



BIBLIOMETRIC ANALYSIS OF COMPUTATIONAL FLUID DYNAMICS (CFD) ON HYDRAULIC ENERGY

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Abstract: Hydroelectric energy has various potential applications for future energy production and it is among the most efficient method to produce energy. In this study, literature data were analyzed with bibliometric methods. Bibliometric analysis is an efficient analysis method used to understand scientific communication, trends, impacts and interactions between research fields. The data used for the analysis were accessed from the WoS database. The article examined research articles published on hydraulic energy and CFD (computational fluid dynamics). As a result of the search conducted between 2000-2024 with the terms hydraulic energy and computational fluid dynamics, 214 documents were obtained. In this study, hydraulic energy was examined with bibliometric analysis and measures to be taken on the subject, comments, suggestions and research were summarized. The results can help and guide future research on the integration of hydraulic energy and related areas.

Keywords: Bibliometric analysis, Fluid dynamic, Hydro-power, Water

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1. Introduction

Hydropower refers to the generation of electrical power through the extraction of energy from the moving water streams (Askari et al., 2015). Water, the primary source of life, energy, all living things; to maintain the food supply and natural environment. Therefore, the rational, conscious and sustainable use of water, the protection of existing water resources, and water management issues are also important, especially for life and energy demand (Kılıç, 2020). Meeting the growing demands all over the world for electricity creates difficult decisions for many countries. Hydropower is providing us with large amounts of energy in the long term (Divyansh et al., 2022). Hydroelectric power plants have an efficiency of about 90%, which is not available from any renewable energy generation source Hydro-energy is a sustainable, renewable and clean energy type among other alternative energy sources and is also ecosystem friendly. Hydraulic energy is one of the most suitable and efficient energy sources (Divyansh et al., 2022). Media development has accelerated with the globalization process, has brought the world of science closer together. Today, the presence of countries in the international arena is directly proportional to the transformation of the useful scientific knowledge they produce into technology. New generation of media, based on the internet are one of the prominent examples of technology

which make people closer to each other and more accessible than in the past (Yazdanpanah, 2021). Bibliometric analysis studies not only enable us to see the developments in a scientific field within a certain period of time, but also provide detailed information about the study and where the scientific field in question will evolve in the future. Use of bibliometric techniques to map and study the knowledge published in different fields has been growing for years. Several areas of research have already been explored in the management field using these methods (Danvila-del-Valle et al., 2019). The use of bibliometric analysis is growing rapidly; these methods allow researchers to base their findings on aggregated bibliographic data produced by other scientists working in the field who express their opinions through collaboration, citation, and writing (Župič and Čater, 2023). Bibliometric studies help with assessments and support for water management systems. Bibliometric analysis is a branch of science that deals with the examination of disciplines and study subjects as reflected in their literature production (Hood and Wilson, 2001). The bibliometric analysis is an analytical method used to obtain any concept and facilitates the monitoring, history, follow-up and interpretation of academic trends through visualization software (Dirik et al., 2023). Bibliometrics is a set of methods used to quantitatively analyze information such as author, field, subject,



citation, institution and country of scientific research using book chapters, articles, patents, notifications, citations and research data in published journals and books with mathematical and statistical tools. Bibliometrics provides information about the subject studied, institutions, countries, authors and collaboration between authors (Ukşul, 2016). WoS and Scopus are the most important databases for bibliometric research, and both databases are transparent in showing references (Leydesdorff et al., 2016). In addition, Google Scholar, PubMed, and Medline databases are widely used for bibliometric research (Chen, 2017). Bibliometric analysis studies evaluate the number of studies attributed to countries, institutions, and authors; the number of citations, the impact of the published study on scientific communities, the number of co-citations, and the number of studies conducted (Zupic and Cater, 2015). Bibliometric analysis methods and research support traditional review methods. Seeing the areas of deficiency in the research subject to be studied and creating a basis for new research are among the most important contributions of bibliometric research to the literature (Kozan, 2020). The analyses in this paper, are based on the SCI-Expanded database from Web of Science Core Collection, which contain the entire literatures of all fields “hydraulic energy” and “computational fluid dynamics” from 2000 to 2024. Literature review was conducted like; Wos categories-water resources or civil engineering; article document type with SCI-expanded index. As a result; 214 documents were taken into consideration in this research. The objective of this research was to assess research activity on hydraulic energy and related areas by bibliometric analysis. Bibliometric analysis methods are widely used today to quickly find and analyze a large number of scientific data.

Bibliometric studies allow us to reveal the evolutionary nuances of the subject to be researched, while shedding light on and guiding new areas in the subject under study. The research application of such studies in some areas is new and in cases not sufficiently developed. Therefore, this article will contribute to the fields conducting studies using bibliometric analysis and is a useful resource to gain insight into current techniques and procedures.

2. Materials and Methods

Bibliometric analysis is a popular, efficient, and rigorous method for gathering, examining, interpreting, and analyzing large amounts of scientific data. Bibliometric analysis is a method that can be used to analyze published data; it is a research area that examines distribution of information among publication using statistical and mathematical techniques (Danvila-del-Valle et al., 2019). In these techniques impacts of indicators, citation and co-citation analysis and mapping are performed. Bibliometric analysis allows obtaining

information many of published journals and citations and keyword analysis (Culnan, 1987). The bibliometric methodology encapsulates the application of quantitative techniques on bibliometric data (Broadus, 1987). A common way to collect data for bibliometric analysis is to analyze databases containing bibliographic data. This section includes information about the purpose, importance, data source, method, findings and evaluations regarding the analysis of bibliometric methods used for the research. Methodology if this research is seen in Figure 1.

2.1. Data Source

There are many databases that can be used in bibliographic research, the most important of which are Scopus, WoS, Medline, PubMed, Google Scholar. WoS is constantly used in bibliometric studies because it covers a large number of journals and provides ease of analysis. In addition, a large portion of journals with high impact factors are scanned in WoS. In this study, (SCI-E) within the (WoS) was used as a citation database.

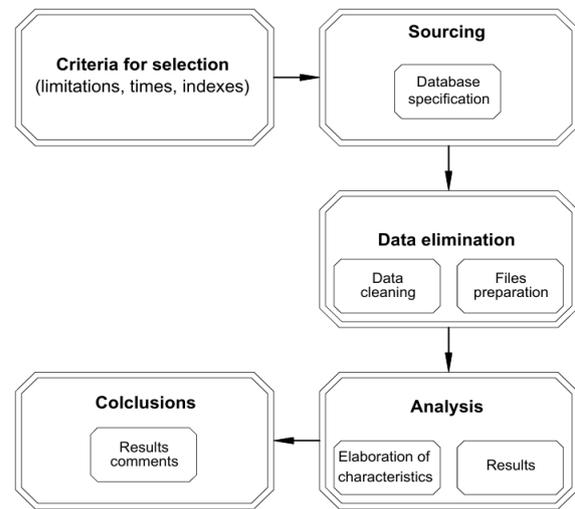


Figure 1. Methodology.

2.2. Bibliometrics and Scientific Mapping Method

Bibliometrics examines publication patterns using quantitative analysis and statistics. Bibliometrics is decisive in determining the studies published on any subject, the citations made, and how these affect subsequent research. Knowing the quantitative characteristics of publications helps in comparisons, while citation analysis helps understand the impact of the study in question on others (McBurney and Novak, 2022). VOSviewer is a probability-based data standardization approach to provide multiple visualizations in terms of co-authors, associations, and keywords, including Network, Overlay, and Density Visualization. It is well known that VOSviewer is the most widely used bibliometric tools (He et al., 2022).

2.3. Data Analysis

The search returned 214 documents from from Web of Science database on 2000-2024. Than, titles, keywords and abstracts were analyzed to ensure that there are no

duplicate and only documents related to the objectives and scope of this paper were chosen. As a result, 214 were selected for bibliometric analysis. Finally, these documents were exported in order to be analyzed via the SciMAT and VOSviewer software tools. During data analysis, the web of science core collection analysis tool and VOSviewer software were used. Preliminary analysis of authors, universities, dates, countries, citations and journals characterizing scientific production on “hydropower” and “CFD; computational fluid dynamics” were performed with the vos analysis tool. VOSviewer software was used to create the density graph. VOSviewer software helps visualize the data obtained in bibliometric analysis studies and explain the concepts in the texts. In the light of the above, water management and water resources issues were explained in this study and analyzed through bibliometric methods. The samples and data of this study are derived from the Web of Science Core Collection, the most widely and largest used database of bibliometric analysis. During this research, we adopt (SCI-E) database; which contain only WOS civil engineering categories and article document type. Publications were obtained through co-authorships, years, countries, co-occurrences, keywords, journals and authors. The paper has explored research articles published on water resources, climate change, drought and water resources management. All keywords (2000-2024), both those reported by authors and those attributed by ISI as well as the words in titles and abstracts. All data obtained have been converted into tables and graphs and are shown in the relevant sections of this study. As only one database (Wos-core collection) was used, the chances for repetition were minimal.

2.3.1. Publication years

According to the findings; the subject of “hydraulic energy” as generally been studied, intensively after 2015. In Table 1, publication output has increased from 1 articles in 2000 to 31 articles in 2023 and 20 papers in 2024. This clearly shows how “hydraulic energy” has received increasing attention from the scientific community since 2000. Table 1 shows the distribution of publication years of documents “hydraulic energy” and “CFD” from 2000 to 2024, which is helpful to examine the progression of literature published. It could be easily observed a steady upward trend according to Table 1, except for a few specific years (2003, 2004, 2005, 2010).

Table 1. “Hydraulic energy” and “CFD” papers output according to 2000-2024

Years	Publication Number
2024	20
2023	31
2022	23
2021	18
2020	28
2019	10
2018	22
2017	15
2016	12
2015	7
2014	5
2013	7
2012	4
2011	1
2009	9
2008	3
2007	1
2006	1
2002	2
2001	1
2000	1

2.3.2. Countries

Bibliometric coupling - countries were scanned as; minimum number of a documents of a country 3, minimum number of a citations of a country 2; and 45 countries 23 meet the thresholds. Table 2 shows the top 18 countries which produced the most documents “hydraulic energy” and “CFD”. In other words, these 18 countries have done more research on the issue (hydraulic energy” and “CFD”) than other countries. As the first country, the China is the most productive country with 86 documents and 865 citations. The second and third countries, USA and Spain, have 25 and 14 documents, respectively, which are lower than the China but higher than the other countries. The following productive countries are; Italy, Canada, Germany, Portugal, Türkiye, Switzerland, Iran, Austria, Norway, England, India, Belgium, Sweden, Australia, Netherlands. China, which has the most productive research institutes, is currently the best scientific research basis on the issue of the “hydraulic energy”. Cooperations among the top 18 countries issue is seen in Figure 2. The number of citations shows difference between countries. The most citations (865) were observed in China documents; this is followed by Usa and Spain. When we look at Table 2, Türkiye is in the eighth place. Türkiye is not among the top 5 countries, the number of publications is 9 and citations are 109.

2.3.4. Analysis of co-citation, cited-references

Studies that were commonly referenced in at least 10 studies are shown in Table 5. Among 6803 documents, at least 10 studies cited all 5 of the 5 studies in Table 5. In another words, 5 of these 5 studies were cited in at least 10 studies (Table 5). A co-author-related density graph was created by analyzing scientific publications obtained from WoS using VOSviewer software. According to this graph in Figure 4, the yellow colored parts are interpreted as places where author-related density is high. As seen in Table 5, the author named Hirt cw, has the most cited articles. Density Map of most cited articles are seen in Figure 4.

Table 5. List of highly cited references, in at least 10 studies

Co-author	Citations
Hirt cw, 1981	45
Çelik ib, 2008	22
Yakhot v, 1994	17
Menter fr, 1994	18
Lauder b.e., 1974	11

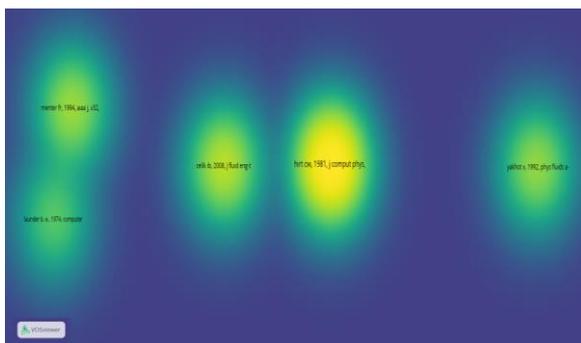


Figure 4. Density Map of most cited articles.

2.3.5. Co-authorship and authors

In analyzes minimum number of documents of an author and citations was selected as two. Of the 839 authors, 72 were evaluated under these conditions. The green group has the densest working network on the subject, and the one in the center has more connections. The size of the balls indicates the number of documents (Figure 5).

2.3.6. Publications in the top productive journals

In analyzes minimum number of documents of an author and citations was selected as 2 of the 51 sources, 25 have at least 3 citations. Data were collected from academic journals in this field from the Web of Science database. According to the analysis of those journals, the publications in the top 9 productive journals shown in Figure 5. The number of citations in journals has also increased due to the increase number of studies (Table 6). As seen in Figure 6, studies are concentrated especially in water and journal of hydraulic engineering journal.

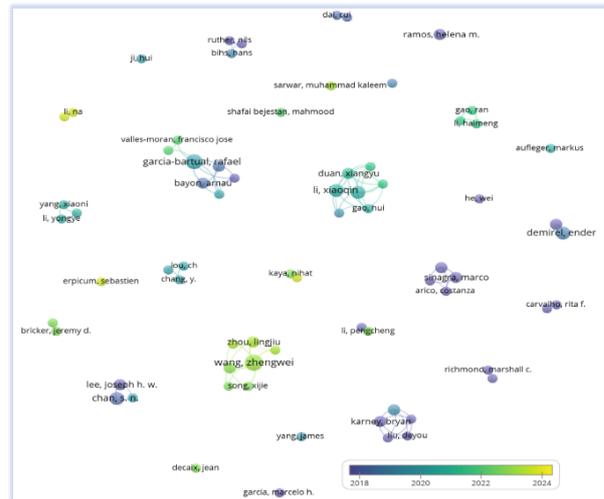


Figure 5. Co-authorship and authors analyzes.

Table 6. List of highly cited references, in at least 10 studies

Journals	Documents	Citations
Water	41	194
J. of Hydraulic Engineering	24	374
Ocean Engineering	21	311
Desalination and Water Treatment	13	132
J. of Hydraulic Research	12	124
J. Irrigation and Dran Eng	11	91
J. of Hydroinformatics	8	54
Water Research	6	163
Desalination	6	8

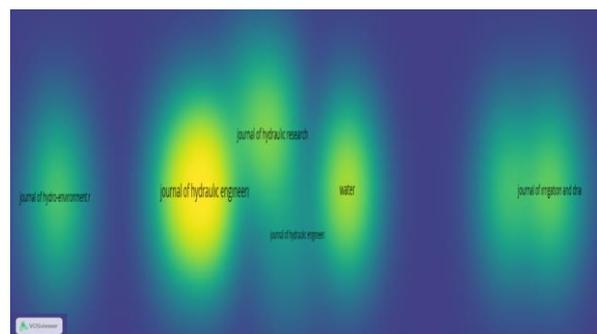


Figure 6. The publications in the top 9 productive journals.

3. Results and Discussion

Almost all energy sources arise from the physical and chemical effects of solar radiation on matter. Hydraulic energy is a continuously renewing energy source. Energy production is achieved by converting the potential energy of water into kinetic energy. Among various energy sources, hydroelectric power plants should be

preferred due to their environmental friendliness and low potential risk. Such power plants can respond to sudden changes in demand. Green energy (hydroelectric, wind, solar and biomass) should be constantly considered in energy policies. Due to its economic, scientific and social benefits, hydropower will drive the development of renewable energy and thus promote urban sustainable development. Therefore, the implementation of a sustainable hydropower development strategy is important for the coordinated development of society, economy and environment. In another study on the subject; Based on 434 publications obtained from the SCI-Expanded database, hydropower sustainability researches from 1991 to 2012 were examined with bibliometric analysis and contributed to the relevant field (Han et al., 2014). Türkiye's precipitation regime is quite irregular and unbalanced in terms of time and place. It has the characteristic of showing significant changes every year depending on meteorological conditions. In this case, it is inevitable that hydroelectric production will also show differences according to years. Türkiye is very rich in terms of macro and micro-hydroelectric potential, and if these resources are utilized, it will be possible to meet the energy needs of many places locally. Bibliometric analysis is a type of research focused on a specific field and helps us understand and better interpret global research trends on the subject, mostly by utilizing the Scopus or WoS database. Bibliometrics can reliably link publications, citations, authors, journals, identify research streams, and produce maps of published research. Interpreting the findings in bibliometric studies depends on the researcher and their specialized field knowledge, which is the difficult part. Bibliometric analysis is an effective and useful method of summarizing and synthesizing literature, without limitations. In this analyzes research, framework of the importance of the subject of hydraulic energy and CFD topics were analyzed. According to the results, water accounting was generally studied after 2015 and mostly in research papers. While China has published the most on this subject, the SCI-Expanded Index was determined as the index with the most relevant publications. There are journals, authors, dates, key-words and countries involved in this analysis research. However, a clear diversity has been observed among developed and developing countries of the world. Quantitative evaluation of the desired studies with bibliometric methods allows for the comparison of developments in the fields of expertise within the framework of world standards or between national institutions. As a result of these comparisons, deficiencies should be eliminated with collaborative studies reflecting theoretical and practical experiences at the highest level, or scientific studies should be supported in order to share expertise on the relevant subject through collaborative studies. Although the literature has covered hydropower, few of them have systematically collected data and conducted a large-scale review of scientific

articles. Jiang et al. used a modeling-based bibliometric analysis method to evaluate the global scientific literature on hydropower from 1994 to 2013. They analyzed 1726 academic articles on the subject to explore the research development, current trends, and intellectual structure of hydropower literature and contribute to the field (Jiang et al., 2016). Similarly in this study 214 paper related hydraulic energy were evaluated; it is believed that this study will also contribute to related fields. This article has shown that bibliometric analysis is a scientific method that can be useful for scholars who wish to pursue retrospectives of broad and rich areas of their research. A better understanding, interpretation and detailed examination of science through bibliometric analysis can facilitate the collection of information not only in research on the subject but also in other areas. With this study, we are taking a short but important step in this direction. Some suggestions about the subject; bibliometric analyses can provide a more detailed and informative perspective on research productivity and the impact of the topic of studies; researchers should aim to find a common ground and strike a balance between presenting data and providing meaningful discussions to make their bibliometric analyses more informative, easy to understand and actionable.

4. Conclusion

In conclusion, the study examines the subject of hydraulic energy, and attempts are made to statistically examine the extent to which this subject finds a place in the literature through academic publications. According to the results obtained; the subject of hydraulic energy has generally been studied in the most article types, intensively after 2015. While China is the country with the most publications, the SCI Expanded index has been determined as the index with the most publications. The USA and China are generally places with high co-author connections. Accordingly, it can be said that there are not enough academic studies related to the subject in the national literature. This paper established that the bibliometric methodology has gained immense popularity in recent times. It is important to conduct more comprehensive research and studies on the subject with different analyses in order to contribute to the relevant literature and subsequent studies. For future research on the subject in this study, a detailed review of the bibliometric analysis research literature can be conducted at certain time intervals. In addition, bibliometric studies are extremely important for obtaining the "big picture" of subject areas. Today, science is multidisciplinary and when it is in this way, efficient results are obtained. Through bibliometric analysis, different branches of science are better understood, connections in interdisciplinary branches of science are easily revealed and comprehensive interpretations are made. With this study, we have taken a short but important step in this direction.

Author Contributions

The percentages of the author' contributions are presented below. The author reviewed and approved the final version of the manuscript.

	Z.K.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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