Study and Designing of Single Basin Solar Still for Soldiers in Remote Area

Singh Sandeep

M. Tech (Mechanical Engineering, , IV Semester, II Year, Rajshree Institute of Management & Technology, India

Abstract: ***Clean and affordable water is now regarded as a great commodity by the international community. A 2007 statement from the Office of the UN High Commissioner for Human Rights states that "it is now time to consider access to safe drinking water and sanitation as a human right, defined as the right to equal and non-discriminatory access to a sufficient amount of safe drinking water for personal and domestic uses—drinking, personal sanitation, washing of clothes, food preparation and personal and household hygiene—to sustain life and health". Safe drinking water is one of our fundamental needs, without which is not possible. Although Water purification units still exist in the military. But it cannot be carried or used everywhere and anytime (Remote area, Hilly area, Wartime, Muddy area etc). The ground was muddy and saturated with water, causing problems. At these places getting pure water is not possible all the time. This paper relates to the study and designing of single basin solar still for Soldiers in those remote area. These solar still is easy to construct. It can be transported anywhere easily and also it requires less maintenance.***

1. Introduction

There is plenty of water available in the form of oceans which covers more than 70% of the earth surface. But sea water is saline and contains large amount of salts, not suitable for human consumption. The salts in the sea water exists in the form of chloride, sodium, sulphate, magnesium, potassium etc. Chloride and sulphate contribute to about 55% and 31% of sea salts respectively.

Table 1.1: Shows different salt concentration in the water

Fresh Water	Brakish water	Saline water	Brine water
<0.5%	0.5-30%	30-50%	>50%

Other problem relates to the water which is mixed with mud / Soil. To extract water from swamp is not possible by any filtration process except evaporation of water.

Other than the salts, there are many other unwanted elements, like bacteria (e. coli, Cholera), Parasites (Giaddia, Cryptosporidium) and heavy metals (Pb, Cd, Hg) in the water.

There are many processes that can convert brackish water or saline to fresh water, eg - reverse osmosis, electro dialysis and distillation.

Distillation is one of the simplest and widely used processes. More than 90% of the world's water desalination process use distillation.

In distillation process water is evaporated, leaving behind the impurities and microbiological organisms, thus vapour contains only fresh molecules. The vapours should be condensed to get the fresh drinking water. The energy required for distillation can be provided by electrical energy or thermal energy. Since the vapourization of the water requires low temperature (around 100°C) , solar radiation energy can easily be used to achieve such low temperatures. The use of solar thermal energy for distillation is similar to the rain cycle of the earth. Solar radiation falling on the earth causes evaporation of water, forming clouds, which then get condensed in the cooler regions and bring back water on the surface.

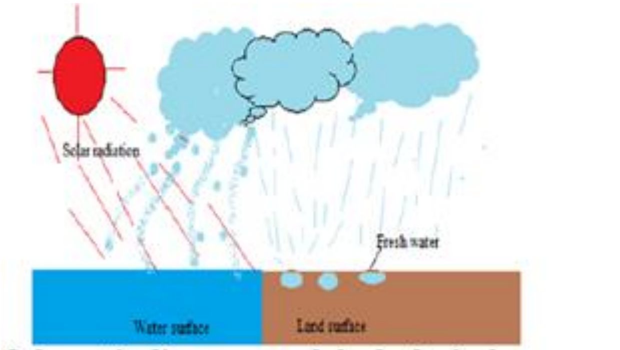
In this way, solar distillation is effective in removing many unwanted impurities as listed below.

- Salts and minerals - Na, Ca, As, Fe, Mn etc
- Bacteria - E. coli , Cholera etc.
- Parasites - Giardis, Cryptosporidium etc
- Heavy metals - Pb, Cd, Hg etc

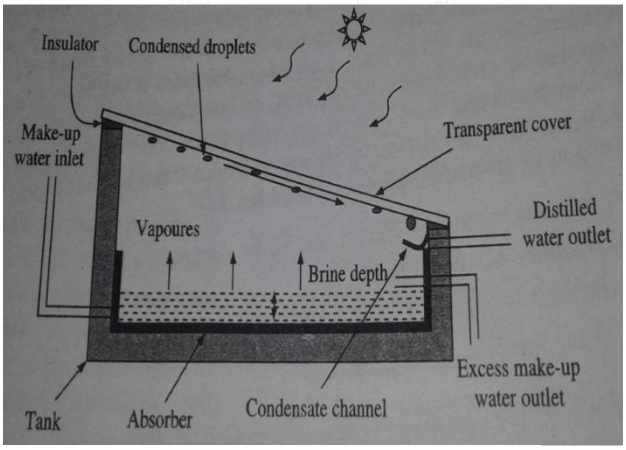
India is blessed with plenty of sunshine. Most of the century gets about 300 sunny days, resulting in daily solar radiation of about 4-7 kWh per m^2 . Therefore, solar distillation technology can be implemented effectively. Design and implementation of solar distillation apparatus is easy and cost effective. In the application of solar energy, like conversion of brackish of saline water into fresh water, intermittent supply of solar radiation should not limit its use as the fresh water is produced as and when solar radiation is available.

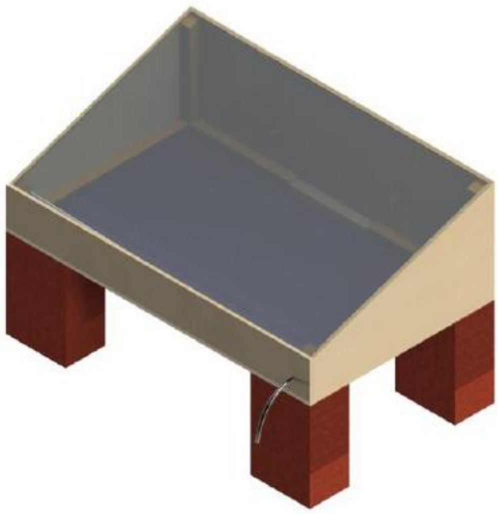
2. Working Principle

A solar still apparatus operates on the same principle as rainwater cycle consisting of two steps, evaporation and condensation. In this way, the basic principle of solar water distillation is simple yet effective. The sun's energy heats water to the point of evaporation .As the water evaporates, water vapour rise, condensing on the glass surface for collection (Fig). This process removes impurities such as salts and heavy metals as well as eliminates microbiological organisms. In the end, water is cleaner than the purest rainwater.



Schematic diagram earth hydrological process





A single basin solar still has a top cover made of glass. It has an interior surface made of a waterproof membrane. This interior surface uses a blackened material to improve absorption of the sunrays. The glass has a property to be transparent to the visible light but opaque to the ultraviolet and infrared light. Therefore, the glass cover of a solar still allows visible part of solar radiation to pass into the still, which is mostly absorbed by the blackened base, resulting in increase in basin temperature. Low temperature object radiates in the infrared region. Due to this, the basin radiates energy in the infrared region which is reflected back into the still by the glass cover, thus , trapping the solar energy inside the still (glass cover absorbs infrared radiation and reradiates part of it back to the basin).

This is similar to a green house effect. Due to this, the water heats up by about 10-20°C, resulting in increased rate of evaporation. 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 the glass cover in the form of small droplets. The condensation at glass cover occurs due to lower ambient temperature outside the glass cover. These drops of water flow into condensate collection channels on the sides, which can be collected externally. In this process, the salts and microbes that were in the original water are left behind. Condensed water trickles down the inclined glass to an interior collection trough and out to a storage bottle.

The long axis of the solar still should be placed along the East-West direction such that the glass slopping is facing towards the south.

Following are the components and their specification

System Component	Specification	
	Material	Purpose
Water basin / Tank	Cement concrete or fiberglass	Container of saline water (brick cement can be used for basin, tank should be insulated at the base to avoid thermal loss)
Insulation	Polyurethane Foam (PUF), Putty, Tars, Silicon sealant	To prevent heat losses (should not become brittle, cracks may form resulting in vapour leakage)
Transparent cover	Glass or polyethylene	To transmit solar energy (glass is heavy, prone to mechanical damage. Polyethylene has low transmittivity and requires a special layer to make it water wettable)
Absorber	Black butyl rubber, black polyethylene or ink or dye	To absorb the heat (should be able to withstand temperature upto 110°C)
Condensate channel	Aluminum galvanized iron	To collect droplet s of water
Make up water inlet	PVC pipe	To supply the saline water
Excess make up water outlet	PVC pipe	To drain the water
Storage Pot	Glass pot	To store distilled water

3. Indentations and Equations

The paper consists of design of Single basin solar still which is suitable for a troop of 20 soldiers.
Location : Rann Of Kutch

Following data is adopted for calculations

1) Latent heat of water evaporation	2260 kJ/kg
2) Requirement of Drinking water	3.7 litre per day = 3.67 kg per day
3) Density of water at 40°C	. 9922 kg / litre
4) Efficiency of Solar still	40%
5) Location of Rann of Kutch	24.0454° N, 70.1456° E
6) Solar radiation at Rann Of Kutch	6.2 kWh per m^2 per day
7) Wind velocity	0

Calculation for Water Quantity

Total quantity of water =
Water required for one soldier X No of soldiers in one troop
= 3.X20 = 73.4 kg

Calculation for solar radiation

Daily available solar radiation = 6.2 kWh per m^2 per day

Useful solar radiation
= Daily solar radiation X distill efficiency
= 6.2X0.4
= 2.48 kWh per m^2 per day
= 8928 kJ per m^2 per day

Calculation for distilled water produced per day per square metre
Latent heat of water evaporation
= 2260 kJ/kg

Number of litres of distilled water produced per square metre per day
= Useful solar radiation / Latent heat of water evaporation
= 8928 / 2260
= 3.95 litres per m^2 per day

Slope of Solar Still
= 24.040°-15°
= 9.040°

Calculation for total area of Solar still
Total requirement of water
= 73.4 Kg per day

Total required area of solar still
= Total requirement / Number of litres produced per square metre
= 73.4/3.95
= 18.5 m^2 (or approx 18.6 m^2)

This area is quite large So three single solar still will be made. Each solar still will have area of 6.2 m^2
Base size of box (Taking square shape) = 2.5 m X 2.5 m

Calculation for pipe size
Since there is no pressure in the process so 1/2" PVC pipe is sufficient.

4. Figures and Tables

Following design values are found for Single Basin Solar Still

SN	Parameter	Value
1	Water requirement	73.4 kg
2	*Water basin / Tank*	*Cement concrete or fiberglass*
3	*Insulation*	*Polyurethane Foam (PUF), Putty, Tars, Silicon sealant*
4	*Transparent cover*	*Glass or polyethylene*
5	*Absorber*	*Black butyl rubber, black polyethylene or ink or dye*
6	*Condensate channel*	*Aluminum galvanized iron*
47	*Make up water inlet*	*PVC pipe (1/2")*
8	*Excess make up water outlet*	*PVC pipe (1/2")*
9	Total area of solar still	18.6 m^2
10	No of single basin solar still	03 Nos
11	Base area of each single basin solar still	6.2 m^2
12	Basic length of belt	200 m2.5 m X 2.5 m

5. Conclusions

Following conclusions are made
A) It requires no power to be operated.
B) It is robust.
C) It is flexible.
D) Its maintenance is easy.
E) It is safe.
F) It has very low set up cost and maintenance cost comparative to other drives.
H) It is eco friendly.

Following are the limitations
A) It cannot be operated in the night
B) It has fragile parts (Glass plate)
C) Its efficiency is less.

References

[1] G.N. Tiwari, J.M. Thomas and E. Khan, Optimisation of glass cover inclination for maximum yield in a solar still, Recovery Systems and CHP, 14 ,1994 ,447–455.
[2] M.K. Phadatare and S.K. Verma, Influence of water depth on internal heat and mass transfer in a plastic solar still, Desalination 217,2007, 267–275.
[3] N.K.A. Jabbar, On the effect of cover tilt angle of the simple solar still on its productivity in different seasons and latitudes, Energy Conversion and Management, 52 ,2011 ,431–436.
[4] https://www.who.int
[5] https://www.armystudyguide.com
[6] http://www.indiaenvironmentportal.org.in/files/srd-sec.pdf
[7] https://mnre.gov.in/file-manager/UserFiles/solar_radiant_energy_over_India.pdf
[8] G.R. Lashkaripour, M. Zivadar, Desalination of brackish water in Zahedan city in Iran, Desalination Vol177.2005,1-5.
[9] Gleick, P.H., Water, War, and Peace in the Middle East, Environment,Vol.36 1994,6 – 42 [3] United Nations, Comprehensive Assessment of the fresh water resources of the world, 1997.
[10] Bchiar Bouchekima, A small solar desalination plant for the production of drinkable water in remote arid areas of southern Algeria, Desalination, Vol. 159 ,2003, 197-204.
[11] J. Joseph, R. Saravanan, S. Renganarayanan. Studies on a single-stage solar desalination system for domestic applications, Desalination, Vol.173,2005, 77-82.