

PERFORAMCNE OF HEMISPHERICAL SOLAR STILL WITH CONVENTIONAL SOLAR STILL: AN EXPERIMENTAL APPROACH

Kumel Nagori[1], Deepak N. Gupta[b], Milap Nayak[2]
[1]Research scholar, Faculty of engineering, Gokul Global University, Sidhpur, Gujarat, India
kumel.mech1987@gmail.com
[2]PhD Guide, Hansaba college of engineering and technology, Gokul Global University, Sidhpur, Gujarat, India
[3]Assistant Professor, Chemical Engineering Department, Vishwakarma Government Engineering College, Chandkheda, Ahmedabad, Gujarat, India.

Abstract

The demand of pure water is increasing day by day due to its limited resource. Solar still is a device which convert the salty water into pure water with the help of solar energy. In present experimental work hemispherical shape conventional type solar still was prepared and its performance was measured with existing conventional type solar still. In hemispherical solar still due to its hemisphere condensing cover the lower value of inner glass cover temperature and higher water temperature of 56 ℃and 60 ℃were achieved. The hemispherical solar still have maximum 23% more distillate output compare to conventional type solar still. It was also found that with modification in design of solar still, higher distillate productivity could be achieved.

[1] Introduction

Pure water is prime requirement for all human being. Population of India is 2nd highest in the world. In many remote areas people do not get pure drinkable water. The sources of pure water are very less on the earth. As per WHO majority of diseases in people are occurs due to impure water and in future the requirement of clean water will be increase. The major portion of water on earth is salty or impure water, there is very little source of clean water. So it is necessary to create the sources which convert the impure water into the pure form. The non-renewable sources are decreasing day by day and they are highly polluting. So the better option is to use renewable sources of energy for water purification. Solar still convert the salty in to clean water using solar radiation. Solar still is the most renewable device which is useful on the areas where supply of electricity is not available. Solar distillation is the method in which saline water can be converted into pure water [1-4]. Desalination is simple and easy technique to use to remove the impurity/ salinity from sea water or brackish water. In solar distillation method clean and pure water can be obtained with solar still. There are many different techniques are available for water cleaning, but solar desalination is best among that due to its simplicity, non- polluting nature and it is useful in that areas where problem of electricity occurs. This is the reason behind wide usage of solar desalination method [5-7]. By evaporation and condensation process distilled water can be achieved from the solar still. Due to higher heat losses the distillate productivity of solar still is very low. It gives around 1.7 to 1.8 ml of water in single day. So this is not enough water for drinking for single person only [8-10].

[2] Literature on Research Work

Many researchers have taken different steps to lower the heat loss and increase the productivity of solar still. They used different technique by changing configuration in still, change the design of still, used a different absorbing material, flat plate collector, fins, evacuated tubes etc [11-12]. To increase the evaporative and absorber area solar still is modified with attachment of trays and mirror inside still by Abdullah et al. 2020 [13]. Patel and Kumar 2016 [14] compare the experiment with changing the lower height of solar still and get better result. Panchal Hitesh. 2016 [15] done experiment with 4mm; 5mm & 6mm glass cover thickness and get optimum result for 4mm. Morad et al. 2015 [16] reduces the top cover losses by applying cooling technique on it. Around 30% higher efficiency can be achieved by this technique. Shyora et. al. 2019 [17] compare the experiment with modifying stepped type solar still and get 23.5% higher efficiency. Panchal and Patel 2017 [18] observed that with higher speed of wind and higher solar radiation gives the higher distillate productivity. Higher wind speed and more solar isolation give higher distillate productivity. To preheat the water inside solar still Badran and Tahaineh 2005 [19] used a FPC and achieved 36% higher efficiency than conventional still. Raju and Narayana 2016 [20] connect a two FPC in series and compare the experiment. The modified system gives 41% higher distillate output than single FPC. Madiouli et al. 2020[21] used a PTC and FPC to achieve and concentrate the more solar radiation with conventional solar still, also it gives maximum efficiency in summer and winter. Fathy et al. 2018[22] conduct an experiment using a fixed and movable PTC with double slope still. El-Sebaii et al. 2008[23] conduct an experiment with solar still by measuring parameters with water mass and its thickness. This system gives higher day and night productivity than existing system. Panchal Hitesh 2014[24] conducted an experiment using energy storage material as metal stones and cow and get better result. A review on different thermal energy storage material like Black rubber, stones, ink, dyes, charcoal particle, jute wick etc done by Panchal Hitesh 2016[25]. It is found that these materials have good energy absorbing capacity. Murugavel and Shrithar 2011[26] used a wick material inside the basin area as an absorber to lower the volumetric heat capacity of still. For higher heat transfer area inside the still Omara et al.2011 [27] used a fins and corrugated absorber surface inside still. These modifications give 40% higher distillate than conventional still. Mevada et al. 2019[28] reviewed with different attachments of fins and found that increasing the height of fins and lower thickness gives higher efficiency in solar still. Sharshir et al.2019[29] used a evacuated tubes and nano fluids with pyramid shape solar still and compare experiment with conventional still. They also found the performance of copper oxide and carbon black nano material with solar still. Kumar et al.2014 [30] used a fan to circulate the water from basin to evacuated tubes with solar still. They found that performance of force mode system is higher than natural mode. Panchal and Shah 2014[31] conduct experiment on double slope type solar still with evacuated tubes and energy storage materials and found that with minimum 2 cm basin water depth gives optimum performance on solar still. A climatic parameters like wind speed, solar intensity also affect on productivity of solar still. The performance of still is decrease with lower wind speed and low solar intensity [32, 33]. To increase the heat transfer coefficient of water Panchal and Sathyamurthi 2017[34] have used a porous type fins. Rajaseenivasan and shrithar 2016[35] check performance of solar still using square and circular type of fins and found that both fins

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper © 2012 IJFANS. All Rights Reserved, Journal UGC CARE Listed (Group-I) Volume 12, Issue 07 Oct 2023

increase the efficiency of solar still. Sebaii and Nagar 2017[36] found that material of the fins does not affect on productivity of solar still. The productivity of solar still can be increased by using different absorbing materials with fins on solar still; it gives higher distillate output than existing conventional system [37, 38]. Addition of nano materials with different absorbing materials and fins on solar still improve its performance, also the day and night productivity can be increased. [39,40] Saravanan et al. 2020 used a kanchey marble as a heat reservoir material and observed that without effect on phase of water medium basin water temperature is increased and around 163% higher distillate output can be achieved[41].

[3] Experimental Set Up

In present experimental work conventional type hemispherical solar still was used. The objective of present experimental work is to check the performance of conventional type hemispherical solar still with existing solar still system. The experiment was conducted under the geometric conditions in Palanpur, Gujarat, India (24° 10' 45.59″ N, 72° 25' 36.05″ E). The experimental readings were taken in month of December 2023 for a total of five days from 8:00 to 7:00 p.m. Different parameters, such as atmospheric temperature (T_a), water temperature (T_w), inner glass cover temperature (T_{gi}), solar intensity (I), and hourly and cumulative distillate outputs, were measured for five days. In this study, an average wind speed of 4 m/s was considered. All measured parameters were recorded on a digital data logger for all the days. From out of the five days readings the optimum readings are taken in calculation. Figure 1 shows the photograph of experimental set up. The solar still was fabricated from iron material and condensing cover is made of acrylic material. To collect the distilled water from solar still, a water jug with capacity of 5 litre is used.

Figure 1. Experimental set up photograph

[4] Results & Discussion

In below figure 2 to 4 shows the results of experimental work done carried out for hemispherical solar still. The different parameters like atmospheric temperature, solar intensity, water temperature, inner glass cover temperature were measure during the experimental work. All the readings were taken during morning 8:00 a,m to evening 7:00 p.m. From figure 2 it was found that in higher solar intensity the atmospheric temperature remains higher. It shows maximum during the noon time. Before noon and evening time due to lower solar intensity the atmospheric temperature remains lower. Solar intensity of 720 w/m^2 reach at 1:00 p.m. Atmospheric temperature has major effect on performance of solar still. With higher value of atmospheric temperature, the water temperature of solar still remains higher, which leads to the maximum distillate output on that particular time. The value to water temperature remains the higher compare to inner glass cover temperature (figure 3). To achieve the maximum value to distillate output the inner glass cover temperature should be a lower, which reduce the heat losses, hence productivity of solar still could be improved. In this experimental work the obtained value of maximum water (T_w) and inner glass cover (T_{gi}) temperature are 60℃ and 56℃ respectively at 1:00 p.m.

In figure 4 the total distillate output for hemispherical and conventional solar still is shown By higher value in water temperature and lower inner glass cover temperature in hemispheric solar still leads to the higher distillate output. The total distillate output obtained for hemispherical and conventional solar still are 1.780 (l/m^2) & 1.450 (l/m^2) respectively. Compare to conventional solar still in hemispherical type the distillate output remains higher due to its hemispherical design. The condensing cover losses minimum heat loss in hemispherical type which maintains the lower inner glass cover temperature in hemispherical solar still.

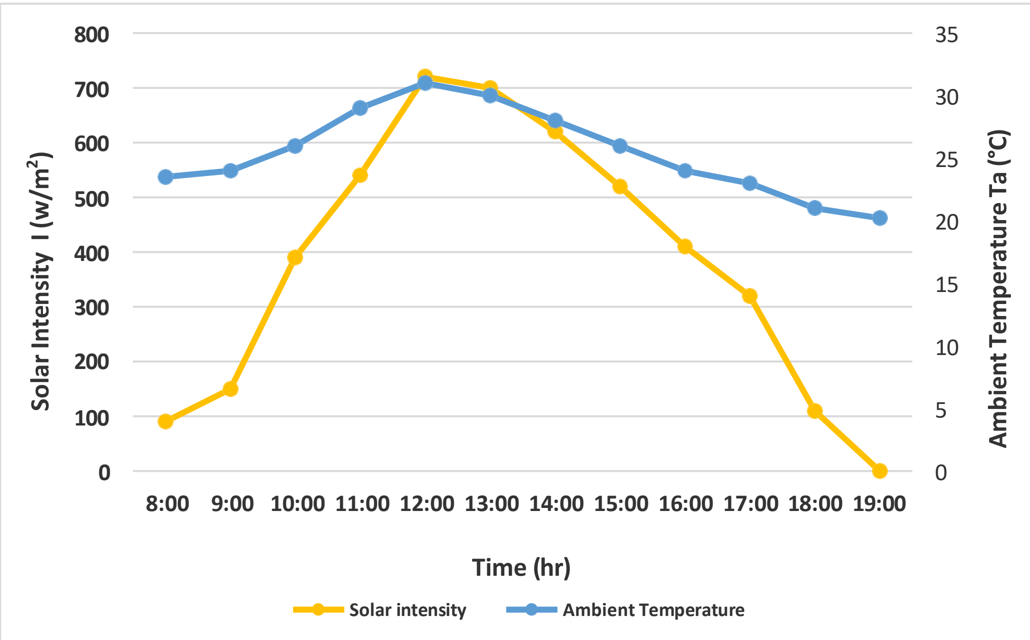

Figure 2. Ambient temperature vs. Solar Intensity

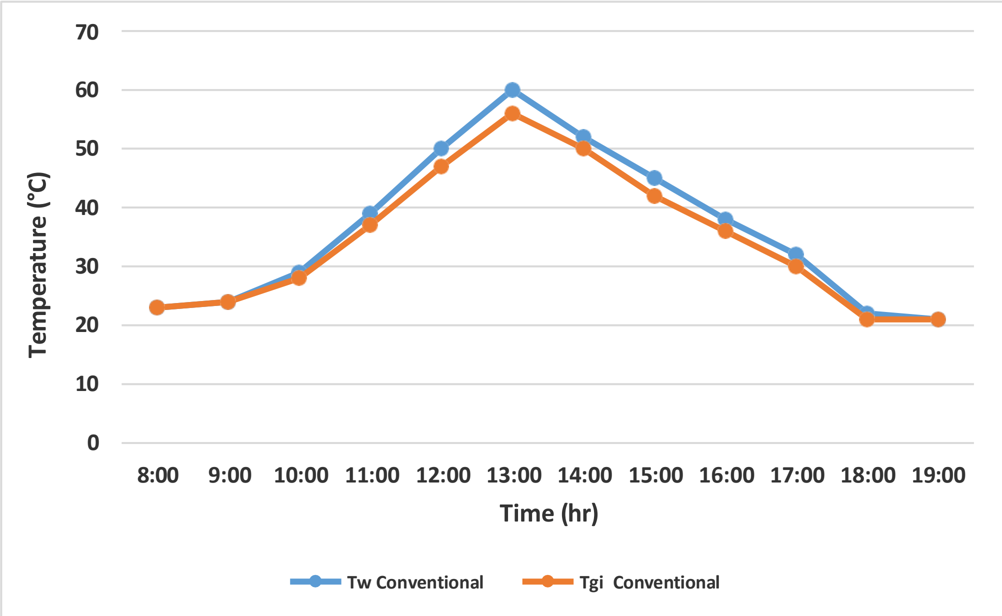

Figure 3. Water temperature & Inner glass cover temperature of hemispherical solar still

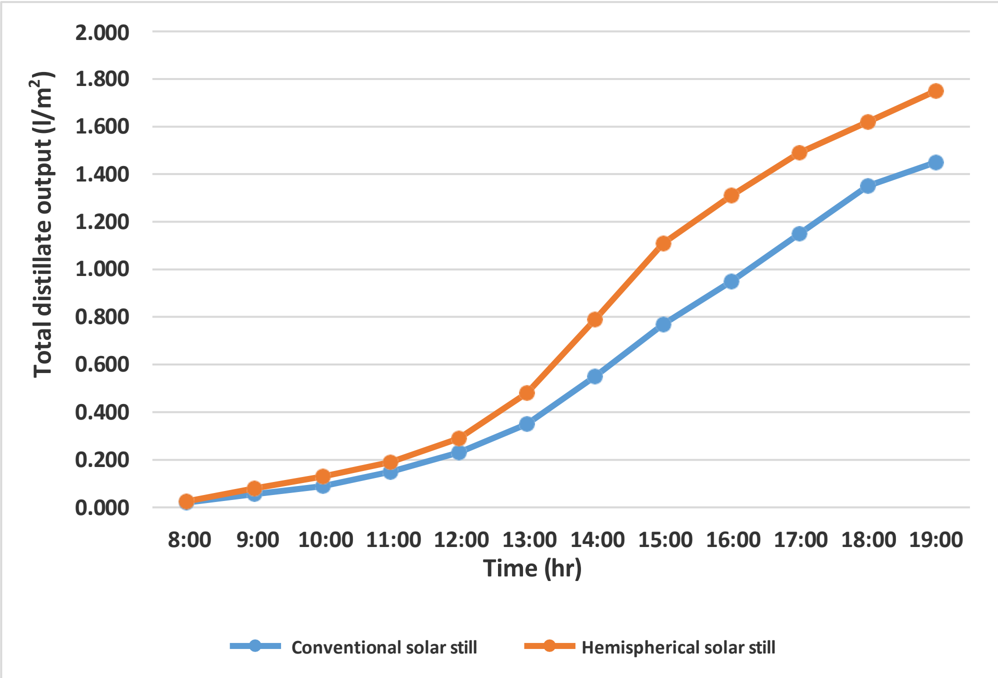

Figure 4. Results of total distillate output for both solar still

[5] Conclusion

From experimental study it was found that by changing the shape and design of solar still, the variation in its performance could be achieved. There are different parameters like atmospheric temperature (T_a), water temperature (T_w), inner glass cover temperature (T_{gi}), solar intensity (I) and wind speed have major impact on performance of solar still. In hemispherical solar still the water temperature and inner glass cover temperature remains lower compare to conventional solar still. The obtained value to water and inner glass cover temperature are 60℃ and 56℃ respectively. Also the total distillate output obtained for hemispherical and conventional solar still are 1.780 (l/m^2) & 1.450 (l/m^2) respectively. The performance of hemispherical shape solar still remains higher compare to existing conventional type solar still. By changing the shape & design of solar still as hemispherical higher distillate in output could be achieved.

6. References

[1] K. Pansal *et al.*, "Use of solar photovoltaic with active solar still to improve distillate output: A review," *Groundw. Sustain. Dev.*, vol. 10, p. 100341, 2020.

[2] H. Panchal, K. K. Sadasivuni, M. Israr, and N. Thakar, "Various techniques to enhance distillate output of tubular solar still: A review," *Groundw. Sustain. Dev.*, vol. 9, no. August, p. 100268, 2019.

[3] D. Mevada *et al.*, "Effect of fin configuration parameters on performance of solar still: A review," *Groundw. Sustain. Dev.*, vol. 10, p. 100289, 2020.

[4] H. N. Panchal and S. Patel, "An extensive review on different design and climatic parameters to increase distillate output of solar still," *Renew. Sustain. Energy Rev.*, vol. 69, no. September 2016, pp. 750–758, 2017.

[5] K. Pansal *et al.*, "Use of solar photovoltaic with active solar still to improve distillate output: A review," *Groundw. Sustain. Dev.*, vol. 10, p. 100341, 2020, doi: 10.1016/j.gsd.2020.100341.

[6] H. Panchal, K. K. Sadasivuni, M. Israr, and N. Thakar, "Various techniques to enhance distillate output of tubular solar still: A review," *Groundw. Sustain. Dev.*, vol. 9, no. August, p. 100268, 2019, doi: 10.1016/j.gsd.2019.100268.

[7] Elsheikh *et al* " Improving the tribological properties of AISI M50 steel using Sns/Zno solid lubricants" *Journal of Alloys and Compounds.* vol.821, April 2020,p.153494.

[8] H. Panchal, "Annual performance analysis of various energy storage materials in the upper basin of a double-basin solar still with vacuum tubes," *Int. J. Ambient Energy*, vol. 41, no. 4, pp. 435–451, 2020, doi: 10.1080/01430750.2018.1472653.

[9] M. Patel, C. Patel, and H. Panchal, "Performance analysis of conventional triple basin solar still with evacuated heat pipes, corrugated sheets and storage materials," *Groundw. Sustain. Dev.*, vol. 11, p. 100387, 2020, doi: 10.1016/j.gsd.2020.100387.

[10] H. Panchal and I. Mohan, "Various methods applied to solar still for enhancement of distillate output," *Desalination*, vol. 415, no. October, pp. 76–89, 2017, doi: 10.1016/j.desal.2017.04.015.

[11] R. Kumar T., L. S. Videla, S. SivaKumar, A. G. Gupta and D. Haritha, "Murmured Speech Recognition Using Hidden Markov Model," 2020 *7th International Conference on Smart Structures and Systems (ICSSS)*, Chennai, India,pp. 1-5, 2020.

[12] A. S. Abdullah, M. M. Younes, Z. M. Omara, and F. A. Essa, "New design of trays solar still with enhanced evaporation methods – Comprehensive study," *Sol. Energy*, vol. 203, no. April, pp. 164–174, 2020, doi: 10.1016/j.solener.2020.04.039.

[13] P. Patel and R. Kumar, "Comparative Performance Evaluation of Modified Passive Solar Still Using Sensible Heat Storage Material and Increased Frontal Height," Procedia Technol., vol. 23, pp. 431–438, 2016, doi: 10.1016/j.protcy.2016.03.047.

[14] L. Zhang, Z. Xu, B. Bhatia, B. Li, L. Zhao, and E. N. Wang, "Modeling and performance analysis of high-efficiency thermally-localized multistage solar stills," *Appl. Energy*, vol. 266, no. March, p. 114864, 2020, doi: 10.1016/j.apenergy.2020.114864.

[15] H. Panchal, "Performance Investigation on Variations of Glass Cover Thickness on Solar Still: Experimental and Theoretical Analysis," *Technol. Econ. Smart Grids Sustain. Energy*, vol. 1, no. 1, 2016, doi: 10.1007/s40866-016-0007-0.

[16] M. M. Morad, H. A. M. El-Maghawry, and K. I. Wasfy, "Improving the double slope solar still performance by using flat-plate solar collector and cooling glass cover," *Desalination*, vol. 373, pp. 1–9, 2015, doi: 10.1016/j.desal.2015.06.017.

[17] A. Shyora, K. Patel, and H. Panchal, "Comparative analysis of stepped and single basin solar still in climate conditions of Gandhinagar Gujarat during winter," *Int. J. Ambient Energy*, vol. 0, no. 0, pp. 1–11, 2019, doi: 10.1080/01430750.2019.1612781.

[18] H. N. Panchal and S. Patel, "An extensive review on different design and climatic parameters to increase distillate output of solar still," *Renew. Sustain. Energy Rev.*, vol. 69, no. September 2016, pp. 750–758, 2017, doi: 10.1016/j.rser.2016.09.001.

[19] O. O. Badran and H. A. Al-Tahaineh, "The effect of coupling a flat-plate collector on the solar still productivity," *Desalination*, vol. 183, no. 1–3, pp. 137–142, 2005, doi: 10.1016/j.desal.2005.02.046.

[20] V. R. Raju and R. Lalitha Narayana, "Effect of flat plate collectors in series on performance of active solar still for Indian coastal climatic condition," *J. King Saud Univ. - Eng. Sci.*, vol. 30, no. 1, pp. 78–85, 2018, doi: 10.1016/j.jksues.2015.12.008.

[21] J. Madiouli, A. Lashin, I. Shigidi, I. A. Badruddin, and A. Kessentini, "Experimental study and evaluation of single slope solar still combined with flat plate collector, parabolic trough and packed bed," *Sol. Energy*, vol. 196, no. August 2019, pp. 358–366, 2020, doi: 10.1016/j.solener.2019.12.027.

[22] M. Fathy, H. Hassan, and M. S. Ahmed, "Experimental study on the effect of coupling parabolic trough collector with double slope solar still on its performance," 2018, doi: 10.1016/j.solener.2018.01.043.

[23] A. A. El-Sebaii, M. R. I. Ramadan, S. Aboul-Enein, and N. Salem, "Thermal performance of a single-basin solar still integrated with a shallow solar pond," *Energy Convers. Manag.*, vol. 49, no. 10, pp. 2839–2848, 2008, doi: 10.1016/j.enconman.2008.03.002.

[24] H. N. Panchal, "Performance analysis of solar still with cow dung cakes and blue metal stones," *Front. Energy*, vol. 9, no. 2, pp. 180–186, 2015, doi: 10.1007/s11708-015-0361-y.

[25] H. N. Panchal, "Use of thermal energy storage materials for enhancement in distillate

output of solar still: A review," *Renew. Sustain. Energy Rev.*, vol. 61, pp. 86–96, 2016, doi: 10.1016/j.rser.2016.03.043.

[26] K. Kalidasa Murugavel and K. Srithar, "Performance study on basin type double slope solar still with different wick materials and minimum mass of water," *Renew. Energy*, vol. 36, no. 2, pp. 612–620, 2011, doi: 10.1016/j.renene.2010.08.009.

[27] Z. M. Omara, M. H. Hamed, and A. E. Kabeel, "Performance of finned and corrugated absorbers solar stills under Egyptian conditions," *Desalination*, vol. 277, no. 1–3, pp. 281–287, 2011, doi: 10.1016/j.desal.2011.04.042.

[28] D. Mevada *et al.*, "Effect of fin configuration parameters on performance of solar still: A review," *Groundw. Sustain. Dev.*, vol. 10, p. 100289, 2020, doi: 10.1016/j.gsd.2019.100289.

[29] S. W. Sharshir, A. W. Kandeal, M. Ismail, G. B. Abdelaziz, A. E. Kabeel, and N. Yang, "Augmentation of a pyramid solar still performance using evacuated tubes and nanofluid: Experimental approach," *Appl. Therm. Eng.*, vol. 160, no. April, p. 113997, 2019, doi: 10.1016/j.applthermaleng.2019.113997.

[30] S. Kumar, A. Dubey, and G. N. Tiwari, "A solar still augmented with an evacuated tube collector in forced mode," *Desalination*, vol. 347, pp. 15–24, 2014, doi: 10.1016/j.desal.2014.05.019.

[31] H. N. Panchal and P. K. Shah, "Enhancement of upper basin distillate output by attachment of vacuum tubes with double-basin solar still," *Desalin. Water Treat.*, vol. 55, no. 3, pp. 587–595, 2015, doi: 10.1080/19443994.2014.913997.

[32] A. Kumar and G. N. Tiwari, "Use of waste hot water in double slope solar still through heat exchanger," *Energy Convers. Manag.*, vol. 30, no. 2, pp. 81–89, 1990, doi: 10.1016/0196-8904(90)90017-S.

[33] A. Agrawal, R. S. Rana, and P. K. Srivastava, "Heat transfer coefficients and productivity of a single slope single basin solar still in Indian climatic condition: Experimental and theoretical comparison," *Resour. Technol.*, vol. 3, no. 4, pp. 466–482, 2017, doi: 10.1016/j.reffit.2017.05.003.

[34] H. Panchal and R. Sathyamurthy, "Experimental analysis of single-basin solar still with porous fins," *Int. J. Ambient Energy*, vol. 41, no. 5, pp. 563–569, 2020, doi: 10.1080/01430750.2017.1360206.

[35] T. Rajaseenivasan and K. Srithar, "Performance investigation on solar still with circular and square fins in basin with CO2 mitigation and economic analysis," *Desalination*, vol. 380, pp. 66–74, 2016, doi: 10.1016/j.desal.2015.11.025.

[36] A. A. El-Sebaii and M. El-Naggar, *Year round performance and cost analysis of a finned single basin solar still*, vol. 110, no. August. Elsevier Ltd, 2017.

[37] H. N. Panchal and S. Patel, "Effect of Various Parameters on Augmentation of Distillate Output of Solar Still: A Review," *Technol. Econ. Smart Grids Sustain. Energy*, vol. 1, no. 1, pp. 1–8, 2016, doi: 10.1007/s40866-016-0005-2.

[38] H. N. Panchal, "Use of thermal energy storage materials for enhancement in distillate output of solar still: A review," *Renew. Sustain. Energy Rev.*, vol. 61, pp. 86–96, 2016, doi: 10.1016/j.rser.2016.03.043.

[39] S. F. Ahmed, M. Khalid, W. Rashmi, A. Chan, and K. Shahbaz, "Recent progress in solar thermal energy storage using nanomaterials," *Renew. Sustain. Energy Rev.*, vol. 67, pp. 450–460, 2017, doi: 10.1016/j.rser.2016.09.034.

[40] N. Abdelal and Y. Taamneh, "Enhancement of pyramid solar still productivity using absorber plates made of carbon fiber/CNT-modified epoxy composites," *Desalination*, vol. 419, no. November 2016, pp. 117–124, 2017, doi: 10.1016/j.desal.2017.06.012.

[41] A. A. M. Moshi, "Experimental investigation on the performance enhancement of single basin double slope solar still using kanchey marbles as sensible heat storage materials," *Mater. Today Proc.*, no. xxxx, 2020, doi: 10.1016/j.matpr.2020.05.710.