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Modified Low cost solar water purifier

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ABSTRACT

Life cannot sustain without water, and healthy life cannot sustain without pure water. In many parts of the world, people do not get even the minimum water requirement. Sometimes the phrase "water, water everywhere ,but not a drop to drink", becomes a reality, especially in coastal areas, where large amounts of high salinity water is present. Also polluted water having high turbidity, high TDS and objectionable material, is of no use. Solar Energy, which is unlimited and free can be used to purify such types of waters. Solar water purification is a simple , cheap and effective process and the setup can be easily fabricated. The purifier is placed in NIT and is yielding good results. The unit produces about 3 to 4 litres per day per m^2 of its surface area. Previous versions had some draw backs which are removed here. Certain modifications have been done, which are:-The evaporating trays are placed in air tight container which prevent heat loss, thus raising the yield. A sedimentation tank is incorporated with the unit which removes 80% of turbidity, before the water is fed in to the trays, thus preventing the covering of black surfaces which absorb solar energy. The sedimentation tank also acts as a pre water heater, raising the temperature to achieve high yield and at the same time accelerating the sedimentation of turbidity particles. Thin film evaporation is achieved by controlling the outlet valves to adjust the inflow rate equal to the rate of evaporation, thus maintaining a thin layer of water for rapid evaporation. These modifications have raised the observed yield. Future modifications have been suggested which will raise the yield almost ten times. The project report has been printed and bound. The full paper will depict colorful graphs, figures and full data. The project has been highly appreciated by all. Cost /benefit analysis has also been done.

Keywords -Modified , Pre heater, Sedimentation , Solar , Insulation

I.INTRODUCTION

The Modified low cost Solar Water Purifier has been designed and fabricated keeping in view the problems associated with non availability of pure water for human needs, although a large quantity is available, but is not fit for use owing to large amounts of suspended and dissolved impurities present in it. Although some work regarding the same has been done, especially in the coastal areas, yet efforts are being made to increase the efficiency. The purpose of the paper is to obtain maximum yields and provide a design for a low cost unit that can serve in remote areas where conventional water treatment is out of question. The units fabricated are decentralized, and are used as individual or house hold needs.

II.OBJECTIVES OF THE PROJECT

2.1 Technical objective

The technical objective of the project is a unit that :

Can be easily fabricated with simple materials, would not require any electricity or fuel, have zero running cost, require no skilled operation, be effective, can be used in remote areas, has no noise pollution, no running parts, and be Eco friendly.

2.2 Social Objective

To provide clean water to every living being. After further treatment(not listed here), the water may be used for even direct human consumption.

2.3 Financial Objective

To create a Cheap and Affordable unit for individual or community use.

2.4 Educational objective

The students can be engaged for project work by taking periodic readings of parameters like:-

Daily max. Temperature, Daily sun shine hours, Rate of evaporation, Quantity of generated DW, Quality of generated DW, Quality of raw water, Percentage reduction in pollutants etc and Creation of a data bank for reference

2.5 Other objectives

Production of distilled water to augment its need in various laboratories of NIT Srinagar

To create awareness among future generations for energy conservations and use of alternate energy sources.

III.MATERIALS AND METHODOLOGY

A solar water purifier has been fabricated and is functional. It is a single slope passive solar still. The outer frame has been fabricated by using MS where as the evaporating trays have been made out of GI sheet and are rectangular in shape. The effective surface area of both the trays is around 0.8 m^2. The trays are enclosed in an air tight frame covered by clear glazing. Sun light penetrates through the glass and evaporates the raw water in the trays. Glazing is an integral component of a solar distillation unit. The purpose of glazing is to admit the maximum possible solar radiation and to minimize upward heat loss. In most of the literature, glass is used as glazing material as it can transmit more than 90% of the incident short wave radiation while its transmittance to the long wave heat radiation of wavelength 5–50 μm, emitted by the absorber plate, is low as it acts as an opaque material for long wave radiation . The use of plastic films and sheets as transparent material has also been reported.

The trays act as absorber plates and are the key component of a solar distillation unit. The purpose of the absorber plate is to absorb maximum possible solar radiation incident on it through the glazing and to transfer the retained heat to water. Materials, such as copper, aluminium and steel, can also be used as the absorber plate material. The coating on the plates is black such that it has high absorptive capacity and poor emissivity for the required temperature range.

The vapours condense on the inner surface of the glass and slide down due to inclination of the glass. The clear water droplets strike against a barrier and are collected in a sloping cross channel, called manifold, which takes the purified water out of the equipment to be collected in a container placed below the plant.

IV.TECHNICAL FEATURES

4.1 Total tray area=2{0.5mx0.8m}=0.8 m^2

4.2 Glass area=1.2m x 0.9m=1.08 m^2

4.3 Raw water tank Capacity= 16 litres

4.4 Tank surface area facing sun=0.165 m^2

4.5 Glass inclination angle=45 degrees

4.6 No. of inlet control valves=2, flush out valve=1

4.7 Manifold length= 1.1

V.HOW IS IT A MODIFIED FORM

The following have been incorporated to increase the efficiency:-

5.1 Sedimentation Tank

As we know, raw water contains various suspended and dissolved impurities. If all the impurities are allowed to go to the evaporating trays, a lot of residue is left behind, coating the trays and reducing the evaporation process, as the trays are painted black to receive maximum heat of the sun. In order to avoid this problem, a sedimentation procedure is incorporated in the raw water tank which removes the suspended materials like sand, silt etc. The particles settle down to the bottom of the tank. The sedimentation tank can be periodically cleaned by a quick function valve located at the bottom of the tank. In this way, water containing high suspended material and having high turbidity can also be processed without creating any operational problem.

5.2 Solar pre heater

The sedimentation tank, apart from acting as a settling tank, is also used to pre heat the raw water before it is fed in to the evaporating trays. The black surface of the tank absorbs solar energy to raise the temperature of raw water, before it is fed in to the evaporating trays. A value of 27.6% augmentation in the productivity as a result of increased evaporation rate caused by the preheating of feed water is obtained.

5.3 Thin film evaporation

The concept of thin film evaporation is applied which enhances the rate of evaporation. To ensure this, flow in to the evaporating trays is regulated by quick function valves which regulate the flow to balance the rate of evaporation with inflow quantity. As the depth of basin water increases the productivity decreases.

5.4 Heat retention by insulation

The unit is completely sealed to ensure maximum heat retention. The base and back side(which do not receive solar heat) are covered with thermo foam to minimise heat loss. The orientation of the plant is kept to receive the sunlight for the maximum period of time

Heat retained in the enclosure ensures evaporation well beyond sun shine hours and the lowered evening outside temperature enhances condensation process.

VI.RESULTS AND DISCUSSIONS

6.1 Yield :- Operating variables that affect the yield performance are heat losses through the glass cover and the base, solar radiation intensity, water depth and ambient temperature, water /glass temperature difference, free surface area of water, temperature of input water, angle of glass Another factor is the intermittent nature of solar radiation despite its abundance in our part of the world. Wind velocity and ambient temperatures also are effective but cannot be controlled. The average yield is around 2 to 3 litres/m2/day, depending on sun shine hours as reflected by "Fig 1" where as the yield has increased by insulating the solar purifier as reflected by "Fig 2". The observed yields are tabulated below.

Yield Table

DAY	Max. Temp deg. C IMD Data	Effective Sun shine	Yield (litres/day)
24/7	30	Partly sunny	1.85
26/7	30	Mostly sunny	2.66
27/7	31	Full day sunny	2.78
28/7	28	Partly sunny	2.21
31/7	32	Mostly cloudy	1.04
03/8	29	Partly sunny	2.3
04/8	32	Partly sunny	2.40
07/8	32	Partly sunny	2.33
10/8	29	Partly sunny	2.43
14/8	20	Full overcast	0.30
17/8	30	Full day sunny	2.66
18/8	32	Full day sunny	2.70
21/8	30	Partly cloudy	2.10
22/8	28	Partly clouded	1.95
23/8	31	Full day sunny	2.67
24/8	28	Partly overcast	1.21
28/8	29	Full day sunny	2.66
04/9	27	Full day sunny	2.58

07/9	26	Mostly overcast	0.66

table-1 Yield versus sunshine conditions / Temperature

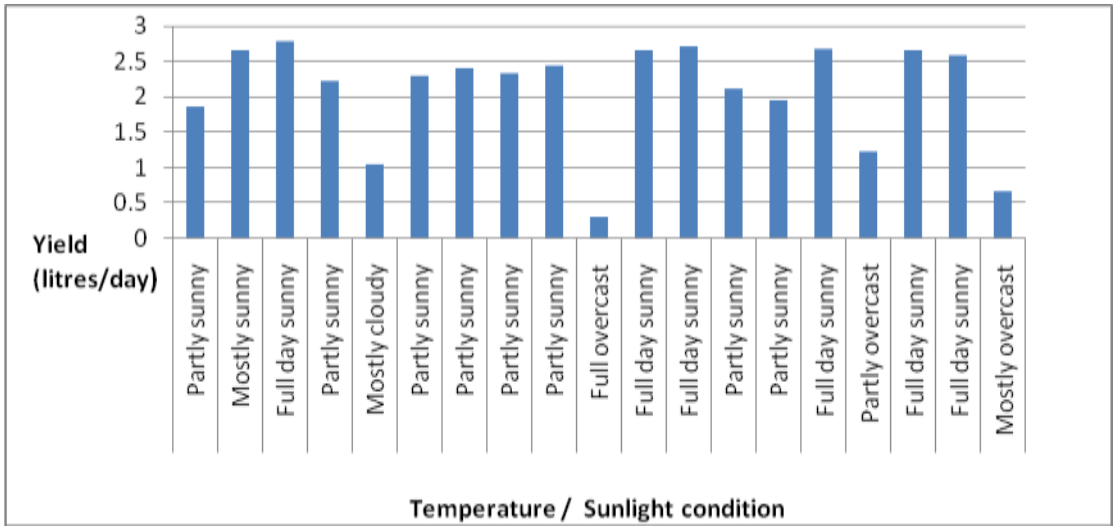

Fig-1 Yield Comparison graph(un insulated VS Insulated)

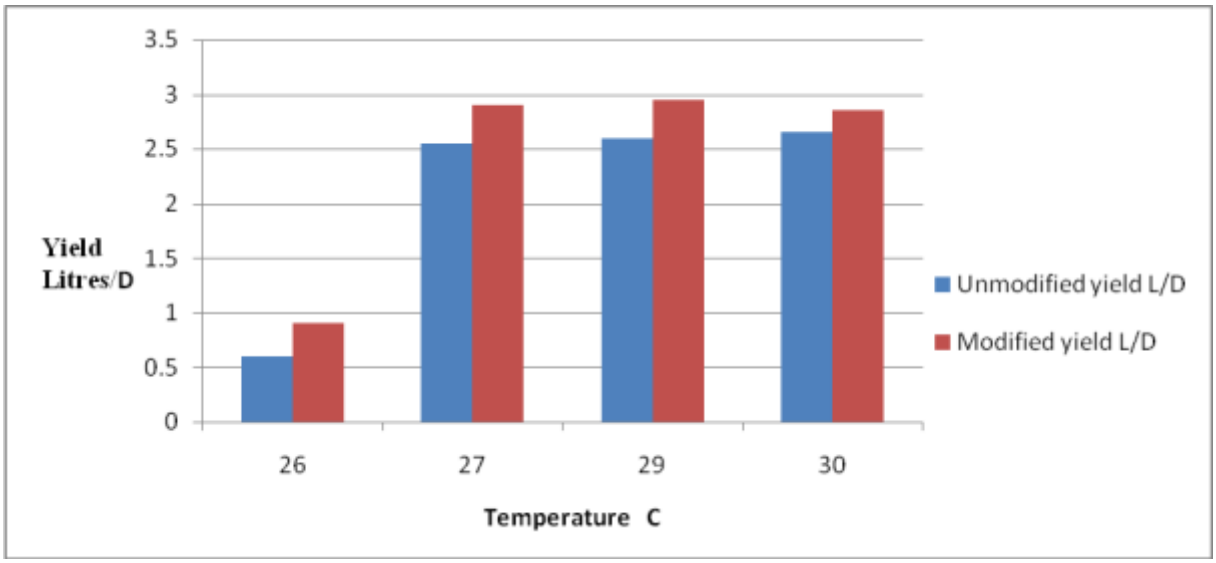

Fig-2It is clear from that the yield is affected mostly by sun shine hours "Fig 1" and by proper insulation "Fig 2"

6.2 Qualitative analysis

The raw water was prepared in to **three** categories to represent true field conditions:-

6.2.1 Normal tap water (Representing municipal water with probable higher values of some water quality parameters

Normal tap water was collected and fed into the purifier sedimentation tank. The raw water characteristics tested in the lab and are given below:

(Normal tap water data)

Parameter	pH	TDS(ppm)	Turbidity (NTU)	Alkalinity (ppm)	Chlorides (ppm)	Colour	Odour
Value	7.88	284	<1	135	48	Colourless	Odourless

Table-2 The water from the purifier was collected and tested in the lab. Results are given below

(Treated tap water)

Parameter	pH	TDS(ppm)	Turbidity (NTU)	Alkalinity (ppm)	Chlorides (ppm)	Colour	Odour
Value	6.85	<1	zero	<1	Zero	Nil	Odourless
% age removal	------	>99.9	----------	>99.9	100	--------	----------

Table-3

6.2.2 High salinity water (Representing sea water)

Sea water has a high salinity, around 35 ppt or 35,000 ppm, about 35 grams per litre of NaCl.

The same was generated in the laboratory using common salt. 35 grams were dissolved in 1000 ml of water.

Replicated Sea Water

Parameter	Salinity (ppm)	Chloride (ppm)	Conductivity Micro S/cm	TDS (ppm)	Turbidity (NTU)	colour	Odour	pH
Value	35,000	19600	54000	36180	10	Hazy	Nil	7.78

Table-4The replicated sea water was processed by the solar purifier and the results are tabulated:-

Treated Sea Water

Parameter	Salinity (ppm)	Chloride (ppm)	Conductivity Micro S/cm	TDS (ppm)	Turbidity (NTU)	Colour	Odour	pH
Value	<1	<1	2	1-2	Zero	Nil	nil	6.63
%age Removal	99.99	99.9	99.9	99.9	100	100	nil	------

Table-5

6.2.3 High turbidity water (Representing muddy water from natural ponds, shallow ground

water etc.

About 2gms/l of fine soil was added and dissolved to create a high turbid water . The raw turbid water was analysed for the following parameters:

High Turbid Water

Parameter	Turbidity (NTU)	TDS (PPM)	colour	Odour	Conductivity Micro S/cm	pH
Value	148	650	Light brown	Earthy 2e	168	7.94

Table-6 Role of sedimentation Tank:-(Modification-1)

In this particular case, sedimentation is a must. If this not done, a lot of silt will accumulate in to the evaporating trays, covering the black top covering, thus reducing the sun light absorption and reducing evaporation. In order to achieve maximum efficiency, an experiment was done in the laboratory . The sample of high turbid water was allowed to undergo sedimentation. Samples were taken after repeated time periods to ascertain the percentage of apparent turbidity that under goes quick settlement due to higher specific gravity of the particles. The particle settlement data is given below with readings taken after 3 minutes interval.

Turbidity VS Time

Time(mts)	03	06	09	12	15	18	21	24	27
Turbidity(NTU)	148	128.6	85.2	48.9	32.0	23.8	21	20	19.6

30	33	36	39	42	45	48	51	54	57
19.4	19.3	19.2	19.1	19	19	19	18.9	18.8	18.8

Table-7

Turbidity versus time graph

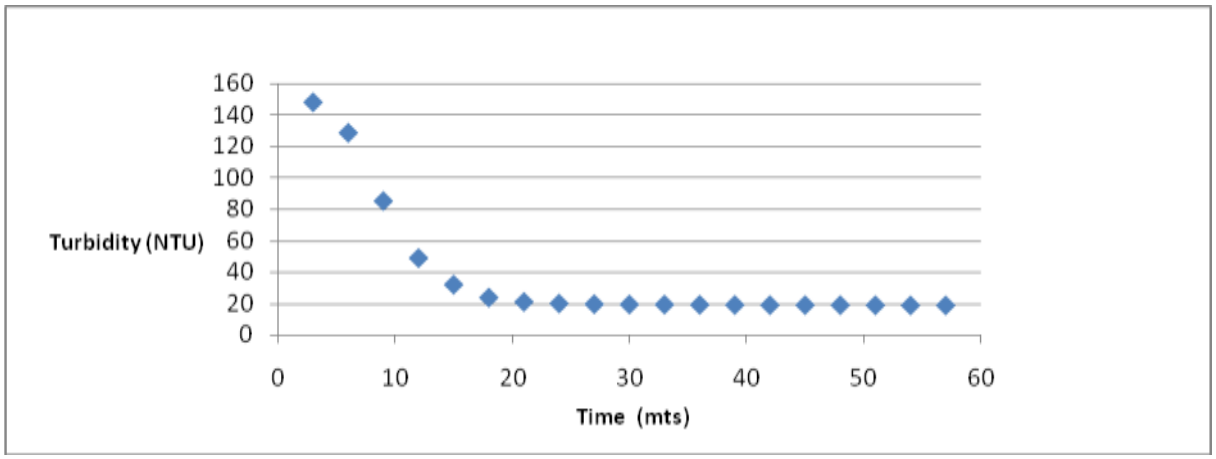

Fig-3From the settlement data, it is clear that the turbidity reduced at a high rate first and then slowed down after around 20 minutes and there after became almost constant. This implies that up to 20 minutes or so, all the suspended material settled down where as the light colloidal material remained in suspension. The percentage of turbidity removal during the first 20 minutes is around 86 %. "Fig 3"

Treated High Turbid Water

Parameter	Turbidity (NTU)	TDS (PPM)	colour	Odour	Conductivity Micro S/cm	pH
Initial Value	148	650	Light brown	Earthy 2e	168	7.94
After sedimentation	21	644	Faint brown	Earthy 1e	158	7.90
After treatment	Zero	<1	Colourless	Nil	<2	6.88

Table-8

VII.CONCLUSIONS

7.1 The amount of yield is mostly dependent on direct sunlight falling on the trays. Temperature has lesser effect on the yield. Thus the equipment is usable even in low temperatures, but high hours of sunshine and hence feasible for places like Kashmir and particularly for Ladakh Region.

7.2 Yield increases appreciably if the setup is insulated properly, retaining sun energy to utilize it in the evening hours when the temperature gradient across the glass increases, thus promoting condensation

7.3 Tap water can be converted to distilled water for use in education institutions and laboratories thus bringing down the cost of purchasing distilled water , practically to zero.

7.4 The equipment will be very useful in coastal areas where raw high salinity water and lots of sun shine is available.

7.5 To prevent accumulation of suspended particles in the evaporating trays, the raw turbid water should be held in the supply tank for a period of around 20 to 25 minutes as proved by experimentation.

7.6 The pre heater raises the temperature of raw water which in turn raises evaporation efficiency. The increased water temperature in the sedimentation tank increases the settling velocity of particles which is governed by the equation; $V_{s=}$ $g/18(S_s-1)d^2/\mu$, where μ is the viscosity of the fluid(water in our case). Higher temperatures reduce the value of μ, hence enhancing settlement of particles.

7.7 Thin film evaporation was achieved by controlling the inlet valves to adjust rate of evaporation with the inflow water quantity Thin film evaporation gave higher rates of evaporation as compared to higher depths of water in the evaporating trays.

7.8 The fabricated purifier has an initial cost of around 20,000 as it involves high quality material. Still if the return from the unit be calculated, it will yield the following results. Cost per liter of Distilled water= Rs 1.50 which is as good as free. Benefit/Cost ratio==27 : 1 which is worth to consider.

7.9 An efficiency of pollutant removal greater than 99% has been observed.

VIII. PHOTOGRAPH

Condensed particles of evaporated water moving down the glass slope

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