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ANALYSIS OF MODERN DEVELOPMENTS IN SOLAR WATER DESALINATORS

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Abstract. ***Introduction.*** *This review explores the evolution and current trends in the publication of research on solar water desalination devices within the Scopus database. As global water scarcity intensifies, innovative solutions like solar water desalination have garnered increasing attention, prompting a substantial body of research aimed at enhancing the efficiency and accessibility of these technologies. The review analyses articles published over the last two decades to identify key developments, thematic shifts, and the geographic distribution of research efforts. Our findings reveal a significant increase in publication volume, reflecting growing academic and industrial interest in solar desalination technologies. This surge is largely driven by advancements in material science, thermal processes, and photovoltaic-powered desalination systems, which have progressively overcome earlier limitations related to energy consumption and cost efficiency. Additionally, the review highlights the contributions from leading countries in this field and discusses the integration of emerging technologies such as nanotechnology and artificial intelligence in optimizing desalination processes. This manuscript aims to provide a comprehensive overview of the landscape of solar water desalination research, offering insights into its developmental trajectory and projecting future research directions.*

Method. *A thorough analysis of papers on solar water desalination systems indexed in the Scopus database was carried out using a methodical methodology. The process is divided into four main phases: data extraction, data collecting, screening and selection, and analysis. This methodical technique guarantees the correctness and dependability of the review findings.*

Results. *1,003 publications overall from the examination of solar water desalination research that was published in the Scopus database. The survey reveals a notable concentration of research effort in China, which accounts for more than half of the papers, with the United States, India, and China following. Articles make up the majority of the document categories linked with this subject (76.4%), indicating a significant emphasis on recent research findings.*

Conclusion. *An examination of solar water desalination papers from the Scopus database shows a notable increase in research production over time, culminating in the last few years. A notable rise in publications—a total of 1,003 recorded papers—reflects this spike. The bulk of these articles originated in China, suggesting a substantial concentration of research activity in this area. In line with this, representation of the different forms of documentation reveals that articles make up the majority (76.4%), indicating a vibrant academic community. Reviews and conference papers also make significant contributions to the conversation around solar water desalination.*

Keywords: *Solar energy, fresh water, Scopus database, publications, analysis, reporting*

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QUYOSH SUV CHUCHUTGICHLAR BO‘YICHA ZAMONAVIY ISHLANMALAR TAHLILI

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Annotatsiya. Kirish. *Ushbu sharh Scopus ma’lumotlar bazasida quyosh suvini tuzsizlantirish qurilmalari bo‘yicha tadqiqotlar nashr etilishining evolyutsiyasi va hozirgi tendentsiyalarini o‘rganadi. Global suv tanqisligi kuchayib borar ekan, quyosh suvini tuzsizlantirish kabi innovatsion yechimlar tobora ko‘proq e’tiborni tortmoqda va bu texnologiyalarning samaradorligi va foydalanish imkoniyatini oshirishga qaratilgan keng ko‘lamli tadqiqotlarni talab qilmoqda. Sharh so‘nggi yigirma yil ichida nashr etilgan maqolalarni tahlil qiladi, asosiy ishlanmalar, tematik siljishlar va tadqiqot harakatlarining geografik taqsimotini aniqlash. Bizning topilmalarimiz nashrlar hajmining sezilarli o‘sishini ko‘rsatadi, bu quyosh energiyasini tuzsizlantirish texnologiyalariga o‘sib borayotgan akademik va sanoat qiziqishini aks ettiradi. Ushbu o‘sish asosan materialshunoslik, issiqlik jarayonlari va fotovoltaik bilan ishlaydigan tuzsizlantirish tizimlaridagi yutuqlar bilan bog‘liq bo‘lib, ular energiya iste’moli va iqtisodiy samaradorlik bilan bog‘liq oldingi cheklovlarni bosqichma-bosqich yengib chiqdi. Bundan tashqari, sharh ushbu sohadagi etakchi mamlakatlarning hissalarini ta’kidlaydi va tuzsizlantirish jarayonlarini optimallashtirishda nanotexnologiya va sun’iy intellekt kabi rivojlanayotgan texnologiyalarning integratsiyasini muhokama qiladi. Ushbu qo‘lyozma quyosh suvini tuzsizlantirish bo‘yicha tadqiqotlar landshaftini har tomonlama ko‘rib chiqish, uning rivojlanish traektoriyasi haqida tushuncha berish va kelajakdagi tadqiqot yo‘nalishlarini loyihalashtirishga qaratilgan.*

Usul. *Scopus ma’lumotlar bazasida indekslangan quyosh suv chuchuklashtirgich tizimlari bo‘yicha ishlarning to‘liq tahlili uslubiy metodologiya yordamida amalga oshirildi. Jarayon to‘rtta asosiy bosqichga bo‘lingan: ma’lumotlarni olish, ma’lumotlarni yig‘ish, saralash va tanlash va tahlil qilish. Ushbu metodik usul ko‘rib tahlil natijalarining to‘g‘riligi va ishonchliligini kafolatlaydi.*

Natijalar. *Scopus ma’lumotlar bazasida nashr etilgan quyosh suv chuchutgich bo‘yicha tadqiqotlar 1003 ta nashr etilgan. Tahlil Xitoyda tadqiqot ishlarining sezilarli kontsentratsiyasini ko‘rsatadi, bu maqolalarning yarmidan ko‘pini tashkil qiladi, keying o‘rinlarda AQSh, Hindiston turadi. Maqolalar ushbu mavzu bilan bog‘liq bo‘lgan nashlar toifalarining ko‘p qismini tashkil qiladi (76,4%), bu so‘nggi tadqiqot natijalariga katta urg‘u berilganligini ko‘rsatadi.*

Xulosa. *Scopus ma’lumotlar bazasidan quyosh suvini tuzsizlantirish bo‘yicha hujjatlarni tahlili vaqt o‘tishi bilan tadqiqot sezilarli o‘sishini ko‘rsatadi. Ushbu maqolalarning asosiy qismi Xitoy hissasiga to‘g‘ri keladi, bu ushbu sohada tadqiqot faoliyatining sezilarli darajada kontsentratsiyasini ko‘rsatadi. Shunga ko‘ra, nashlarning turli shakllarini taqdim etishda maqolalar ko‘pchilikni (76,4%) tashkil etishini ko‘rsatadi. tahliliy va konferentsiya nashrlari quyosh suv chuchutgich borasida olib borilayotgan tadqiqotlarga ham katta hissa qo‘shadi.*

Kalit so‘zlar: *Quyosh energiyasi, toza suv, Scopus ma’lumotlar bazasi, nashrlar, tahlillar, hisobotlar*

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АНАЛИЗ СОВРЕМЕННЫХ РАЗРАБОТОК ПО СОЛНЕЧНЫМ ОПРЕСНИТЕЛЯМ ВОДЫ

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Аннотация. Введение. *В этом обзоре рассматриваются эволюция и текущие тенденции публикации исследований солнечных устройств для опреснения воды в базе данных Scopus. По мере того, как глобальный дефицит воды усиливается, инновационные решения, такие как опреснение воды с помощью солнечной энергии, привлекают все большее внимание, что побуждает к проведению значительного объема исследований, направленных на повышение эффективности и доступности этих технологий. В обзоре анализируются статьи, опубликованные за последние два десятилетия, с целью выявления ключевых событий, тематических сдвигов и географического распределения исследовательских усилий. Наши результаты показывают значительное увеличение объема публикаций, что отражает растущий академический и промышленный интерес к технологиям опреснения воды с помощью солнечной энергии. Этот всплеск во многом обусловлен достижениями в области материаловедения, тепловых процессов и фотоэлектрических систем опреснения, которые постепенно преодолевают прежние ограничения, связанные с потреблением энергии и экономической эффективностью. Кроме того, в обзоре освещается вклад ведущих стран в этой области и обсуждается интеграция новых технологий, таких как нанотехнологии и искусственный интеллект, в оптимизацию процессов опреснения. Целью этой рукописи является предоставление всестороннего обзора исследований в области опреснения воды с помощью солнечной энергии, предложение понимания траектории его развития и прогнозирование будущих направлений исследований.*

Методы. *С использованием методической методики проведен тщательный анализ статей по солнечным системам опреснения воды, индексируемых в базе данных Scopus. Процесс разделен на четыре основных этапа: извлечение данных, сбор данных, проверка и отбор, а также анализ. Данный методический прием гарантирует правильность и достоверность результатов обзора.*

Результаты*.В базе данных Scopus имеется 1003 опубликованных исследования по солнечным очистителям воды. Анализ показывает значительную концентрацию исследований в Китае, на который приходится более половины статей, за которым следуют США и Индия. Статьи составляют большую часть категорий статей по этой теме (76,4%), что указывает на сильный акцент на результатах последних исследований.*

Заключение. *Анализ статей об опреснении воды с помощью солнечной энергии из базы данных Scopus показывает значительный рост количества исследований с течением времени. Основная часть этих статей предоставлена Китаем, что указывает на значительную концентрацию исследовательской деятельности в этой области. Соответственно, видно, что артикли составляют большинство (76,4%), представляющие разные формы предложений. Аналитические публикации и публикации на конференциях также вносят большой вклад в исследования солнечных водоочистителей.*

Ключевые слова: *Солнечная энергия, чистая вода, база данных Scopus, публикации, анализ, отчеты*

Introduction

Alternative techniques for desalinating water are becoming more and more popular as a result of the world's growing need for freshwater and the depletion of conventional water supplies. Particularly in arid and semi-arid countries with plentiful solar energy, solar water desalination systems have emerged as a viable approach to meet the difficulties of freshwater shortage [1]. These devices use reverse osmosis, distillation, and hybrid techniques to turn brackish or salted water into drinkable water using solar energy [2].

Using the sun's energy to power the desalination process minimizes greenhouse gas emissions and dependence on fossil fuels, making solar desalination a sustainable and ecologically benign method [3]. In isolated and off-grid areas where traditional energy sources are expensive or unavailable, this technology is very helpful [4]. Furthermore, integrating solar desalination with

renewable energy sources might strengthen water supply systems' resilience and reduce their susceptibility to the effects of climate change [5].

Solar desalination systems come in a variety of forms, each with special mechanisms and efficiency. For example, solar stills work on the idea of solar distillation, which involves heating the salty water with sunshine until it evaporates. Salts and other conta'minants are left behind when the vapor condenses on a colder surface [6]. Reverse osmosis systems using photovoltaic power employ solar panels to produce energy, which powers the process of removing impurities and salts from water [7]. Multiple desalination techniques are used in hybrid systems to maximize output and efficiency [8].

Solar desalination systems have a number of technical and financial obstacles, notwithstanding their promise. These consist of expensive starting expenses, frequent maintenance requirements, and capacity restrictions for producing water [9]. The performance and cost-effectiveness of these systems can only be enhanced by developments in materials science, such as the creation of solar collectors and membranes with higher efficiency [10]. In order to guarantee a steady supply of water, research is also concentrated on improving the thermal efficiency of solar stills and incorporating energy storage technologies [11].

Significant advancements in solar desalination methods have been shown in recent research. For instance, advances in nanotechnology have produced sophisticated solar absorbers and photothermal materials that improve solar still efficiency [12]. Furthermore, it has been demonstrated that phase change materials (PCMs) can enhance thermal storage and energy efficiency in solar desalination systems [13]. To maximize efficiency and save operating costs, artificial intelligence and machine learning techniques are also being investigated for use in the design and management of solar desalination facilities [14].

To sum up, solar water desalination systems offer a workable and sustainable way to deal with the world's water shortage. To fully realize the promise of this technology and overcome current obstacles, research and development must continue. The goal of this study is to present a thorough analysis of the state of solar desalination technology today, emphasizing new developments, difficulties, and potential paths forward [15].

Methods

A thorough analysis of papers on solar water desalination systems indexed in the Scopus database was carried out using a methodical methodology. The process is divided into four main phases: data extraction, data collecting, screening and selection, and analysis. This methodical technique guarantees the correctness and dependability of the review findings.

Data Collection

Database Search: Because of its comprehensive coverage of peer-reviewed literature from a variety of areas, the Scopus database was selected. A targeted search query was created to find all pertinent articles: Title: ABS-KEY (desalination, water, sun, and device).

Time Frame: To guarantee a thorough examination of all accessible material, publications from the database's founding to the present were taken into consideration.

The inclusion criteria consisted of only English-language publications that were categorized as conference papers or journal articles. Original research and case studies were prioritized above reviews, book chapters, and editorials.

Choosing and Filtering

First Screening: Articles that did not expressly address solar water desalination technologies were excluded based on their titles and abstracts. In order to exclude irrelevant subjects, this stage used automated technologies.

Detailed Review: Using predetermined criteria (innovation in design, efficiency gains, comparative studies, and application settings), the complete texts of possibly relevant papers were reviewed to verify their applicability.

Extraction of Data

Data Points: Information on the author(s), year of publication, study goals, kind of solar desalination technology (e.g., solar still, photovoltaic-driven systems, etc.), major conclusions, and technical improvements were taken from each chosen article.

Database administration: Using data management software, extracted data were arranged into a structured manner for simple access and modification in preparation for additional analysis.

Analysis

Trend Analysis: To determine patterns in research concentration over time, such as transitions from conventional solar still designs to sophisticated hybrid systems integrating renewable energy sources, data were studied.

Thematic Synthesis: To compile data on recurring themes, difficulties, and gaps in the state of the field, a thematic analysis was carried out. To do this, the retrieved data had to be coded in order to find trends pertaining to economic, environmental, and technical factors.

Evaluation of the Studies' Quality: To make sure that the results reached are supported by solid evidence, the methodological rigor and depth of the study were appraised using a standardized checklist.

Reporting

Synthesis of Results: The analysis's conclusions are presented in a logical way, stressing significant advancements, the effectiveness of various solar desalination systems, and suggestions for further study.

Publication: The final paper is created with detailed tables, figures, and references that bolster the review's narrative. It is organized in accordance with the target journal's criteria.

The review attempts to give a thorough and scientifically sound summary of the developments in solar water desalination technology as seen in Scopus-indexed literature by using this methodological methodology. Researchers, decision-makers, and practitioners working on the creation and use of sustainable water desalination systems will find this to be a useful resource.

Result and discussion

A thorough examination of academic papers about solar water desalination that were taken from the Scopus database between 2000 and 2024 is shown in Fig. 1. Both the yearly publishing patterns and the regional distribution of research contributions are displayed:

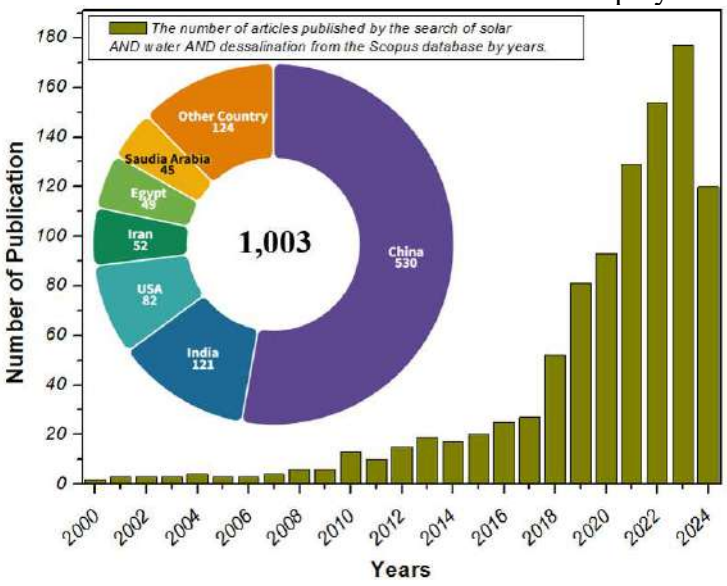

Fig. 1 Number of publications for solar water desalination device in the Scopus dataset.

The number of publications has been rising steadily since 2000, according to the bar graph, with a noticeable uptick in the last few years, especially in 2018. This upward trend highlights how solar water desalination technologies are becoming more and more popular as a solution to the world's water shortage and environmental issues. The number of publications has been rising steadily since 2000, according to the bar graph, with a noticeable uptick in the last few years,

especially in 2018. This upward trend highlights how solar water desalination technologies are becoming more and more popular as a solution to the world's water shortage and environmental issues. Of the 1,003 papers that were examined, the pie chart illustrates the contributions made by the various nations. With 530 papers, China comes out on top as the country that contributes the most to the research output. India comes in second with 121 articles, followed by the USA with 82. This indicates that these two countries have a significant emphasis on solar desalination technology, maybe as a result of their different demands for scalable and sustainable water purifying systems. Due to their advantageous locations for utilizing solar energy and the serious water problems they encounter, Saudi Arabia, Egypt, and Iran also make noteworthy contributions.

The data not only shows the growing worldwide trend toward the use of renewable energy sources for desalinating water, but it also emphasizes the important contributions to research that Asia—China and India in particular—has made to the field. This development might lead to more joint ventures and creative endeavors in the industry, with an emphasis on cost savings, increased productivity, and the incorporation of solar desalination systems into larger water delivery networks.

The distribution of various document types published on the subject of solar water desalination, as indexed in a scholarly database, is shown in Fig. 2.

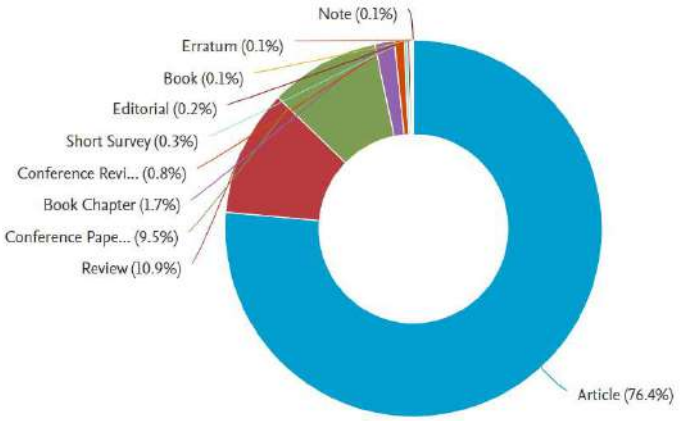

Fig. 2 Documents by type. Copyright © 2024 Elsevier B.V. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

Research papers make up 76.4% of the total literature. This noteworthy proportion suggests that there has been a substantial number of primary research and in-depth studies that add to the body of knowledge in the field of solar water desalination. Review articles, which make up 10.9% of publications, are important because they summarize the body of research, point out trends, and emphasize areas that require more investigation. Their significant contribution highlights how crucial they are for integrating various studies and directing the course of future study. These articles, which account for 9.5% of the publications, are crucial for the communication of innovative findings and useful developments in solar water desalination technology. They provide researchers a forum to share their most recent discoveries and have conversations that can result in important breakthroughs and joint ventures. Book chapters, which make up 1.7% of the total, aid in a deeper examination of certain solar water desalination subjects by providing thorough evaluations, theoretical frameworks, and extensive background. Included in this are book reviews (0.8%), erratum (0.1%), editorials (0.2%), brief surveys (0.3%), books (0.1%), and notes (0.1%). These papers, which include criticism, corrections, and updates on current research, contribute to the diversity and depth of the academic discourse even though they make up a smaller fraction of all publications.

Conclusion

A thorough analysis of research on solar water desalination that is indexed in the Scopus database reveals a growing body of work and significant contributions from a number of

countries, with a focus on the last ten years as Figure 1 illustrates. With a significant number of publications, China emerges as the top contributor, followed by the USA, India, and other nations, demonstrating a widespread understanding of the value of solar desalination technology in alleviating the world's water shortage. Journal articles make up 76.4% of all papers, the bulk of publications, which highlights the active research and peer-reviewed discussions in the subject. Reviews and conference articles also provide a substantial contribution, demonstrating the continual exchange of ideas and information among scholars. The relative abundance of articles relative to other document kinds indicates a developed and dynamic study field with well-established methods and notable advances in theory and experimentation. This analysis demonstrates how important it is to continue researching solar water desalination in order to improve sustainable water supply options, especially in areas where water shortage is a major issue. A continuing upward trajectory in research innovations is predicted by the increasing trend in publications, which is driven by technological advancements and the urgent need for globally accessible clean water solutions. This trend also highlights the urgency of developing efficient and sustainable desalination technologies.

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