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Performance analysis of solar still using various techniques: A review

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Abstract: Humans and other living species require freshwater, yet only around 2.5 percent of the world's water is potable. Freshwater is scarce throughout the world, with only one-third of the population having access to safe drinking water. Solar still is the one method in the direction of the portable water purification process in which hydrological cycle's nature principle. The current review on performance analysis of solar still using various techniques represents recent work to improve the performance and output of the solar still distillation method. Various techniques reviewed such as single slope solar still with sand troughs interaction, impact of glass cover, passive solar still with a twin wedge-shaped glass cover, pyramidal solar still experimental analysis and the use of passive baffles to boost single slope solar still.

***Index Terms* - Solar Still, Glass Cover**

Introduction:

Freshwater is a vital requirement for humans and other living organisms, yet only around 2.5 per cent of the world's water is potable [1,2]. Freshwater is in short supply around the world, with just one-third of the population having access to safe drinking water [3]. As a result, drinking water is a global issue, as demand for potable water is increasing at a rate of 4–5% each year as the world's population and living standards improve [4]. Furthermore, demand for fresh water is predicted to rise to 6900 billion m3 by 2030, an increase of more than 53% from present levels [5]. Water from lakes and rivers was once consumed immediately because it was considered fresh, but today, toxic effluents such as 90–95 percent of sewage and 70 percent of industrial wastes are discharged untreated into surface waters, polluting these water sources and making them unsafe for consumption by living beings, including direct dumping into the ground [6-8]. The impurity of the water ranged from a few hundred to several thousand parts per million (PPM), and water with salinity up to 500 ppm can only be consumed directly because it is considered fresh and safe for people. However, in some circumstances, such as dryness and desert conditions, it may reach 1000 ppm for a short time. According to the WHO study report, water with increased impurity and salinity can cause a variety of water-borne diseases such as cholera, jaundice, cancer, etc. [9]. Due to a lack of education, restricted infrastructure and resources, and the lack of a freshwater supply chain, individuals living in isolated and rural areas, mostly in developing nations, face serious issues [10]. People living near the coast have similar challenges because seawater has a very high salinity on the order of 35000–40000 ppm, making it unfit for direct consumption. Several case studies have been conducted in various regions and parts of the world in this respect by a number of researchers [11-18].

Khanna et al. [11] performed a rigorous investigation on water quality in Chui hamlet, around 220 kilometers west of Rajasthan's capital city, Jaipur. They came to the conclusion that, due to the region's poor rainfall, there is an over-reliance on groundwater not only for direct use but also for irrigation. As a result of this overexploitation of groundwater, obtaining clean and potable water in the state has become extremely difficult. They also discovered that in some parts of the state, groundwater in hand pumps (bore wells) is acidic and often contains high levels of fluorides, contributing to skeletal fluorosis and so making it unfit for direct consumption. According to the data, approximately 21,190 inhabitants were affected by disproportionate salinity, and approximately 23,297 habitations were affected by excessive fluoride content. On the other side, excess nitrate was discovered in around 20,659 localities, with around 56 percent of water supplies being deemed to be non-potable, according to safety regulations (Bureau of Indian Standards)

Another study conducted by Ayoob et al. [13] revealed that the majority of Indians (80% rural and 50% urban) rely on groundwater for domestic consumption due to a scarcity of clean surface water, because there is an increase in pollution levels in the country's water bodies. This is due to the fact that the bulk of industries operating in various locations do not adhere to environmental regulations, and local governments do not take their responsibilities seriously, resulting in contamination of both surface and groundwater. Fluorosis is India's most common geochemistry plague, impacting more than 66 million people, including 6 million children under the age of 14. India houses 16 percent of the world's population yet only possesses 4% of the world's freshwater supply. As a result, safe and drinking water remains a major issue in most Indian cities and villages, posing a serious public health concern. They [13] also stated that people are forced to drink water with fluoride concentrations as high as 44 ppm in various regions of Rajasthan, while it is approximately 23 ppm in Assam, and Delhi, as a megacity, is endemic to fluorosis with a fluoride concentration as high as 32 ppm.

Furthermore, as a result of humankind's industrialization, motorization, and rising living standards, freshwater demand has expanded globally, and naturally accessible freshwater reserves are insufficient to meet the ever-increasing demands. Nandi A. et al. [14] stated that, according to the United Nations Organization (UNO), the majority of people live in severe water shortage zones, and a lack of clean and safe water is a primary reason for the development of infectious illnesses around the world. In the majority of countries, annual freshwater availability has been decreasing day by day. For example, in 1951, India's freshwater availability was 5177 cubic metres; by 2001, it had dropped to 1869 cubic metres, and by 2025, it was anticipated to drop even more to 1341 cubic metres, and by 2050, it was extremely likely to reach 1140 cubic metres. More than 6000 children die every day as a result of a lack of fresh water, and 2.2 million people or possibly more die each year as a result of a lack of freshwater; the situation is significantly worse in other regions of the world [15-17]. Although there is no shortage of water because it covers 75% of the land, the majority of it is in the form of oceans. Freshwater lakes and rivers hold less than 0.1% of global water and less than 3% of all freshwater lakes and rivers, with more than two-thirds locked in the form of glaciers and ice caps [18]. As a result, scientists are working hard to find a solution to this problem using renewable energy sources like solar energy. There are numerous methods for converting available polluted water into potable water, with solar desalination being one of the most well-proven [19]. The fundamental advantage of solar desalination is that it can efficiently use sun energy to produce freshwater [20,21]. This motivated the researcher to investigate alternate desalination facilities, such as solar stills, as a possible solution for freshwater production and supply.

The solar still is one of these devices that is suitable for producing potable water. It is the most affordable, straightforward, and easily accessible solution for small families, as well as an ecologically friendly technology [22,23]. However, due to a variety of factors such as climate, design, and operating conditions, traditional solar still-based desalination technology has low productivity. Several major studies have been conducted in order to raise the yield rate (2.5–5 $L/m^2/d$) by modifying the various parameters that control its efficiency rate. To increase the amount of fresh water distillate produced, a variety of improvements to the conventional solar still have been developed [24-26]. To increase distillation productivity, the wick, corrugated, and finned SS [27], stepped solar distiller [28,29], rotating elements to maximize the evaporation area as well as the exposed area to solar energy and to break the basin water surface tension rotating wick SS [30,31], and many more types of solar stills such as blades solar still [32,33], disc and rotating-drum solar still [34-36] have all been thoroughly researched.

Many computational and practical studies have been conducted to determine the best design by assessing various performance characteristics utilizing various solar still configurations. The current research focuses on the performance, productivity, and parametric study of solar panels, particularly the operating, climatic, and design conditions, such as water–glass cover temperature difference, absorption area, inlet water temperature, heat storage, minimum water depth, phase change materials, vacuum technology, use of reflectors, and condensers, among others.

Solar distillation techniques

The solar distillation system's working principle is based on the hydrological cycle's nature [37,38]. As shown in Fig. 1, the solar still's functioning theory is based on the evaporation and condensation of water. The water basin is filled with water, and the inclination glass cover allows the sun's rays to pass through, heating the water. The basin must still be blacked with black paint to receive the greatest sun flow. When sunlight strikes the basin, it is absorbed, and the water is heated, resulting in the creation of vapour inside the still. As shown in Fig. 1, the vapour condenses on the inner surface of the glass, which is cooler than the basin, and water is collected through the trough linked.

Water demand is increasing rapidly, and it is estimated that by 2030, worldwide water demand would be 16,900 billion m^3 (Bnm^3), with a 2400 Bnm^3 shortfall, as indicated in Fig. 2 [39]. Desalinated water was only available to roughly 400 million people in 2015, and by 2025, 14 percent of the world's population is expected to be compelled to utilize seawater [40]. This gap was filled by various distillation technologies, and India's Ministry of New and Renewable Energy (MNRE) is now focusing on cutting-edge research on solar thermal energy. National Solar Science Fellowship Programs encourage scholars in this field to do research and development (NSSFP) [41].

The two primary types of solar thermal water desalination systems are: a) direct system and b) indirect system. The main difference between these desalination technologies is that with a direct system, solar energy is absorbed and turned into heat during solar desalination operations, causing seawater to evaporate within the device. The indirect approach, on the other hand, employs two different systems: a solar collection array comprised of fluid-based thermal and/or photovoltaic (PV) collectors, and a discrete traditional distillation plant to extract the latent heat of condensation loss [42].

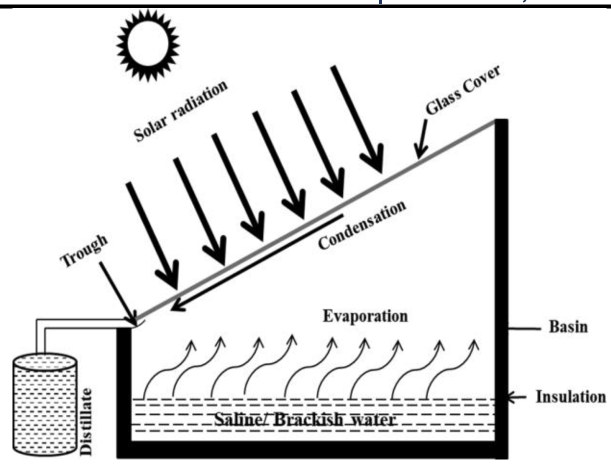

Fig. 1. Schematic of a conventional basin-type solar still [37,38].

Direct solar desalination

In this system, the process of heat collection and condensation takes place in the same system. Solar radiation is partly absorbed by the absorber and partly by the saline or brackish water in the basin when it passes through the glass surface. As a result, the temperature of the water rises faster than the temperature of the glass cover. Evaporation of water occurs, and the vapour rises due to typical convection, causing condensation on the inner surface of the glass cover. Gravity causes the condensate water to flow into the distiller tank.

The impact of adding supplemental effects such a multi-stage evacuated still and wicking material to the still basin was studied, and it was discovered that these enhancements enhanced output per unit area [44].

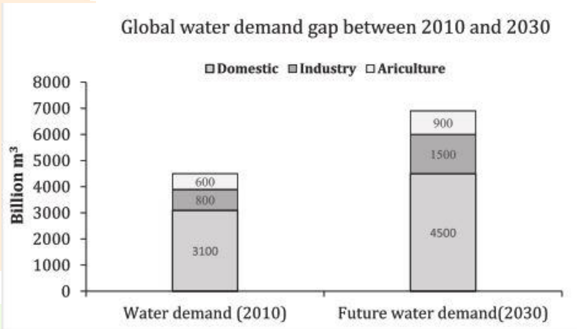

Fig. 2. Comparison of water demand in 2010 and the projected demand in 2030 [39]

As solar radiation collection requires a large area, it is not feasible, especially near cities where land is limited and expensive. Installation costs appear to be significantly greater than for comparable systems when compared. Because of the frequent repairs required to eliminate vapour leaks, scale formation, and damage to glazing plates, labour costs are likely to be significant [45]. However, it is most suited (cost-effectively) to small-scale families and industry in small towns, where solar electricity and low-cost labour are abundant in nature [46].

Indirect solar desalination

Indirect solar desalination is the technique of harnessing solar energy to desalinate water using PV modules or thermal solar collectors. This system can be classified into two categories of thermal technologies: electrical and mechanical. Multi-stage flash (MSF), vapour compression (VC), multi-effect distillation (MED), and membrane distillation (MD) are thermal desalination procedures that require collectors as a source of energy, whereas reverse osmosis (RO) and freezing are mechanical desalination technologies. For sun desalination, electrodialysis (ED) is the only method that uses electricity, while RO, freezing, and reverse osmosis can also be powered by electricity [47]. RO is the most energy-efficient large-scale desalination method, with yields of up to 1.8 kWh/m^3.

Various methodologies to analyse the performance of solar stills.

1. Experimental Performance analysis of single slope solar still with sand troughs interaction

V. Nagarajua, G. Muralib et al. has improved the performance of a single slope solar still with a 1.5 m^2 aperture area, a new way of adding sand troughs is proposed. Experiments with 1 cm, 2 cm, and 3 cm of water levels in the basin are conducted on clear days. For 1 cm water level at 2 PM, the maximum yield is 0.453 L/m^2 for solar still with sand troughs and 0.2 L/m^2 for solar still without sand troughs, respectively. Even with reduced sun radiation, solar still produces a superior yield with a low depth of water level. The solar still's evaporation rate and yield were enhanced by raising the water level and using sand troughs.

When saline water is employed, the still with sand troughs shows a maximum daily productivity increase of 71.4 percent for 1 cm water level. The annual cost of producing pure water in a modified still with sand troughs is predicted to be 0.801 per litre after 12 years of still life. The water level has a significant impact on the solar stills' production. Solar stills with Sand troughs have a 65.08 percent efficiency at 1 cm water depth, but stills without S.T have a 37.9% efficiency at 1 cm water depth.

2. The impact of a clear glass cover on the output of a double-slope solar still

K.S.Maheswari, K.Mayandi S. and Joe Patrick Gnanaraj et al. had studied stretched transparent PVC cover that might be used instead of a standard clear glass sheet for solar distillation equipment. Black cotton cloths with expanded fibres were used on the bottoms of stills to increase the evaporative surface area. More distilled water was collected from the transparent PVC sheet covered still when the angle of inclination (13°) was comparable to that of a glass sheet-covered still. Because of an accumulation of water droplets stuck to the PVC cover, the solar still's collector got less sunlight than it could have. An anti-water surface adhesion chemical or a plastic sheet material with reduced water surface adhesion is the best option. Until this is achieved, standard glass-covered covers will be the preferred cover material.

3. An experimental study of passive solar still with a twin wedge-shaped glass cover was conducted.

By A. Wesley Jeevadason and S.Padmini has proposed desalination systems based on solar thermal energy, such as solar stills, produce fresh distilled water with zero carbon emissions. The performance of a passive type solar still with a double wedge shape glass cover is experimentally explored in this research, as well as the economics component. The Twin Wedge Solar Still is a new form of solar still (TWSS). The system's economics in terms of cost per litre are also discussed. In this study, the performance of TWSS is compared to that of a Conventional Solar Still (CSS). The TWSS's revolutionary glass cover shape design enhances the condensation surface area, which raises the condensation rate, allowing it to deliver 2.68 L of fresh distilled water per m2 of solar still area.

For the same constraints, CSS returned just two-thirds of TWSS, making TWSS 51.5 percent more efficient than CSS. According to the economic research, TWSS has a lower cost per litre rate (0.028 $/l) than CSS, allowing it to reach a faster payback period (one year for TWSS). The TWSS is more favourable than other unique and new design solar stills because of its simple and symmetrical form. Integration of thermal energy storage components in the basin structure is proposed as a future study to increase the TWSS vaporation rate.

4. For a pyramidal solar still, experimental investigation and CFD modelling are used.

Aman Kumar and Ambrish Maurya et al. has discussed desalination of saltwater with the aid of a solar still can be utilised to get drinkable water to meet the demands of an ever-increasing population. Solar is still a simple and dependable method for usage in arid and sunny climates, but it has the drawback of poor productivity. Different shapes other than traditional single slope solar can still be employed to overcome this limitation. In this study, we offer an experimental investigation and CFD modelling of a new shape solar still, the pyramidal solar still.

The major goal of this research is to predict the performance of pyramidal solar panels using a CFD model, which allows us to change the input parameters at any time to simulate different scenarios. Temperatures of the mixture (air, water, and vapour) inside the still, as well as the absorber plate (base of the basin) and the glass cover on the top of the still, act as a driving mechanism for the performance of the solar still, and the study shows that CFD modelling is a very powerful tool for predicting these temperatures, as simulation results were in close agreement with actual experimental results for the climatic conditions of Patna, India.

5. The use of passive baffles to boost a single-slope solar still's yield

D.E. Benhadji Serradj , T.N. Anderson and R.J. Nates has discussed the effect of baffle position and length on natural convection inside single slope solar still geometries with a wide range of cover angles and aspect ratios was investigated in depth in this study. The results show that the presence of a baffle in a still had a significant impact on natural convection, with the baffle increasing the convective heat transfer coefficient, a proxy for the still's yield, by about 20% in some situations. However, the baffle's position and length must be carefully considered in order to achieve the proper flow and avoid a reduction in the heat transfer coefficient.

For all baffle positions, it was discovered that short baffles had the greatest influence at lower cover angles. Furthermore, it was discovered that baffles installed closer to the front wall provided better heat transfer across a wider variety of situations. Additionally, layouts that result in several vertical cells should be avoided since they impede the natural convection transport process. Furthermore, the material of the baffle must be carefully considered; high transmittance materials with low conductivity are ideal since they prevent heat transfer through the baffle and shading of the absorber. Finally, a correlation was created to describe natural convection in baffled solar stills, which would hopefully benefit future designers of these devices.

6. With an economic analysis, a study on the annual performance of solar still utilising shape-stabilized phase transition materials was conducted.

Yong-Le Nian , Yan-Kai Huo and Wen-Long Cheng has provided the annual performance of the solar still employing SSPCM which was analysed by a developed comprehensive model in this study, with a focus on production and economics. During the modelling process, the internal heat conduction in PCM was taken into account. To validate the constructed model, an experimental solar still employing SSPCM was set up. The annual performance of three different types of solar stills was compared.
By simulating heat conduction in SSPCM, it was discovered that the length of phase change decreased as the distance from the top of the PCM increased, even though the phase change had not yet occurred in the place near the bottom due to lower temperature and thermal conductivity. As a result, the thermal conductivity increasing function for PCM is required to increase the PCM temperature and hence the duration and area of phase change.

Conclusion:

There are various methos and techniques were discussed to improve the efficiency of solar still. following are the conclusive points from the current review.

1. Solar still with 1 cm saline water level with sand trough have efficiency of 65.08 percent when compared to solar stills without sand trough having only 35.9 percent efficiency.
2. More distilled Water can be collected while using transparent PVC sheet compared to glass covered sheet at an angle of inclination 13 degree.
3. The TWSS's unique glass cover shape design increases the condensation surface area, allowing it to offer 2.68 L of fresh distilled water per m2 of solar still space.
4. The temperature of the combination (air, water, and vapour) inside the still, as well as the absorber plate (basin base) and the glass cover on the top of the still, operate as a driving mechanism for the solar still's performance.
5. The installation of baffles drastically improves the natural convection in the solar still and also discovered that small size baffle.

From current review we propose work can be done on solar still with saline water based solar still sand trough, small baffles and transparent PVC cover would have great impact on the performance of solar still.

References: -

[1] Kandasamy S, Vellingiri M, Sengottain S, Balasundaram J. Performance correlation for single-basin double-slope solar still. Int J Energy Environ Eng 2013;4:1–6.

[2] Bernstein S. Freshwater and human population: a global perspective. Yale School of Forestry Environ Studies Bull 2002:149–57.

[3] Singh SK, Tyagi SK, Kaushik SC. Desalination Using Waste Heat Recovery with Active Solar Still. In: Proceedings of the 7th International Conference on Advances in Energy Research. Springer Proceedings in Energy. Singapore: Springer; 2020. https://doi.org/10.1007/978-981-15-5955-6_42.

[4] Singh DB, Singh AK, Navneet K, Dwivedi VK, Yadav JK, Singh G. Performance analysis of special design single basin passive solar distillation systems: a comprehensive review. In: Advances in Engineering Design. Singapore: Springer; 2019. p. 301–10.

[5] Shatat M, Worall M, Riffat S. Opportunities for solar water desalination worldwide. Sustainable Cities Society 2013;9:67–80.

[6] El-Sebaey MS, Shams El-Din S, Habib M, El-Hanafy A. An EXperimental study on a new design of double slope solar still with external flatted and internal parabolic reflectors. J Mech Civil Eng (IOSR-JMCE) 2013;9(6):40–54.

[7] Srivastava, V. S., Singh, S. K., Patel, R. V., & Singh, R. K. (2019, November). Conceptual Investigation of Renewable Energy for Desalination Purposes. In IOP Conference Series: Materials Science and Engineering (Vol. 691, No. 1, p. 012045). IOP Publishing.

[8] Hinrichsen, D., & Robey, B. (2000). Population and the environment: the global challenge. Population Reports, Series M, No. 15. Baltimore, Johns Hopkins University School of Public Health.

[9] http://www.lenntech.com/WHO-EU-water-standards.html (accessed on April,2020).

[10] Reddy, K. V. K., Somanchi, N. S., Kumar, B. S. P., Banoth, H. B., Gugulothu, R., & Naveen, B. S. (2014). EXperimental Investigation on Performance Evaluation of A Single Basin Solar Still Using Different Energy Absorbing Materials. In Proceedings of the ASME 2014, 8th International Conference on Energy Sustainability, ES2014, held on Boston, Massachusetts, USA on 30th June–2nd July.

[11] Khanna RK, Rathore RS, Sharma C. Solar still an appropriate technology for potable water need of remote villages of desert state of India—Rajasthan. Desalination 2008;220(1–3):645–53.

[12] Product manual for drinking water according TO IS 10500 : 2012. https://bis. gov.in/wp-content/uploads/2020/10/PM-IS-10500.pdf. (accessed on December,2020).

[13] Ayoob S, Gupta AK. Fluoride in drinking water: a review on the status and stress effects. Critical reviews in environmental science and technology 2006;36(6): 433–87.

[14] Nandi A, Megiddo I, Ashok A, Verma A, Laxminarayan R. Reduced burden of childhood diarrheal diseases through increased access to water and sanitation in India: A modeling analysis. Soc Sci Med 2017;180:181–92.

[15] Kumar CP. Fresh water resources: a perspective. India: National Institute of Hydrology; 2003.

[16] Schamschula RG, Suga´r E, Un PS, To´th K, Barmes DE, Adkins BL. Physiological indicators of fluoride exposure and utilization: an epidemiological study. Commun Dent Oral Epidemiol 1985;13(2):104–17.

[17] Whitford GM, Sampaio FC, Arneberg P, Von der Fehr FR. Fingernail fluoride: a method for monitoring fluoride exposure. Caries Res 1999;33(6):462–7.

[18] Jackson BR, Carpenter RS, Dahm NC, McKnight MD, Naiman JR, Postel LS, et al. Water in a changing world. Ecol Appl 2001;11(4):1027–104.

[19] Somanchi NS, Sagi SLS, Kumar TA, Kakarlamudi SPD, Parik A. Modeling and analysis of single slope solar still at different water depth. Aquat Procedia 2015;4: 1477–82.

[20] Babalola TA, Boyo AO, Kesinro RO. Effect of Water Depth and Temperature on the Productivity of a Double Slope Solar Still'. Journal of Energy and Natural Resources 2015;4(1):1–4.

[21] Singh AK, Singh DB, Mallick A, Kumar N. Energy matrices and efficiency analyses of solar distiller units: a review. Sol Energy 2018;173:53–75.

[22] Kumar SA, Kumar PSM, Sathyamurthy R, Manokar AM. A study of life cycle conversion efficiency and CO2 role in the pyramid shape solar stills–Comparative analysis. Groundwater Sustainable Dev 2020;11:100413.

[23] Vaithilingam S, Gopal ST, Srinivasan SK, Manokar AM, Sathyamurthy R, Esakkimuthu GS, et al. An extensive review on thermodynamic aspect based solar desalination techniques. J Therm Anal Calorim 2020:1–17.

[24] Amiri H, Aminy M, Lotfi M, Jafarbeglo B. Energy and exergy analysis of a new solar still composed of parabolic trough collector with built-in solar still. Renewable Energy 2021;163:465–79.

[25] Bait O. EXergy, environ–economic and economic analyses of a tubular solar water heater assisted solar still. J Cleaner Prod 2019;212:630–46.

[26] Abujazar MSS, Fatihah S, Rakmi AR, Shahrom MZ. The effects of design parameters on productivity performance of a solar still for seawater desalination: A review. Desalination 2016;385:178–93.

[27] Omara ZM, Kabeel AE, Abdullah AS, Essa FA. EXperimental investigation of corrugated absorber solar still with wick and reflectors. Desalination 2016;381: 111–6.

[28] Velmurugan V, Pandiarajan S, Guruparan P, Subramanian LH, Prabaharan CD, Srithar K. Integrated performance of stepped and single basin solar stills with mini solar pond. Desalination 2009;249(3):902–9.

[29] Essa FA, Omara ZM, Abdullah AS, Shanmugan S, Panchal H, Kabeel AE, et al. Wall-suspended trays inside stepped distiller with Al2O3/paraffin wax miXture and vapor suction: EXperimental implementation. J Storage Mater 2020;32: 102008.

[30] Abdullah AS, Essa FA, Omara ZM. Effect of different wick materials on solar still performance–a review. Int J Ambient Energy 2021;42(9):1055–82.

[31] Abdullah AS, Omara ZM, Essa FA, Alarjani A, Mansir IB, Amro MI. Enhancing the solar still performance using reflectors and sliding-wick belt. Sol Energy 2021; 214:268–79.

[32] Abdel-Rehim ZS, Lasheen A. Improving the performance of solar desalination systems. Renewable Energy 2005;30(13):1955–71.

[33] Kabeel AE, Hamed MH, Omara ZM. Augmentation of the basin type solar still using photovoltaic powered turbulence system. Desalin Water Treat 2012;48 (1–3):182–90.

[34] Essa FA, Abdullah AS, Omara ZM. Improving the performance of tubular solar still using rotating drum–EXperimental and theoretical investigation. Process Saf Environ Prot 2021;148:579–89.

[35] Abdullah AS, Essa FA, Omara ZM, Rashid Y, Hadj-Taieb L, Abdelaziz GB, et al. Rotating-drum solar still with enhanced evaporation and condensation techniques: comprehensive study. Energy Convers Manage 2019;199:112024.

[36] Alawee WH, Mohammed SA, Dhahad HA, Abdullah AS, Omara ZM, Essa FA. Improving the performance of pyramid solar still using rotating four cylinders and three electric heaters. Process Saf Environ Prot 2021;148:950–8.

[37] Singh CP, Mayank AM. Study and Design of Double Slope Passive Solar still. Trans. Eng Sci 2015;3.

[38] Singh AK, Singh DB, Mallick A, Sharma SK, Kumar N, Dwivedi VK. Performance analysis of specially designed single basin passive solar distillers incorporated with novel solar desalting still: A review. Sol Energy 2019;185:146–64.

[39] Ng KC, Thu K, Kim Y, Chakraborty A, Amy G. Adsorption desalination: an emerging low-cost thermal desalination method. Desalination 2013;308:161–79.

[40] Das R, Ali ME, Hamid SBA, Ramakrishna S, Chowdhury ZZ. (2014). Quenching the world's thirst for sea water Desalination. https://www.elsevier.com/connect/ atlas-award-quenching-the-worlds-thirst-for-seawater.

[41] Ministry of New Renewable Energy http://mnre.gov.in/information/current- notices/ seawater (accessed on 20/09/2020).

[42] Kumar M, Puri A. A review of permissible limits of drinking water. Indian journal of occupational and environmental medicine 2012;16(1):40.

[43] Aybar HS, Assefi H. A review and comparison of solar distillation: Direct and indirect type systems. Desalin Water Treat 2009;10(1–3):321–31.

[44] Buros OK. The ABCs of desalting. Topsfield, MA: International Desalination Association; 2000.

[45] Miller JE. Review of water resources and desalination technologies. Sandia National Laboratories, Albuquerque, NM 2003;49:2003–10800.

[46] Samee MA, Mirza UK, Majeed T, Ahmad N. Design and performance of a simple single basin solar still. Renew Sustain Energy Rev 2007;11(3):543–9.

[47] Ali MT, Fath HE, Armstrong PR. A comprehensive techno-economical review of indirect solar desalination. Renew Sustain Energy Rev 2011;15(8):4187–99.

[48] V. Nagaraju, G. Murali, Anand K. Bewoor, Ravinder Kumar, Mohsen Sharifpur, Mamdouh El Haj Assad, Mohamed M. Awad. Experimental study on performance of single slope solar still integrated with sand troughs. Sustainable Energy Technologies and Assessments, Vol. 50, March 2022, 101884.

[49] K.S. Maheswari, K. Mayandi, S. Joe Patrick Gnanaraj, M. Appadurai. Effect of transparent glass cover material on double slope solar still productivity. International Conference on Emerging Treads a in Material Science and Technology, 2022

[50] A. Wesley Jeevadason, S. Padmini. Experimental investigation of a passive type solar still with double wedge shape glass cover. International Conference on Materials, Machines and Information Technology, Vol 56 Part 1, 2022:308-313.

[51] Abhiesk Saxena, Erdem Cuce, A.E. Kabeel, Mohamed Abdelgaied, Varun Goel. A thermodynamics review on solar stills. Solar Energy, Vol 237, May 2022:377-413.

[52] Aman Kumar, Ambrish Maurya. Experimental analysis and CFD modelling for pyramidal solar still. International Conference on Design, Manufacturing and Materials Engineering.

[53] Nandipha Pangwa, Velaphi Msomi. Progress made in eliminating factors affecting solar stills productivity. Third International Conference on Aspects of Materials Science and Engineering. Vol 57, Part 2, 2022, 969-974.

[54] D.E. Benhadji Serradj, T.N. Anderson, R.J. Nates. The use of passive baffles to increase the yield of a single slope solar still. International Solar Energy Society, Solar Energy 226 (2021) 297–308.

[55] Yong-Le Nian , Yan-Kai Huo , Wen-Long Cheng. Study on annual performance of the solar still using shape-stabilized phase change materials with economic analysis. Solar Energy Materials & Solar Cells 230 (2021) 111263