Artificial Intelligence in Water Desalination: A Novel Approach for Global Sustainability

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Abstract. Artificial intelligence (AI) is an efficient technique frequently used to tackle practical issues in various engineering and medical fields. Apart from different areas, water desalination is essential in surviving humans, animals, and plants. It is a crucial industry for a sustainable planet, and we cannot live without water. As a result, engineers and researchers are quite active in this area. Recent studies based on Elsevier's Scopus database demonstrate how automation using emerging technologies has enhanced the traditional desalination process. AI offers enormous potential to address numerous problems and real-time optimization procedures. According to Elsevier's Scopus database, water desalination has extensively used AI optimization tools, especially after 2010, such as artificial neural networks (ANN), genetic algorithms (GA), fuzzy logic, and natural swarm global optimization techniques to improve water quality and quantity. Finally, it was determined that AI technologies would surely pave the way for better operation, water resource management, and process automation in the water sector in an increasingly unstable climate.

Keywords. Artificial intelligence (AI), water desalination, artificial neural network (ANN), Scopus database, Global Sustainability

1 Introduction

Significant research has been conducted in water desalination technology during the last few decades [1–3]. However, the supply of clean drinking water has emerged as a pressing issue on a global scale [4]. The newly developed reverse osmosis (RO) technology is anticipated to significantly advance pretreatment, energy recovery, and RO membrane modules while lowering total operational costs [5,6]. Energy consumption, performance stability, and cost minimization have received much attention [7,8,21-25]. According to recent surveys, the

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water desalination sectors focus on artificial intelligence (AI) to boost production and procedures. The self-adaptive and real-time optimization algorithms used in the water desalination industry have recently been discovered to use AI. AI's goals in water desalination include improving data quality, achieving scalability, and improving productivity. AI also allows for automatic characteristics. Despite these benefits, AI in water desalination does have certain drawbacks. It aids in locating fixes for knowledge-based decision extraction. It may now use a variety of facts to make better conclusions.

It incorporates the training dataset used for system training and outputs information in line with that. The cost-effectiveness of various water desalination processes can be increased using AI technologies. Different machine learning algorithms, including random forest, support vector machine, image processing and digital filters [9,10], Deep learning and DSP [11,12], logistic regression, K-nearest neighbour, decision tree and AI-based algorithms, like the fuzzy inference system [7,13–20], have been applied in recent studies. As a result, AI can enhance and support the processes of saltwater desalination and water treatment.

Three sections make up this review article: the introduction provides background information on water desalination and AI technologies. Next, conduct a thorough analysis based on the most recent Elsevier's Scopus database in the second part. In the end, there is a conclusion with valuable data and results.

2 Literature survey based on Elsevier's Scopus database

Elsevier's Scopus database was introduced in 2004. The top-tier subjects covered by Scopus include the life sciences, social sciences, physical sciences, and health sciences, with almost 36,377 titles from roughly 11,678 publishers. It encompasses three sources: trade journals, book series, and journals. The four forms of high-quality measure articles are SCImago Journal Rank (SJR), h-Index, source normalized impact per paper (SNIP), and CiteScore. Scopus searches include searches of the patent database as well. The criteria for a high-quality set by various research grant agencies for their award recipients in numerous nations are believed to be met by journals listed in Scopus.

2.1 Number of publications per year

As illustrated in Figure 1, the most recent Scopus database reveals that AI has been actively engaged in the field of water desalination since 2010. Engineers and researchers are widely used, and this trend has dramatically risen. There were around 2948 total publications in the peer-reviewed journal in 2022. Additionally, while this year is still in progress, publications from the year 2023 have been released around 2238. There is a strong likelihood that this year's overall number of publications will exceed 3500. It displays the researcher's enthusiasm for both water desalination and artificial intelligence.

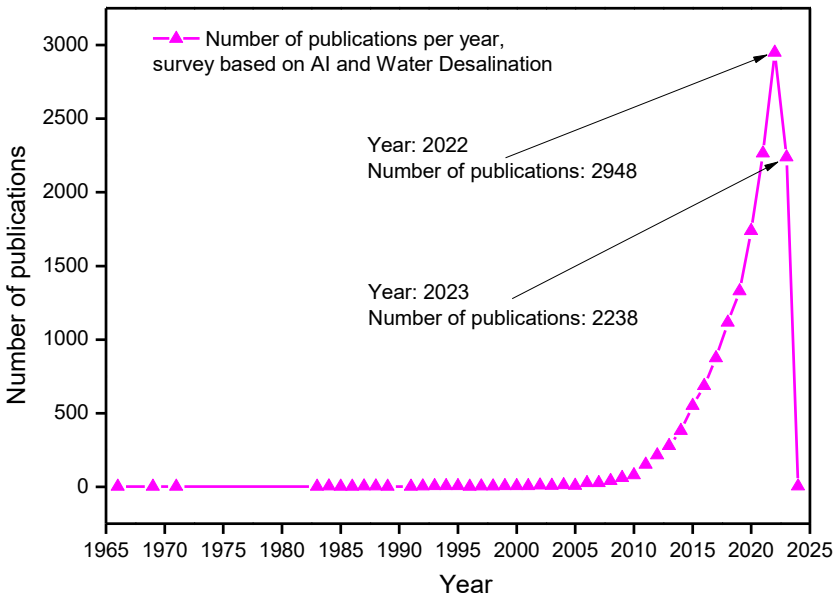

Fig. 1. Number of publications per year based on AI and Water Desalination (Data collected from Elsevier's Scopus database 2023)

2.2 Number of publications based on document types

Research articles, review articles, book chapters, conference papers, and other publications have all been considered while analyzing the additional survey. According to Figure 2, 74% of research articles have been published in this field, with review articles coming in second at 19%, book chapters (4%), conference papers (2%), books (1%), and other publications. The researcher's focus on journal articles is evident from document-type developments.

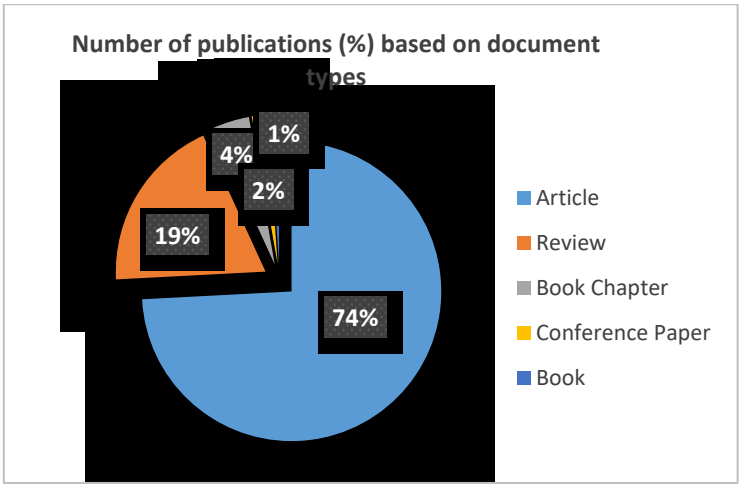

Fig. 2. Number of publications (in %) based on AI and Water Desalination with document types (Data collected from Elsevier's Scopus database 2023)

2.3 Number of publications based on the subject areas

Additional studies show the involvement of AI and water desalination in many different kinds of engineering and medical domains. Figure 3 shows that the environmental science, chemical engineering, chemistry and engineering fields have received a lot of attention and research articles have been published widely. This study area has also included contributions from material science, energy, physics, medicine and others.

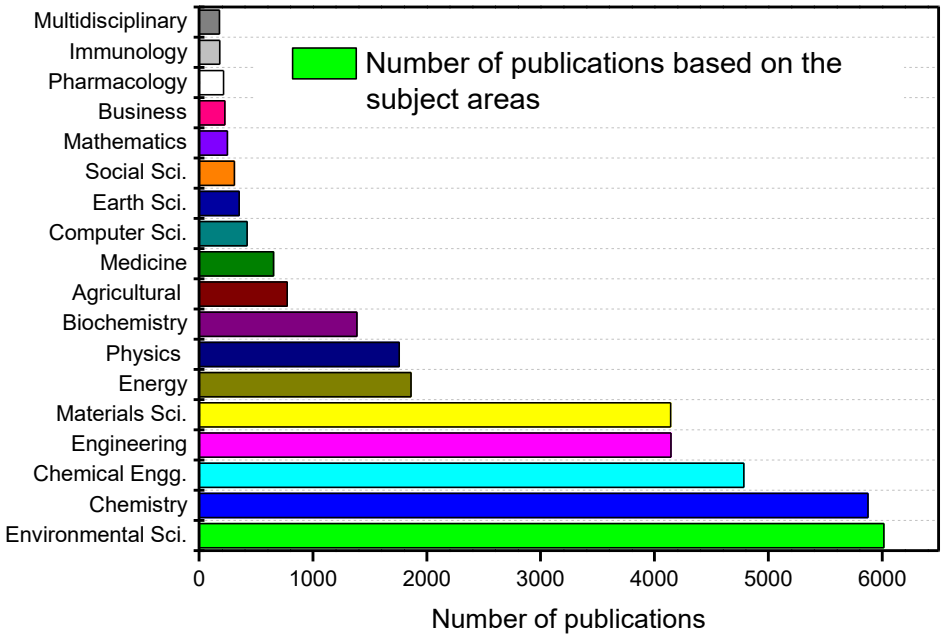

Fig. 3. Number of publications based on the subject areas (Data collected from Elsevier's Scopus database 2023)

2.4 Number of publications around the country/territory

According to other studies, there is a connection between AI and water desalination across the nation and its territories. Figure 4 demonstrates that China has published more publications than any other nation (>7153). Second highest, India has published research articles (>1715). Results show that China has been more actively involved than any other nation. USA (>1231), Saudi Arabia (>695), South Korea (>585), Iran (>1186) and Iran (>1185) have also contributed to these sectors. According to a survey based on artificial intelligence and water desalination, China, India and the United States are the most highly contributed countries worldwide.

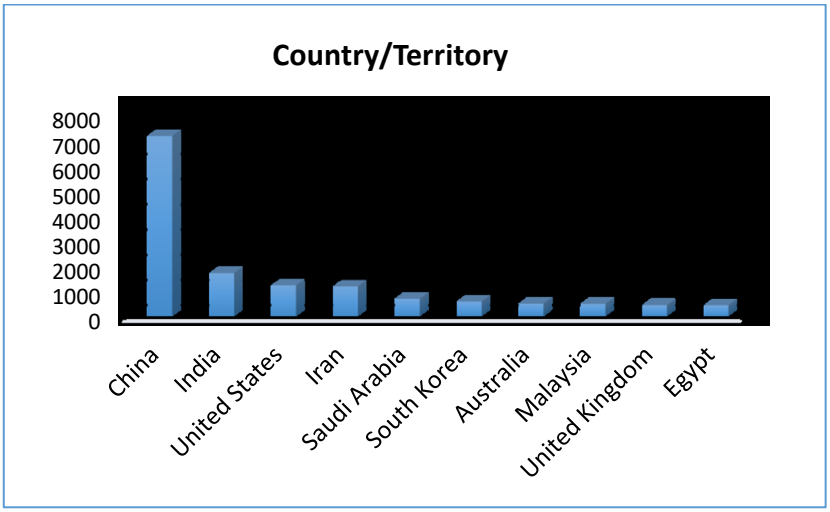

Fig. 4. Number of publications around the country/territory (Data collected from Elsevier's Scopus database 2023)

3 Funding sponsors around the world for AI & water desalination

Artificial intelligence and water desalination fields have attracted the attention of numerous funding organizations, research groups, and foundations. Table 1 shows how actively the Chinese National Natural Science Foundation has been involved in this field's published (>4127) research articles. The research database demonstrates that China is a major supporter of this field. The USA, Korea, Japan, India, Canada, Malaysia, Taiwan and other nations have also sponsored this research area.

Table 1. Funding sponsors around the world for AI & water desalination research domain.

Funding Sponsors	**Publications**
National Natural Science Foundation of China	4127
National Key Research and Development Program of China	674
Fundamental Research Funds for the Central Universities	656
China Postdoctoral Science Foundation	310
National Research Foundation of Korea	246
Natural Science Foundation of Jiangsu Province	194
National Science Foundation	190
Chinese Academy of Sciences	177
Natural Science Foundation of Shandong Province	165
Department of Science & Tech., Ministry of Science and Tech., India	152
China Scholarship Council	149
Priority Academic Prog. Develop. of Jiangsu Higher Education Institutions	140
Ministry of Education of the People's Republic of China	129
Ministry of Science, ICT, and Future Planning	124
Conselho Nacional de Desenvolvimento Científico e Tecnológico	109

4 Conclusion and future recommendations

The exponential population expansion and the effects of climate change on humans have had a wide range of impacts in the twenty-first century. The solutions that AI has provided to meet the growing demands, however, are truly astonishing. The future of the water industry appears to be automation technologies. The current water infrastructure of our society, which is more dependable, strong, safe, and profitable, can be significantly improved. Before fully realizing and utilizing AI's benefits in water desalination, there is a period of adaptation in response to advancements in automation technology and AI. Artificial intelligence tools can improve customer interactions, speed up data analysis and optimization, and can be helpful in decision-making. When AI technologies are implemented in the water desalination industry, they will immediately reduce operational and energy costs by issuing alerts for atypical faults such as membrane failure, pipe corrosion, and poor permeate steam quality. For quicker handling of operational difficulties, AI delivers a faster response. This review aims to enhance the research area for artificial intelligence and water desalination. Water desalination and AI's future directions will both keep growing. The survey results indicate that these domains' management, process automation, and operation are being driven by artificial intelligence.

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