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TRENDS IN WATER QUALITY RESEARCH: A BIBLIOMETRIC STUDY OF FACTORS AND PARAMETERS IN DRINKING WATER

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ABSTRACT

This study examines trends in water quality research through a bibliometric approach with the aim of mapping dominant factors and parameters and identifying research gaps in this area. The introduction of this research highlights the importance of water quality as a global issue that affects public health and environmental sustainability. The main objective of the study was to analyze water quality-related publications published between 2017 and 2024 using the Publish or Perish application to identify trends, distribution, and research focus. The method used involved collecting data from the 50 highest-ranked journals on Google Scholar, then classifying them by year of publication, publication type, number of citations, and author country. The data obtained was analyzed with the VOSviewer application to generate network visualizations, overlays, and densities to reveal the linkages between research topics. The analysis showed that research on water quality is highly diversified with the main focus on factors affecting water quality and the development of assessment methods. The publications reviewed highlighted global challenges in water quality management and the need for cross-disciplinary collaboration. The conclusions of this study emphasize several research gaps, such as the need for the development of more sensitive water quality indices, the application of new technologies, and further research in local and regional contexts. This research provides valuable insights into current research trends and encourages further exploration to improve water quality management effectively and sustainably.

Keywords: Water Quality, Bibliometrics, Assessment Methods, Emerging Technologies, Research Gaps.

INTRODUCTION

Water quality is one of the most pressing environmental issues of importance to human health and global ecosystems. With an increasing world population and increasingly complex industrial activities, the challenge of maintaining and monitoring water quality has become even more critical. Water quality not only impacts human health, such as through the consumption of contaminated water, but also affects environmental, agricultural and industrial sustainability. Therefore, effective monitoring and accurate assessment of water quality is essential to ensure the sustainability of water resources and reduce health risks.

Since the late eighteenth century, post-industrial revolution, humans have been discovering new sources of pollution almost every day, resulting in air and water pollution in many places.

Understanding of changes in pollution levels is still very limited. The rise in water-related diseases gives a clear indication of the extent to which pollution affects the environment. This research addresses water quality parameters from an ecological point of view, not only for humans but also for other living things. Based on its quality, water can be divided into four categories. The discussion of the four types of water quality includes an in-depth review of important attributes including physical, chemical and biological parameters. These water quality parameters are analyzed from the aspects of their definitions, sources, impacts, effects, and measurement methods (Hasan O, 2020).

One of the most important requirements for maintaining human health is the availability of clean drinking water. Water is the most common compound on the Earth's surface and is a renewable resource necessary for life to take place. Unfortunately, water will become increasingly scarce as a result of population growth, urbanization, and climate change (Nawaz, R et al, 2023). Drinking water must meet the requirements set by the government in the Minister of Health Regulation No. 2 Year 2023 on Drinking Water Quality Requirements in order to be considered safe for consumption. Drinking water quality is the most important aspect due to its impact on public health. Good drinking water quality is essential for maintaining health and preventing various diseases (Susanto et al., 2019).

Understanding the spatial distribution of environmental features is essential for evaluating drinking water quality. However, water quality monitoring, especially in large groundwater basins, can be expensive. Therefore, reliable and flexible tools are needed to address the problem. The use of technologies such as geographic information systems (GIS) facilitates spatial analysis, water quality monitoring, and supports strategic planning and decision-making processes related to water management. In the event of an emergency or waterborne disease outbreak, GIS can also help with real-time tracking, monitoring and visualization of affected areas, people at risk and available resources.

GIS-generated maps and interactive visualizations can be used to sensitize the public on water-related issues and to improve public understanding of potential hazards, sources, and quality of drinking water. Through the application of GIS technology, drinking water quality across the region can be presented with fewer observations, which lowers costs and increases the overall effectiveness of water management and monitoring initiatives. The synthetic pollution index (SPI) and water quality index (WQI) are the most frequently used methods to classify and reflect water quality and pollution risk in an area. WQI and SPI have been used by researchers from several countries to evaluate water quality in various places (Latief M et al, 2024).

In recent decades, research on water quality has undergone significant development, with studies focusing on various aspects such as physical, chemical, and biological parameters of water. This research includes the development of water quality indices, new monitoring techniques, and the impact of environmental factors on water quality. However, although much research has been conducted, there is still a large amount of literature that needs to be analyzed to comprehensively understand trends, patterns, and progress in this field.

This study aims to provide a deeper understanding of research trends in the field of water quality using a bibliometric approach. Through the analysis of publications published between 2017 and 2024, this research will identify the main focus of water quality research, examine the distribution and type of publications, and reveal the linkages between research topics. Using the Publish or Perish and VOSviewer applications, this research

aims to map dominant factors and parameters, and identify research gaps that need to be further explored.

The importance of this study lies in its ability to integrate various bibliometric data to provide a clear picture of the progress and challenges in water quality research. The results of this study are expected to make a valuable contribution to the development of better and more sustainable water quality management strategies.

OVERVIEW

Access to safe and clean drinking water is universally recognized as a fundamental human right and a key determinant of public health. Drinking water quality is closely linked to individual and community well-being, impacting not only physical health but also psychological and socio-economic dimensions (Sarango, M, 2023). Water is a very important natural resource and has social and economic value for humans (Kumar 2018). Without water, human existence would be threatened (Zhang 2017). The most important sources of drinking water in the world are surface water and groundwater (Paun et al. 2016).

Decreases in water quality over time have been shown to cause maintenance and treatment problems at drinking water treatment plants. There is evidence that increases in dissolved organic matter can lead to fouling and clogging of membranes and filters, cause harmful disinfection by-products, facilitate biological regrowth in distribution systems and the transport of pesticides, pharmaceuticals and heavy metals into treatment systems. There are a number of studies highlighting the link between water quality and water treatment, which can lead to inadequate water supplies for human consumption. Changes in water quality on a global scale can be a critical concern for our ability to maintain clean and sufficient water supplies (Advisian Worley Group, 2019).

Surface water contamination (particularly in rivers and streams) is mainly caused by urbanization, agriculture, and factory discharge (Sasakova et al, 2018). In addition, physical environmental factors can also cause contamination, while the temperature of the aquatic environment can fluctuate with hot water discharged from power plants (Manjunatha S, 2015). In addition, water heated with hot water or water containing certain contaminants may not be a problem at any time of the year if it is immediately diluted by combining it with surface water (Issakhov A, 2017). Furthermore, pollutants released by agricultural activities include metals, pesticides, pathogens, nutrients and salts that affect surface water. In addition, untreated and partially treated sewage, construction waste, and solid/liquid waste factors contain harmful substances that are emitted into river water by urban activities (Parris K, 20111).

Water quality is a measure of the condition of water in terms of its physical, chemical and biological characteristics. Water quality also shows a relative measure of the needs of aquatic biota. Water quality is often the standard measure of the health of aquatic ecosystems (Agustia al., 2020). Water conditions change over time and are highly dependent on local environmental conditions, so water quality is a very complex topic in environmental science. Industrial activities such as manufacturing, mining, construction and transportation are major causes of water pollution, as well as surface runoff from agriculture and urban areas (Water Management Institute, 2010).

Natural variations in water quality are influenced by geographic location and temporal factors. For example, rivers in the mountains tend to have lower temperatures compared to wider rivers in the lowlands, where water temperatures are affected by the intensity of solar radiation throughout the day. Differences in climate and vegetation around the

river can also cause significant temperature variations. Some rivers may have higher natural temperatures than others, while disturbances such as fires, high winds or debris flows can affect turbidity and other water quality parameters. In addition, geology, geomorphology, and climate play key roles in determining the water quality characteristics of a region (Oregon Department of Environmental Quality, 2015).

Standards and limits known as water quality standards regulate water quality for various purposes, such as human consumption, industrial needs, and environmental protection. These standards cover parameters such as bacteria, chemicals, and other harmful substances that can affect water quality and pose a risk to human health. These standards serve as a guide to ensure that water consumed or used by the public meets safe quality standards. Routine monitoring and testing is conducted to ensure that water meets the set quality standards. One example of an important water quality standard is the drinking water quality standard set by world health organizations such as WHO (World Health Organization) and national health agencies (Jonni Mardizal et al., 2024).

The parameters used to measure water quality are physical, microbiological, chemical and radioactive parameters included in the reference parameters for safe drinking water for environmental health quality standards. The task of the local government is to conduct scientific research to determine additional relevant parameters. This drinking water media is made based on the Water Media Environmental Health Quality Standards as a reference for drinking water providers, environmental sanitation officers at health centers, provincial and district / city health offices, and other relevant stakeholders (Permenkes Number 2 Year, 2023).

Water quality feasibility testing is a process that is passed before carrying out cultivation activities in an aquatic environment. The feasibility of a water body can be seen from the aquatic environment and the quality of the water itself. Water quality indicators commonly used to assess the feasibility of cultivation are based on chemical, physical, and biological factors. Water physics factors observed include temperature, brightness, depth, current strength. Chemical factors include total dissolved solid (TDS), total suspended solids (TSS), dissolved oxygen (DO), ammonia, nitrate, and nitrite. Meanwhile, biological indicators of water quality that are starting to be widely developed today are observations of organisms that live in a body of water. In this research, the feasibility of Sekalayan river water quality is the main target being studied. Of course, it is expected to obtain water quality measurement data on the Sekalayan river so that later the cultivation process using floating net cages can be applied (Kuing L, 2023).

The water quality index (WQI) is one of the most widely used tools to describe water quality. It is based on physical, chemical, and biological factors combined into a single value that ranges from 0 to 100 and involves 4 processes: (1) parameter selection, (2) transformation of raw data into a common scale, (3) weighting, and (4) aggregation of sub-index values. The background of WQI is presented in this review study, the stages of development, the development of the field of study, the various WQIs, the benefits and drawbacks of each approach, and recent efforts in WQI studies. To develop and elaborate an index in some way, WQI must be linked to a scientific (e.g. ecological) breakthrough. As a result, an advanced WQI that takes into account statistical methods, interactions between parameters, and scientific and technological improvements should be created for use in future investigations (Chidiac S. Et al, 2023).

In water quality testing, procedures and parameters can be categorized into several types, namely

physical, chemical, bacteriological, and microscopic. Physical testing involves observing the color, turbidity, amount of dissolved solids, and smell and taste of the water. Water color can be caused by minerals or organic matter, while turbidity can indicate the presence of suspended solids or microorganisms. Odor and taste are usually related to decaying organic matter or industrial waste, which can degrade water quality and affect its use.

Chemical tests focus on parameters such as pH, hardness, and BOD (Biochemical Oxygen Demand). pH measures the acidity or alkalinity of the water, where extreme pH values can affect the effectiveness of chlorination and cause corrosion. BOD indicates the amount of oxygen required by microorganisms to decompose organic matter, with high BOD indicating the presence of organic pollution which can reduce oxygen for aquatic life.

Bacteriological testing aims to detect the presence of bacteria as an indicator of fecal pollution, although this method is often impractical for routine surveillance as results can vary. Bacteriological testing is important when there are indications of water quality degradation or potential pollution. In practice, testing focuses more on the detection of coliform bacteria, such as Escherichia coli, which serve as indicators of pollution by fecal material. These bacteria should be easy to isolate, identify and survive longer in water than other pathogens, although not all of these criteria can be met by one type of organism. The use of this indicator enables assessment and control of the microbial quality of drinking water.

RESEARCH METHODS

This research is a bibliometric study that aims to analyze trends and patterns in water quality research with a particular focus on factors and parameters that affect drinking water quality. With the title "Trends in Water Quality Research: A Bibliometric Study of Factors and Parameters in Drinking Water," this study used the Publish or Perish application to collect data from Google Scholar with keywords such as "drinking water," "water," "water quality," "factors," "parameters," "chemical," and "physical." The data collected included the top 50 journals published between 2017 and 2024, a period chosen to reflect current and relevant research in this field.

The research method begins with the collection of bibliometric data from Google Scholar using the Publish or Perish application. This application allows the selection of journals based on highest rank and relevance, which further provides important information such as year of publication, journal type, number of citations, and country of origin of authors. Using this data, an analysis was conducted to classify the distribution of publications based on various parameters, including year of publication to identify temporal trends in publications, journal type to understand the dominant publication type, and number of citations to assess the impact and influence of each publication.

The collected data was then analyzed using VOSviewer, a powerful software tool used for visualization and analysis of bibliometric data. In this analysis, VOSviewer was applied to generate networking, overlay, and density images of keywords that frequently appear in publications. The occurrence 4 and term 18 settings were chosen to ensure that only keywords that appeared frequently enough in the literature and that had significant relevance were included in the analysis. This allows researchers to focus attention on the most representative and influential terms in water quality studies.

The network visualization from VOSviewer reveals how keywords in the literature are interlinked and form major clusters. This shows the relationship between the various factors and parameters that affect water quality, and identifies areas of major focus in

research. These clusters describe groups of keywords that frequently appear together, reflecting interconnected research themes. For example, clusters containing terms such as "water quality index," "groundwater quality," and "parameters" indicate that research often focuses on the development and application of water quality indices and groundwater quality evaluation.

Overlay visualizations provide insights into the evolution of research over time. By displaying changes in attention to certain topics from year to year, these visualizations help in identifying temporal trends and shifts in focus in research. For example, if attention to "machine learning" in water quality research increases over time, this could indicate an increased interest in applying new technologies to water quality data analysis.

The density of the visualization indicates areas of high research concentration. The bright colors in this visualization signify terms that appear frequently in the literature and indicate that the topic is a major focus in water quality studies. Terms such as "chemical factors" and "physical parameters" that appear in lighter areas indicate that chemical and physical factors are topics of high concern in current research.

Overall, the results from this analysis provide an in-depth look at trends and patterns in water quality research. This research not only identifies key areas that are frequently discussed, such as chemical and physical factors and assessment parameters, but also reveals research gaps that have not been widely explored. By understanding the distribution and intensity of these research foci, researchers can better plan their studies, explore under-researched topics, and formulate strategies for further research. In addition, this information is also very useful for policy makers and practitioners to develop and implement more effective and data-driven water quality management policies and strategies.

While this research provides deep insights into trends and patterns in water quality studies, there are some research gaps that need to be addressed. One major gap is the lack of focus on the integration of new technologies, such as artificial intelligence and big data analytics, in water quality evaluation. In addition, there is a need for more in-depth research on the impacts of climate change on water quality and sources of pollution that have not been fully explored, especially in regional contexts that have received less attention. Research is also still limited to specific parameters, so further exploration of the interactions between various chemical and physical factors under more complex conditions could open up opportunities for a more holistic understanding. Addressing these gaps will help expand knowledge and improve water quality management more effectively and sustainably.

RESULTS AND DISCUSSION

This research successfully collected and analyzed bibliometric data from the top 50 journals relevant to drinking water quality in the time span of 2017 to 2024. Through the use of Publish Or Perish and VOSviewer, various patterns and trends in drinking water quality research were identified. This results and discussion section will present the main findings of the analysis, including the distribution of journals by publication year, journal type, number of citations, and country of origin. In addition, the keyword network visualization will be interpreted to reveal the interconnections between research topics as well as the gaps that remain for further exploration.

The results show how interest in specific topics in drinking water quality has evolved and adapted to technological developments and changing societal needs. The geographical distribution of researchers also provides insight into international collaboration and the

contribution of countries to the research. Visualization analysis using VOSviewer highlighted the close relationships between factors affecting drinking water quality, and helped identify areas that remain under-researched.

This discussion will explore the interpretation of these results, provide insights into the trends and dynamics of research in drinking water quality, and offer recommendations for future research. As such, it is hoped that the results and discussion can make a significant contribution to the development of more effective research strategies to improve drinking water quality in different parts of the world.

Discussion and Analysis of Publication Trends by Journal Type

Based on the analysis of the distribution of publication types in drinking water quality research, it can be concluded that research articles dominate with a significant number, namely 41 publications or 82% of the total. This dominance indicates that empirical research involving experiments, field data collection, and direct data analysis is highly favored in the field of drinking water quality. This reflects the strong interest of the scientific community to continue exploring and finding solutions related to water quality issues, which contributes greatly to an in-depth understanding of the various factors and parameters that affect drinking water quality.

In contrast, the review literature amounted to only one publication, or 2% of the total. The low number of literature reviews suggests that while it is important to summarize and evaluate existing research, the main focus is still on empirical research. Literature reviews have an important role in identifying trends, filling research gaps, and providing guidance for future research. This small number suggests that there is still room for more comprehensive literature reviews in this area, which can help provide a holistic perspective on the development of drinking water quality research.

Books, as another type of publication, amounted to six publications or 12% of the total. Books as publications provide broader and more in-depth documentation of knowledge on drinking water quality. Books are often used as long-term references and sources of more detailed knowledge, which are useful for researchers, practitioners and policy makers. The presence of books demonstrates an effort to document knowledge comprehensively and thoroughly.

Finally, publications in international journals amounted to two publications or 4% of the total. Publications in international journals are important for global knowledge dissemination and cross-country collaboration. Although the number is relatively small, the existence of these publications shows the contribution of the international scientific community in drinking water quality research. It also reflects the importance of international collaboration in addressing global issues such as drinking water quality.

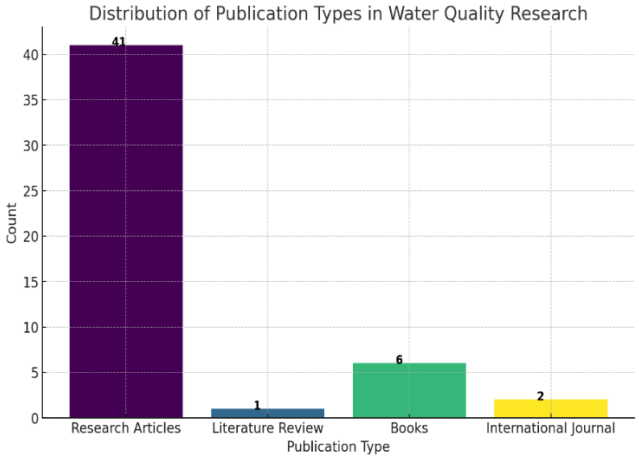

Figure 1. Distribution of Publication Types

Overall, the distribution of publication types in drinking water quality research provides important insights into the focus and priorities in this field. The dominance of research articles indicates a strong interest in empirical research, while the low number of literature reviews indicates the potential for more studies that summarize and evaluate existing research. International books and journals, although fewer in number, play an important role in deeper documentation of knowledge and global dissemination of knowledge. This analysis provides valuable guidance for researchers to understand current trends and identify areas that still require further attention, which is important for directing research efforts towards more effective efforts to improve drinking water quality in the future.

Discussion and Analysis of Publication Trends by Publisher

This distribution of publications by publisher underscores the collaborative nature of water quality research, which includes a wide variety of publishers ranging from commercial academic publishers to international health organizations. To provide a visual representation of the distribution of publications by publisher, the following bar chart illustrates the proportion of contributions from each publisher:

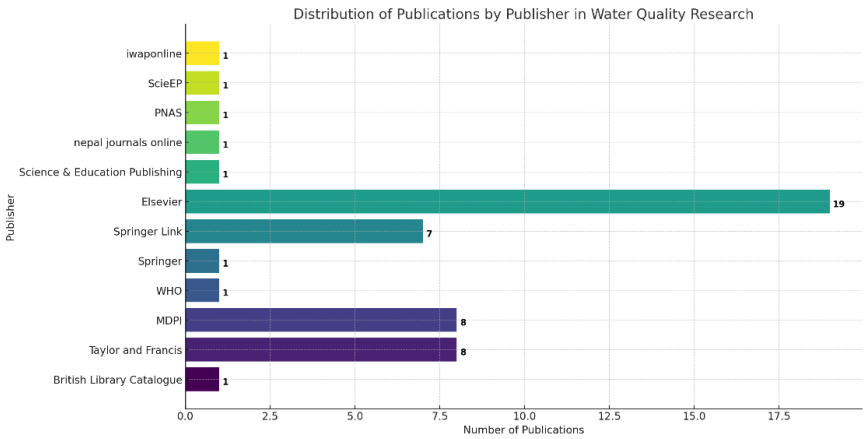

Figure 2. Distribution of Publications by publisher

The figure above clearly shows Elsevier's dominance in this field, followed by Taylor and Francis, MDPI, and Springer Link. This visualization provides a clear picture of how water quality research is distributed across different

publishing platforms, highlighting the central role some publishers play in the academic landscape.

Bibliometric analysis of water quality research publications showed significant variation in publisher distribution. Of the total 50 publications analyzed, Elsevier dominated with 19 publications or 38% of the total. This suggests that Elsevier is a major platform for the dissemination of water quality-related research, possibly because it has many journals with high impact factors that attract many researchers to submit their work.

Taylor and Francis and MDPI have 8 publications each, accounting for 16% of the total. These two publishers are also known for their extensive collections of scientific journals, covering a wide range of fields including environmental science and public health. The significant contributions of these publishers highlight their role in facilitating the dissemination of research findings in the field of water quality.

Springer Link accounted for 7 publications or 14%, demonstrating its importance as a publisher in this domain. Springer's comprehensive portfolio of academic journals provides an important platform for researchers to publish their work, ensuring visibility and wide dissemination.

Other publishers such as British Library Catalogue, WHO, Springer, Science & Education Publishing, Nepal Journals Online, PNAS, ScieEP, and iwaponline each contributed 1 publication, representing 2% of the total. Despite their smaller contributions, these publishers are still important in adding to the wealth of research available in this field. The involvement of the WHO, for example, highlights the relevance of research to global health initiatives and standards.

Understanding these trends can help researchers and institutions identify key publishers for their work and facilitate targeting of their research outputs to maximize impact and dissemination. In addition, it highlights the importance of multiple publishing avenues in ensuring comprehensive coverage and accessibility of research findings in the field of water quality.

Discussion and Analysis of Publication Trends by Year of Publication

To provide a visual picture of the distribution of publications based on the year of publication, here is a bar chart illustrating the number of publications each year with additional curve lines to show publication trends:

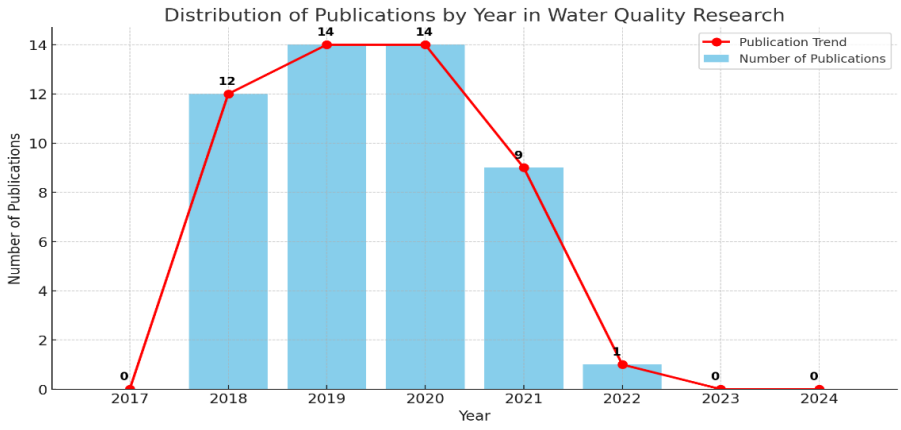

Figure 3. Related Publication Trends by years

This bar chart shows peaks in publications in 2019 and 2020, as well as significant declines in subsequent years. The red curve line adds visual context on

the changing trend of the number of publications from year to year, which helps in understanding the overall pattern. Analysis of water quality research publication trends by year of publication showed significant fluctuations in the number of publications over the period 2017 to 2024. In 2017, no publications were recorded. This may be due to the lack of attention or interest in this topic at that time, or it may be because relevant publications have not yet been published.

A significant increase began to be seen in 2018 with the number of publications reaching 12. This trend continued to increase and peaked in 2019 and 2020, with 14 publications each. This increase can be attributed to the increasing global awareness of the importance of drinking water quality, as well as encouragement from various research and funding institutions that focus attention on water quality-related issues.

However, in 2021, there was a decrease in the number of publications to 9. This decrease may be due to various factors, including the impact of the COVID-19 pandemic which affects many aspects of life, including research activities and scientific publications. Nonetheless, the number of publications in that year is still relatively high compared to the beginning of the analysis period. The year 2022 shows a drastic decline with only 1 publication. This could reflect a shift in research focus or challenges faced in the research and publication process. In 2023 and 2024, no publications were recorded in this data, which could be due to incomplete data or a decline in publication activity in the field of water quality during this period.

Understanding these trends is important for researchers and policymakers to identify factors affecting research productivity and publications. In addition, it can help in planning future research strategies to ensure sustainability and improvement in the quality and quantity of research in the field of drinking water quality. By knowing the peak and decline periods of publications, stakeholders can be better prepared to face challenges and optimize opportunities for better and more effective research.

Discussion and Analysis of Publication Trends by Country

To provide a visual overview of the distribution of publications by country, here is a horizontal bar chart depicting the number of publications from each country:

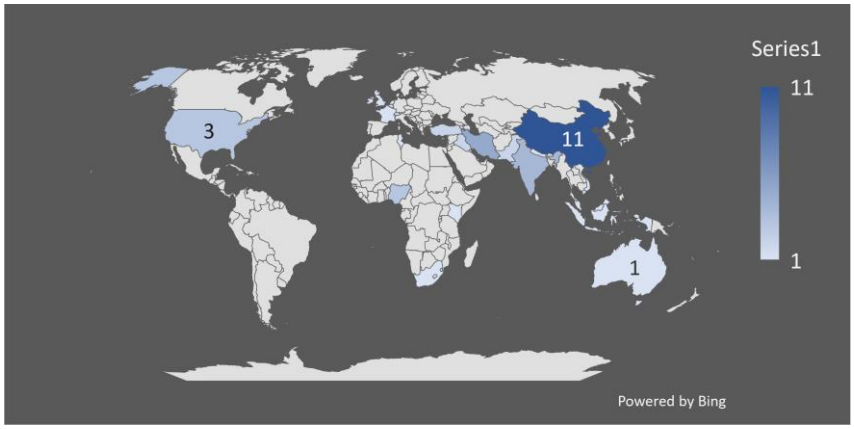

Figure 4. Related Publication Trends by country

The figure above shows China's dominance in the number of publications, followed by Iran, India, Nigeria and the USA. This visualization helps in understanding how research contributions to water quality are spread

across different countries, highlighting the important role of some countries in the global research landscape.

Analysis of publication trends by country revealed significant variations in the number of water quality research publications across countries. From the data collected, China emerged as the country with the highest number of publications, with 11 publications. This suggests that China has a great deal of interest in water quality issues and likely has many funded research initiatives to address these issues.

Iran followed with 5 publications, showing that the country is also active in water quality research. Other countries with a significant number of publications include India with 4 publications, as well as Nigeria and USA with 3 publications each. The active participation of these countries indicates a global concern for water quality issues, with various research initiatives being undertaken to improve the quality of drinking water in their regions.

Some countries such as Switzerland, Turkey, Pakistan, and Iraq contributed 2 publications each, indicating moderate involvement in the research. Other countries such as UK, Malaysia, Australia, Ireland, Indonesia, Netherland, France, South Africa, Korea, Tunisia, Vietnam, Nepal, and Kenya have 1 publication each. Although the number of publications from these countries is relatively small, their contributions are still important in enriching the global literature on water quality.

The distribution of this publication reflects a global collective effort in understanding and addressing water quality issues. The involvement of various countries shows that water quality issues are universal issues that require international attention and cooperation.

Understanding these trends is important for researchers and policymakers to identify key countries active in water quality research. In addition, it can help in planning more effective international collaborations and ensuring that water quality research gets the support and attention it needs worldwide.

Discussion and Analysis of Publication Trends Based on Top Citations

To provide a visual representation of the citation distribution of the most cited publications, here is a horizontal bar chart showing the number of citations of each of the top publications:

This bar chart shows the dominance of WHO Guidelines in terms of number of citations, followed by publications on microplastics, water quality data and introduction to water quality. This visualization helps in understanding the relative influence of each publication in the water quality research community.

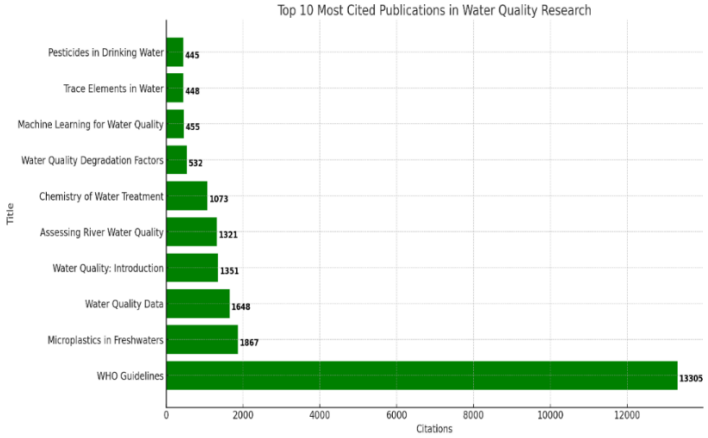

Figure 5. Related Publication Trends by citation

Table 1. Publication Trends by Citation

Citation	Author	Title	Year	Publisher
13305	World Health Organization	Guidelines for drinking-water quality: incorporating the first and second addenda	2022	books.google.com
1867	AA Koelmans, NHM Nor, E Hermsen, M Kooi, ...	Microplastics in freshwaters and drinking water: Critical review and assessment of data quality	2019	Elsevier
1648	A Hounslow	Water quality data: analysis and interpretation	2018	taylorfrancis.com
1351	CE Boyd	Water quality: an introduction	2019	books.google.com
1321	Z Wu, X Wang, Y Chen, Y Cai, J Deng	Assessing river water quality using water quality index in Lake Taihu Basin, China	2018	Elsevier
1073	SD Faust, OM Aly	Chemistry of water treatment	2018	api.taylorfrancis.com
532	N Akhtar, MI Syakir Ishak, SA Bhawani, K Umar	Various natural and anthropogenic factors responsible for water quality degradation: A review	2021	mdpi.com
455	AN Ahmed, FB Othman, HA Afan, RK Ibrahim, ...	Machine learning methods for better water quality prediction	2019	Elsevier
448	J Xiao, L Wang, L Deng, Z Jin	Characteristics, sources, water quality and health risk assessment of trace elements in river water and well water in the Chinese Loess Plateau	2019	Elsevier
445	M Syafrudin, RA Kristanti, A Yuniarto, ...	Pesticides in drinking water-a review	2021	mdpi.com

Understanding these citation trends is important for researchers and policy makers to identify key references in the field of water quality. In addition, it can help in planning further research with reference to the most influential publications, as well as ensuring that the latest research builds on an established foundation of knowledge.

Discussion on VOS Viewer Network Visualization Publication

VOSviewer's overlay visualization of research publications on water quality provides a comprehensive overview of the relationship between different research topics that frequently co-occur. In this visualization, frequently co-occurring keywords are grouped in

different clusters, each with a different color for easy identification.

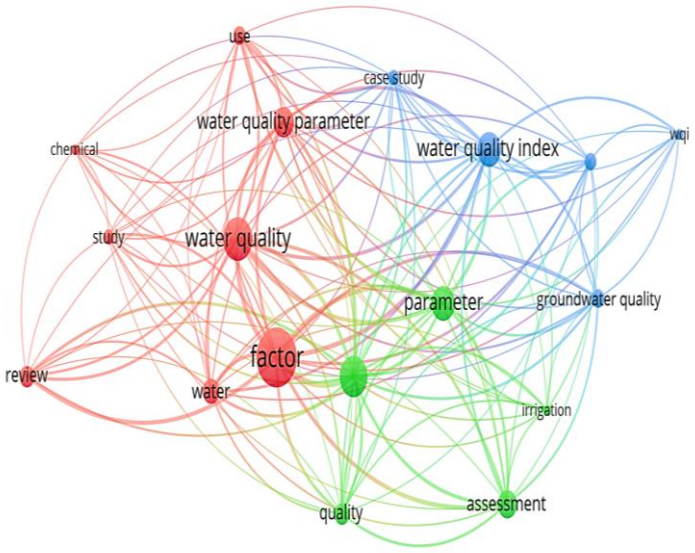

Figure 6. Related Publication Trends by VOS Viewer Network Visualization

a. **Red Cluster: Factors and Water Quality**
The red cluster, which includes keywords such as "factor", "water quality", "water quality parameter", and "chemical", highlights research that focuses on factors that affect water quality. These topics include various chemical aspects and water quality parameters, as well as studies on how these factors interact and affect water quality. This cluster also includes review research that combines findings from different studies to provide a holistic picture of factors affecting water quality.

b. **Green Cluster: Water Quality Parameters and Assessment**
The green cluster includes keywords such as "parameters", "assessment" and "quality". Research in this cluster tends to focus on the specific parameters used to assess water quality, as well as the assessment and analysis methods used to determine water quality. Research in this cluster is important for the development of accurate and reliable water quality indices, which are used by policy makers and researchers to monitor and manage water resources.

c. **Blue Cluster: Water Quality Index and Groundwater Quality**
The blue cluster includes keywords such as "water quality index", "groundwater quality", and "wqi". Research in this cluster focuses on developing and applying water quality indices to assess overall water quality conditions. The main focus of this cluster is on groundwater quality, which is the main source of drinking water in many areas. The research includes case studies and evaluation of health risks associated with groundwater quality.

Linkages between Clusters

This visualization also shows the close linkages between these clusters. For example, research on factors affecting water quality (red cluster) is often linked to research on water quality parameters and assessment (green cluster), as these factors are important components of the measured parameters. Similarly, water quality indices (blue cluster) often use the parameters and factors discussed in the

red and green clusters to develop comprehensive assessment tools.

These VOSviewer overlay visualizations provide valuable insights into how different topics in water quality research are interconnected and form complex research networks. By understanding these clusters and the relationships between them, researchers can identify important research areas, as well as discover research gaps that may need to be further explored. It also helps in facilitating collaboration between researchers from different disciplines to address challenges in water quality management holistically.

Discussion Related to VOS Viewer Overlay Visualization Publication

VOSviewer's density visualization of research publications on water quality provides deep insight into the distribution and intensity of research focus in this field. The colors in this visualization indicate the density or frequency of occurrence of related keywords in the analyzed literature.

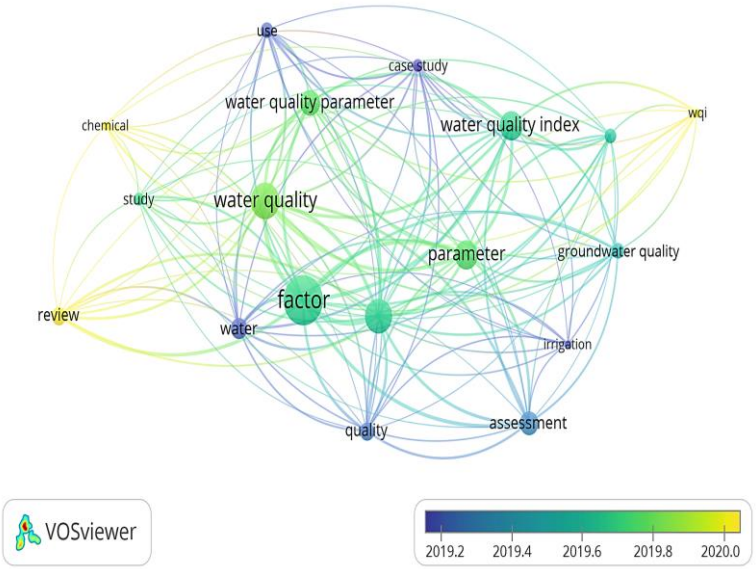

Figure 7. Related Publication Trends by VOS Viewer Overlay Visualization

From this visualization, it can be seen that the terms "factor" and "water quality" have a high density, indicating that research on factors affecting water quality is a highly researched area. The terms "parameter" and "assessment" also show high density, signaling the importance of studies on specific parameters and assessment methods in assessing water quality.

In addition, "water quality index" and "groundwater quality" are also frequently occurring topics, indicating significant attention to the development of water quality index and groundwater quality evaluation. The lighter color around these terms indicates that they are the main focus in the 2019 to 2020 timeframe.

Keywords such as "review" and "chemical" are edged with a darker color, indicating that although important, they are not as intensive as other topics in terms of number of publications. This could indicate that there is room for more research in these topics or that research in these areas has reached saturation point.

Overall, this visualization helps in identifying key areas and research gaps in water quality studies. Researchers can use this information to plan their studies, identify potential collaborations, and focus their efforts on areas that need the

most attention. Understanding the distribution of these research topics is also important for policymakers to support research initiatives that can have a significant impact on water quality management and improvement.

Discussion Related to VOS Viewer Density Visualization Publication

VOSviewer's density visualization of research publications on water quality provides a clear picture of the distribution and intensity of research topics in this field. In this visualization, brighter colors such as yellow and red indicate areas of high density, i.e. where keywords frequently co-occur in the analyzed literature.

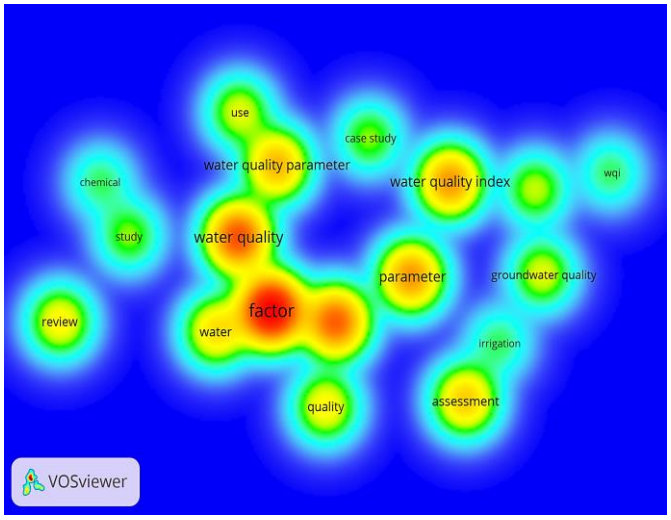

Figure 8. Related Publication Trends by VOS Viewer Density Visualization

The keywords "factors" and "water quality" are centered in bright red, indicating that research focusing on factors affecting water quality is the most studied and frequently appears in the literature. This suggests that this topic is front and center for researchers in their efforts to understand and improve water quality.

Around this center, keywords such as "water quality parameter", "parameter", and "water quality index" also show high density in yellow. This reflects the importance of studies on specific parameters and assessment methods used to evaluate water quality. This research is essential for developing accurate and reliable water quality indices, which are used by policy makers and researchers to monitor and manage water resources.

Other terms such as "groundwater quality", "assessment", and "irrigation" also have a high density, indicating a significant focus on groundwater quality and assessment methods related to irrigation. This is important because groundwater is the main source of drinking water in many areas, and its management is critical to public health.

Keywords such as "review" and "chemical" that are edged in a darker color indicate that while important, these topics are not as intensive as other topics in terms of number of publications. This could indicate that there is room for more research in these areas or that research in these areas is already quite saturated.

Overall, this visualization helps researchers identify key areas and research gaps in water quality studies. By understanding the distribution and density of these research topics, researchers can plan their studies, find potential collaborations, and focus their efforts on areas that need the most attention. This understanding is also important for policymakers to support

research initiatives that can have a significant impact on water quality management and improvement.

CONCLUSIONS

Based on the analysis and visualization results of this study, there are several significant gaps that can be further explored. Firstly, while many studies have addressed the factors and parameters that affect water quality, studies on the complex interactions between these factors are limited. More in-depth research is needed to understand how the combination of various chemical and biological factors affect water quality in a regional or environmentally specific context, including the impacts of climate change and industrial activities.

Second, although many water quality indices have been developed, there is still a need for innovation in assessment methods. Current indices may not cover all relevant parameters or be insensitive to small changes in water quality. Research leading to the development of new indices or improved assessment methods, including the use of advanced technologies such as real-time sensors, would be highly beneficial.

Third, the application of new technologies such as artificial intelligence and machine learning in predicting and monitoring water quality is promising but not yet fully explored. Further research into the application of these technologies could improve accuracy and efficiency in water quality management.

Fourth, studies focusing on local and regional contexts are lacking, whereas more in-depth research on specific challenges at the local level could provide more targeted solutions. Targeting these areas can expand our understanding of water quality and contribute to more effective and sustainable management strategies.

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