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Desalination of Salt Water using Solar Energy

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Abstract – *The main objective of this paper is to reduce the water scarcity problems and to convert salt water into drinking water by using solar energy. This project is based on the small scale desalination system where solar energy is used as the main source for this process. Solar distillation plants supplying the desalinated water into many sea coastal and rural areas. It can construct by local people by locally available materials, but the disadvantage of this plant is cost. So the solar distillation plants is made by the low cost materials. It is made by the process of vapour compression. The system consists of glass, lens and aluminum plate, was designed and built. Natural sea water was used as a feed and the experiment was conducted during typical sea water. It is compact in nature as it is easy to assemble and dissemble. The project research shows progressing a lot of efficiency. Suitable modification of solar still can produce high output with minimum areas of land even in cloudy days. The goal is to assess the feasibility and profitability for desalination plants by using solar energy. The average rejection of salt was over 90%.. An literature study has been made with all available research and technology by using solar energy for desalination. From that study, it has been made that anumber of research setup and devices are used at high cost. But this research paper it is lower in cost.*

Key words: **desalination, vapour compression, glass, aluminum plate, sea water.**

1. INTRODUCTION

Extracting fresh water from seawater requires a great deal of energy, both thermal and mechanical method. Renewable energy driven desalination is becoming more viable despite its expensive infrastructure because it employs free natural energy sources and releases no harmful effluents to the environment. The rapid use of energy caused demand and supply. In today's world, energy requirements is increased. The proper steps to be taken to reduce the demand by using renewable energy. The main demand of this energy source is water and the main environmental issue is shortage of water. After few years, there will be no more available for producing the water. Most our earth surface is covered with water. But it deals with salinated water only 1% water is considered as the fresh water. There are many countries do not have enough water to maintain agriculture, economic developments and for drinking purposes. Solar energy based desalination plants can reduce water scarcity problems in low cost without any environmental degradation problem. There will be many limitations for using desalination plants, but by using solar energy the problem will be reduced. It can be installed at any capacity in lower in cost. The different method of desalination is used all over the world (i.e RO, MSF, MED) to reduce the water crisis problem. In common, human body needs three requirements for daily life- oxygen, water and food. Oxygen plays major and first role in human body, one cannot survive without oxygen. Next to oxygen, water plays a important role in human's life. The average adult body consists of 75% of water. But water available on earth is about 79%. Out of this, 97% water is sea water and the rest is fresh water with various sources. The drinking water problems is increased day by day because 3% fresh water is not enough for the world population. The fresh water which is used for the drinking water for humans without any harm. Similarly, many coastal areas have abundant sea water, but drinking water is not safe. For those areas, desalination can be used with solar energy. The most effective water purifier in the market is reverse osmosis, but this process cost is high. Inspite of this, solar energy is determined as free energy, due to this it is literally as lower in cost. In future, the world's population will face water shortage problems. The desalination process has three technologies: MSD, MSF and RO, it will be more competitive in future. One of the best way to get pure water by desalination of sea water by vapour compression which can made by any people with locally available materials. Vapour compression method is generally done by thermal or by mechanical method. This method is generally low in cost, it is made by solar technologies and it can reduce the water demand problems

1.1 Desalination process

- Multi stage flash distillation
- Multiple Effect distillation.
- Reverse osmosis
- Solar technologies

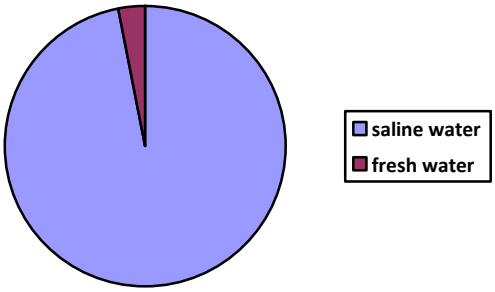

Chart-1 sea water and fresh water available on earth

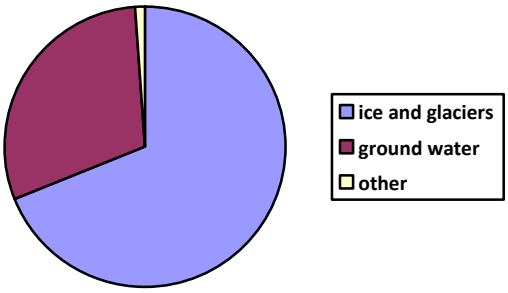

chart -2 fresh water on earth

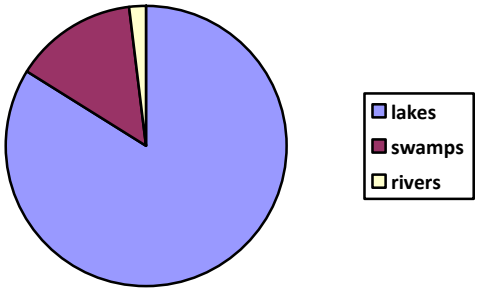

Chart-3 fresh water on surface

The above chart information are types of water available on earth (courtesy: http//www.pacificwater.org/ water demand management/water distribution)

The quality and quantity of fresh water output from this desalination by vapour compression method were also tested. The results confirmed the feasibility producing fresh water with solar energy vapour compression method.

Fig 1-Water Scarcity problems

2. Literature Review

2.1 Desalination with solar energy integrated vacuum membrane distillation system

A new type of solar energy integrated VMD system for sea water desalination was tested under environmental conditions in China. This study determines the feasibility of using solar integrated VMD to obtain fresh water from natural sea water during a typical day, and to test the performance of the system in terms of both quality and quantity of fresh water produced. According to the results, the solar collector and solar cooker showed favorable performance related to temperature, membrane flux increased as seawater temperature increased, and the system was able to generate 36kg (per m^2 membrane module) distilled fresh water during the test day. The retention rate was between 99.67 and 99.98%, EC was between 0.00276 and 0.0673mS/cm, and the average salt rejection was above 90%. These results confirm that solar energy integrated with VMD is an appropriate and effective combination for seawater desalination systems.

2.2 Solar Energy for Water Desalination

Solar MED and MSF, though appearing to be natural and tempting solutions, cannot be taken as proven technologies. More and more developments in both solar power and desalination technologies are expected to keep as solutions competitive compared to RO systems coupled with conventional Power plant. Main advantage of that installation is that RO can run during night times when electricity costs are low and MSF work during daytime with low running costs due to low pressure steam. Water storage offers flexible solution with energy consumption optimised. Addition of solar energy from start of the project (with parabolic troughs) would have low cost impact but no GHG emissions.

3. Desalination Solar Technologies

Desalination technologies is described here by solar thermal energy. This technology is generally used in many countries by receiving huge intensity of solar radiation, to use a solar power for the running of plants. This technology linked with the vapour compression which produce drinking water through this method.

3.1 Two Categories:

This technologies is divided in two categories:

- Concentrating solar power plant technologies
- Photovoltaic technology

CSP technologies mainly include in Parabolic Trough. In this technology it shows that solar radiation onto an absorptive pipe which contains heat transfer fluid (water). When water is used, the radiation from the sun converts the water to steam by direct steam generation.

3.2 Solar Stills

The main advantage of using solar still is reducing the cost. Solar still acted as apparatus to desalinate impure water. In which glass is acted as a solar still and it evaporates the water. The radiation from the sun evaporates water inside a closed glass covered chamber at a temperature higher than the ambient. This method can be adopted at any places and it is oldest method of desalination. It acts on the principle of greenhouse effect. The saline water is kept on the black plate of lower portion of distiller. The heat from the sun which causes water to evaporate and water vapour from purely distilled water in drops and it reaches the leaning surface. The water will be collected and kept on it. Solar still is classified in active desalination and passive desalination system. The disadvantage of this solar still is some deposition of salt will be occurred and its advantage is efficiency will be good. The schematic diagram of solar still is given below:

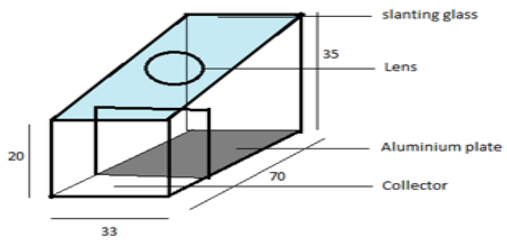

Fig 2: components of solar still

3.3 Components and specifications of solar still:

Glass
Type : Annealed Glass
Thickness : 6mm
Cross section : 44 x28 cms
Angle inclination: 22 degree

Aluminium plate
Size : 33 x48cms
Thickness: 1mm
Form : plain sheet
Hardness: soft
Material : acted as a absorber plate
Colour : coated with black paint
Black paint absorber: 0.09

Lens
Type : convex
Diameter: 8cm
Shape : circle

Parameter	Unit	Value
pH	-	7.88
Temperature	C°	20
Salinity	psu	15
Turbidity	NTU	10.8
TDS	(mg/L)	10,310
EC	(mS/cm)	20.7
SS	(mg/L)	4.0
Total bacterial	CFU/mL	24,100
COD	(mg/L)	16.8
Na^+	(mg/L)	4,3615
Br	(mg/L)	38.1
F^-	(mg/L)	0.54

Table -1 characteristics of Sea water

Collector specifications:
Solar irradiation : 1000W/m^2
Base plate temperature: constant
Wind velocity : 2m/s
Inlet air temperature : 28°C
Ambient temperature : 32°C

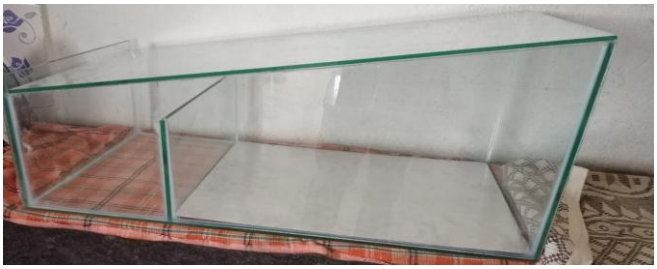

Fig 3: model of solar still

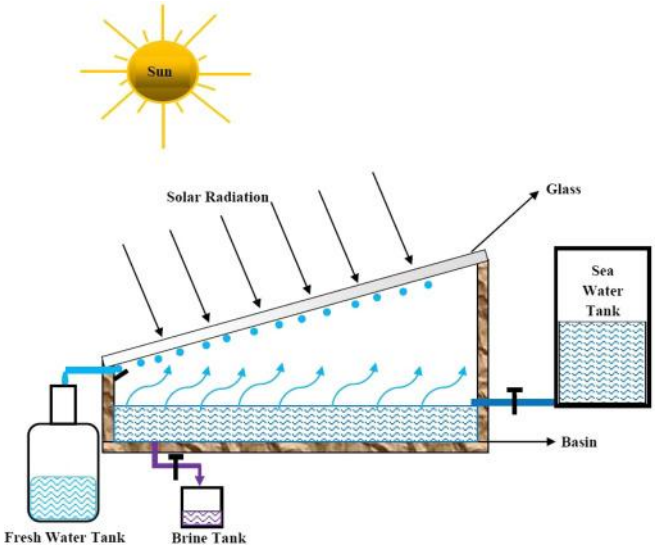

Fig 4-Desalination plant

Parameter	Unit	Value
pH	-	7.5
Temperature	C°	27.4
Salinity	psu	0
Turbidity	NTU	0.17
TDS	(mg/L)	1.2
EC	(mS/cm)	0.00279
SS	(mg/L)	1.4
Total bacterial	CFU/mL	5
COD	(mg/L)	0.39
Na^+	(mg/L)	0.25
Br	(mg/L)	Not detected
F^-	(mg/L)	0.54

Table 2- Characteristics of fresh water

In addition, temperature measurements along the solar is distributed.

Time	Inlet temperature(°C)	Outlet temperature(°C)
11:30 AM	31	44
11:45 AM	32	48
12:00 PM	32	54
12:15 PM	32	58
12:30 PM	35	67
1:00 PM	36	73

Table -3 Temperature distribution

Temperature measurements is taken to determine the temperature drop in the system as saline water injected in the system. Because of heat and mass transfer in the mist of water and air, the change of phase from liquid to vapour takes place. The efficiency of solar stills is strongly dependant on several factors other than their design and principle. The factors like input saline water temperature, outside temperature, airflow, intensity of available solar radiation, etc. have strong influence on the solar still performance.

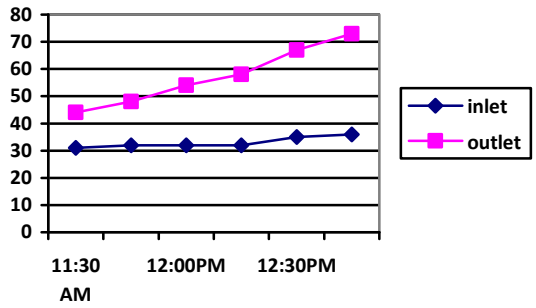

Chart -4 Temperature Distribution

Conclusion

This process is considered as very low cost and there is no defects in the out coming of fresh water. Inclination of glass gives more fresh water in a short period of time and there is no energy consumption in this process.

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