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Trend in Publication in Chemical Engineering in Indonesia: A Bibliometric Analysis Perspective Relating to Particle Technology

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ABSTRACT

This research analyzed publication trends in the field of Chemical Engineering in Indonesia from a bibliometric perspective. Using data from the Scopus database, this research explored various aspects such as the number of publications, annual distribution, most popular topics, most productive authors, as well as document types and publication sources. The analysis results showed fluctuations in the number of publications over the last five years, with the highest peak in 2020 with a total of 18 documents. Journal articles were the type of document and source most often chosen by researchers. In addition, international collaboration was confirmed to be very important because it increased the chances of producing articles that were highly cited by other researchers. Therefore, chemical engineering was a topic of great interest to researchers in Indonesia. It is hoped that the findings from this study can contribute to the development of research strategies and academic policies in the field of Chemical Engineering in Indonesia, especially relating to particle technology.

1. Introduction

The development of science and technology in the field of chemical engineering in Indonesia has shown significant growth in the last few decades [1]. This was triggered by rapid industrial progress and the need for innovation in the management and processing of raw materials in an efficient and environmentally friendly manner. Scientific publications are not only the main indicator, but also an important marker in mapping the direction and evolution of research in this field. Through these publications, the scientific community can identify the main challenges facing the chemical industry in Indonesia, such as the development of more efficient processes, sustainable use of natural resources, and integration of the latest technologies in industrial practices. One important area of chemical engineering research is particle technology, which focuses on the processing and manipulation of materials on a microscopic scale, with broad applications in the pharmaceutical, mining, and energy industries [2]. Particle technology plays a major role in increasing the efficiency of industrial processes and developing new materials are more environmentally friendly [3].

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At the same time, scientific publications also reflect increasingly close collaboration between researchers, industry and educational institutions in Indonesia. This collaboration is important in presenting innovative solutions are relevant to local needs, as well as increasing research capacity at the national level. Thus, analysis of scientific publication trends not only reveals academic achievements but also illustrates the dynamics of scientific networks support the growth and transformation of the chemical engineering sector in Indonesia as a whole, especially in the context of particle technology which is one of the rapidly developing sub-fields.

Bibliometric studies are an effective approach for analyzing scientific publication trends, mapping researchers' contributions, and evaluating the impact and relevance of research in a field of science [4-8]. Bibliometrics is a method of quantitative analysis of scientific literature used to measure and analyze various aspects of academic publications [9-11]. This analysis provides in-depth insight into researcher productivity, collaboration between researchers, geographic distribution of publications, and dominant research topics in a certain period. By utilizing this technique, we can assess the development and dynamics of chemical engineering research in Indonesia, including the field of particle technology, as well as identify future research directions and priorities.

Many studies have been carried out using bibliometric analysis, as can be seen in Table 1. However, comprehensive literature studies regarding publication trends in the field of chemical engineering in Indonesia from the perspective of bibliometric analysis are still very limited.

Table 1
Previous research on bibliometric analysis

No.	Title	Result	Ref.
1.	Bibliometric Analysis of Publications on Essential Oil-loaded Nanoparticles as Antibacteria using VOSViewer.	The development of research related to Nanoparticles containing Essential Oils as Antibacterials increased in 2013-2015, and from 2016 to 2019 it also continued to increase, in 2019 compared to 2020 research publications related to Nanoparticles containing Essential Oils as Antibacterials increased very large and significantly. 2021 is the year with the highest total publications of 241 articles. Meanwhile, as of September 2022, there were 227 articles related to Nanoparticles Loaded with Essential Oils as Antibacterials, although this has decreased from the previous year, this number is still relatively high.	[12]
2.	Introducing ASEAN journal of science and engineering: A bibliometric analysis study	Based on the research results obtained, journal editors with homogeneous coverage can increase the value of publications. Apart from this, it was identified that AJSE could be a medium for cooperation with international countries outside Asian countries, this was proven by many authors from more than 24 countries on 5 continents involved.	[13]
3.	A computational bibliometric analysis of science education research using VOSviewer	The research results show from 2017 to 2021 the number of research on science education continues to decline. A significant decline occurred in 2019. Until now, the exact cause has not been found, but one factor is suspected to be the result of the spread of Covid-19. The conditions and situation of the pandemic have resulted in researchers experiencing a decrease in the productivity of their research activities.	[14]
4.	Particle size and pore size of rice husk ash on the resin-based brake pads performance: experiments and bibliometric literature review	The results of this research show brake linings with a combination of resin mixtures with small rice husk particle sizes have increased compressive strength, puncture strength, and density.	[15]

No.	Title	Result	Ref.
5.	A Bibliometric analysis of nanocrystalline cellulose synthesis for packaging application research using VOSviewer	The analysis results from this research show the number of research articles on the synthesis of cellulose nanocrystals has increased significantly every year. This is due to the need for new packaging materials that are environmentally friendly and biodegradable.	[16]
6.	Effect of FeCl3 Addition on the Dehydrogenation Properties of 2NaAlH4+ Ca (BH4) 2 Composite System for Solid State Hydrogen Storage.	The results of this research indicate doping with Iron (III) chloride (FeCl3) in the 2NaAlH4 + Ca(BH4)2 composite can improve hydrogen storage properties. The six-hour ball milling process succeeded in changing NaAlH4 and Ca(BH4)2 into Ca(AlH4)2 and NaBH4 phases, with FeCl3 doping significantly reducing the decomposition temperature, as evidenced by the release of hydrogen starting at 100 °C, lower than 125 ° C on undoped material.	[17]
7.	Analysis of COVID-19 Aerosol Dispersion in a Car Cabin Due to Driver's Cough.	The results of this study show the SARS-CoV-2 virus can spread in the car cabin due to the driver's cough, with virus particles able to survive in the air and circulate to various parts of the car, increasing the risk of infection for passengers. Analysis of airflow and speed distribution reveals that spread pathways and circulation zones can exacerbate transmission between drivers and other passengers. The research also highlights the importance of ventilation and other preventative measures to reduce airborne transmission levels in vehicles.	[18]
8.	Radiation Application in Consumer and Health Application-A Preliminary Review.	The results of this research are to discuss the effects of irradiation on detergents and their relation to health applications, especially in relation to iodine deficiency which is still a global public health problem. This research also highlights the effect of iodine absorption on the thyroid gland which can cause thyroid disease, as well as providing an overview of detergents that have been exposed to radiation and their impact on health.	[19]
9.	Response of a magnetorheological brake under inertial loads.	The results of this study demonstrate the response of a magnetorheological brake (MRB) system to a freely moving inertial mass. This research includes MRB system design using 3D modeling software, magnetostatic analysis, and finite element simulation to predict magnetic flux density and friction forces between static and moving parts. The test results show the relationship between stopping time and braking torque by modeling the system using second-order differential equations and comparing the simulation results with real measurements. The achieved braking torque is also presented based on the average value from the load sensor.	[20]
10.	Preliminary Review of Local Diagnostic Reference Level (DRLS) for Government Healthcare Dental Centres in Abu Dhabi.	The results of this study show the importance of using radiological examinations, especially in dental diagnosis, by emphasizing the need for minimal use of ionizing radiation by the ALARA (As Low As Reasonably Achievable) concept to protect patients. Dental radiology technology has evolved since 1919, starting with safe intraoral imaging techniques, followed by the introduction of panoramic imaging in the 1960s and the use of computed tomography in the 1970s. To ensure optimal performance in procedures involving ionizing radiation, it is important to establish Diagnostic Reference Levels (DRLs).	[21]
11.	Mxene and Strontium Titanate Hybrid Casson Nanofluid with CMC Base via the	The research results show increasing the fractional parameter α causes an increase in temperature and fluid	[22]

No.	Title	Result	Ref.
	Caputo-Fabrizio Fractional Derivative over a Vertical Riga Plate	velocity. The thermal radiation parameter N has a different influence on temperature and speed, where the temperature increases but the speed decreases as N increases. Due to the high electrical conductivity of Mxene and SrTiO3, the Hartmann number of modification E increases the speed, while the skin friction increases with SrTiO3, and the Nusselt number decreases with increasing N due to the CMC base characteristics.	
12.	Development of Graphical User Interface Based Taguchi's T-Method	The results of this research show developing a MATLAB-based application with a Graphical User Interface (GUI) for data analysis using Taguchi's T-Method can make it easier for users to predict data efficiently.	[23]
13.	Introducing Semarak Ilmu Publishing in Publishing Science and Engineering: Bibliometric Analysis.	The results of this research show Semarak Ilmu Publishing has published more than 40 articles between 2019 and 2024, with the number of articles varying per year, namely 45 articles in 2019, 75 articles in 2020, 50 articles in 2021, 79 articles in 2022, 66 articles in 2023, and 17 articles in 2024 (still early in the year). Although the number of publications in 2024 is relatively low, each published article has received a large number of citations, with the average number of citations per year reaching 263.53 citations. This research provides an initial basis for further evaluation of the contribution of Semarak Ilmu Publishing in supporting the scientific ecosystem.	[24]
14.	What Phenomena Happen During Pyrolysis of Plastic? FTIR AND GC-MS Analysis of Pyrolyzed Low Linear Density Polyethylene (LLDPE) Polymer Particles Completed with Bibliometric Research Trend and Pyrolysis Chemical Reaction Mechanism.	The results of this research show the Low Linear Density Polyethylene (LLDPE) pyrolysis process produces a two-phase liquid in the first condenser and a single-phase liquid in the second condenser. Analysis using Fourier Transform Infrared (FTIR) and Gas Chromatography-Mass Spectroscopy (GC-MS) identified the presence of O-H, CH_2, and C=O functional groups in the liquid sample. GC-MS on condenser sample 2 revealed the presence of acetone compounds, which indicated the breaking of LLDPE chain bonds and the formation of smaller chemical compounds, as well as oxidation occurred due to the oxygen content in the reactor.	[25]
15.	Concept of Computational Fluid Dynamics and Its Application in Sport Science: Bibliometric Analysis of Modelling Thermal Comfort in Sport Hall.	Based on the research results, it was found publications related to CFD in sports science increased in 2022, with significant contributions from countries such as the United States, which produced 103 publications.	[26]

From the studies shown in Table 1, no one has yet conducted research on publication trends in the field of chemical engineering in Indonesia from a bibliometric perspective, especially in the sub-field of particle technology. Therefore, to determine publication trends in the field of Chemical Engineering in Indonesia, it is necessary to analyze publication trends using the systematic literature review (SLR) method with bibliometric analysis. This analysis is important to understand how research developments in this field follow global trends as well as explore the contributions that have been made by local researchers.

Although many studies use bibliometric analysis to evaluate publication trends in various fields of science, there has been no comprehensive research that specifically highlights publication trends in the field of chemical engineering in Indonesia. This gap is important to overcome because chemical engineering is a crucial field for industrial and technological development in Indonesia. Identifying publication trends can help understand the direction and focus of research in this area, as well as

provide insight into international collaborations and trending topics. By filling this gap, it is hoped this research can contribute to research development strategies and academic policies in the future.

To make this research easier, several research questions (RQ) were prepared which later be answered in the results and discussion sections. The following are some of the questions used in this research:

i. RQ 1. What is the number of publications regarding chemical engineering in Indonesia from year to year?
ii. RQ 2. What is the distribution of types of publication documents regarding chemical engineering in Indonesia?
iii. RQ 3. How is the international collaboration between Indonesian researchers and researchers from other countries?
iv. RQ 4. What are the subjects are often used?
v. RQ 5. What journals are frequently cited by other researchers?
vi. RQ 6. What journals and conferences frequently publish articles on chemical engineering?
vii. RQ 7. Who are the most productive researchers conducting research on Chemical Engineering in Indonesia?
viii. RQ 8. What is the form of data visualization using VOSviewer?
ix. RQ 9. What is the concept of chemical engineering?
x. RQ 10. How does the topic of chemical engineering influence the level of publications in Indonesia?
xi. RQ 11. How does particle technology contribute to the development of chemical engineering publications in Indonesia?

By conducting this research, it is hoped it provide valuable insights for researchers, academics, and policy makers in developing more effective research and policy strategies in the future.

2. Methodology

This research used bibliometric analysis methods. The bibliometric method was used to determine trends and developments in research on adsorption and its relationship with education. Based on Figure 1 there are five stages carried out in this research.

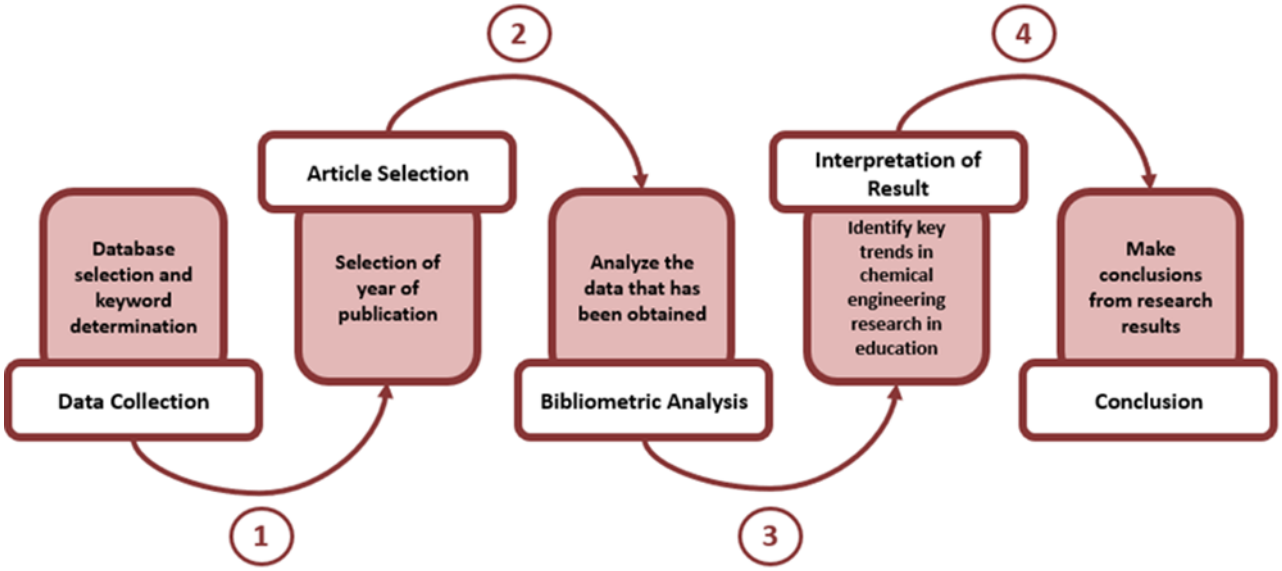


Fig. 1. Research steps

2.1 Data Collection

The first stage carried out in this research was collecting article data which would be processed to obtain results and discussion. This stage is divided into two, namely database selection and keyword determination. The Scopus database was chosen as the place to collect articles to be used. In addition, this research uses the following keywords, (TITLE-ABS-KEY ("chemical engineering") AND LANGUAGE ("English") OR LANGUAGE ("Indonesian")) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (AFFILCOUNTRY, "Indonesia"))

2.2 Article Selection

The second stage carried out in this research was article selection. The articles used in this research are articles published in the last 5 years, namely from 2019-2024 with the article publishing country being Indonesia. The articles used are only journal articles in Indonesian and English.

2.3 Bibliometric Analysis

The third stage carried out in this research was bibliometric analysis. VOSviewer and Bibliometrix were used as software to analyze the data. VOSviewer is used to perform network visualization showing the relationship between authors, keywords, and relationships between documents in the field of chemical engineering. VOSviewer makes it possible to create a visual map of co-authorship, the most frequently occurring keywords, as well as the relationship between one document and another. In this research, VOSviewer is used to analyze visualizations of relationships between frequently researched topics [27]. Meanwhile, Bibliometrics is used for more in-depth bibliometric analysis by identifying publication trends, document distribution, and citation analysis. With Bibliometrix, you can calculate the number of publications per year, analyze author productivity, and identify journals that most frequently cite related research. The parameters used in Bibliometrix include the number of publications per year, citation index, author collaboration analysis, and publishing network analysis.

2.4 Interpretation of Results

The fourth stage carried out in this research was an interpretation of the results. Identify key trends in chemical engineering research, such as the most researched topics, research methods used, and practical applications. In addition, it analyzes the temporal development of research topics and how the research focus changes over time. The final stage in this research is to conclude from the research results.

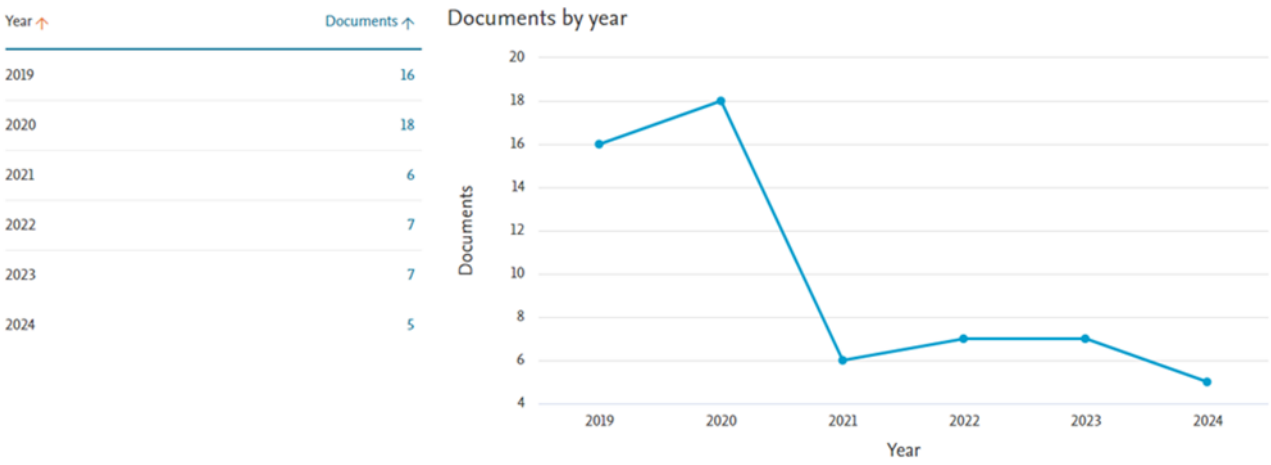
3. Results and Discussion

3.1 Number of Publications and Research Trends

The number of publications regarding chemical engineering in Indonesia in the last five years shows significant fluctuations (Figure 2). In 2019, the number of publications reached 16 documents, reflecting the relatively high interest in research in this area. The 30.50% increase in the number of publications in 2020 shows there is a strong push in the scientific community to develop research in the field of chemical engineering. This increase may be driven by government policies supporting research, increased research funding, or broader collaboration between researchers and institutions [28].

However, the significant increase in 2020 did not last long. In 2021, there was a drastic decrease in the number of publications, with only 6 documents published, representing a decrease of 33.33% from the previous year. This decline could be caused by several factors, such as changes in research priorities, lack of funding, or the impact of global situations such as the COVID-19 pandemic which may affect research activities and publications [29]. This drastic decline highlights the challenges that need to be addressed by the scientific community and policymakers to ensure continuity and improvement in chemical engineering research [30].

In the following years, namely 2022 to 2024, the number of publications remains relatively low, with 7 documents in 2022 and 2023, and decreasing to 5 documents in 2024. This shows despite efforts to increase publications, the challenges faced in 2021 may not be completely resolved. To overcome these fluctuations, more consistent and sustainable strategies are needed, such as increased funding, training programs for researchers, and stronger collaboration between research institutions and industry [31]. Thus, it is hoped the number of publications regarding chemical engineering in Indonesia can increase steadily and make a more significant contribution to the progress of science and technology in this country.



Year	Documents
2019	16
2020	18
2021	6
2022	7
2023	7
2024	5

Fig. 2. Number of publications

Several external factors may influence fluctuations in the number of chemical engineering publications, including Changes in funding, government policies, the COVID-19 pandemic, and international collaboration.

(i) Funding Changes. Research funding is the main factor influencing research productivity. Increased funding from government or private institutions can encourage more research and publications. Conversely, reduced funding can hinder research activities. For example, research by King and David [31] shows strong funding is correlated with a high number of publications in developed countries .
(ii) Government Policy. Policies that support research, such as incentives for international publications or research grant programs, can contribute to an increase in the number of publications. For example, research by Adams and Jonathan [32] highlights how policies that support international collaboration can improve the quality and quantity of publications .
(iii) COVID-19 pandemic. This global pandemic has had a significant impact on research activities around the world. Social restrictions, laboratory closures, and diversion of funds for handling the pandemic may cause a decrease in the number of publications. Interviews with researchers in chemical engineering can provide further insight into how the pandemic is affecting their work. A study by Korbel *et al.,* [33] shows the negative impact of the pandemic on research productivity in various scientific fields.
(iv) International Collaboration. Collaboration with international researchers can increase the quality and number of publications. A decrease in international collaboration due to travel restrictions or changes in international policy may affect the number of publications. According to research by Glänzel *et al.,* [34], articles resulting from international collaborations tend to be cited more frequently.

In addition, based on the results displayed in Figure 2, the development of research in the field of chemical engineering has decreased over the last few years. To understand these trends better, it is important to compare them with global and regional trends. According to recent studies, countries such as China, the United States, and Germany lead in the volume of chemical engineering publications due to large research funding and advanced research infrastructure [35-37], On the contrary, Indonesia also shows some improvement in certain years, the number of publications is still relatively low compared to these leading countries. These differences highlight the need for increased investment in research and international collaboration to increase Indonesia's presence in the global research community. Therefore, additional efforts are needed to achieve stability and continuous improvement to be on par with global and regional standards.

3.2 Publication Type

Figure 3 shows several types of documents obtained from search results on the Scopus database. Based on Figure 3, from a total of 59 articles obtained, there were 6 types of documents, namely articles with a total of 36 documents (61.0%), conference papers with a total of 16 documents (27.1%), reviews with a total of 3 documents (5, 1%), editorials with a total of 2 documents (3.4%), and book chapters and errata with 1 document each (1.7%). Based on the results above, it is known the majority of publications regarding chemical engineering in Indonesia are journal articles, followed by conference papers and other types of documents.

The dominance of journal articles shows research in the field of chemical engineering in Indonesia is mostly published in the form of articles that go through a strict peer review process, showing high quality and credibility [38]. Research published in the form of conference papers also shows many researchers actively participate in conferences to share their latest research results. This is important because conferences often become the initial platform for the dissemination of research results before they are published in journals [39].

Other types of documents such as reviews, editorials, book chapters, and erratum, which are smaller in number, show diversification in publication forms, although in smaller proportions. Review articles, although few, play an important role in summarizing and analyzing the latest developments in the field of chemical engineering, providing a broader and more in-depth view of a particular topic [40]. Editorials and book chapters demonstrate the contribution of Indonesian researchers in providing additional perspectives and knowledge in this field, while errata demonstrate a commitment to accuracy and correction in scientific publications.

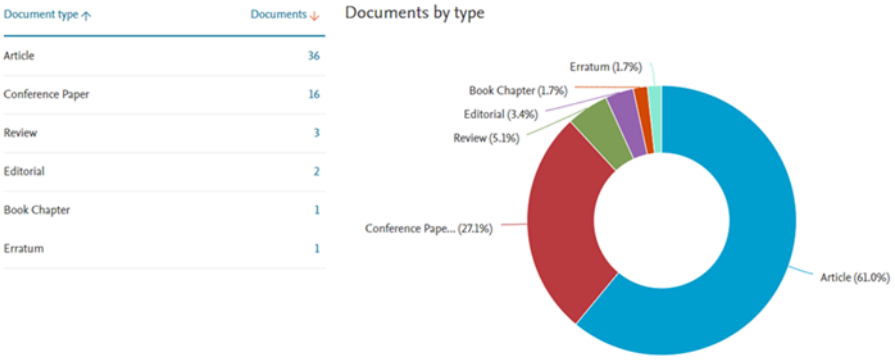


Fig. 3. Document type

3.3 International Collaboration

International collaboration plays a crucial role in improving the quality and visibility of research in chemical engineering. Through collaboration with researchers from various countries, Indonesian researchers can access resources, technology, and expertise that may not be available domestically. This allows improving the quality of research through the use of cutting-edge methods and technology obtained from these collaborations [41]. International collaboration also opens up opportunities to obtain funding from international institutions, which can help overcome limited research funds in Indonesia.

International collaboration also contributes to increasing research visibility. Research conducted jointly with international institutions tends to be more easily accepted and published in highly reputable journals. Publication in these journals not only increases research visibility but also the credibility of researchers and institutions in the eyes of the global scientific community. Additionally, these collaborations often result in more frequently cited articles, indicating greater scientific impact [42].

Table 2 shows 10 articles where the authors of the articles are a combination of several authors from various countries. Based on Table 2, articles whose authors consist of collaborations with authors from other countries (aside from Indonesia) have quite a high number of citations, for example, the article written by Yuliarto *et al.,* [43] with the title "Defect-Rich Hierarchical Porous UiO-66(Zr) for Tunable Phosphate Removal" has received 172 citations. Although Yuliarto is not the first author, he has collaborated with authors from China, Australia, and Japan. This is the opinion of

Glänzel and Schubert [42], articles resulting from international collaboration are more often cited by other researchers.

Table 2
Example of international collaboration data

No	Title	Author	Country	Citations	Ref.
1.	Defect-Rich Hierarchical Porous UiO-66(Zr) for Tunable Phosphate Removal	Li *et al.,*	China, Australia, Japan, Indonesia	172	[43]
2.	Techno-economic analysis of bio-briquette from cashew nut shell waste	Ifa *et al.,*	Indonesia, Malaysia	60	[44]
3.	Integrated project-based learning (IPBL) implementation for first-year chemical engineering student: DIY hydraulic jack project	Ruslan *et al.,*	Malaysia, Indonesia	21	[45]
4.	Behavior of Schmutzdecke with varied filtration rates of slow sand filter to remove total coliforms	Matuzahroh *et al.,*	Indonesia, Malaysia	19	[46]
5.	Nocathioamides, uncovered by a Tunable Metabologenomic Approach, Define a Novel Class of Chimeric Lanthipeptides.	Saad *et al.,*	Germany, Egypt, Indonesia	18	[47]
6.	Reduction of the acidity and peroxide numbers of tengkawang butter (Shorea stenoptera) using thermal and acid activated bentonites	Darmawan *et al.,*	Indonesia, Malaysia	13	[48]
7.	Application of Strontium Aluminate Europium and Dysprosium Doped in Cement Mortar as a Luminescent Material for the Maintenance of Green Environments	Naeem *et al.,*	Pakistan, Estonia, China, Indonesia, Malaysia	4	[49]
8.	Web-based ionic liquids learning media to measure the competence of polytechnic students	Yulianti *et al.,*	Indonesia, Malaysia	3	[50]
9.	Purification and characterization of proteins in multi floral honey from kelulut bee (stingless bee)	Sahlan *et al.,*	Indonesia, Japan	3	[51]
10.	New hydraulic binder and binder-based material with burning pulverized coal ash, household waste, Mediterranean soil, and calcined clay waste	Kirgiz and Syarif	United States, Indonesia	2	[52]

We can also see there are several collaborations carried out by each author. This collaboration involves authors from various countries. Figure 4 shows 10 authors collaborating with other authors from different countries. The number of collaborations varies, such as those brought by Li *et al.,* [43] who collaborated with authors from Australia, Japan, and Indonesia, and Neem *et al.,* [49] who collaborated with authors from Estonia, China, Indonesia, and Malaysia.

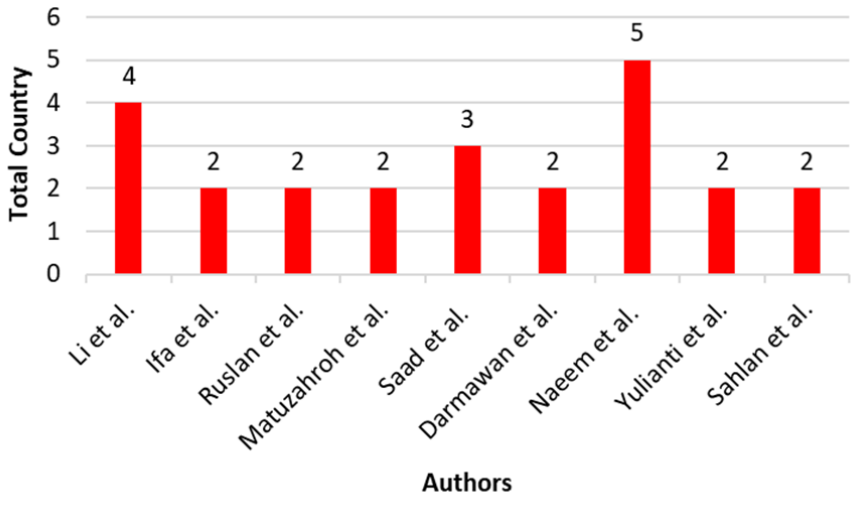


Fig. 4. Author and country collaboration

3.4 Trending Research Subject Areas

Figure 5 shows the subject areas contained in publications regarding chemical engineering. Based on Figure 5, Multidisciplinary is the most widely used subject area with a total of 18 documents. This shows that the field of chemical engineering in Indonesia is increasingly moving towards a cross-disciplinary approach. This approach allows the integration of knowledge from various fields, resulting in innovation that is more comprehensive and relevant to real problems. Multidisciplinary chemical engineering research can increase the effectiveness and efficiency of the solutions produced, as well as expand the scope of research to be more holistic [53].

Apart from that, this trend also reflects the need to collaborate with other scientific disciplines to face complex challenges that cannot be solved by one scientific field alone. For example, research on waste processing requires collaboration between chemical engineering, biology, and environmental science to produce more effective and environmentally friendly solutions. Multidisciplinary collaborations like this have been proven to accelerate innovation and the adoption of new technologies in various industrial sectors [54].

Apart from multidisciplinary, there are other subject areas related to research on chemical engineering, including engineering (16 documents), materials science (11 documents), chemical engineering (10 documents), physics and astronomy (10 documents), chemistry (9 documents), computer science (6 documents), earth and planetary sciences (5 documents), social sciences (5 documents), environmental science (4 documents), decision sciences (3 documents), biochemistry, genetics, and molecular biology (2 documents), mathematics (2 documents), agricultural and biological sciences (1 document), arts and humanities (1 document), and business, management, and accounting (1 document).

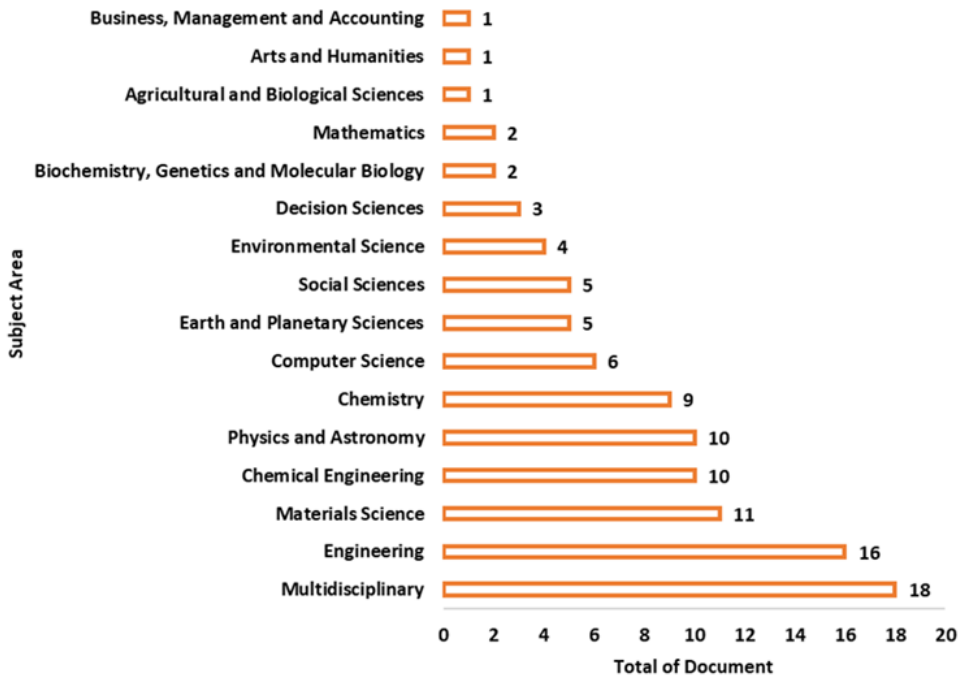


Fig. 5. Trending research subject area

3.5 Cited Papers Analysis

Based on Table 3 and Figure 6, the article "Defect-Rich Hierarchical Porous UiO-66(Zr) for Tunable Phosphate Removal" by Li *et al.,* [43] has received many citations with a total of 172 citations over the last five years (2019-2024). This shows the article has a significant impact on the field of chemical engineering research, especially in the development of materials for processing phosphate waste. This number of citations also reflects the relevance of the topics discussed and the quality of research recognized by the scientific community [55].

Articles are frequently cited usually indicate the research is considered important and is a reference by many other researchers. It can also show the research results have broad and relevant applications in industry or advanced research. For example, the development of materials with adjustable porosity for waste processing is a crucial topic in environmental sustainability efforts and natural resource management.

The high number of citations can also be attributed to international collaborations carried out by the authors, as well as publications in highly reputable journals have a large impact factor. Research conducted by Li *et al.,* shows the potential for broad and relevant applications in a global context, which helps in increasing the visibility and impact of such research [56].

Table 3
Journal analysis and cited papers

No.	Title	Author	Cites	Ref.
1.	Defect-Rich Hierarchical Porous UiO-66(Zr) for Tunable Phosphate Removal	Li *et al*.	172	[43]
2.	A bibliometric analysis of chemical engineering research using vosviewer and its correlation with Covid-19 pandemic condition	Nandiyanto *et al*.	78	[57]
3.	Techno-economic analysis of bio-briquette from cashew nut shell waste	Ifa *et al*.	60	[44]
4.	Production of protein hydrolysate containing antioxidant activity from Hermetia illucens	Firmansyah and Abduh	59	[58]
5.	Optimization of cellulose nanocrystals from bamboo shoots using Response Surface Methodology	Wijaya *et al*.	45	[59]
6.	Optimization and reaction kinetics on the removal of Nickel and COD from wastewater from electroplating industry using Electrocoagulation and Advanced Oxidation Processes	Moersidik *et al*.	43	[60]
7.	Interpretation of Fourier Transform Infrared Spectra (FTIR): A Practical Approach in the Polymer/Plastic Thermal Decomposition	Nandiyanto *et al*.	32	[61]
8.	Preservation of meatballs with edible coating of chitosan dissolved in rice hull-based liquid smoke	Desvita *et al*.	29	[62]
9.	Evaluation on research effectiveness in a subject area among top class universities: A case of Indonesia's academic publication dataset on chemical and material sciences	Nandiyanto *et al*.	28	[63]
10.	Effect of size variation on microbubble mass transfer coefficient in flotation and aeration processes	Suwartha *et al*.	28	[64]

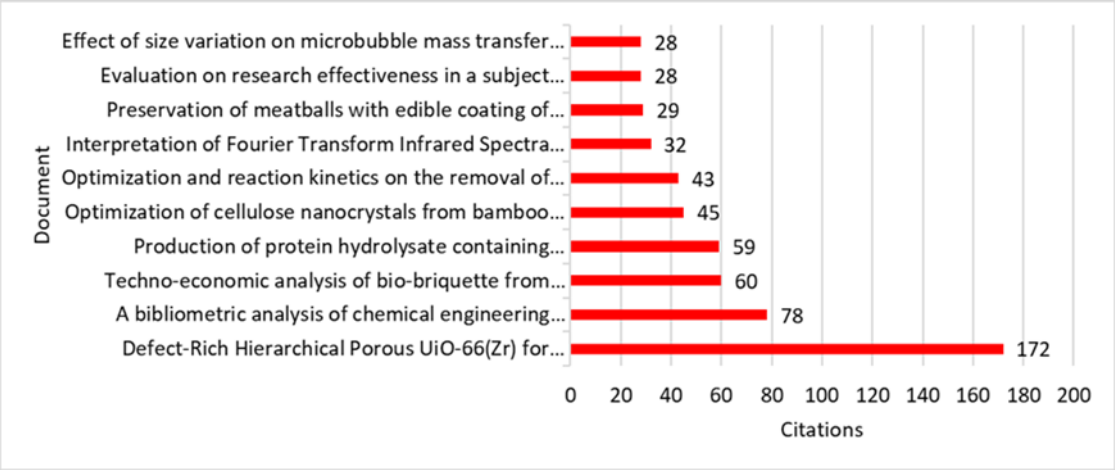


Fig. 6. Articles with top citations

3.6 Source Type Analysis

Figure 7 shows the number of documents from each source starting from journals, conference proceedings, book series, and books. Based on Figure 7, journals and conference proceedings are the sources often chosen by researchers to publish their articles. Over the last five years, there have been 40 articles published in journals, while there have been 15 documents in conference proceedings. Based on this, publications in leading journals and conferences are very important because they provide higher visibility and credibility for their research. Publications in prestigious journals often go through a rigorous peer review process, ensuring high quality and validity of research [65].

Publications in journals have quite a significant influence. This is because publications in journals can have a greater scientific impact, expand collaboration networks, and increase funding opportunities and academic awards. Journals have a high impact factor and tend to be read by more researchers, work published in them has a greater chance of being cited, which ultimately increases the h-index and the researcher's reputation. Additionally, articles published in journals are often more easily accessible to the global scientific community through indexation databases such as Scopus and Web of Science, broadening the reach of research impact [66].

Thus, researchers in the field of chemical engineering in Indonesia must continue to be encouraged to publish their work in leading journals and conferences. This effort not only improves the quality and visibility of Indonesian research in the international arena but also makes a greater contribution to the development of science and technology in the field of chemical engineering. Support from academic institutions and government in the form of funding, research facilities, and training to write quality scientific articles is essential to achieving this goal [31].

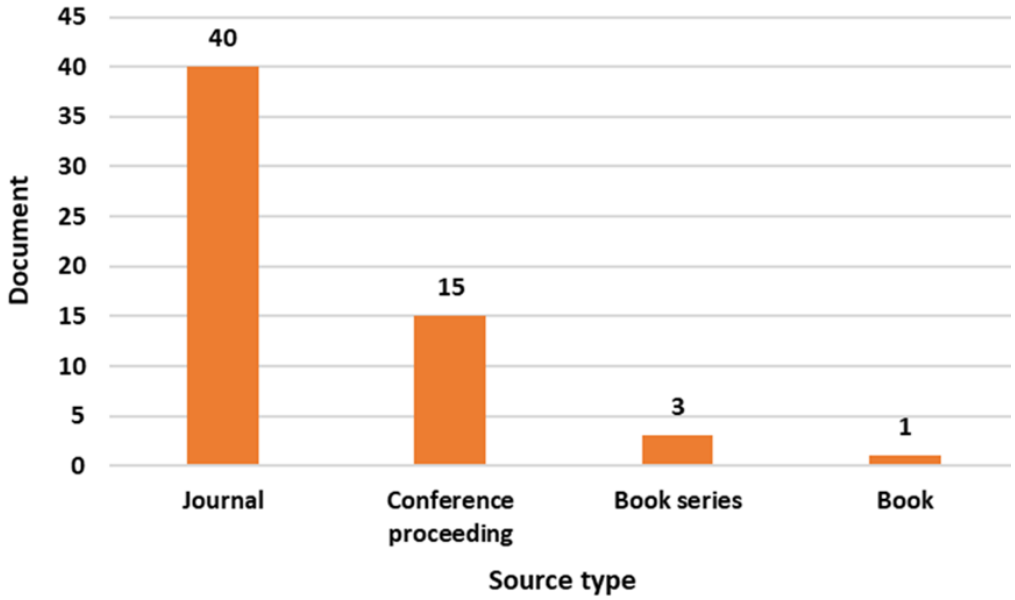


Fig. 7. Source type

3.7 Analysis of Author Productivity

Based on Table 4, Nandiyanto A.B.D. has been one of the most productive researchers in the field of chemical engineering in Indonesia over the last five years with a total of 5 publications. Apart from that, other researchers such as Santosa, S., Mas'udah, Livotov, P., and Gunawan, S. each have 3 publications. Meanwhile, Soerawidjaja, T. H., Shlan, M., Rizkiana, J., Prakoso, T., and Moersidik, S. S. each contributed 2 documents.

Table 4
Author productivity

No.	Author	Total
1	Nandiyanto, A.B.D.	5
2	Santosa, S.	3
3	Mas'udah	3
4	Livotov, P.	3
5	Gunawan, S.	3
6	Soerawidjaja, T.H.	2
7	Sahlan, M.	2
8	Rizkiana, J.	2
9	Prakoso, T.	2
10	Moersidik, S.S.	2

Based on the results above, it can be seen there is a concentration of research productivity in the hands of a few leading researchers. This shows significant contributions to chemical engineering research in Indonesia are dominated by certain individuals who have high dedication to their field. Researchers such as Nandiyanto *et al.,* [67] demonstrate consistent productivity, which contributes to increased knowledge and publications in the discipline. This success is often supported by strong collaboration with other institutions and access to adequate research resources.

3.8 Article Data Visualization

Network visualization in bibliometric analysis is an important tool for identifying and analyzing relationships between scientific articles, authors, journals, or certain keywords in a research field

[68]. The results of network visualization are usually graphics showing nodes and edges representing entities and the relationships between them. For example, in a co-authorship visualization, nodes can represent authors, and edges represent collaboration between those authors. This helps researchers to identify collaboration patterns, centers of interest, and research trends that are developing in a field of science.

Figure 6 shows the shape of the visualization network from the analysis results using the VOSviewer application. This visualization form is obtained after carrying out several settings such as:

(i) The data type selected is "create a map based on text data".
(ii) The data source used is a file in *.ris format.
(iii) Title and abstract fields are selected in determining the items to be searched.
(iv) The counting method used is binary counting with the minimum number of occurrences of a term being 2.

Based on Figure 8, the visualization network in this research produces 3 cluster groups, namely cluster 1 has a total of 8 items marked in red, cluster 2 has a total of 7 items marked in green, and cluster 3 has a total of 6 items marked in blue. Further explanation of the resulting clusters is shown in Table 5.

Table 5
Cluster division based on network visualization

Cluster	Color	Items
1	Red	Article, chemical, chemical engineering, Indonesia, number, research, type, and year.
2	Green	Condition, effect, efficiency, min, optimization, removal, and time.
3	Blue	Ability, concertation, production, rage, study, and yield.

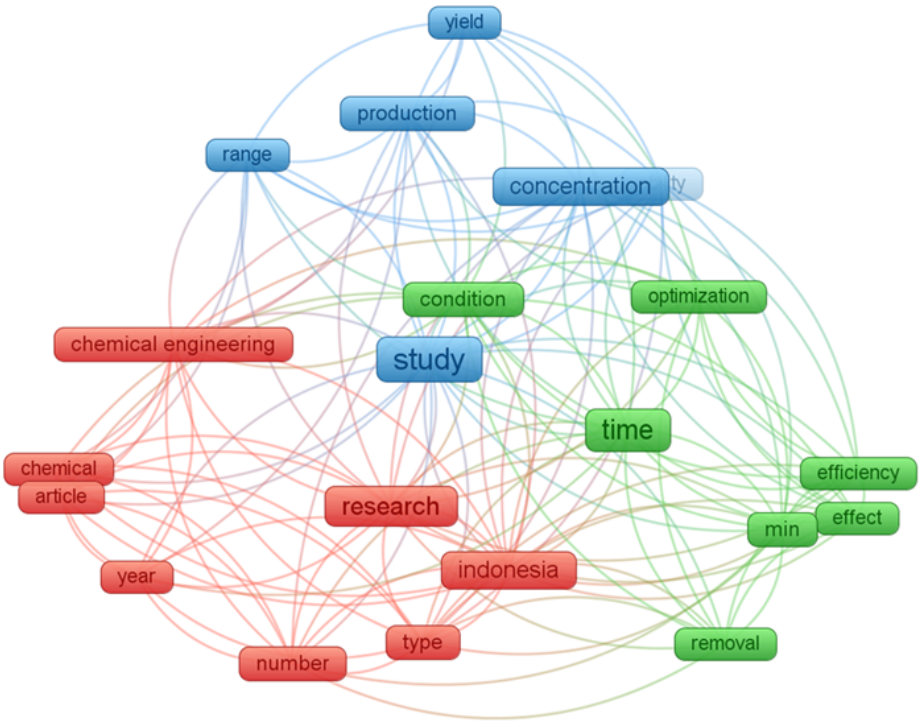


Fig. 8. Network visualization based on keywords

3.9 Concept of Chemical Engineering

Chemical engineering is a scientific discipline that combines the principles of chemistry, physics, mathematics, biology, and economics to process raw materials into products that are more useful and economically valuable [69]. Chemical engineers design, develop, and optimize processes and systems to produce, convert, and transport materials, with a focus on efficiency, safety and environmental sustainability.

Key concepts in chemical engineering include mass transfer, heat transfer, chemical reactions, thermodynamics, and process control. Mass transfer relates to the transfer of substances from one location to another, which is very important in the separation and purification of chemicals. Heat transfer refers to the transfer of thermal energy, which is important in various operations such as heating, cooling, and phase changes. Chemical reactions are at the heart of many chemical engineering processes, where chemical engineers must understand reaction kinetics and mechanisms to design efficient reactors. Thermodynamics provides the basis for understanding energy and matter transfer in chemical systems, while process control ensures processes proceed according to the desired design [70].

In practical applications, chemical engineering covers various industries from the petrochemical, pharmaceutical and food, to energy industries. Chemical engineers not only focus on production but also on environmental aspects, such as waste treatment and pollution control, to ensure processes are sustainable and environmentally friendly. Their role is very important in technological innovation and new product development, which contributes to economic progress and quality of life [71].

3.10 The Influence of Chemical Engineering Topics on Publication Levels in Indonesia

The influence of topics in the field of chemical engineering on the level of publications in Indonesia can be seen from how various sub-disciplines of chemical engineering influence the number and quality of publications produced. Several topics in chemical engineering, such as nanotechnology, waste processing, renewable energy, and biotechnology, have shown a significant influence in increasing research interest and publications in Indonesia. Research focuses on environmental issues and renewable energy, for example, often receives greater attention because of its relevance to global and local challenges.

The development of renewable energy technologies, such as bioenergy, solar power, and wind power, has driven a lot of research in Indonesia. This topic is not only important for national energy security, but also for meeting global commitments to reduce carbon emissions [72]. Therefore, research in this area tends to produce more high-quality publications due to the high level of interest and support received.

Biotechnology offers wide applications in the production of chemicals, pharmaceuticals, and biofuels. Research in biotechnological process engineering often has a major impact on publications due to its relevance to industry and public health [73]. Thus, these topics play an important role in driving the number and quality of publications in the field of chemical engineering in Indonesia.

3.11 Contribution of particle technology to the development of chemical engineering publications in Indonesia

Particle technology has become an important element in the development of chemical engineering because many chemical processes involve interactions between particles in reactions and material processing. In the Indonesian context, the contribution of particle technology to publication trends in the field of chemical engineering can be seen from the increase in the number

of publications covering this topic in recent years. Based on bibliometric analysis, particle technology has emerged as a topic that is receiving increasing attention in chemical engineering research in Indonesia. Although publication trends on chemical engineering show fluctuations, there has been a significant increase in publications related to the topic of particle technology which is in line with efforts to increase the efficiency and sustainability of chemical industrial processes in Indonesia (Figure 9).

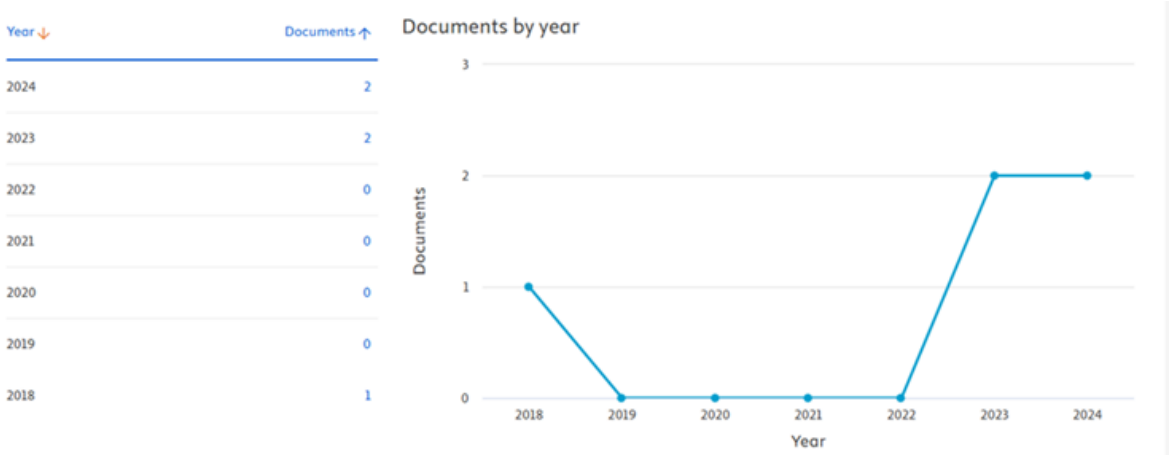


Fig. 9. Publication trends in particle technology in chemical engineering in Indonesia based on Scopus database

The application of particle technology in several studies focuses on several main areas, such as materials engineering, particle-based catalysis, and particle-based separation. In the chemical industry, the use of particles to maximize chemical reactions or separation of substances has been proven to increase energy and raw material efficiency. Research on particle-based separation and particle-based catalysis can improve the efficiency of energy conversion and chemical reaction processes by accelerating reaction rates and increasing product selectivity, ultimately reducing the use of additional energy and maximizing the yield from the raw materials used.

For example, in Concentrated Solar Power (CSP) systems, particle technology is used to increase the efficiency of the energy conversion process. The use of particle materials with high absorption capabilities, such as nano-particles or metal particles, can improve the performance of heat receiving systems convert solar energy into heat energy. These particles have a large surface area and high thermal conductivity, which allows efficient heat absorption and optimal heat transfer to the storage medium. This process is very important in the context of energy efficiency, because the more efficient the heat receiving system, the less energy is wasted in the conversion process (Figure 10).

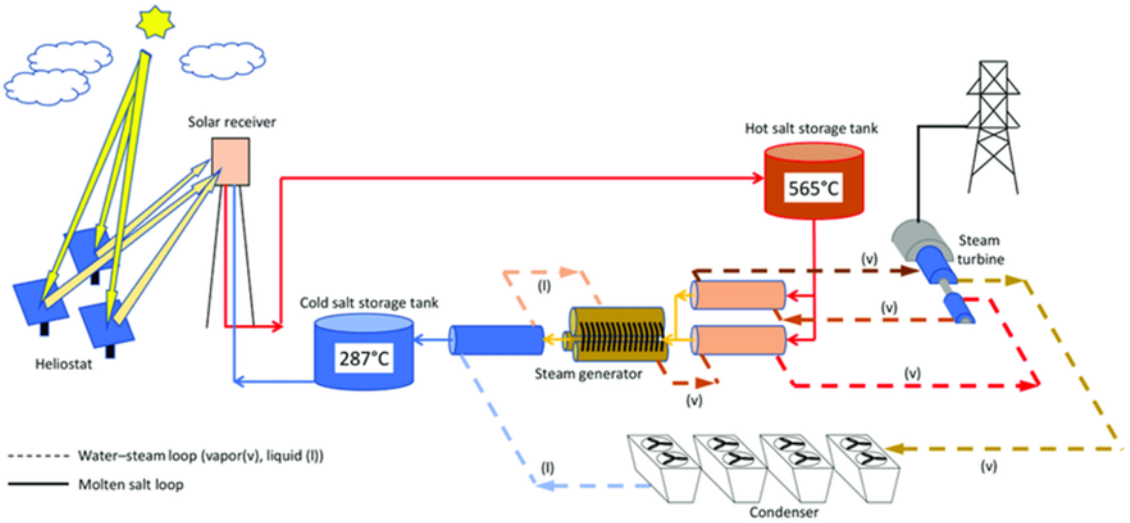


Fig. 10. Concentrated Solar Power (CSP) systems [74]

4. Conclusion

This research succeeded in analyzing publication trends in the field of chemical engineering in Indonesia from a bibliometric perspective using data from the Scopus database. The results of the analysis show there have been fluctuations in the number of publications over the last five years, with the highest peak in 2020 which recorded 18 documents. The document types most frequently selected by researchers were articles and journals, indicating a strong preference for publication sources that are widely recognized in the academic community. Topics that are often discussed include multidisciplinary, engineering, materials science, chemical engineering, physics and astronomy, chemistry, computer science, earth and planetary sciences, social sciences, environmental science, decision sciences, biochemistry, genetics and molecular biology, mathematics, agricultural and biological sciences, arts and humanities, as well as business, management, and accounting, who show a high interest in issues relevant to global and local challenges.

International collaboration was also found to be an important factor in increasing the quality and quantity of publications. Through collaboration with researchers from abroad, Indonesian researchers have a greater opportunity to produce articles and receive more citations. Therefore, the field of chemical engineering is one of the topics is of great interest to researchers in Indonesia. It is hoped the findings from this study can make a significant contribution to the development of research strategies and academic policies in the field of chemical engineering in Indonesia, as well as encourage more international collaboration to increase the impact of research in the future.

References

[1] Putera, Prakoso Bhairawa, and Sri Rahayu. "Perkembangan Kinerja Ilmuwan Kimia Indonesia Dalam Satu Dekade Terakhir: Perbandingan Publikasi Internasional Bidang Kimia Indonesia Dengan Negara ASEAN (The Development of Research Activity on Chemistry by Indonesian Scientists in the Last Decade: Comparison of International Publication Chemistry Indonesia with ASEAN Countries)." In *Prosiding Seminar Nasional Kimia Unesa*. 2009.

[2] Cocero, María José, Ángel Martín, Facundo Mattea, and Salima Varona. "Encapsulation and co-precipitation processes with supercritical fluids: Fundamentals and applications." *The Journal of Supercritical Fluids* 47, no. 3 (2009): 546-555. https://doi.org/10.1016/j.supflu.2008.08.015

[3] Ulusoy, Ugur. "A review of particle shape effects on material properties for various engineering applications: from macro to nanoscale." *Minerals* 13, no. 1 (2023): 91. https://doi.org/10.3390/min13010091

[4] Budianto, Eka Wahyu Hestya. "Pemetaan Penelitian Risiko Reputasi pada Perbankan Syariah dan Konvensional: Studi Bibliometrik VOSviewer dan Literature Review." *Al-Masraf: Jurnal Lembaga Keuangan Dan Perbankan* 8, no. 1 (2023): 94-113. https://doi.org/10.15548/al-masraf.v8i1.425

[5] Saputra, Hellen Monica Ghaby Ayu, Eka Wahyu Hestya Budianto, and Nindi Dwi Tetria Dewi. "Pemetaan Topik Penelitian Seputar Koperasi Jasa Keuangan Syariah (KJKS): Studi Bibliometrik VOS viewer dan Literature Review." *El Mudhorib: Journal of Islamic Economics and Islamic Banking* 3, no. 2 (2023): 131-148. https://doi.org/10.53491/elmudhorib.v3i2.655

[6] Doulani, Abbas. "A bibliometric analysis and science mapping of scientific publications of Alzahra University during 1986–2019." *Library Hi Tech* 39, no. 4 (2021): 915-935. https://doi.org/10.1108/LHT-06-2020-0131

[7] Nandiyanto, Asep Bayu Dani, Dwi Novia Al Husaeni, and Dwi Fitria Al Husaeni. "Introducing ASEAN journal of science and engineering: A bibliometric analysis study." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 31, no. 3 (2023): 173-190. https://doi.org/10.37934/araset.31.3.173190

[8] Wiendartun, W., C. H. A. N. D. R. A. Wulandari, J. N. Fauzan, L. I. L. I. K. Hasanah, HARBI SETYO Nugroho, R. E. Pawinanto, and B. U. D. I. Mulyanti. "Trends in research related to photonic crystal (PHC) from 2009 to 2019: A bibliometric and knowledge mapping analysis." *Journal of Engineering Science and Technology* 17, no. 1 (2022): 0343-0360.

[9] Chusumastuti, Dhety, Christine Riani Elisabeth, Nurali Nurali, Mochamad Suryadharma, and Hommy Dorthy Ellyany Sinaga. "Gangguan digital dan transformasi ekonomi: menganalisis dampak e-commerce terhadap industri tradisional." *Jurnal Ekonomi Dan Kewirausahaan West Science* 1, no. 03 (2023): 173-185. https://doi.org/10.58812/jekws.v1i03.508

[10] Baas, Jeroen, Michiel Schotten, Andrew Plume, Grégoire Côté, and Reza Karimi. "Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies." *Quantitative science studies* 1, no. 1 (2020): 377-386. https://doi.org/10.1162/qss_a_00019

[11] Al Husaeni, Dwi Fitria, Dwi Novia Al Husaeni, Meli Fiandini, and Asep Bayu Dani Nandiyanto. "The research trend of statistical significance test: Bibliometric analysis." *ASEAN Journal of Educational Research and Technology* 3, no. 1 (2024): 71-80.

[12] Hernawan, Jihan Nurafifah, and Asep Bayu Dani Nandiyanto. "Bibliometric Analysis of Publications on Essential Oil-loaded Nanoparticles as Antibacteria using VOSViewer." *Urecol Journal. Part G: Multidisciplinary Research* 2, no. 2 (2022): 108-119.

[13] Nandiyanto, Asep Bayu Dani, Dwi Novia Al Husaeni, and Dwi Fitria Al Husaeni. "Introducing ASEAN journal of science and engineering: A bibliometric analysis study." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 31, no. 3 (2023): 173-190.

[14] Maryanti, R. I. N. A., ASEP BAYU DANI Nandiyanto, A. C. H. M. A. D. Hufad, S. Sunardi, D. N. Al Husaeni, and D. F. Al Husaeni. "A computational bibliometric analysis of science education research using VOSviewer." *Journal of Engineering Science and Technology* 18, no. 1 (2023): 301-309.

[15] Nandiyanto, Asep Bayu Dani, S. I. T. I. Fatimah, R. I. S. T. I. Ragadhita, and D. N. Al Husaeni. "Particle size and pore size of rice husk ash on the resin-based brake pads performance: experiments and bibliometric literature review." *Journal of Engineering Science and Technology* 17, no. 6 (2022): 4065-4081.

[16] Maulidah, Gusnine Sari, and Asep Bayu Dani Nandiyanto. "A Bibliometric analysis of nanocrystalline cellulose synthesis for packaging application research using VOSviewer." International Journal of Research and Applied Technology (INJURATECH) 1, no. 2 (2021): 330-334. https://doi.org/10.34010/injuratech.v1i2.6727

[17] Mustafa, Nurul Shafikah Mohd, Noor Azniza Mohd Noor, Zarina Omar, Muhammad Syarifuddin Yahya, and Mohammad Ismail. "Effect of FeCl3 Addition on the Dehydrogenation Properties of 2NaAlH4+ Ca (BH4) 2 Composite System for Solid State Hydrogen Storage." *Semarak International Journal of Applied Sciences and Engineering Technology* 1, no. 1 (2024): 27-35. https://doi.org/10.37934/sijaset.1.1.2735a

[18] Abdurrahman, Ridwan, Nuraqilah Zahari, Ishkrizat Taib, and Ali Kamil Kareem. "Analysis of COVID-19 Aerosol Dispersion in a Car Cabin Due to Driver's Cough." *Semarak Journal of Thermal-Fluid Engineering* 1, no. 1 (2024): 23-33. https://doi.org/10.37934/sjotfe.1.1.2333a

[19] Shamsuri, Siti Balqis Mohd, Siti Amira Othman, and Nurun Saqinah Jasrin. "Radiation Application in Consumer and Health Application-A Preliminary Review." *Semarak Current Biomedical Technology Research Journal* 1, no. 1 (2024): 40-47. https://doi.org/10.37934/scbtrj.1.1.4047

[20] Imaduddin, Fitrian, Muhammad Nizam, and Saiful A. Mazlan. "Response of a magnetorheological brake under inertial loads." *International Journal on Electrical Engineering and Informatics* 7, no. 2 (2015): 308. https://doi.org/10.15676/IJEEI.2015.7.2.11

[21] Al Shamsi, Wadha Mohammed Ali, and Siti Amira Othman. "Preliminary Review of Local Diagnostic Reference Level (DRLS) for Government Healthcare Dental Centres in Abu Dhabi." *Semarak Current Biomedical Technology Research Journal* 1, no. 1 (2024): 48-59. https://doi.org/10.37934/scbtrj.1.1.4859

[22] Reyaz, Ridhwan, Ahmad Qushairi Mohamad, Yeou Jiann Lim, Arsshad Khan, and Sharidan Shafie. "Mxene and Strontium Titanate Hybrid Casson Nanofluid with CMC Base via the Caputo-Fabrizio Fractional Derivative over a Vertical Riga Plate." *Semarak International Journal of Nanotechnology* 1, no. 1 (2024): 45-64.
[23] Hassan, Faten Nur Izati, Nolia Harudin, Farah Elida Selamat, and Zulkifli Marlah. "Development of Graphical User Interface Based Taguchi's T-Method." *Semarak Engineering Journal* 1, no. 1 (2023): 26-33.
[24] Sidik, Nor Azwadi Che, Asep Bayu Dani Nandiyanto, and Dwi Novia Al Husaeni. "Introducing Semarak Ilmu Publishing in Publishing Science and Engineering: Bibliometric Analysis." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 49, no. 1 (2025): 26-53. https://doi.org/10.37934/araset.49.1.2653
[25] Nandiyanto, Asep Bayu Dani, Riri Noor Sucianto, Salsa Rahmita Matildha, Fauziyyah Zayyan Nur, Ida Kaniawati, Teguh Kurniawan, Muhammad Roil Bilad, and Nor Azwadi Che Sidik. "What Phenomena Happen During Pyrolysis of Plastic? FTIR AND GC-MS Analysis of Pyrolyzed Low Linear Density Polyethylene (LLDPE) Polymer Particles Completed with Bibliometric Research Trend and Pyrolysis Chemical Reaction Mechanism." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 46, no. 1 (2024): 250-260. https://doi.org/10.37934/araset.46.1.250260
[26] Rachmat, Boby, Kristi Agust, Nur Indri Rahayu, and M. Muktiarni. "Concept of computational fluid dynamics and its application in sport science: Bibliometric analysis of modelling thermal comfort in sport hall." *CFD Letters* 16, no. 1 (2024): 1-21. https://doi.org/10.37934/cfdl.16.1.121
[27] Al Husaeni, Dwi Fitria, and Asep Bayu Dani Nandiyanto. "Bibliometric using Vosviewer with Publish or Perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post Covid-19 pandemic." *ASEAN Journal of Science and Engineering* 2, no. 1 (2022): 19-46. https://doi.org/10.17509/ajse.v2i1.37368
[28] Rafols, Ismael, Alan L. Porter, and Loet Leydesdorff. "Science overlay maps: A new tool for research policy and library management." *Journal of the American Society for information Science and Technology* 61, no. 9 (2010): 1871-1887. https://doi.org/10.1002/asi.21368
[29] Setia, Paelani, and Mohammad Taufiq Rahman. "Kekerasan Antaragama: Tinjauan Literatur Sistematis dan Analisis Bibliometrik." *Hanifiya: Jurnal Studi Agama-Agama* 6, no. 2 (2023): 199-212. https://doi.org/10.15575/hanifiya.v6i2.29607
[30] Korbel, Jan O., and Oliver Stegle. "Effects of the COVID-19 pandemic on life scientists." *Genome biology* 21 (2020): 1-5. https://doi.org/10.1186/s13059-020-02031-1
[31] King, David A. "The scientific impact of nations." *Nature* 430, no. 6997 (2004): 311-316. https://doi.org/10.1038/430311a
[32] Adams, Jonathan. "The rise of research networks." *Nature* 490, no. 7420 (2012): 335-336. https://doi.org/10.1038/490335a
[33] Korbel, Jan O., and Oliver Stegle. "Effects of the COVID-19 pandemic on life scientists." *Genome biology* 21 (2020): 1-5. https://doi.org/10.1186/s13059-020-02031-1
[34] Glänzel, Wolfgang, and András Schubert. "Analysing scientific networks through co-authorship." In *Handbook of quantitative science and technology research: The use of publication and patent statistics in studies of S&T systems*, pp. 257-276. Dordrecht: Springer Netherlands, 2004. https://doi.org/10.1007/1-4020-2755-9_12
[36] Kostoff, Ronald N. "Comparison of China/USA science and technology performance." *Journal of Informetrics* 2, no. 4 (2008): 354-363. https://doi.org/10.1016/j.joi.2008.06.004
[37] Fu, Hui-Zhen, Xiao Long, and Yuh-Shan Ho. "China's research in chemical engineering journals in Science Citation Index Expanded: a bibliometric analysis." *Scientometrics* 98 (2014): 119-136. https://doi.org/10.1007/s11192-013-1047-z
[38] Zhou, Ping, and Loet Leydesdorff. "The emergence of China as a leading nation in science." *Research policy* 35, no. 1 (2006): 83-104. https://doi.org/10.1016/j.respol.2005.08.006
[38] Inawati, Inawati, Devinna Anugrah Dinanti, Diah Saras Wati, and Enggar Rizki Pratama. "Efektivitas Pemanfaatan E-Journal Mahasiswa Pascasarjana Universitas Negeri Malang." *Literatify: Trends in Library Developments* 4, no. 2 (2023): 76-93. https://doi.org/10.24252/literatify.v4i2.41296
[39] Gruzd, Anatoliy, Kathleen Staves, and Amanda Wilk. "Connected scholars: Examining the role of social media in research practices of faculty using the UTAUT model." *Computers in Human Behavior* 28, no. 6 (2012): 2340-2350. https://doi.org/10.1016/j.chb.2012.07.004
[40] Pautasso, Marco. "Ten simple rules for writing a literature review." *PLoS computational biology* 9, no. 7 (2013): e1003149. https://doi.org/10.1371/journal.pcbi.1003149
[41] Adams, Jonathan. "The rise of research networks." *Nature* 490, no. 7420 (2012): 335-336. https://doi.org/10.1038/490335a

[42] Glänzel, Wolfgang, and András Schubert. "Analysing scientific networks through co-authorship." In *Handbook of quantitative science and technology research: The use of publication and patent statistics in studies of S&T systems*, pp. 257-276. Dordrecht: Springer Netherlands, 2004. https://doi.org/10.1007/1-4020-2755-9

[43] Li, Mohua, Yanbiao Liu, Fang Li, Chensi Shen, Yusuf Valentino Kaneti, Yusuke Yamauchi, Brian Yuliarto, Bo Chen, and Chong-Chen Wang. "Defect-rich hierarchical porous UiO-66 (Zr) for tunable phosphate removal." *Environmental Science & Technology* 55, no. 19 (2021): 13209-13218. https://doi.org/10.1021/acs.est.1c01723

[44] Ifa, La, Setyawati Yani, Nurjannah Nurjannah, Darnengsih Darnengsih, Andi Rusnaenah, Maizirwan Mel, Mahfud Mahfud, and Heri Septya Kusuma. "Techno-economic analysis of bio-briquette from cashew nut shell waste." *Heliyon* 6, no. 9 (2020). https://doi.org/10.1016/j.heliyon.2020.e05009

[45] Ruslan, Muhammad Syafiq Hazwan, Muhammad Roil Bilad, Mohd Hilmi Noh, and Suriati Sufian. "Integrated project-based learning (IPBL) implementation for first year chemical engineering student: DIY hydraulic jack project." *Education for chemical engineers* 35 (2021): 54-62. https://doi.org/10.1016/j.ece.2020.12.002

[46] Fitriani, Nurina, Putri Eka Ardiyanti, Eko Prasetyo Kuncoro, Wahid Dian Budiyanto, Dwi Ratri Mitha Isnadina, Febri Eko Wahyudianto, and Radin Maya Saphira Radin Mohamed. "Behavior of schmutzdecke with varied filtration rates of slow sand filter to remove total coliforms." *Heliyon* 6, no. 4 (2020). https://doi.org/10.1016/j.heliyon.2020.e03736

[47] Saad, Hamada, Saefuddin Aziz, Matthias Gehringer, Markus Kramer, Jan Straetener, Anne Berscheid, Heike Brötz-Oesterhelt, and Harald Gross. "Nocathioamides, uncovered by a tunable metabologenomic approach, define a novel class of chimeric lanthipeptides." *Angewandte Chemie International Edition* 60, no. 30 (2021): 16472-16479. https://doi.org/10.1002/anie.202102571

[48] Darmawan, Muhammad Arif, Bagas Zaki Muhammad, Andre Fahriz Perdana Harahap, Muhammad Yusuf Arya Ramadhan, Muhammad Sahlan, Teguh Supriyadi, Suraini Abd-Aziz, and Misri Gozan. "Reduction of the acidity and peroxide numbers of tengkawang butter (Shorea stenoptera) using thermal and acid activated bentonites." *Heliyon* 6, no. 12 (2020): e05742. https://doi.org/10.1016/j.heliyon.2020.e05742

[49] Naeem, Muhammad, Saileen Khan, Ivar Zekker, Fazle Subhan, Muhammad Salman, Alamgir, Asmat Ullah et al. "Application of strontium aluminate europium and dysprosium doped in cement mortar as a luminescent material for the maintenance of green environments." *Journal of Hazardous, Toxic, and Radioactive Waste* 27, no. 1 (2023): 04022032. https://doi.org/10.1061/(ASCE)HZ.2153-5515.0000716

[50] Yulianti, Ina, Ida Hamidah, Mumu Komaro, Ahmad Mudzakir, and Maizam Alias. "Web-based ionic liquids learning media to measure the competence of the Polytechnic student." *JOTSE* 11, no. 2 (2021): 284-294. https://doi.org/10.3926/jotse.1145

[51] Sahlan, Muhamad, Kaysa Faradis Mahira, Ihsan Wiratama, Alfiani Guntari Mahadewi, Masafumi Yohda, Heri Hermansyah, and Keiichi Noguchi. "Purification and characterization of proteins in multifloral honey from kelulut bee (stingless bee)." *Heliyon* 5, no. 11 (2019): e02835. https://doi.org/10.1016/j.heliyon.2019.e02835

[52] Kırgız, Mehmet Serkan, and Muhammad Syarif. "New hydraulic binder and binder-based material with burning pulverised coal ash, household waste, Mediterranean soil, and calcined clay waste." In *Advance Upcycling of By-Products in Binder and Binder-based Materials*, pp. 123-142. Woodhead Publishing, 2024. https://doi.org/10.1016/B978-0-323-90791-0.00004-4

[53] Porter, Alan, and Ismael Rafols. "Is science becoming more interdisciplinary? Measuring and mapping six research fields over time." *Scientometrics* 81, no. 3 (2009): 719-745. https://doi.org/10.1007/s11192-008-2197-2

[54] Wagner, Caroline S., J. David Roessner, Kamau Bobb, Julie Thompson Klein, Kevin W. Boyack, Joann Keyton, Ismael Rafols, and Katy Börner. "Approaches to understanding and measuring interdisciplinary scientific research (IDR): A review of the literature." *Journal of informetrics* 5, no. 1 (2011): 14-26. https://doi.org/10.1016/j.joi.2010.06.004

[55] Sari, Resy Anggun, Fadhilah Dirayati, and Teuku Muhammad Fawaati HS. "penilaian kinerja pengajaran dosen menggunakanhasil data pengisian yang terkomputerisasi." *Jurnal SIMADA (Sistem Informasi dan Manajemen Basis Data)* 7, no. 1 (2024): 26-36. https://doi.org/10.30873/simada.v7i1.411

[56] Lundberg, Jonas, Göran Tomson, Inger Lundkvist, John Sk? r, and Mats Brommels. "Collaboration uncovered: Exploring the adequacy of measuring university-industry collaboration through co-authorship and funding." *Scientometrics* 69, no. 3 (2006): 575-589. https://doi.org/10.1007/s11192-006-0170-5

[57] Nandiyanto, Asep Bayu Dani, and Dwi Fitria Al Husaeni. "Bibliometric analysis of engineering research using vosviewer indexed by google scholar." *Journal of Engineering Science and Technology* 17, no. 2 (2022): 883-894.

[58] Firmansyah, Mochamad, and Muhammad Yusuf Abduh. "Production of protein hydrolysate containing antioxidant activity from Hermetia illucens." *Heliyon* 5, no. 6 (2019): e02005. https://doi.org/10.1016/j.heliyon.2019.e02005

[59] Wijaya, Christian J., Suryadi Ismadji, Hakun W. Aparamarta, and Setiyo Gunawan. "Optimization of cellulose nanocrystals from bamboo shoots using Response Surface Methodology." *Heliyon* 5, no. 11 (2019). https://doi.org/10.1016/j.heliyon.2019.e02807

[60] Moersidik, Setyo Sarwanto, Rudi Nugroho, Mira Handayani, and Mochamad A. Pratama. "Optimization and reaction kinetics on the removal of Nickel and COD from wastewater from electroplating industry using Electrocoagulation and Advanced Oxidation Processes." *Heliyon* 6, no. 2 (2020). https://doi.org/10.1016/j.heliyon.2020.e03319
[61] Nandiyanto, Asep Bayu Dani, Risti Ragadhita, and Meli Fiandini. "Interpretation of Fourier transform infrared spectra (FTIR): A practical approach in the polymer/plastic thermal decomposition." *Indonesian Journal of Science and Technology* 8, no. 1 (2023): 113-126. https://doi.org/10.17509/ijost.v8i1.53297
[62] Desvita, Hera, and Muhammad Faisal. "Preservation of meatballs with edible coating of chitosan dissolved in rice hull-based liquid smoke." *Heliyon* 6, no. 10 (2020): e05228. https://doi.org/10.1016/j.heliyon.2020.e05228
[63] Nandiyanto, Asep Bayu Dani, Muhammad Kunta Biddinika, and F. A. R. I. D. Triawan. "Evaluation on research effectiveness in a subject area among top class universities: a case of Indonesia's academic publication dataset on chemical and material sciences." *Journal of Engineering Science and Technology* 15, no. 3 (2020): 1747-1775.
[64] Suwartha, Nyoman, Destrianti Syamzida, Cindy Rianti Priadi, Setyo Sarwanto Moersidik, and Firdaus Ali. "Effect of size variation on microbubble mass transfer coefficient in flotation and aeration processes." *Heliyon* 6, no. 4 (2020): e03748. https://doi.org/10.1016/j.heliyon.2020.e03748
[65] Bornmann, Lutz, and Hans-Dieter Daniel. "What do citation counts measure? A review of studies on citing behavior." *Journal of documentation* 64, no. 1 (2008): 45-80. https://doi.org/10.1108/00220410810844150
[66] Meho, Lokman I., and Kiduk Yang. "Impact of data sources on citation counts and rankings of LIS faculty: Web of Science versus Scopus and Google Scholar." *Journal of the american society for information science and technology* 58, no. 13 (2007): 2105-2125. https://doi.org/10.1002/asi.20677
[67] Larivière, Vincent, Yves Gingras, Cassidy R. Sugimoto, and Andrew Tsou. "Team size matters: Collaboration and scientific impact since 1900." *Journal of the Association for Information Science and Technology* 66, no. 7 (2015): 1323-1332. https://doi.org/10.1002/asi.23266
[68] Budianto, Eka Wahyu Hestya, and Nindi Dwi Tetria Dewi. "Pemetaan penelitian rasio Dividend Per Share (DPS) pada perbankan syariah dan konvensional: studi bibliometrik VOSviewer dan literature review." *Al-Mal: Jurnal Akuntansi Dan Keuangan Islam* 4, no. 1 (2023): 109-126. https://doi.org/10.21107/kompetensi.v17i1.20002
[69] Anwar, Dedy. "perkembangan ilmu teknik kimia dari masa pra sejarah hingga masa sekarang." *Jurnal Sistem dan Teknologi Informasi (JSTI)* 6, no. 2 (2024): 116-125.
[70] Biegler, Lorenz T., Ignacio E. Grossmann, Arthur W. Westerberg, and Zdravko Kravanja. *Systematic methods of chemical process design*. Vol. 796. Upper Saddle River, NJ: Prentice Hall PTR, 1997.
[71] Siirola, Jeffrey J. "The impact of shale gas in the chemical industry." *AIChE Journal* 60, no. 3 (2014). https://doi.org/10.1002/aic.14368
[72] Ajanovic, Amela. "Biofuels versus food production: does biofuels production increase food prices?." *Energy* 36, no. 4 (2011): 2070-2076. https://doi.org/10.1016/j.energy.2010.05.019
[73] Velickovic, T. Cirkovic, Jelena Radosavljevic, and Dragana Stanic. "Digestibility of food allergens." *CABI Reviews* 2009 (2009): 1-17. https://doi.org/10.1079/PAVSNNR20094034
[74] Hernández, Catalina, Rodrigo Barraza, Alejandro Saez, Mercedes Ibarra, and Danilo Estay. "Potential map for the installation of concentrated solar power towers in Chile." *Energies* 13, no. 9 (2020): 2131. https://doi.org/10.3390/en13092131