -3.1-Time v/s Distillate output

Chart 3.1 shows the variation of the hourly productivity (amount of distillated water) along the day for the two stills setup. With aluminum and without aluminum material. In this experimental procedure hourly productivity taken of both still as increasing time the output of distillate water is increased as shown in above fig, with increasing time after the afternoon the output of still is decreased in sunset output of still is very low but due to hotness of water and small amount of heat radiation inside the basin, however output is very less.

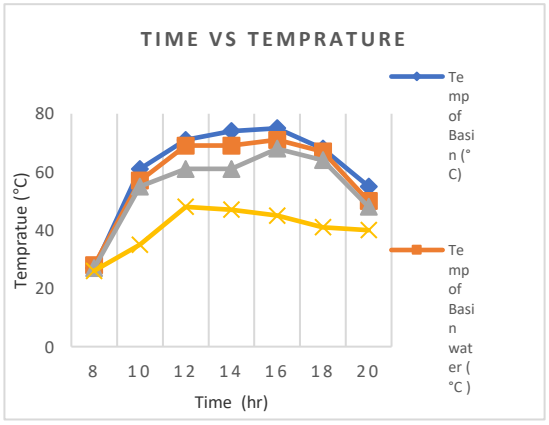

Chart: - 3.2-Time v/s Temperature

The observation of time and temperature is shown in above Chart 3.2, in this observation taken of different temperature measurements of outside and inside of still. As rising of time, the temperature was also rise and after the sunset or afternoon the decreasing of the temperature. This all temperature is taken by using of PT-100 sensor with Data-logger. The table 1 shown in above, in this table given technical specification of solar still.

Specification	Dimension
Basin area (A_b)	0.5mm(4ft*6ft)
Glass area (A_g)	4mm (94cm*89cm)
Latent heat of vaporization for water (h_{fg})	2382.9 kJ/kg
Emissivity of glass (g)	0.89
Emissivity of water (w)	0.96
Thickness of thermocol (L_{th})	18mm
Thermal conductivity of thermocol (K_{th})	0.050 `W//mK
Thickness of wood (L_{wood})	16mm
Thermal conductivity of wood (K_{wood})	0.13W/mK

Table -1 Technical specification of the l

4. Initial Investment

Sr no	Component details	Size	Quantity	Cost
1	Stainless Steel Sheet (SS304)	Thick: 0.5mm(4ft*6ft)	2	4400
2	Wooden Sheet	Thick: 18mm(4ft*8ft)	2	2500
3	Toughness Glass	Thick:4mm (94cm*89cm)	2	3100
4	Thermocol sheet	Thick: 18mm	16	640
5	wooden Bidding	3.5 ft	10	250
6	Pipe System (Valve, pipe, joints)	10ft PVC pipe	2Each	800
7	C Clamp	-	8	680
8	PT-100 Sensor	Length: 80 inches	10	6100
9	Datalogger, pyranometer	-	1Each	8500
10	Rubber Seal	-	4	450
11	Carpenter	-	-	700

5. Instruments

1. Ten PT-100 Resistance Temperature Detectors or RTD coupled to digital datalogger with a temperature range from 20° to 80°C with ±2.5°C accuracy is used to measure the temperatures of the various components of the still system.

2. The solar intensity was measured with the help of a calibrated pyranometer of least count of 2 mw/cm^2 (1mW/cm^2=10W/m^2). It's generally measured the total solar radiation. Range is 210 to 3600 µm

3. 150 mm steel rule fixed inside wall is used to measure water level inside basin with least count of 0.5 mm

4. The distillate output was recorded with the help of a measuring cylindrical beaker of least count 1 ml.

6. WHO standard for water quality

Parameters	WHO standard for drinking water	India standard for drinking water	Before Distillation	After Distillation
PH	6.5-8.5	6.5-8.5	7.5	6.9
TDS (total dissolved solid)	600 mg/l	500 mg/l	14050	190.36

Table – 2 WHO drinking water standard

7. Reading & Calculation

Here, it is how we will calculate mass of water after the experimentation

Theoretical Calculation:

We have to calculate **Distillate Output** (m_{ev}) in ml/hr. Taking,

Temperature of glass (T_g)=39 °C

Temperature of water (T_w)=49 °C

Now,

Partial vapor pressure at glass temperature (P_g)

P_g = exp (25.317 – 5144/ T_g + 273)

P_g = exp (25.317 – 5144/39 + 273)

P_g = 6835.059 N/m^2

Partial vapor Pressure at water temperature (Pw)

P_w = exp (25.317 – 5144/T_w + 273)

P_w = exp (25.317 – 5144/49 + 273)

P_w = 11405.428 N/m^2

To Calculate ΔT', ΔT' = [(T_w – T_g) + (P_w – P_g) (T_w + 273)/26809 *10^3 – P_w]

ΔT' = [(322-312) + (11405.428-6835.059) (49+273)/2689*10^3-11405.428]

ΔT' = 15.7153 °C

From above value find,

Convective heat transfer coefficient between water and glass cover

Then, h_c = 0.88 (Del T')$^{1/3}$

h_c = 0.88 (1507153)$^{1/3}$

h_c = 2.204

Now, Calculate Evaporative heat transfer coefficient from water surface to glass cover (W/m^2°C)-(h_{ew})

h_{ew} = 0.016273*h_c*(P_w-P_g) /(Tw-T_g)

h_{ew} = 0.016273*2.204*(11405.428-6835.059)/ (49-39)

h_{ew} = 16.3919W/m^2°C

Now, Calculate

Evaporative heat transfer from water surface to glass cover (W)

Q_{ew} = h_{ev} (T_w - T_g)

Q_{ew} = 16.3919 (49 - 39)

Q_{ew} = 163.919 W

The Latent heat is given by,

L = 3.1615*10^6 * [1 - 7.6160 *10^{-4} T]

L= 3149.461 J/kg K

Distillate output in ml/hrs. (hourly)

Therefore, by theoretical calculation we have find Distillate output (m).

Nomenclatures

h_c - Convective heat transfer coefficient between water and glass cover, (W m^{-2} K^{-1})

h_{cw} — Convective loss coefficient (W/m^2°C)

h_{ew} — Evaporative heat transfer coefficient from water surface to glass cover (W/m^2°C)

L — Latent heat of vaporization (J/kgk)

m_{ew} — Distillate output (ml/h)

P_g — Partial vapor pressure at glass temperature (N/m^2)

P_w — Partial vapor pressure at water temperature (N/m^2)

q_{cw} — Convective heat transfer from water surface to the glass cover (W)

q_{ew} — Evaporative heat transfer from water surface to glass cover (W)

T — Operating temperature (°C)

T_g — Glass temperature (°C)

T_w — Water temperature (°C)

The hourly distillate output of the solar still is estimated by the theoretical analysis. The convective heat losses and, evaporative loss and others losses coefficients are calculated using standard correlations as discussed above.

8. CONCLUSIONS

From the experimental and theoretical studies, and several parameters were found to impact of the performance of the solar still the maximum daily productivity can be found in this solar still. The hourly productivity of the solar still with and without coal cinder depends on the evaporation rate. Solar still will be effective at night because material which is

used is a heat storage material. As per above results if the water depth increases, the output of the still decrease. It is also pointed out that the operating temperature of the vapour, basin water and basin liner are lowered when the water depth is increased. The highest average daily output was 670 lit /day from 5 days of observation. The variation was found in output of distillated freshwater due to aluminum (Al) as an energy storage material. The variable in the output of solar distillation is shown in above fig 3.1. The solar still reduces most of the impurities well below the standards set by WHO and it can be used for drinking purpose also. Due to shortage of fresh water solar still distillation is most appropriate for long distance area and communities who's suffer from freshwater. Solar still distillation is belaud technology because this method uses no electricity to run the distillation process, require no running water to work, and easy to maintenance of setup and easy to use. Solar still is ecofriendly, not pollute the environment and remove all contaminate such like salt, impurities, sand, arsenic, fluoride and micro-organicism.

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