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Performance Investigation of Single Basin Double Slope Solar Still With and Without Phase Change Material and Effect of Reflector and Fins

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Abstract – *It is found that Solar distillation systems economically feasible in desalination of saline water. A solar distillation system is cost-effective and simple technology. Free of cost, non-polluting type solar energy is used to produce distilled water. The present work shows that high grade energy savings is possible with use of different efficiency enhancement techniques for solar stills. Experimentation is carried out total 14 days in month of May 2018 (from 10th May, 2018 to 25th May, 2018). The efficiency of simple solar still is up to 14.36%, this increase up to17.17% with use of only black coating, 22.17% with use of black coating with finned surface, 24.43% with use of black coating with reflectors and 40.53% with use of black coating with phase change material. The unit cost of desalination of saline water is estimated to be INR 8.3181/L for simple setup, INR 6.1183/L for simple setup with only black coating, INR 4.8888/L for black coating with finned surface, INR 3.6201/L for black coating with PCM and INR 4.8542/L for black coating with reflector attachment, these unit costs are less compared to market selling price of distillate. The payback periods of the passive solar still are found to be in the range of 1.3966 to 3.6181 years if the market selling price of distilled water is INR 15/L.*

Key Words: Solar Energy, Active and Passive Solar Stills, Phase change material, Finned surface, Reflector.

1. INTRODUCTION

Solar distillation is a relatively simple treatment of brackish (i.e. contain dissolved salts) water supplies. Distillation is one of many processes that can be used for water purification and can use any heating source. Solar energy is a low tech option. In this process, water is evaporated; using the energy of the sun then the vapour condenses as pure water. This process removes salts and other impurities. Solar distillation is used to produce drinking water or to produce pure water for lead-acid batteries, laboratories, hospitals and in producing commercial products such as rose water. It is recommended that drinking water has 100 to 1000 mg/l of salt to maintain electrolyte levels and for taste. Some saline water may need to be added to the distilled water for acceptable drinking water. Solar water distillation is a very old technology. An early large-scale solar still was built in 1872 to supply a mining community in Chile with drinking water. It has been used for emergency situations including the navy introduction of inflatable stills for lifeboats. There are a number of other approaches to desalination, such as photovoltaic powered reverse-osmosis, for which small-scale commercially available equipment is available; solar distillation has to be compared with these options to determine its appropriateness to any situation. If treatment with polluted water is required rather than desalination, slow sand filtration is a low-cost option [27].

Other techniques are also possible by which performance of solar still will improve out of them use of black coating on inner surface, finned surface in solar still basin, use of reflectors or mirrors attachment, use of phase change material etc. In this experimental investigation separate observations were carried out on the same capacity single basin double slope solar still with and without use of Finned surface, with and without use of phase change material, with and without use of Reflectors and it is compared with simple setup without any enhancement technique.

2. LITTERATURE REVIEW

B. Selva Kumar et al. [1] analysed the thermal performance of a “V” type solar still with charcoal absorber distilled water & collection output is estimated. The presence of floating charcoal increases the absorption of radiation in the water and it results in increasing the evaporation rate. The boosting mirror concentrates the incident radiation over the basin area and it increases the evaporation and water collection.

Bharat Kumar Patil et al. [2] carried out an experimental investigation on a double slope single basin solar still using Phase changing materials like (paraffin wax) and Sensible heat storage elements like (black pebbles). The percentage productivity observed in case of Paraffin wax and black coated tray is 30%, black pebbles and black coated tray is 18%, Paraffin wax and black pebbles is 13%.

B. N. Subramanian et al. [3] studied the important parameters affecting the performance of still such as depth of water, temperature of inlet water and water-glass cover temperature difference. The results reveal that depth of water in the solar still is inversely proportional to the productivity of the still. The addition of finned-PCM heat recovery unit increased the inlet temperature of saline water closer to its saturated temperature which in turn reduces the amount of heat required to evaporate the water in the still and leads to a still with higher productivity and efficiency.

M.E. El-Swify et al. [4] theoretically analysed and experimentally tested a solar still of double exposure. It is compared experimentally with other identical stills without modification (ordinary L-type) during a complete year. The concept of planer reflectors is introduced in this modification. It is found theoretically that the double exposure still gained much more daily energy than that of the ordinary one in winter and summer

A. K. Singh et al. [5] they carried out an optimization of the orientation for higher yield of a solar still in terms of the glass cover inclination. The effect of water depth on the hourly instantaneous cumulative and overall thermal efficiency and internal heat transfer coefficient has also been studied. Numerical computations have been made for Delhi Climatic conditions.

A.A. El-Sebaii et al. [6] was designed and fabricated a single slope single basin solar still with baffle suspended absorber (SBSSBA) using locally available materials. The model uses the lumped system of analysis in which the system is divided into several elements, each of which was treated as a lumped system by itself. The effects of vent area and water depth of the upper and lower water columns on the daily productivity of the still were studied. Comparisons of the performance of the SBSSBA and the conventional unit, the single slope single basin solar still (SBSS), have been carried out. It is found that the daily productivity of the SBSSBA is about 20% higher than that of the conventional still (SBSS).

Mohammed Farid et al. [7] were designed and fabricated a single basin solar still having area of 1.5 m^2 from galvanized steel sheet with an inclined glass cover. The unit was insulated with Staropor. Efficiency of solar still was found to be independent of solar radiations. An increase in productivity was observed with increase in ambient temperature and decrease in wind velocity.

Hiroshi Tanaka et al. [8] analytically investigated the effect of the vertical flat plate external reflector on the distillate productivity of the tilted wick solar still. They propose a geometrical method to calculate the solar radiation reflected by the external reflector and absorbed on the evaporating wick, and also performed numerical analysis of heat and mass transfer in the still to predict the distillate productivity on four days (spring and autumn equinox and summer and winter solstice days) at 30˚EN latitude. They found that the external reflector can increase the distillate productivity in all but the summer seasons, and the increase in the daily amount of distillate averaged over the four days is predicted to be about 9%.

Ragh Vendra Singh et al. [9] they done the thermal analysis of a solar still integrated with evacuated tube collector in natural mode. Performance has been predicted theoretically in terms of water and inner glass cover temperatures, yield, energy and exergy efficiencies during typical summer day of New Delhi (India). The variation of instant overall energy and exergy efficiencies has been found to be in the range of 5.1–54.4% and 0.15–8.25% respectively during the sunshine hours for 0.03 m water depth, which decreases with increase in depth.

Kazuo Murase et al. [10] they have made Experimental and numerical analysis of a tube-type networked solar still for desert technology Experimental data measured in our laboratory using infrared lamps showed the effectiveness of the method for productivity, the design of the basin tray and thermal efficiency up to 12.5%

Avesahemad S.N. Husainy et al. [16] has studied Hygienic drinkable water is a basic necessity for man along with food and air. Fresh water is also required for agricultural and industrial purposes. Most water sources are contaminated by industrial waste, sewage and agricultural runoff. The higher growth rate in world population and industries resulted water in a large acceleration of demand for fresh water. From this experimentation it was observed that, solar still continues to produce the fresh water by converting mud water. The distillate production is said to be increased to 10-25% with PCM. The energy storage materials in the still store considerable amount of heat during noon hours and release the stored heat to the basin water in the late afternoon hours when radiation is low, and are found to influence the temperature of the solar still components considerably.

3. METHODOLOGY AND EXPERIMENTATION

Experimental Location: Experimentation is carried at Kurundwad, Tal. Shirol, Maharashtra, India. It has exceptionally hot & dry during summer with temperature reaching as high as 40°C. Kurundwad is situated at Latitude: 16° 40' 54.4" N and Longitude: 74° 35' 24.57" E and Altitude of 546 m above sea level.

All the observations & readings on experimental setups are taken in the month of May 2018 from 10th May, 2018 to 25th May, 2018. The time duration for observations of solar still is from 9:00 AM to 5:00 PM for experimental setups of arrangement of only Black Coating, Black Coating with Finned Surface and Black Coating with reflector arrangement. And 9:00 AM to 8:00 PM for experimental setup with use of Phase Change Material as Paraffin Wax. All the readings are taken at 2.025 cm depth of water in Basin so that total 10 lit. of water in inner basin of single basin double slope solar still. Temperature and solar intensity was measured in every 1 hr with the help of digital temp meter and solar power meter (solar flux meter).

In Experimentation total Four Efficiency enhancement techniques are used separately like Black Coating only, Black Coating with Finned surface, Black Coating with

Reflector and Black Coating with Phase Change Material. Total two Experimental setups of solar still are manufactured, one is simple setup which does not contains any Enhancement techniques and another setup is containing one Enhancement technique as mentioned above. Experimentation is carried out on two setups at same time so that each solar still with enhancement technique is compared with simple Experimental setup of solar still. Dimension of Outer Basin are (900mm×600mm×280mm) and Inner Basin Dimension are (870 mm×570 mm×105 mm). Thickness of insulation is 15mm.

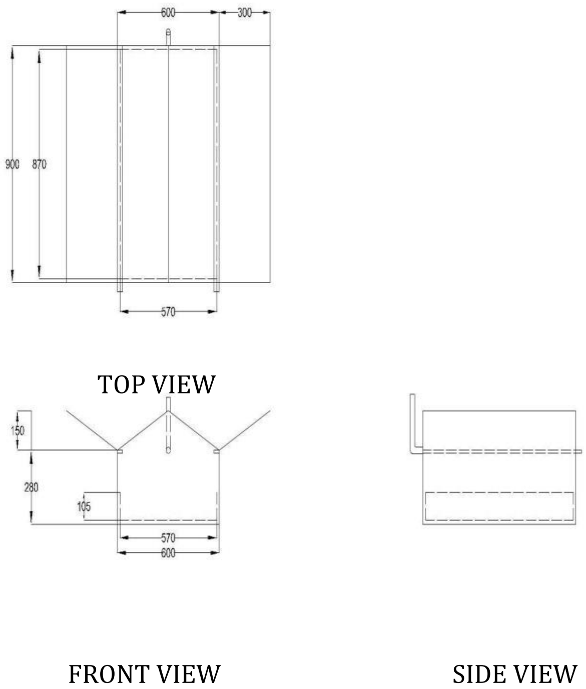

Fig.-1: CAD model of double slope type solar still

Main components of solar still are;

Basin: It is the part of the system in which the water to be distilled is kept. It is therefore essential that it must absorb solar energy. Hence, it is necessary that the material has high absorptivity or very less reflectivity and very less transmitivity. These are the criteria for selecting the basin materials.

Condensate Channel: It is the part of the system in which condensed water is collected. Sheet of required dimension is first cut out, and then it is folded by using the folding machine.

Black Liner: Solar radiation transmitted through transparent cover is absorbed in the black lining. Black bodies are good absorbers. Black paint is used as liner.

Transparent Cover: Glazing glass is used and thickness of 5 mm is selected. The use of glass is because of its inherent property of producing greenhouse effect inside the still. Glass transmits over 90% of incident radiation in the visible range.

Insulation: Thermocol / Glass-wool is used as insulator to provide thermal resistance to the heat transfer that takes place from the system to the surrounding.

Reflector: Reflecting Mirror is used with one side silver coated and is supported by ply wood to prevent its breakage.

PCM : Phase change Material is used as Paraffin Wax which absorbs the sun radiations by changing its phase from solid to liquid and releases the heat when sun radiations are absent in evening time.

Aluminium Tubes: Aluminium pipes are used to store/ fill up the paraffin wax. Size of Al tube is 0.75 inch = 19.05 mm Dia. and 850mm length.

End Close Caps: End Close Capes are used to close / seal the Aluminium Pipes which contains PCM. These are made up of Plastic.

Solar Power Meter: It is used to measure intensity of solar radiations.

Table -1: Capital Cost of Solar Still per square meter.

Sr. No.	Setup Type	Capital Cost (Rs.)
1	Simple Setup	11014/-
2	Simple Setup with Black Coating	11064/-
3	Setup with Black Coating & Finned Surface	11114/-
4	Setup with Black Coating & PCM	11679/-
5	Setup with Black Coating & Reflector Attachment	12164/-

Table -2: Result Table with simple Experimental Setup.

Sr. No.	Setup Type	Day	Distillate output (Kg)	Average Distillate	Efficiency %
1	Simple Setup Without any Enhancement Technique	Day1	0.467	0.5239	11.12
2		Day2	0.387		9.22
3		Day3	0.604		14.30
4		Day4	0.395		9.41
5		Day5	0.588		14.0
6		Day6	0.564		13.43
7		Day7	0.482		11.48
8		Day8	0.562		13.38
9		Day9	0.547		13.03
10		Day10	0.506		12.05
11		Day11	0.551		13.12
12		Day12	0.603		14.36
13		Day13	0.590		14.05
14		Day14	0.488		11.62

Table -3: Result Table with different Experimental Setups.

Sr. No.	Setup Type	Day	Distillate output (Kg)	Average Distillate(Kg)	Efficiency %
1	Setup With Only Black Coating	Day1	0.710	0.7155	16.91
2		Day14	0.721		17.17
3	Setup With Black Coating & Finned Surface	Day2	0.881	0.8995	20.98
4		Day3	0.931		22.17
5		Day4	0.880		20.96
6		Day5	0.906		21.58
7	Setup With Black Coating & Reflectors	Day6	1.026	0.9915	24.43
8		Day7	0.930		22.15
9		Day8	1.000		23.81
10		Day9	1.010		24.05
11	Setup With Black Coating & PCM	Day10	0.910	1.2765	21.67
12		Day11	0.923		21.98
13		Day12	1.702		40.53
14		Day13	1.571		37.41

Efficiency of solar still

$$E = \frac{q \times 2.3}{A \,.\, G} \times 100$$

E = Efficiency of the still.

A = Aperture area of the still in m^2 = 0.4959 m^2

q = Distillate Output in lit./day

G = Global irradiation energy in MJ/m^2

= 19.476 MJ/m^2 for Kurundwad location

= 5.41KWh/m^2

Sample calculation for Efficiency of solar still

For Simple Setup without any Enhancement Technique, Day1;

q = 0.467 lit./day

A = 0.4959 m^2

G =19.476 MJ/m^2

$$E = \frac{q \times 2.3}{A \,.\, G} \times 100 = \frac{0.467 \times 2.3}{0.4959 \times 19.476} \times 100 = 11.12\ \%$$

For Setup with Only Black Coating, Day 1;

q = 0.710 lit./day

A = 0.4959 m^2

G =19.476 MJ/m^2

$$E = \frac{q \times 2.3}{A \,.\, G} \times 100 = \frac{0.710 \times 2.3}{0.4959 \times 19.476} \times 100 = 16.91\ \%$$

Likewise all efficiency calculations are carried out.

Economic Feasibility Evaluation

The economic feasibility of any solar still can be assessed primarily on the basis of 'the unit cost of desalination of saline water' and 'payback period' (n_p) of the investment made for the solar stills. In this section, the conventional model of techno-economic analysis is given to evaluate the unit cost of desalination of saline water (UC_{dw}) and payback period. The cost of desalination of saline water from a passive solar still depends mainly on the present capital cost of the solar still (C_s), interest rate on annual basis (i), expected useful life of solar still in years (n), salvage value of solar still in future (S), average annual productivity in liters (M_{Yearly}), and annual operation and maintenance cost (OMC). The cost of land to install the solar still, annual tax and insurance charge (if any), and the annual cost of saline water are ignored here. The OMC includes the annual cost involved in regular cleaning of the glass cover, removal of scaling due to salt deposition on the basin liner and side walls, regular filling of saline water to maintain the level of saline water in the basin, and safe collection of distilled water regularly to avoid contamination.[26]

Table -4: Economic Analysis Parameter [26]

Parameters	Values
$\mathbf{C_s}$	Capital cost of the solar still per $\mathbf{m^2}$
OMC	Annual operation and maintenance cost.(15% of the annualized capital cost of solar still $\mathbf{AC_S}$)
N	10 years (Expected useful life of solar still)
i	12%
S	10% of the present capital cost of the solar still (Cs)
$\mathbf{M_{Yearly}}$	Average annual productivity per sq. meter of the solar still
$\mathbf{N_d}$	250 (Number of clear days in a year)
$\mathbf{m_d}$	Mean daily distillate output per $\mathbf{m^2}$
CRF	Capital recovery factor
SFF	Sinking fund factor
CF	Cash flow

TAC	Total annualized cost
ASV	Annualized salvage value
UC_{dw}	Unit cost of desalination of saline water

1] Unit cost of distillate,

$$UC_{dw} = \frac{\text{Total annualized cost (TAC)of passive solar still}}{M_{Yearly}}$$

A] Average annual productivity per sq. meter of the solar still,

$$M_{Yearly} = N_d \times m_d$$

B] Total annualized cost (TAC)of passive solar still

$$TAC = ACs + OMC - ASV$$

I) Annualized capital cost of solar still,

$$AC_S = C_s \times CRF$$

Capital recovery factor,

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

II) Annual operation and maintenance cost (OMC),

$$OMC = 15\% \text{ of the annualized capital cost of solar still } AC_S = 0.15 \times AC_S$$

III) Annualized salvage value (ASV),

$$ASV = S \times SFF$$

Sinking Fund Factor (SFF),

$$SFF = \frac{i}{(1+i)^n - 1}$$

2] Pay Back Period (n_p),

$$n_p = \frac{\ln[\frac{CF}{CF - (C_s \times i)}]}{\ln(1+i)}$$

Cash Flow (CF),

$$CF = M_{Yearly} \times \text{Market Selling price of distillate } (S_p)$$

Sample Calculation for Economic Feasibility Evaluation

Simple Setup without any enhancement;

$C_s = \text{Rs. } 11014/-$

$i = 12\% = 0.12$

$n = 10 \text{ years}$

$S = 10\% \text{ of } C_s = 0.10 \times 11014 = \text{Rs. } 1101.40/-$

$N_d = 250 \text{ days}$

$m_d = 1.0487 \text{lit/m}^2$

A] Average annual productivity per sq. meter of the solar still,

$$M_{Yearly} = N_d \times m_d = 250 \times 1.0478 = 261.95 \text{ lit/m}^2$$

B] Total annualized cost (TAC)of passive solar still

$$TAC = ACs + OMC - ASV$$

I) Annualized capital cost of solar still,

$$AC_S = C_s \times CRF$$

Capital recovery factor,

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.12(1+0.12)^{10}}{(1+0.12)^{10} - 1} = 0.1769841642$$

$$AC_S = C_s \times CRF = 11014 \times 0.176984164$$

$$AC_S = \text{Rs. } 1949.303584/-$$

II) Annual operation and maintenance cost (OMC),

$$OMC = 15\% \text{ of the annualized capital cost of solar still } AC_S$$

$$OMC = 0.15 \times AC_S = 0.15 \times 1949.303584$$

$$OMC = \text{Rs. } 292.395538/-$$

III) Annualized salvage value (ASV),

$$ASV = S \times SFF$$

Sinking Fund Factor (SFF),

$$SFF = \frac{i}{(1+i)^n - 1} = \frac{0.12}{(1+0.12)^{10} - 1} = 0.05698416416$$

$$ASV = S \times SFF = 1101.40 \times 0.05698416416$$

$$ASV = \text{Rs. } 62.762358/-$$

$$TAC = ACs + OMC - AS$$

$$TAC = 1949.303584 + 292.395538 - 62.762358$$

$$TAC = \text{Rs. } 2178.936764/-$$

1] Unit cost of distillate,

$$UC_{dw} = \frac{\text{Total annualized cost (TAC)of passive solar still}}{M_{Yearly}}$$

$$UC_{dw} = \frac{2178.936764}{261.95} = \text{Rs.}\,8.31814/-$$

2] Pay Back Period (n_p),

$$n_p = \frac{\ln[\frac{CF}{CF-(C_s \times i)}]}{\ln(1+i)}$$

Cash Flow (CF),

$$CF = M_{Yearly} \times \text{Market Selling price of distillate } (S_p)$$

$$\text{Market Selling price of distillate } (S_p) = \text{Rs.}\,15/-$$

$$CF = 261.95 \times 15 = \text{Rs.}\,3929.25/-$$

$$n_p = \frac{\ln[\frac{CF}{CF-(C_s \times i)}]}{\ln(1+i)} = \frac{\ln[\frac{3929.25}{3929.25-(11014 \times 0.12)}]}{\ln(1+0.12)}$$

$$n_p = 3.6181 \text{ years}$$

4. RESULTS AND DISCUSSION

Table -5: Comparison of Economic Feasibility & Payback Period of solar still.

Sr. No.	Setup Type	Unit cost of distillate per lit. (INR)	Payback Period (Years)	Market Selling Price of Distillate per lit. (INR)
1	Simple Setup without any Enhancement	8.3181/-	3.6181	15/-
2	Simple Setup with only Black Coating	6.1183/-	2.5081	15/-
3	Setup with Black Coating & Finned surface	4.8888/-	1.9436	15/-
4	Setup with Black Coating & PCM	3.6201/-	1.3966	15/-
5	Setup with Black Coating & Reflector	4.8542/-	1.9282	15/-

Distillate output is more in experimental setup which consists of only Black Coating compared to simple setup. Also it has been seen that distillate output is more in experimental setup which consists of Black Coating with finned surface, Black Coating with reflector arrangement and Black Coating with phase change material as Paraffin Wax. Hence efficiency of simple setup is increases by use of Black Coating, Finned Surface, Reflector and Phase Change Material; or combinations of Black Coating & one enhancement technique as Finned Surface or Reflector or Phase Change. The unit cost of distillate manufacturing is decrease for experimental setups as Simple Setup with only Black Coating, Setup with Black Coating & Finned surface, Setup with Black Coating & Reflector and Setup with Black Coating & PCM. Payback period is decreases for experimental setups as Simple Setup with only Black Coating, Setup with Black Coating & Finned surface, Setup with Black Coating & Reflector and Setup with Black Coating & PCM respectively.

Table -6: Chemical analysis of impure and pure water samples.

Sr. No.	Chemical Property	Saline Water	Distilled Water
1	pH	7.49	6.75
2	E. Conductivity	34800 μmhos/cm	64 μmhos/cm
3	Alkalinity	430 mg/l	16 mg/l
4	Total Hardness	640 mg/l	6 mg/l
5	Chlorides	17500 mg/l	10 mg/l

5. CONCLUSION

From this Experimental investigation we can conclude that the increase in temperature and hence the evaporation is maximum in the period of 12:00 am to 03:00 pm. The saline water we have supplied was 10 litres and at the end of the experiment we got distilled water 3.404 – 1.420 litre per square meter for different experimental setups as mentioned earlier. The pH of purified water obtained is 6.75, Electric Conductivity is obtained as 64 μmhos/cm, Total hardness is obtained as 6 mg/l and amount of Chlorides reduced as 10 mg/l. So the water obtained is chemically potable. The efficiency of the still has been improved up to 40.53%. The unit cost of distillation of saline water is estimated to be INR 8.3181/L for simple setup, INR 6.1183/L for simple setup with only black coating, INR 4.8888/L for black coating with finned surface, INR 3.6201/L for black coating with PCM and INR 4.8542/L for black coating with reflector attachment, these unit costs are less compared to market selling price of distillate. The payback periods of the different types of passive solar still are found to be in the range of 1.3966 to

3.6181 years if the market selling price of distilled water is INR 15/L.

REFERENCES

[1] B. Selva Kumar, Sanjay Kumar, R. Jayaprakash, "Performance analysis of a "V" type solar still using a charcoal absorber and a boosting mirror", Desalination 229 (2008), Pg. 217–230.

[2] Bharat Kumar Patil, Sanjay Dambal, "Design and Experimental Performance Analysis of Solar Still Using Phase Changing Materials and Sensible Heat Elements", IJRMET, Vol. 6, Issue 2, May - Oct 2016.

[3] B.N. Subramanian and P. Chandrasekaran, "A Novel Method of Enhancing the Productivity and Efficiency of Solar Still – An Experimental Study", I J C T A, 9(37) 2016, pg. 545-553, International Science Press.

[4] M.E. El-Swify, M.Z. Metias, "Performance of double exposure solar still", Renewable Energy 26 (2002), Pg. 531–547.

[5] A.K.Singh, G.N.Tiwari, P.B.Sharma,& Emran Khan, "Optimization of Orientation for Higher Yield of Solar Still for a given Location", Energy Convers. Mgmt Vol.36, No.3, Pg.175-187, 1995.

[6] A.A. El-Sebaii, S. Aboul-Enein, E. El-Bialy, "Single basin solar still with baffle suspended absorber", Energy Conversion & Management 41 (2000), Pg. 661-675.

[7] Mohammed Farid & Faik Hamad, "Single Basin Solar Still", Renewable energy Vol.3, No.1, Pg.75-83,1993.

[8] Hiroshi Tanaka, Yasuhito Nakatake, "Improvement of the tilted wick solar still by using a flat plate reflector", Desalination 216 (2007), Pg. 139–146.

[9] Ragh Vendra Singh, Shiv Kumar , M.M. Hasan, M. Emran Khan, G.N. Tiwari, "Performance of a solar still integrated with evacuated tube collector in natural mode", Desalination 318 (2013), Pg. 25–33.

[10] Kazuo Murase, Hiroshi Tobata, Masayuki Ishikawa, Shigeki Toyama, "Experimental and numerical analysis of a tube-type networked solar still for desert technology", Desalination 190 (2006), Pg. 137–146.

[11] A.A.El-Sebaii, A.A.Al-Ghamdi, F.S. Al-Hazmi, Adel S. Faidah, "Thermal performance of a single basin solar still with PCM as a storage medium", Applied Energy 86 (2009), Pg.1187–1195.

[12] A.A.El-Sebaii, S.J.Yaghmour, F.S.Al-Hazmi, Adel S.Faidah, F.M.Al-Marzouki, A.A. Al-Ghamdi "Active single basin solar still with a sensible storage medium" Desalination 249 (2009), Pg. 699–706.

[13] K. Kalidasa Murugavel, Kn.K.S.K. Chockalingam, K. Srithar "An experimental study on single basin double slope simulation solar still with thin layer of water in the basin" Desalination 220 (2008), Pg. 687–693.

[14] Chendake A.D., Pawar R.S., Thorat P.V. and Pol A.D., "Design and Development of Double Slope Type Solar Distillation Unit", Res. J. Agriculture and Forestry Sci., Vol. 3(4), April (2015) , Pg. 1-6.

[15] Amar S. Sawant, Prof.N.N.Shinde and Prof.M.M.Wagh, "Design, Development And Experimental Analysis Of Single Slope And Double Slope Solar Still With Ifferent Materials", IJMTER, Pg. 151-159.

[16] Avesahemad S.N. Husainy, Omkar S. Karangale, Vinayak Y Shinde, "Experimental Study of Double Slope Solar Distillation with and without Effect of Latent Thermal Energy Storage", ARME ISSN: 2249 - 6289 Vol. 6 No. 2, 2017, Pg.15-18.

[17] A. A. Ibrahim, M. Dauda, G. Y. Pam and D. O. Obada, "Design, Construction And Performance Comparison Of Two Solar Stills Having Different Absorber Design", Nigerian Journal of Technology (NIJOTECH) Vol. 34 No. 4, October 2015, Pg. 761 – 767.

[18] Sagar Suresh Agrawal, "Distillation of Water- Using Solar Energy with Phase Change Materials", (IJERA) ISSN: 2248-9622, RESEARCH ARTICLE.

[19] Prof. Alpesh Mehta, Arjun Vyas, Nitin Bodar and Dharmesh Lathiya, "Design of Solar Distillation System", International Journal of Advanced Science and Technology, Vol. 29, April 201. Pg. 67-74.

[20] A. Madhlopa, J. A. Clarke, " Theoretical study of the aspect ratio of a solar still with double slopes" , World Renewable Energy Congress-2011, Sweden, Solar Thermal Applications, 8-13 May, 2011,Linkoping, Sweden, Pg. 3873-3880.

[21] S. Nanda kumar, P.P.Shantharaman, "Fabrication of solar water distillation system", (IJCEM) Volume 2, Issue 1, April 2015, Pg. 179-186.

[22] S H Sengar, Y P Khandetod and A G Mohod, "New Innovation of low cost solar still", European Journal of Sustainable Development (2012), ISSN: 2239-5938, Pg. 315-352.

[23] Rusul Dawood Salim1, Jassim Mahdi AL-Asadi1, Aqeel Yousif Hashim, "Design and Manufacture Three Solar Distillation Units and Measuring Their Productivity", Science Journal of Energy Engineering 2015, Pg. 6-10.

[24] N. Ukrainczyk, S. Kurajica, and J. Šipušie, "Thermophysical Comparison of Five Commercial Paraffin Waxes as Latent Heat Storage Materials", Chem. Biochem. Eng. Q. 24 (2), (2010), Pg. 129–137.

[25] Kantesh. D. C, "Design of solar still using Phase changing material as a storage medium", International Journal of Scientific & Engineering Research, Volume 3, Issue 12, December-2012, ISSN 2229-5518, Pg. 1- 6.

[26] K. R. Ranjan and S. C. Kaushik, "Economic feasibility evaluation of solar distillation systems based on the equivalent cost of environmental degradation and high-grade energy savings", International Journal of Low-Carbon Technologies 2016, 11, Pg. 8–15.

[27] "Solar distillation", Practical Action Technical Brief.

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