Boosting Desalination Efficiency: A 20-Year Global Bibliometric Analysis of Active Solar Stills Enhanced by Thermosolar Integration

Aumentar la eficiencia de la desalinización: Un análisis bibliométrico global de 20 años de alambiques solares activos mejorados mediante integración Termosolar

Pallares-Carballo Esteban[1], Tarazona-Romero Brayan Eduardo [2], Ascanio-Villabona Javier Gonzalo[3], Lengerke-Pérez Omar[4]

Abstract

Solar stills represent an alternative for seawater desalination; however, their low production capacity poses significant limitations for broader applications. To address this, solar stills are increasingly integrated with Thermosolar systems to enhance performance and boost production capacity. This study undertakes a bibliometric analysis to evaluate the evolution of research on active solar stills integrated with Thermosolar systems over the period 2004-

2024. Using data from the Scopus database and VOSviewer software, this analysis explores

[1] *Faculty of Natural Sciences and Engineering, Unidades Tecnológicas de Santander, Student Street 9-82, Bucaramanga, 680005, Colombia. E-mail: epallaresc@uts.edu.co ORCID: https://orcid.org/0009-0008-98947791*

[2] *Faculty of Natural Sciences and Engineering, Unidades Tecnológicas de Santander, Student Street 9-82, Bucaramanga, 680005, Colombia. E-mail: btarazona@correo.uts.edu.co ORCID: https://orcid.org/0000-00016099-0921*

[3] *Faculty of Natural Sciences and Engineering, Unidades Tecnológicas de Santander, Student Street 9-82, Bucaramanga, 680005, Colombia. E-mail: jascanio@correo.uts.edu.co ORCID: https://orcid.org/0000-00031749-5399*

[4] *Faculty of Natural Sciences and Engineering, Unidades Tecnológicas de Santander, Student Street 9-82, Bucaramanga, 680005, Colombia. E-mail: olengerke@correo.uts.edu.co ORCID: https://orcid.org/0000-00019360-7319*

key trends in publication output, co-occurrence of terms, leading authors, countries, continents, and universities. The findings highlight the most frequently studied types of active solar stills and their relationship with global solar radiation patterns. Additionally, the study assesses the contributions of various continents to this research domain, providing insights into the global landscape and identifying areas for future development.

Keywords: *Active Solar Stills, Bibliometric Analysis, Desalination, Thermosolar Systems, VOSviewer*

Resumen

Los destiladores solares representan una alternativa para la desalinización de agua de mar; sin embargo, su baja capacidad de producción plantea limitaciones significativas para aplicaciones más amplias. Para abordar esto, los destiladores solares se integran cada vez más con los sistemas termosolares para mejorar el rendimiento y aumentar la capacidad de producción. Este estudio realiza un análisis bibliométrico para evaluar la evolución de la investigación sobre destiladores solares activos integrados con sistemas termosolares durante el período 2004-2024. Utilizando datos de la base de datos Scopus y el software VOSviewer, este análisis explora las tendencias clave en la producción de publicaciones, la coocurrencia de términos, los autores principales, los países, los continentes y las universidades. Los hallazgos destacan los tipos de destiladores solares activos estudiados con más frecuencia y su relación con los patrones de radiación solar global. Además, el estudio evalúa las contribuciones de varios continentes a este dominio de investigación, brindando información sobre el panorama global e identificando áreas para el desarrollo futuro.

Palabras clave: *Destiladores solares activos, Análisis bibliométricos, Desalinización, Sistemas Termosolares, VOSviewer*

1. Introduction

Water, despite covering 71% of the Earth's surface, is a limited resource, as only 2.5% is fresh and most of it is frozen in Antarctica, leaving less than 1% available for human consumption [1]. The growing water crisis, exacerbated by climate change, has intensified drinking water scarcity in many regions [2]. Prolonged droughts and changes in precipitation patterns further complicate the situation, leading to the search for alternatives such as desalination to ensure future drinking water supplies [3].

Desalination can be classified into two types: active and passive [4]. Active desalination, which uses external energy [5], is efficient but costly due to its high energy consumption and the maintenance requirements of its mechanical components [6]. On the other hand, passive desalination, which does not require external energy or uses renewable sources such as solar energy [7], is cheaper but less efficient in terms of water production, limiting its use to small communities or areas with low demand [8].

Among the passive desalination methods, solar still stands out for its simplicity and low cost [9].

This system uses solar radiation to evaporate water and then collects the condensed vapor as distilled water, separated from the salts [10]. Although this technology is affordable and low maintenance, its production capacity is limited and ways to improve its efficiency are currently being investigated [11].

The use of solar energy in desalination offers several advantages. It is a clean and abundant source that reduces dependence on fossil fuels, and its design is simple and economical [12]. In addition, solar systems are especially efficient in areas with high solar

radiation and require little maintenance, making them suitable for remote or resource-limited areas [13].

However, there are disadvantages to the use of solar stills. Their efficiency depends directly on solar irradiation, which makes them less effective in areas with low sun exposure [14]. In addition, they require large surface areas to operate optimally, and their water production can be intermittent, especially on cloudy or rainy days. More advanced systems, such as solar stills with collectors, improve efficiency by capturing more solar energy, but this increases their complexity and cost [15]. Based on these considerations, a bibliometric analysis of passive solar stills is conducted to identify current trends in their research and application. The study is organized into four sections: the first presents the introduction, the second describes the methodology used, the third presents the results obtained, and the fourth discusses the main conclusions.

2. Methodology

This study used a four-stage bibliometric analysis to examine the evolution of research on active solar stills with solar thermal integration between 2004 and 2024. First, a search strategy was designed in the Scopus database with keywords such as “Solar Still” and “Solar Still

Desalination” to collect relevant publications. The data were downloaded on August 23, 2024, *including information on authors, institutions, countries and journals.*

The data were then processed with VOSviewer software to identify patterns of co-occurrence of terms and collaborative networks between authors and institutions. This analysis revealed the main trends in research, highlighting the most active countries and

the most relevant technological configurations. Table 1 shows the search equations applied in Scopus, which refined the results from 2911 documents to 12 specific studies on solar stills with thermal collectors.

Table 1. *Equations*

Item	*Equation*	*Number of documents*
1	*Solar Still*	*2911*
2	*Solar Still AND Desalination*	*1362*
3	*Solar Still AND Solar Energy*	*966*
4	*Solar Still AND Integration*	*99*
5	*Solar Still AND Integration AND Desalination*	*53*
6	*Solar Still AND Solar energy AND Integration*	*42*
7	*Solar Still AND thermal collector*	*12*

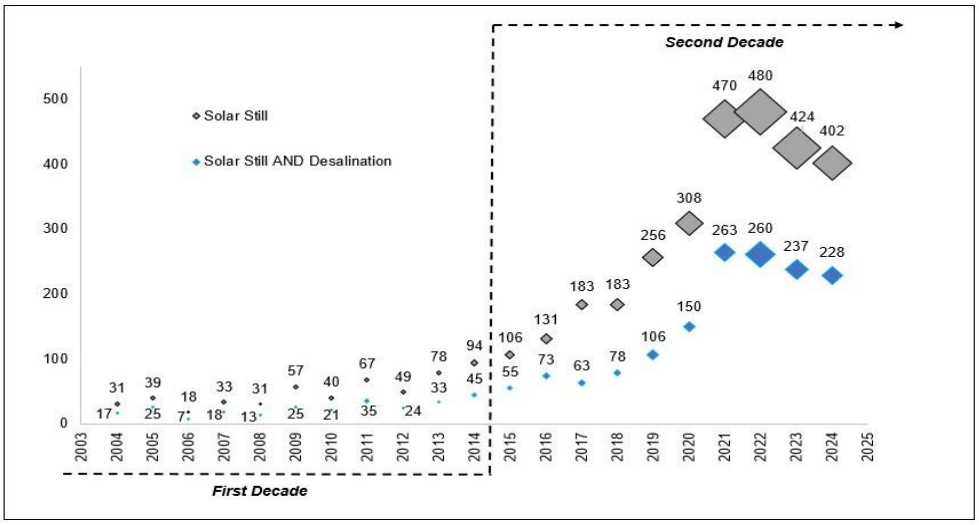
3. *Results and discussion*

The term co-occurrence analysis based on Table 1 reveals a steady evolution in research on solar stills and desalination between 2004 and 2024. Key terms such as “Solar Still”, with 2911 *papers, have dominated the research, reflecting a broad and sustained interest in solar stills.*

“Desalination,” with 1362 papers, has also been a recurring theme, showing a strong *relationship with solar, appearing in 966 papers. Emerging areas such as the integration of solar distillation systems with life cycle analysis (53 papers) and the combination of solar energy and integration (42 papers) have gained prominence in recent years, pointing to a trend towards* optimizing the efficiency of these systems. Concepts such as “Thermal Collector”, with only 12 *papers, indicate a more recent focus on improving heat capture to increase efficiency.*

In the first decade, research on “Solar Still” averaged 38 papers per year, with a peak of 78 in 2013, while studies on “Solar Still AND Desalination” were even more limited. In contrast*, the* second decade showed exponential growth, peaking in 2022 with 480 publications on “Solar Still” and 263 papers in 2021 for “Solar Still AND Desalination”. This increase reflects the *growing interest in the optimization of solar still distillation technologies, driven by the growing water crisis.*

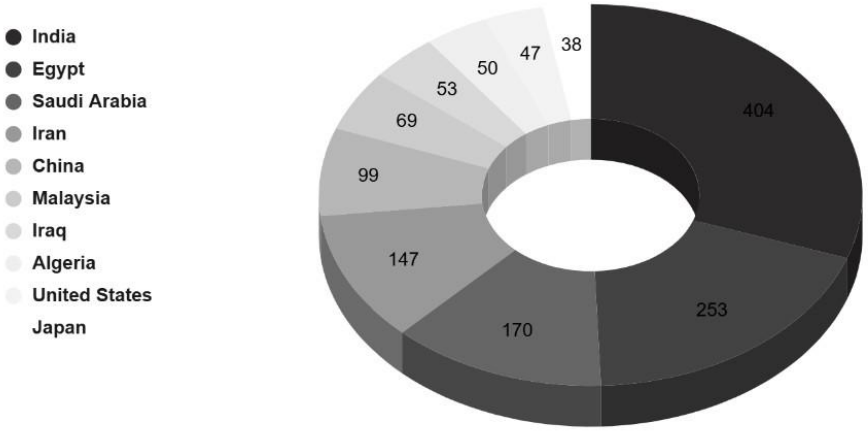
Figure 1. *Number of publications with respect to years for equations 1 and 2.*



On the other hand, for the bibliometric analysis of publications on solar stills and desalination between 2004 and 2024 highlights a clear supremacy of Asia, which generates 73.8% of the research in this field. India is the leading country, with 404 papers, representing 30.4% of the total, followed by Iran, Saudi Arabia, China and other countries in the region, reflecting their focus on research into technologies to address water scarcity. This interest is particularly relevant in Asia, where water-related problems are increasingly critical due to growing demand and climate change.

Africa is the second continent in scientific production, with Egypt and Algeria as the main contributors, accumulating 24% of the publications. This highlights the importance of solar desalination in the region, where water scarcity is an urgent challenge. In contrast, North America has a lower contribution, with the United States contributing 3.5% of the publications, suggesting a lower focus on this technology compared to Asia and Africa. Figure 2 evidence this regional leadership, with India and Egypt standing out in advancing research on solar stills.

Figure 2. *Top 10 countries with the most publications on solar stills.*



On the other hand, when comparing the publications data (see Figure 2) with the direct normal irradiance (DNI) levels measured in W/m² for the year 2023 from the Global Solar Atlas, it is observed that some countries with high solar irradiation, such as Australia and several North African countries, are not among those with the highest number of scientific publications in solar energy. Despite the fact that these regions have irradiation levels above 2500 kWh/m², their scientific output in this field is relatively low compared to countries such as India, Iran and China. This suggests that although solar irradiance is an

important resource for the development of solar technologies, other factors such as research investments, academic infrastructure and local energy policies can significantly influence the number of publications and scientific development. Therefore, although solar irradiance is a relevant indicator, it does not always translate directly into more research.

Figure 3 shows the top universities that have contributed to research on solar stills and desalination between 2004 and 2024, with Africa leading in publications. Tanta University tops the list with 162 papers, followed by Kafrelsheikh University with 104 publications. Other African institutions, such as Suez University and Delta University for Science and Technology, also contribute significantly. These universities play a key role in the development of solar desalination technologies, highlighting Africa's role as a continent committed to applied research to solve water scarcity.

In Asia, Prince Sattam Bin Abdulaziz University leads with 53 publications, followed by the KPR Institute of Engineering and Technology and Anna University, with 39 and 35 publications respectively. In addition, institutions such as the National Institute of Technology and B.S. Abdur Rahman University contribute outstanding research, reflecting Asia's growing interest in desalination technologies. This panorama coincides with the previously mentioned continents, where Africa and Asia are positioned as the main drivers of solar desalination research, reflecting the urgency of both regions to develop technological solutions to the water crisis.

Figure 3. *Top universities with the most publications on solar stills.*

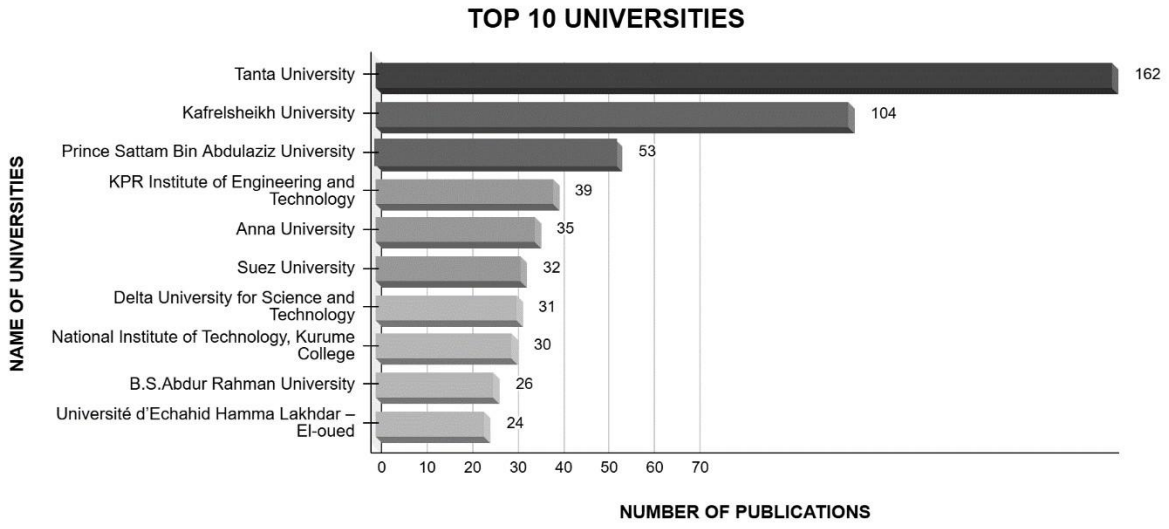
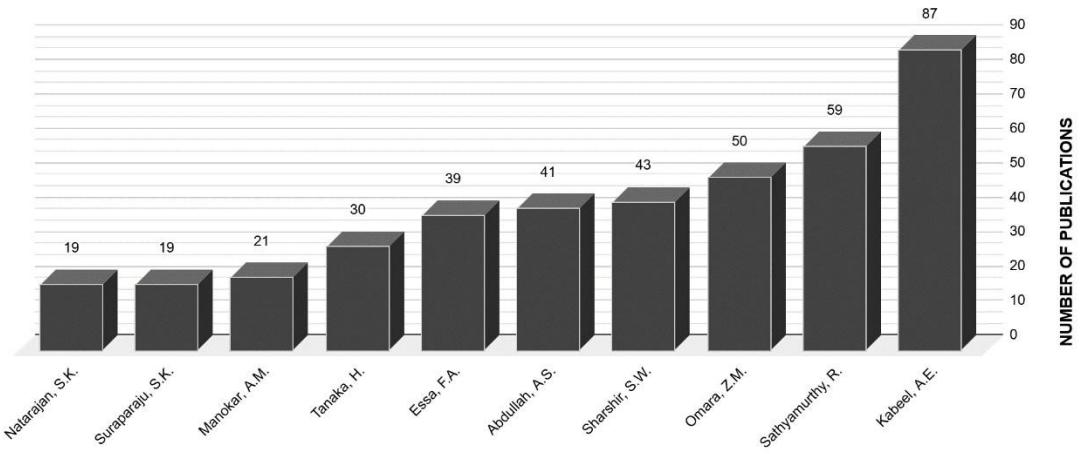


Figure 4 highlights the top 10 authors who have contributed to solar stills and desalination research between 2004 and 2024. A.E. Kabeel tops the list with 87 publications, evidencing his leadership in this field and his sustained focus on developing technological solutions for solar desalination. He is followed by R. Sathyamurthy, with 59 publications, consolidating his position as a key player in solar technologies research for water management. Z.M. Omara and S.W. Sharshir rank third and fourth with 50 and 43 publications, respectively, reflecting their impact on expanding knowledge in this area.

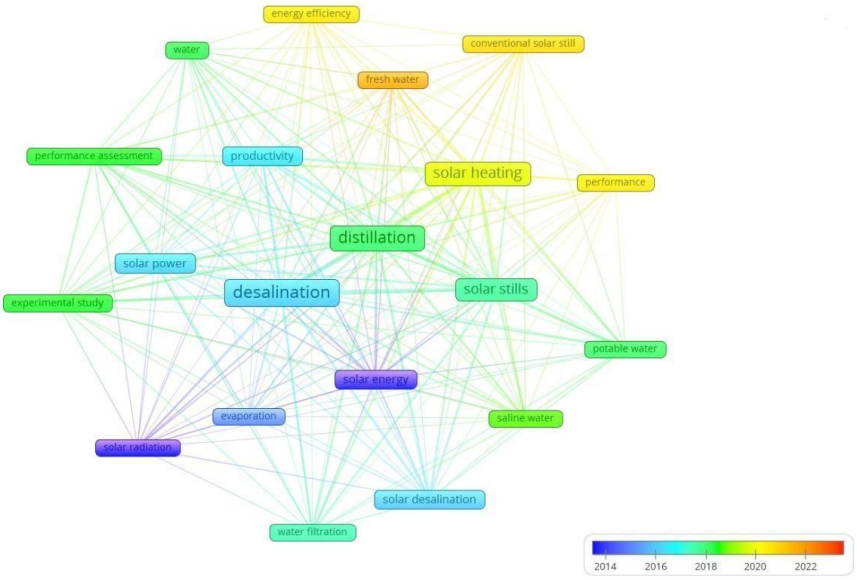
Figure 4. *Top 10 authors with more publications on solar stills.*



A.S. Abdullah, with 41 publications, and F.A. Essa, with 39, also stand out for their significant contributions to the development of solar desalination technologies. H. Tanaka, with 30 publications, reinforces his position as one of the leading researchers in Asia. Other authors, such as A.M. Manokar, S.K. Suraparaju and S.K. Natarajan, complete the top 10, demonstrating a growing interest and commitment to solar still research, underlining the importance of this field in the search for sustainable solutions to water scarcity.

The co-occurrence analysis of terms is presented in Figure 5 and shows that research on solar stills and desalination has focused primarily on the integration of solar technologies to produce drinking water from saline water. Key terms such as desalination and distillation are the most connected concepts, reflecting the sustained interest in these technologies. Initial studies between 2014 and 2016 focused on solar radiation and solar energy, while in more recent years topics such as energy efficiency and solar heating have gained prominence, indicating a growing interest in optimizing the performance of these systems.

Figure 5. *Cooccurrence of terms*



In recent years (2020-2024), research has moved towards improving conventional solar stills, with a particular focus on integration with active solar thermal technologies, which has partly displaced interest in passive systems. Although passive solar stills continue to be a viable option, recent studies highlight more efforts to optimize active systems to improve energy efficiency and drinking water production. This reflects a trend towards implementing more complex and sustainable technological solutions to address the global water crisis.

On the other hand, the table shows the studies of the last decade that focus on the integration of solar stills with solar collector systems. Research on solar desalination has shown a trend towards the integration of solar collectors, mainly flat plate and evacuated tube collectors. However, solar concentrators, such as parabolic and Fresnel concentrators, have seen more frequent use in recent years, especially in studies focused on improving the performance of solar stills through hybrid technologies or integrated

systems with energy storage, such as phase change materials (PCMs). Solar collector systems predominate in experimental studies, while solar concentrators are more common in research combining experimentation with simulation.

In terms of research methodologies, the experimental approach remains the dominant one, reflecting a growing interest in testing and optimizing technologies under real conditions to improve the efficiency of solar stills. Simulations, although less frequent, are mainly used to analyze and compare different designs prior to their experimental validation. Recent trends show an increase in the use of hybrid technologies, such as the integration of solar collectors with phase change materials (PCM) and nanofluids, with the aim of improving energy storage and transfer. The year 2023 and 2022 are the periods with the highest research activity, according to the table, with notable growth in innovative approaches such as parabolic tube collectors and advanced concentrating solar systems. This reflects a growing interest in improving the efficiency and feasibility of solar desalination in various regions of the world.

Table 2. *Recent Studies on the Integration of Solar Stills with Solar Collectors (2014-2024)*

Author (APA)	Year	Purpose	Article Type	Study Type	Technology
[16]	*2024*	*Explore a cylindrical solar still integrated with various technologies.*	*Article*	*Experimental*	*Cylindrical solar still with parabolic concentrators*
[17]	*2024*	*Examine large scale applications of solar desalination using evacuated glass tube collectors.*	*Review*	*Review*	*Evacuated glass tube collectors in desalination*
[18]	*2024*	*Evaluate the integration of solar collectors with conventional solar stills.*	*Article*	*Experimental*	*Solar collectors with conventional stills*
[19]	*204*	*Review advances in solar still technology for desalination.*	*Review*	*Review*	*Solar stills*

[20]	*2024*	*Review advanced desalination technologies for all-day, allweather freshwater systems.*	*Review*	*Review*	*Advanced desalination technologies*
[21]	*2023*	*Analyze the performance of a single slope solar still with solar dish concentrator.*	*Article*	*Experimental*	*Single slope solar still with dish concentrator*
[22]	*2023*	*Improve fresh water production using magnetic flux, solar collector, and phase change materials.*	*Conference Paper*	*Experimental*	*Solar distillation with magnetic flux and phase change materials*
[23]	*2023*	*Enhance the performance of solar distiller with phase change material and parabolic trough collector.*	*Article*	*Experimental*	*Solar distiller with phase change material and trough collector*
[24]	*2023*	*Understand and compare different designs of solar still.*	*Conference Paper*	*Theoretical*	*Various solar still designs*
[25]	*2023*	*Evaluate the use of evacuated tubes, perforated fins, and pebbles in solar stills.*	*Article*	*Experimental*	*Evacuated tubes, perforated fins, and pebbles in solar stills*
[26]	*2022*	*Enhance productivity of drum solar still using parabolic solar concentrators and nanoparticles.*	*Article*	*Experimental*	*Drum solar still with parabolic concentrator and nanoparticles*
[27]	*2022*	*Analyze thermal performance of solar still using silver nanofluids in direct absorption.*	*Article*	*Experimental*	*Silver nanofluids in solar stills*

[28]	*2022*	*Improve performance of hybrid solar desalination system under various conditions.*	*Article*	*Experimental*	*Hybrid solar desalination*
[29]	*2022*	*Evaluate self-powered solar desalination using solar still with PCM and external solar collector.*	*Article*	*Experimental*	*Solar still with PCM and external solar collector*
[30]	*2022*	*Enhance solar desalination with evacuated tube heat pipe and wind ventilator condenser.*	*Article*	*Experimental*	*Evacuated tube heat pipe and external condenser in solar desalination*
[31]	*2022*	*Improve thermal efficiency and water yield of tubular solar still with neural network optimization.*	*Article*	*Experimental*	*Tubular solar still with neural network optimization*
[32]	*2022*	*Study phase change materials integrated in solar still with solar collector.*	*Article*	*Experimental*	*Phase change materials in solar stills*
[33]	*2022*	*Evaluate a V-type solar still integrated with hybrid solar concentrator and heat exchanger.*	*Article*	*Experimental*	*V-type solar still with hybrid solar concentrator*
[34]	*2021*	*Explore sea-water desalination using a parabolic trough collector and activated carbon.*	*Article*	*Experimental*	*Sea-water desalination with parabolic trough and activated carbon*

[35]	*2021*	*Enhance solar desalination efficiency with parabolic trough collector.*	*Article*	*Experimental*	*Parabolic trough collector in solar desalination*
[36]	*2021*	*Techno-economic study of a new hybrid solar desalination system for fresh water in hot-arid climates.*	*Article*	*Experimental*	*Hybrid solar desalination system*
[37]	*2021*	*Review of evacuated tube solar collector for desalination.*	*Article*	*Review*	*Evacuated tube solar collector*
[38]	*2021*	*Evaluation of solar still productivity in different climates.*	*Article*	*Experimental*	*Flat plate and parabolic trough collectors*
[39]	*2021*	*Review of nanomaterials' impact on solar distillation systems.*	*Review*	*Review*	*Nanomaterials in solar stills*
[40]	*2021*	*Performance enhancement of tubular solar still using PCM-tubes.*	*Article*	*Experimental*	*PCM-tubes in solar stills*
[41]	*2021*	*Evaluate performance of pyramidshaped solar still with flat plate collector.*	*Article*	*Experimental*	*Pyramid-shaped solar still with flat plate collector*
[42]	*2021*	*Investigate a solar desalination system coupled with solar collector and packed bed.*	*Article*	*Experimental*	*Solar desalination with solar collector and packed bed*
[43]	*2020*	*Analyze solar desalination under concentrated solar flux and reduced pressure.*	*Article*	*Experimental*	*Solar desalination under concentrated solar flux and reduced pressure*
[44]	*2020*	*Examine performance of a threeeffect tubular solar desalination system with vacuum operation.*	*Article*	*Experimental*	*Three-effect tubular solar desalination system*
[45]	*2019*	*Analyze performance of a solar desalination system with concentrated solar power (CSP).*	*Conference Paper*	*Experimental*	*Solar desalination with concentrated solar power (CSP)*
[46]	*2018*	*Theoretical investigation of solar desalination with phase change material and solar collector.*	*Article*	*Theoretical*	*Solar still with phase change material and solar collector*
[47]	*2018*	*Development and performance evaluation of an active solar distillation system with vacuumtype heat exchanger.*	*Article*	*Experimental*	*Active solar distillation system with vacuum-type heat exchanger*
[48]	*2018*	*Solar desalination using solar still enhanced by external solar collector and PCM.*	*Article*	*Experimental*	*Solar still enhanced by external solar collector and PCM*
[49]	*2017*	*Review of hybrid solar desalination and water heating systems.*	*Review*	*Review*	*Hybrid solar desalination and water heating system*
[50]	*2017*	*Investigate exergy and yield of a passive solar water desalination system with parabolic concentrator and latent heat storage.*	*Article*	*Experimental*	*Passive solar desalination system with parabolic concentrator and latent heat storage*

[51]	*2016*	*Analyze performance of a desalination unit coupled with a solar water lens concentrator.*	*Conference Paper*	*Experimental*	*Solar desalination unit with water lens concentrator*
[52]	*2016*	*Evaluate performance of a triple basin solar desalination system with cover cooling and parabolic dish concentrator.*	*Article*	*Experimental*	*Triple basin solar desalination system with cover cooling and parabolic dish*
[53]	*2016*	*Examine seasonal behavior and techno-economic analysis of a multi-stage solar still with Fresnel lens.*	*Article*	*Theoretical*	*Multi-stage solar still with point-focus Fresnel lens*
[54]	*2015*	*Improving double slope solar still performance using flat-plate solar collector and cooling glass cover.*	*Article*	*Experimental*	*Double slope solar still with flat-plate collector*
[55]	*2015*	*Single slope solar water still with enhanced solar heating system.*	*Book Chapter*	*Experimental*	*Single slope solar still with solar preheating*
[56]	*2015*	*Spiral multiple-effect diffusion solar still coupled with vacuum-tube collector and heat pipe.*	*Article*	*Experimental*	*Spiral multiple-effect diffusion solar still*
[57]	*2014*	*Multiple-effect diffusion solar still coupled with a vacuum-tube collector and heat pipe.*	*Article*	*Experimental*	*Multiple-effect diffusion solar still with vacuum-tube collector*

4. Conclusions

Most of the research on solar stills has been experimental in nature, focusing on the practical validation and optimization of these technologies under real conditions. This reflects the importance of testing the efficiency and viability of solar systems in different environments, prioritizing the implementation of applied solutions over the exclusive use of theoretical simulations.

While countries with high solar irradiance, such as India and Iran, lead in research on solar technologies, some regions with high irradiance, such as Australia and North Africa, do not have a proportionally high scientific output. This suggests that, in addition to irradiance, factors such as research investments, academic infrastructure and local energy policies are crucial in driving scientific output.

In recent years, there has been a significant increase in the development of solar desalination systems that integrate hybrid technologies, such as solar collectors and phase change materials (PCMs). This trend reflects a growing focus on improving energy efficiency and water production capacity, highlighting the importance of technological innovation in the search for more sustainable and efficient solutions to the global water crisis.

References

[1] B. E. Tarazona-Romero, A. Campos-Celador, y Y. A. Maldonado-Muñoz, «Can solar desalination be small and beautiful? A critical review of existing technology under the appropriate technology paradigm», *Energy Research & Social Science*, vol. 88, p. 102510, jun. 2022, doi: 10.1016/j.erss.2022.102510.

[2] S. N. Farabi *et al.*, «The future of solar-driven interfacial steam generation for sustainable water desalination: Drivers, challenges, and opportunities-review», *Results in Engineering*, vol. 23, p. 102649, sep. 2024, doi: 10.1016/j.rineng.2024.102649.

[3] M. Ghazy *et al.*, «State-of-the-art-solar energy-driven adsorption desalination systems», *Energy Nexus*, vol. 15, p. 100319, sep. 2024, doi: 10.1016/j.nexus.2024.100319.

[4] Z. Hu y Y. Chen, «Advancements in sustainable desalination with ocean thermal energy: A review», *Desalination*, vol. 586, p. 117770, oct. 2024, doi: 10.1016/j.desal.2024.117770.

[5] S. Almasoudi y B. Jamoussi, «Desalination technologies and their environmental impacts: A review», *Sustainable Chemistry One World*, vol. 1, p. 100002, mar. 2024, doi: 10.1016/j.scowo.2024.100002.

[6] S. M. J. Seyed Sabour y B. Ghorashi, «A comprehensive review of major water desalination techniques and mineral extraction from saline water», *Separation and Purification Technology*, vol. 349, p. 127913, dic. 2024, doi: 10.1016/j.seppur.2024.127913.

[7] N. T. Alwan, B. M. Ali, O. R. Alomar, N. M. Abdulrazzaq, O. M. Ali, y R. M. Abed, «Performance of solar still units and enhancement techniques: A review investigation», *Heliyon*, vol. 10, n.º 18, p. e37693, sep. 2024, doi: 10.1016/j.heliyon.2024.e37693.

[8] S. Kumar *et al.*, «SOLAR STILLS: A REVIEW FOR WATER SCARCITY SOLUTIONS», *Heliyon*, p. e38751, sep. 2024, doi: 10.1016/j.heliyon.2024.e38751.

[9] H. Saleem, N. Abounahia, H. R. Siddiqui, y S. J. Zaidi, «Qatar desalination research: An overview», *Desalination*, vol. 564, p. 116802, oct. 2023, doi: 10.1016/j.desal.2023.116802.

[10] M. Elashmawy, M. M. Z. Ahmed, W. H. Alawee, S. Shanmugan, y Z. M. Omara, «Scientometric analysis and review of materials affecting solar still performance», *Results in Engineering*, vol. 23, p. 102574, sep. 2024, doi: 10.1016/j.rineng.2024.102574.

[11] M. E. Murad, W. H. Alawee, y H. A. Dhahad, «Advanced techniques for augmenting the performance of double-slope solar stills: A comparative study», *Desalination and Water Treatment*, vol. 320, p. 100581, oct. 2024, doi: 10.1016/j.dwt.2024.100581.

[12] A. A. M. Omara, A. A. M. Mohammedali, y R. Dhivagar, «Magnetic field effect in solar stills: A critical review», *Solar Energy*, vol. 277, p. 112739, jul. 2024, doi: 10.1016/j.solener.2024.112739.

[13] T. Gunay, C. Gumus, y A. Z. Sahin, «The impact of using nanofluid on the performance of solar stills: A comprehensive review», *Process Safety and Environmental Protection*, vol. 189, pp. 1464-1516, sep. 2024, doi: 10.1016/j.psep.2024.06.104.

[14] Z. M. Omara, W. H. Alawee, A. Basem, y A. D. Jawad Al-Bayati, «Heat loss reduction techniques for walls in solar stills: A review», *Results in Engineering*, vol. 22, p. 101996, jun. 2024, doi: 10.1016/j.rineng.2024.101996.

[15] P. Mehta, N. Bhatt, G. Bassan, Z. Said, y A. ElCheikh, «Exploring stepped solar still developments with a case study for potable water provision in salt farming regions», *Sustainable Energy Technologies and Assessments*, vol. 64, p. 103700, abr. 2024, doi: 10.1016/j.seta.2024.103700.

[16] M. Elamy, «Novel cylindrical solar still integrated with parabolic solar concentrators, vapor extraction fan, and nanoenhanced phase change material». Accedido: 30 de septiembre de 2024. [En línea]. Disponible en: https://ehu.on.worldcat.org/atoztitles/link/?sid=Elsevier:Scopus&genre=article&issn=00119164&volume=585&issue=&spage=&epage=&pages=&artnum=117756&date=2024&title=Desalination&atitle=Novel+cylindrical+solar+still+integrated+with+parabolic+solar+concentrators%2c+vapor+extraction+fan%2c+and+nanoenhanced+phase+change+material&aufirst=M.I.&auinit=M.I.&auinit1=M&aulast=Elamy

[17] M. Mistry, P. Parikh, P. Mehta, y N. Bhatt, «Insights into evacuated glass tube collectors-assisted solar desalination systems: Pathways for large scale applications for potable water provision», *Solar Energy*, vol. 280, p. 112857, sep. 2024, doi: 10.1016/j.solener.2024.112857.

[18] H. O. Abdulridha, H. G. Hameed, y B. N. Merzah, «Performance study for single slope solar still integrated with different types of solar collectors», *Desalination and Water Treatment*, vol. 319, p. 100538, jul. 2024, doi: 10.1016/j.dwt.2024.100538.

[19] M. A. Tony y H. A. Nabwey, «Recent advances in solar still technology for solar water desalination», *Appl Water Sci*, vol. 14, n.º 7, p. 147, jun. 2024, doi: 10.1007/s13201-024-02188-1.

[20] T. Arunkumar, D. Parbat, y S. J. Lee, «Comprehensive review of advanced desalination technologies for solar-powered all-day, all-weather freshwater harvesting systems», *Renewable and Sustainable Energy Reviews*, vol. 199, p. 114505, jul. 2024, doi: 10.1016/j.rser.2024.114505.

[21] Y. Maruthupandian, G. S. Esakkimuthu, S. Vaithilingam, y G. Dhamodaran, «Experimental Analysis of Single-Slope Solar Still with Solar Dish Concentrator Using the Energy and Exergy Approach», *Iranian Journal of Chemistry and Chemical Engineering*, vol. 42, n.º 10, pp. 3495-3510, oct. 2023, doi: 10.30492/ijcce.2023.1971443.5674.

[22] A. S. Shareef, H. J. Kurji, y A. Omran, «Improving fresh water production in solar distillation by adding magnetic flux, solar collector and phase change materials», *AIP Conference Proceedings*, vol. 2830, n.º 1, p. 070013, jul. 2023, doi: 10.1063/5.0158002.

[23] M. Alsehli, «Improving the performance of a modified solar distiller with phase change material and parabolic trough collector», *Environ Sci Pollut Res*, vol. 30, n.º 12, pp. 32710-32721, mar. 2023, doi: 10.1007/s11356-022-24238-4.

[24] P. Gupta *et al.*, «Recent Progress in the Design of Solar Still: An Understanding and Comparison», en *Advances in Engineering Design*, R. Sharma, R. Kannojiya, N. Garg, y S. S. Gautam, Eds., Singapore: Springer Nature, 2023, pp. 103-119. doi: 10.1007/978-981-99-3033-3_11.

[25] H. Panchal *et al.*, «Performance evaluation of using evacuated tubes solar collector, perforated fins, and pebbles in a solar still – experimental study and CO2 mitigation analysis», *Environ Sci Pollut Res*, vol. 30, n.º 5, pp. 11769-11784, ene. 2023, doi: 10.1007/s11356-022-22809-z.

[26] U. F. Alqsair, A. S. Abdullah, y Z. M. Omara, «Enhancement the productivity of drum solar still utilizing parabolic solar concentrator, phase change material and nanoparticles' coating», *Journal of Energy Storage*, vol. 55, p. 105477, nov. 2022, doi: 10.1016/j.est.2022.105477.

[27] S. Kumar, A. Kumar, N. Chander, y D. K. Singh, «Thermal performance analysis of a novel direct absorption solar collector augmented solar still using silver nanofluids», *Environmental Progress & Sustainable Energy*, vol. 41, n.º 5, p. e13858, 2022, doi: 10.1002/ep.13858.

[28] M. Alsehli *et al.*, «Improving the performance of a hybrid solar desalination system under various operating conditions», *Process Safety and Environmental Protection*, vol. 162, pp. 706-720, jun. 2022, doi: 10.1016/j.psep.2022.04.044.

[29] M. Al-Harahsheh, M. Abu-Arabi, M. Ahmad, y H. Mousa, «Self-powered solar desalination using solar still enhanced by external solar collector and phase change material», *Applied Thermal Engineering*, vol. 206, p. 118118, abr. 2022, doi: 10.1016/j.applthermaleng.2022.118118.

[30] S. Shoeibi, H. Kargarsharifabad, N. Rahbar, G. Khosravi, y M. Sharifpur, «An integrated solar desalination with evacuated tube heat pipe solar collector and new wind ventilator external condenser», *Sustainable Energy Technologies and Assessments*, vol. 50, p. 101857, mar. 2022, doi: 10.1016/j.seta.2021.101857.

[31] E. B. Moustafa, A. H. Hammad, y A. H. Elsheikh, «A new optimized artificial neural network model to predict thermal efficiency and water yield of tubular solar still», *Case Studies in Thermal Engineering*, vol. 30, p. 101750, feb. 2022, doi: 10.1016/j.csite.2021.101750.

[32] T. Maridurai *et al.*, «Performance study on phase change material integrated solar still coupled with solar collector», *Materials Today: Proceedings*, vol. 59, pp. 1319-1323, ene. 2022, doi: 10.1016/j.matpr.2021.11.539.

[33] A. A. Kiran, P. V. Sivashankar, P. U. Suneesh, y D. C. Denkenberger, «V-Type solar still integrated with hybrid solar concentrator», *Cogent Engineering*, vol. 9, n.º 1, p. 2073650, dic. 2022, doi: 10.1080/23311916.2022.2073650.

[34] A. K. Thakur *et al.*, «Sea-water desalination using a desalting unit integrated with a parabolic trough collector and activated carbon pellets as energy storage medium», *Desalination*, vol. 516, p. 115217, nov. 2021, doi: 10.1016/j.desal.2021.115217.

[35] R. Bellatreche, M. Ouali, M. Balistrou, y D. Tassalit, «Thermal efficiency improvement of a solar desalination process by parabolic trough collector», *Water Supply*, vol. 21, n.º 7, pp. 3698-3709, may 2021, doi: 10.2166/ws.2021.131.

[36] M. Makkiabadi, S. Hoseinzadeh, M. M. Nezhad, A. Sohani, y D. Groppi, «Techno-Economic Study of a New Hybrid Solar Desalination System for Producing Fresh Water in a Hot–Arid Climate», *Sustainability*, vol. 13, n.º 22, Art. n.º 22, ene. 2021, doi: 10.3390/su132212676.

[37] R. Kumar, D. B. Singh, A. Dewangan, V. K. Singh, y N. Kumar, «Performance of evacuated tube solar collector integrated solar desalination unit — a review», *Desalination and Water Treatment*, vol. 230, pp. 92-115, ago. 2021, doi: 10.5004/dwt.2021.27463.

[38] H. M. A. Al-Ahmadi, O. O. Badran, K. S. AlQdah, R. A. H. Anani, y M. A. A. Nawar, «Evaluation of productivity enhancement of a solar still coupled with flat solar collector and parabolic trough under medina climate», *Desalination and Water Treatment*, vol. 223, pp. 1-12, may 2021, doi: 10.5004/dwt.2021.27124.

[39] I. M. Alarifi, A. G. Abo-Khalil, A.-R. Al-Qawasmi, W. Alharbi, y M. Alobaid, «On the effects of nanomaterials on the performance of solar distillation systems-A comprehensive review», *Solar Energy*, vol. 218, pp. 596-610, abr. 2021, doi: 10.1016/j.solener.2021.03.018.

[40] M. Elashmawy, M. Alhadri, y M. M. Z. Ahmed, «Enhancing tubular solar still performance using novel PCM-tubes», *Desalination*, vol. 500, p. 114880, mar. 2021, doi: 10.1016/j.desal.2020.114880.

[41] R. S. Subramanian, G. Kumaresan, R. Ajith, U. Sabarivasan, K. K. Gowthamaan, y S. Anudeep, «Performance analysis of modified solar still integrated with flat plate collector», *Materials Today: Proceedings*, vol. 45, pp. 1382-1387, ene. 2021, doi: 10.1016/j.matpr.2020.06.409.

[42] M. Boukhriss, K. Zarzoum, M. A. Maatoug, y M. Timoumi, «Innovation of Solar Desalination System Coupled with Solar Collector: Experimental Study», *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, vol. 80, n.º 1, Art. n.º 1, 2021.

[43] I. Altarawneh, M. Batiha, S. Rawadieh, M. Alnaief, y M. Tarawneh, «Solar desalination under concentrated solar flux and reduced pressure conditions», *Solar Energy*, vol. 206, pp. 983-996, ago. 2020, doi: 10.1016/j.solener.2020.06.058.

[44] G. Xie, W. Chen, T. Yan, J. Tang, H. Liu, y S. Cao, «Three-effect tubular solar desalination system with vacuum operation under actual weather conditions», *Energy Conversion and Management*, vol. 205, p. 112371, feb. 2020, doi: 10.1016/j.enconman.2019.112371.

[45] Z. Y. Ho y R. Bahar, «Performance Analysis of a Solar Desalination System with Concentrated Solar Power (CSP)», *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 268, n.º 1, p. 012023, jun. 2019, doi: 10.1088/1755-1315/268/1/012023.

[46] M. Abu-Arabi, M. Al-harahsheh, H. Mousa, y Z. Alzghoul, «Theoretical investigation of solar desalination with solar still having phase change material and connected to a solar collector», *Desalination*, vol. 448, pp. 60-68, dic. 2018, doi: 10.1016/j.desal.2018.09.020.

[47] A. Hosseini, A. Banakar, y S. Gorjian, «Development and performance evaluation of an active solar distillation system integrated with a vacuum-type heat exchanger», *Desalination*, vol. 435, pp. 45-59, jun. 2018, doi: 10.1016/j.desal.2017.12.031.

[48] M. Al-harahsheh, M. Abu-Arabi, H. Mousa, y Z. Alzghoul, «Solar desalination using solar still enhanced by external solar collector and PCM», *Applied Thermal Engineering*, vol. 128, pp. 1030-1040, ene. 2018, doi: 10.1016/j.applthermaleng.2017.09.073.

[49] N. Balachandran, «Hybrid solar desalination and water heating system: A review», *Journal of Advanced Research in Dynamical and Control Systems*, vol. 9, pp. 1275-1283, ene. 2017.

[50] A. E. Kabeel, M. Elkelawy, H. Alm El Din, y A. Alghrubah, «Investigation of exergy and yield of a passive solar water desalination system with a parabolic concentrator incorporated with latent heat storage medium», *Energy Conversion and Management*, vol. 145, pp. 10-19, ago. 2017, doi: 10.1016/j.enconman.2017.04.085.

[51] K. K. Chaithanya, V. R. Rajesh, y R. Suresh, «Experimental Analysis of Desalination Unit Coupled with Solar Water Lens Concentrator», *IOP Conf. Ser.: Mater. Sci. Eng.*, vol. 149, n.º 1, p. 012182, sep. 2016, doi: 10.1088/1757899X/149/1/012182.

[52] K. Srithar, T. Rajaseenivasan, N. Karthik, M. Periyannan, y M. Gowtham, «Stand alone triple basin solar desalination system with cover cooling and parabolic dish concentrator», *Renewable Energy*, vol. 90, pp. 157-165, may 2016, doi: 10.1016/j.renene.2015.12.063.

[53] O. Younas, F. Banat, y D. Islam, «Seasonal behavior and techno economical analysis of a multi-stage solar still coupled with a point-focus Fresnel lens», *Desalination and Water Treatment*, vol. 57, n.º 11, pp. 4796-4809, mar. 2016, doi: 10.1080/19443994.2014.1001443.

[54] M. M. Morad, H. A. M. El-Maghawry, y 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, oct. 2015, doi: 10.1016/j.desal.2015.06.017.

[55] A. M. Al-Shabibi y M. Tahat, «Single Slope Solar Water Still with Enhanced Solar Heating System», en *Recent Progress in Desalination, Environmental and Marine Outfall Systems*, M. Baawain, B. S. Choudri, M. Ahmed, y A. Purnama, Eds., Cham: Springer International Publishing, 2015, pp. 25-34. doi: 10.1007/978-3-319-19123-2_3.

[56] B.-J. Huang, T.-L. Chong, P.-H. Wu, H.-Y. Dai, y Y.-C. Kao, «Spiral multiple-effect diffusion solar still coupled with vacuum-tube collector and heat pipe», *Desalination*, vol. 362, pp. 74-83, abr. 2015, doi: 10.1016/j.desal.2015.02.011.

[57] T.-L. Chong, B.-J. Huang, P.-H. Wu, y Y.-C. Kao, «Multiple-effect diffusion solar still coupled with a vacuum-tube collector and heat pipe», *Desalination*, vol. 347, pp. 66-76, ago. 2014, doi: 10.1016/j.desal.2014.05.023.