
Bibliometric Analysis for Research Trends Nanofiltration Membranes in The Past Decade to 2023

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Abstract

Water treatment is an important part that has an impact on life, to understand the progress of nanofiltration membrane research literature related to this field was obtained from the Google Scholar database. Based on mapping and visualization software VOSviewer, the number of publications and groupings were calculated and analyzed. Research advances and trends in the field of nanofiltration membranes are summarized. The results of the study show that since 2013 the quantity of publications in this field has increased every year until 2020 then decreased in 2021 and then increased again in 2022. This field has received attention including its wide application in water treatment. Related studies have been published in the journal of Membrane Science and Desalination which is the authoritative journal in this field with the largest number of publications. According to the keyword network map of nanofiltration membranes there are 8 clusters, and this field can generally be divided into three research stages, namely synthesis, characterization, and performance testing. To achieve the goals of research development, it must be further deepened in future work. This article will provide a reference for researchers engaged in membrane technology and its applications.

Keywords: Bibliometric, Computational mapping analysis, Nanofiltration membrane, Vosviewer.

1. Introduction

Water treatment technology using membranes has been widely used because the separation process can be carried out continuously, it is easy to use, and there are no added chemicals so it is non-destructive and environmentally friendly (Kusworo *et al.*, 2021). Nanofiltration membrane (NF) is considered as a promising technology in water treatment because it has more advantages such as effective separation with a pore size of 0.001 μ m compared to other technologies (Behdarvand *et al.*, 2021a). Because of this, the application of nanofiltration membranes is used in separating contaminants in water and as a pre-treatment in water desalination (Ihsanullah, 2019; Thakur & Voicu, 2016).

During the last five decades the study of membranes as a water treatment technology has intensified. Due to the increasing concern about water pollution and the increasingly limited availability of clean water, it has attracted a lot of attention in recent years. A continuous and fast increase in the number of publications can be observed, especially since 2010 more than 5,000 Journals on membrane technology have been published, indicating that this technology is a growing research area in water treatment. Most studies in this field have been carried out, several authors have studied and analyzed the process of synthesis (Behdarvand *et al.*, 2021b; Park *et al.*, 2020), modification (Bet-Moushoul *et al.*, 2016; Karimi *et al.*, 2019), and the performance of antifouling NF membranes (Yuan *et al.*, 2014), antimicrobial (Wang *et al.*, 2018) and separation of contaminants in water (Bagheripour *et al.*, 2019). There are many emerging researches on water

treatment using NF membranes. Therefore, it is very important to study the characteristics and research status of NF membranes through bibliometric analysis methods.

Bibliometric analysis can analyze the impact or value of research achievements that combine statistical and mathematical methods to map the state of a growing research field based on online databases (Google Scholar, Pub Med, and Web of Science) to determine new scientific research directions and themes. [Ding & Zeng, \(2022\)](#) used bibliometrics to analyze research on household wastewater treatment, [Plaza-Garrido *et al.*, \(2022\)](#) analyzed the prospects for challenges of membrane separation processes to remove viruses, [Mao *et al.*, \(2021\)](#) analyzed sewage treatment industry from 1998 to 2019.

The results of the bibliometric analysis mapping research can be visualized using VOSviewer software to provide an overview of data representation and mapping of the relationship to the keyword "membrane nanofiltration" which has been published in related fields. Thus this study aims to conduct a bibliometric review of the literature regarding the general perspective of synthesis, materials, and applications developed regarding NF membranes.

METHODS

In order to trace the development trend of nanofiltration membranes in the last few decades, a statistical and visual study on literature published in 2013-2023 based on bibliometrics was carried out in this article. The research process is shown in Figure 1. First, literature related to the keyword "membrane nanofiltration" was searched using the Publish or Perish software through the Google Scholar database. Second, all literature information is exported as a (ris) file. Then the text files are imported in the visualization software (VOSviewer) for bibliometric analysis. Data mapping consists of three types, namely network, density, and overlay visualization. In addition, we also filter terms that will be included in the VOSviewer network mapping visualization. Finally obtained the results of the analysis and conclusions. Research [Al Husaeni & Nandiyanto \(2021\)](#) provides detailed information on how to install and use the Publish or Perish and VOSviewer software. Research by [Azizah *et al.*, \(2021\)](#) also provides detailed information about how to search the article database on Google Scholar.

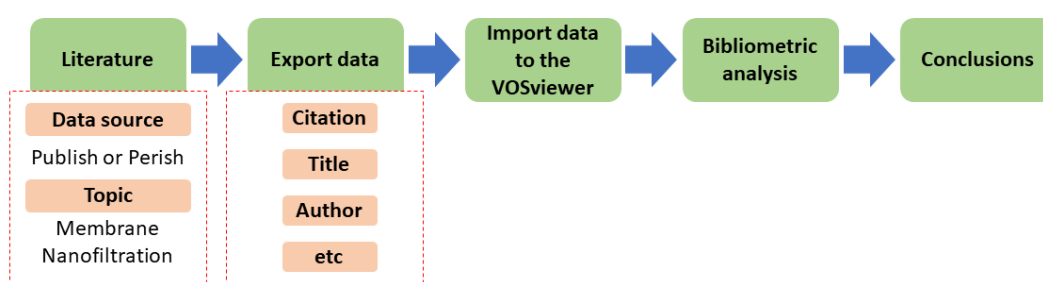


Figure 1. The Research Process

3. Results and Discussion

The bibliometric study described here examines the analytical development of nanofiltration membrane research. This bibliometric analysis seeks to analyze and find research results, interactions between science and technology, map fields of science, track or trace the development of new knowledge in certain fields, and serve as an indicator of the future in providing a more competitive advantage. In strategic planning. Here a bibliometric analysis of nanofiltration membrane studies is carried out for 10 periods from 2013 to 2023 (Figure 2).

3.1 Development of publication in the field of nanofiltration membranes

The development of publications in the field of NF membranes indexed by Google Scholar has increased significantly for 8 periods from 2013 to 2020. However, there has been a significant decline in 2021 due to the COVID-19 pandemic which has limited the number of research

activities. Publications increased again in 2022 to 76 publications. Furthermore, the number of articles decreased in 2023 because the data for this study were collected in mid-2023 (Table 1).

In this research, there are 73649 total citations from all articles; 7364.90 number of citations per year; 73.80 the number of citations per article; 4.92 average authors per article; all articles have an h-index of 130 and a g-index of 195.

Table 1. Development of Nanofiltration Membrane Research

Year of Publication	Number of Publication
2013	73
2014	84
2015	97
2016	101
2017	110
2018	112
2019	119
2020	132
2021	64
2022	76
2023	55

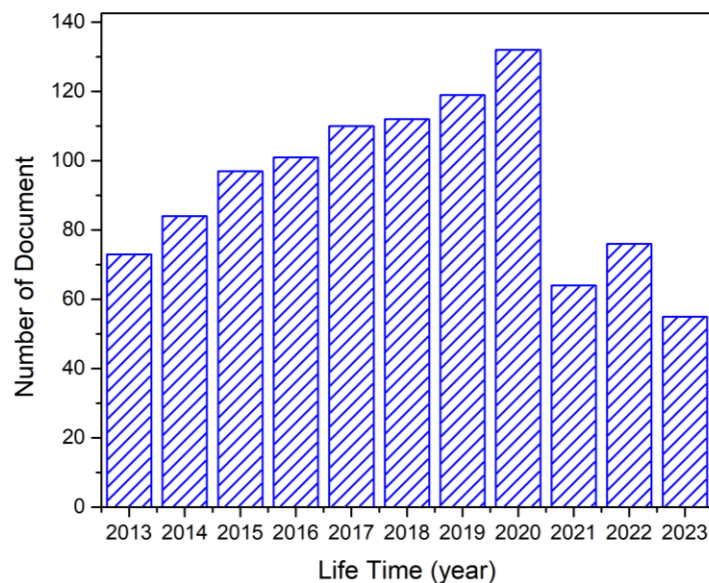


Figure 2. Level of Development in Nanofiltration Membrane Research

3.2 Visualization of nanofiltration membrane topic area using VOSviewer

In this study, 5 minimum quantities and 276 maximum quantities were used. If there are terms that are considered irrelevant to the research topic, they can be omitted. Furthermore, the article data is computationally mapped. Network visualization (Figure 3) shows 8 clusters that correlate with the NF membrane topic and the relationship between one term and another. Each of these items has been divided into 8 clusters, namely:

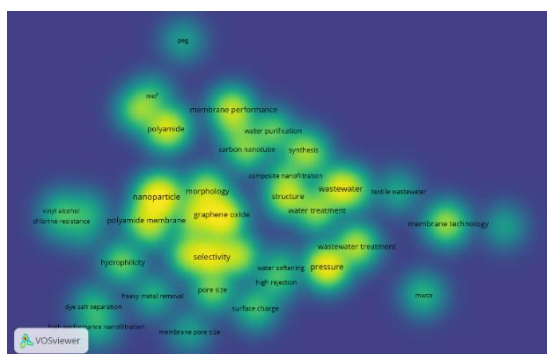


Figure 5. Density Visualization of Nanofiltration Membrane

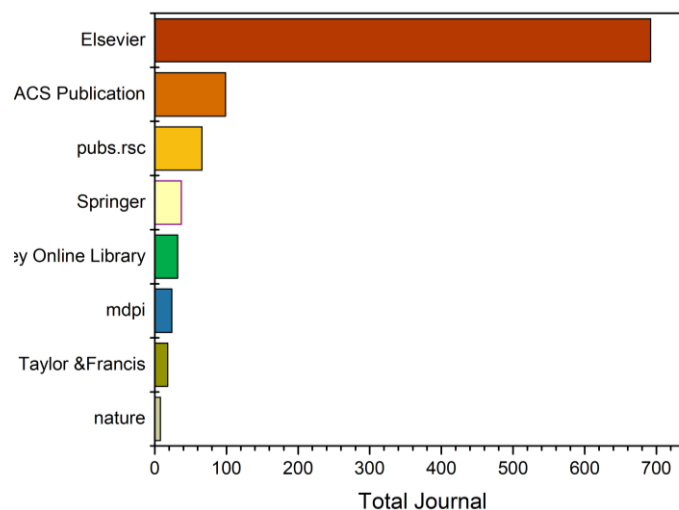


Figure 6. Publisher Portal and Number of Publications

Table 2. Top 10 Papers with Cited Frequency

Year	Title of the article	Source	Author	Cited numbers
2015	Nanofiltration membranes review: Recent advances and future prospects	Desalination	AW Mohammad	1551
2013	Ultrathin graphene nanofiltration membrane for water purification	Advanced Functional Materials	Y Han	1467
2014	Molecular separation with organic solvent nanofiltration: a critical review	Chemical Reviews	P Marchetti	1241
2016	Large-area graphene-based nanofiltration membranes by shear alignment of discotic nematic liquid crystals of graphene oxide	Nature Communications	A Akbari	586
2013	Removal of heavy metal ions by nanofiltration	Desalination	BAM Al-Rashdi	557
2013	Effects of pH and salt on nanofiltration—a critical review	Journal of Membrane Science	J Luo	511

2018	Nanoparticle-templated nanofiltration membranes for ultrahigh performance desalination	Nature Communications	Z Wang	501
2015	Graphene oxide modified polyamide nanofiltration membrane with improved flux and antifouling properties	Journal of Materials Chemistry	S Bano	456
2015	High-flux graphene oxide nanofiltration membrane intercalated by carbon nanotubes	ACS applied materials & interfaces	Y Han	445
2019	Large-area graphene-nanomesh/carbon-nanotube hybrid membranes for ionic and molecular nanofiltration	Science	Y Yang	420

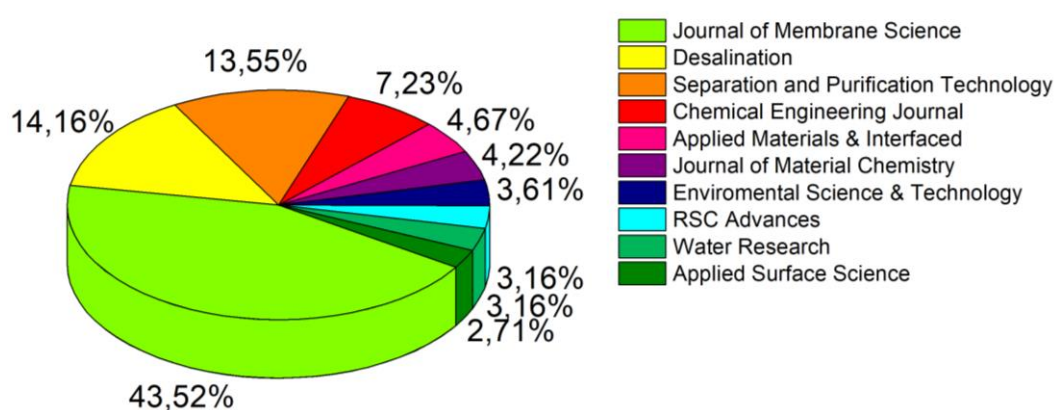


Figure 7. Top 10 Journals in The Number of Published Articles

4. Conclusion

Based on bibliometric analysis, since the publication of the field of membrane technology in 2013, the total number of annual publications has experienced a period of ups, downs and then up again, and in recent years the topic of nanofiltration membranes has been in a period of rapid development, influenced by developments regarding modification of nanofiltration membranes with the addition of fillers. to improve the morphological structure of the membrane and the performance of the membrane. a large number of researchers have developed this field in various water treatment applications such as wastewater treatment, salt rejection to water desalination and achieved rapid development.

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