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A Bibliometric Analysis of Chemistry Industry Research Using Vosviewer Application with Publish or Perish

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Abstract

The chemical industry is one of several industries that are active on a vast scale. Chemical industries are any industries that use materials or chemical compounds found in nature, either as a raw material or as a supporting material, in the process or as a result of the process or one of them. The goal of this study is to perform bibliometric analysis in the chemical industry by combining visualization analysis using VOSviewer software. The research data gathered are the results of a keyword search of "Chemical Industry". This search obtained 988 articles relevant to keywords that were published from 2017 to 2021. The results demonstrated that research in the chemical sector experienced a significant decline year after year. This paper discusses the significance of bibliometric analysis in providing analytical data to determine a topic related to the "Chemical Industry" theme. This research is expected to help and become a reference for researchers to conduct and choose research topics.

Keywords: *Chemical Industry, Data Analysis, Database, Bibliometric, VOSviewer*

1. Introduction

The current industrial development is unavoidable because of the progress of a region, namely by increasing an industrial sector linkage in the region. The chemical sector is one of several businesses whose growth is being encouraged. The government is still encouraging the domestic chemical sector to grow and become a driving force in the national economy. This is due to the chemical industry's importance in supplying raw materials to other manufacturing industries such as the plastic and textile industries [1]. There are still numerous opportunities for the growth of the national chemical industry. Indonesia, with a population of around 230 million people and enormous natural resources, has established itself as a pioneer in the development of the chemical sector [2].Chemists have an essential role in chemical product manufacturing, inspection, and safe handling, as well as product development and general management [3]. Basic chemicals such as oxygen, ammonia, sulfuric acid, and chlorine are produced as raw materials for industries such as textiles, agricultural goods, pulp, paint, metals, and paper. Specialty chemicals are manufactured in smaller amounts and utilized in sectors such as medicines, detergents, food, packaging, and perfumes. Monitoring and controlling bulk chemical processes, particularly those involving heat transfer, is a common concern for chemists and chemical engineers. VOSviewer is software that converts bibliometric data into multiple visual formats [4-9]. By using the VOSviewer software, visualization and various information on the development of the field of science. Vosviewer can map various types of bibliometric analysis, supports several major bibliographic databases, and can analyze large data using layout and cluster techniques [10-14]. One of the essential areas that must be studied is the chemical industry. Many previous studies on the chemical industry have been conducted, including a study by Machmud et al. [15] on the efficiency of the chemical sector in Indonesia using the Stochastic Frontier Analysis (SFA) technique. Research conducted by Elviani et al (2022) is examining factors that can affect the earnings response coefficient of chemical industry companies in Indonesia [16]. Another study conducted by Chen et al (2020), investigated chemical safety in China, identified the causes of accidents, and formulated safety management requirements in the chemical industry [17]. Kleinekorte et al. (2020) developed an engineering-level global chemical industry representing 75% of greenhouse gas emissions, allowing them to analyze potential disruptive changes through large-scale CO_2 usage and resulting emission reductions [18]. Several studies discuss industrial chemicals, however, there are still relatively few studies on bibliometric analysis in the chemical sector. This bibliometric analysis might be beneficial for estimating the amount and current status of a study field. The research aims to undertake mapping analysis in bibliometric engineering research in the chemical sector utilizing VOSviewer software. This research is expected to help and become a reference for other researchers in conducting and determining the research topics to be pursued, especially in the chemical industry.

2. Materials and Methods

This study uses data from articles that have been published and indexed by Google Scholar. The process of collecting research data using the reference manager software, namely Publish or Perish. Publish or Perish is used in conducting a literature review on the theme under study. Each article data utilized must be indexed by Google Scholar, formatted as a journal article, and backed up into the file used in utilizing VOSviewer. All article data obtained will be filtered and only include articles related to the chemical industry. Researchers searched for data in Publish or Perish using the keyword "Chemical Industry", using title, abstract and keyword criteria in the 2017-2021 timeframe. As a result, 988 articles were obtained and evaluated based on the selected topics. The submitted articles are saved in *.ris format.

VOSviewer software is used to visualize and analyze trends in the form of bibliometric map visualization. We compiled data mapping articles from database sources that had been processed. This study also analyzed the

differences in the number of publications each year and classified the 20 articles with the highest number of citations in each publisher from the 988 articles.

3. Results and Discussion

3.1. Research developments in the Chemical Industry field

Figure 1 depicts the development graph of chemical industry research from 2017 to 2021. The development of chemical engineering research over the last 5 years, namely from 2017 to 2021 continues to decline. This is shown by the number of articles in 2017 as many as 292 articles, decreasing to 247 articles in 2018. The number has decreased again in 2019 to 213 articles, to 161 articles in 2020, and continues to decline to only 75 in 2021.

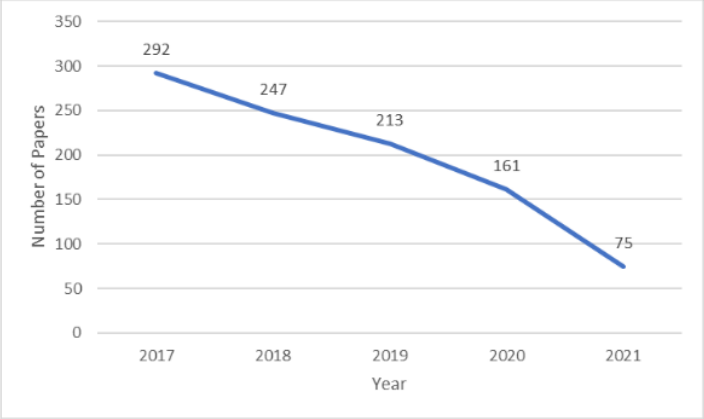

Figure 1. Level of development of research in the chemical industry.

Based on the obtained article data from 2017 to 2021. Table 1 shows the classification of articles related to the chemical industry with the highest number of citations. From Table 1, the most referenced article is "Toxic Capitalism: Corporate Crime and the Chemical Industry," written by Pearce et al. in 2019 and published by taylorfrancis.com, which has 412 citations. The 20th highest article is "Developing a mentoring program in the chemical industry: From conceptual development to implementation follow-up" written by Santos et al. in 2019, published by emerald.com and cited 6 times. On the other hand, a recent article published in 2021 by Shi et al, entitled "Case study on wastewater treatment technology of coal chemical industry in China" did not necessarily occupy the top position. This explains that the age of the article has less influence than other factors, such as relevance and number of citations.

Table 1. Data articles with the highest number of citations in the field of the Chemical Industry

No	Citation Number	Title	Publisher	Year	Authors
1	231	Life cycle assessment for the design of chemical processes, products, and supply chains	annualreviews.org	2020	Kleinekorte, J., et al. [18]
2	412	Toxic Capitalism: Corporate Crime and the Chemical Industry: Corporate Crime and the Chemical Industry	taylorfrancis.com	2019	Lynch, M. J., et al. [19]
3	75	Two decades of laccases: advancing sustainability in the chemical industry	Wiley Online Library	2017	Cannatelli, M. D., & Ragauskas, A. J. [20]
4	65	Consequential life cycle assessment of carbon capture and utilization technologies within the chemical industry	pubs.rsc.org	2019	Thonemann, N., & Pizzol, M. [21]
5	59	Integral assessment of the development of Russia's chemical industry	ceeol.com	2017	Burenina, I., et al. [22]
6	54	R&D cooperation and knowledge spillover effects for sustainable business innovation in the chemical industry	mdpi.com	2018	Hájek, P., & Stejskal, J. [23]
7	53	Risk analysis of French chemical industry	Elsevier	2018	Dakkoune, A., et al. [24]
8	52	Electrification of biotechnology: status quo		2017	Harnisch, F., & Holtmann., D [25]
9	48	Advances and approaches for chemical recycling of plastic waste	Willey Online Library	2020	Thiounn, T., & Smith, R. C [26]
10	36	Carbon dioxide and ethanol from sugarcane biorefinery as renewable feedstocks to environment-oriented integrated chemical plants	Elsevier	2018	Machado C. F. R., et al. [27]
11	35	Specifying technology readiness levels for the chemical industry	ACS Publications	2019	Buchner, G. A., et al. [28]
12	25	Communicating CSR in high profile industries: Case study of Czech chemical industry	dk.upce.cz	2018	Tetřevová, L. [29]
13	24	Prediction of maximum oil-yield from almond seed in a chemical industry: A novel type-2 fuzzy logic approach	journals.co.za	2019	Roy, K., et al. [30]
14	21	Technical Efficiency Chemical Industry in Indonesia: Stochastic Frontier Analysis (SFA) Approach.	search.ebscohost.com	2018	Machmud, A., et al. [15]
15	19	Evaluation of surface water quality in mining and chemical industry	search.proquest.com	2017	Pohrebennyk, V., et al. [31]
16	12	Case study on wastewater treatment technology of coal chemical industry in China	Taylor & Francis	2021	Shi, J., et al. [32]
17	11	Perceived quality and relationship quality as antecedents and predictors of loyalty in the chemical industry: A literature review	core.ac.uk	2018	Samudro, A., et al. [33]
18	10	Renewable hydrogen for the chemical industry	cambridge.org	2020	Rambhujun, N., et al. [34]
19	9	The marketing channel structure: A case of chemical industry company	pen.ius.edu.ba	2019	Bilovodska, O., et al. [35]
20	6	Developing a mentoring program in the chemical industry: From conceptual development to implementation follow-up	emerald.com	2019	Santos, M., et al. [36]

3.2. Visualization of chemical industry topic area using VOSviewer

In the visualization of mapping analysis, the minimum number of relationships between terms in VOSviewer is set by 2 terms [5]. VOSviewer can display bibliometric maps in three different visualizations, which are network visualization, overlay visualization, and density visualization. A colorful circle denotes each term. The size of the circle is related to the number of times the keywords appear in the title and abstract. As a result, the size of the letters and circles is determined by how frequently they occur. The higher the font size and circle, the more frequently the keyword appears.

3.2.1. Network visualization of chemical industry keyword

Network visualization shows the network between visualized terms [5]. Relationships in network visualization are described as networks or lines from one term to another. Figure 2 shows the clusters for each research topic area. From the identification results, it is known that there are 10 main clusters in the network, with a total link strength of 629 and 123 items with the main node "construction industry" in Cluster 1, "chemical industry park" in Cluster 2, "modern chemical industry" in Cluster 3, "chemical engineering" in Cluster 4, "goal chemical industry" in Cluster 5, "chemical plant" in Cluster 6, "us chemical industry" in Cluster 7, "chemical composition" in Cluster 8, "chemical property" in Cluster 9, and " chemical industry enterprises". approach" in Cluster 10. In addition, the main nodes in this network are identified based on the links they have to other keywords and the frequency with which they appear in 988 articles. Each cluster is marked with a different color.

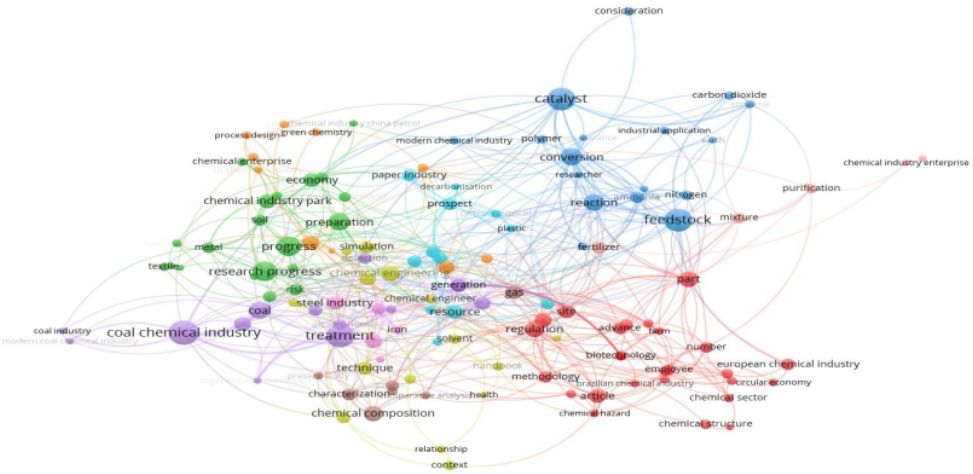

Figure 2. Network visualization of chemical industry keywords.

Research related to the chemical industry based on visualization of mapping analysis is divided into 10 clusters, namely Cluster 1 has 25 items, which are advanced, article, biotechnology, Brazilian chemical industry, chemical company, chemical environment, chemical hazard, chemical manufacturing, chemical sector, chemical structure, chemical industry, circular economy, construction, construction industry, effectiveness, employee, european chemical industry, methodology, number, overview, part, place, regulation, site, and term. Figure 3 below is a network visualization of cluster 1. "Regulation" is the major node in Cluster 1, and it connects to a total of 25 nodes.

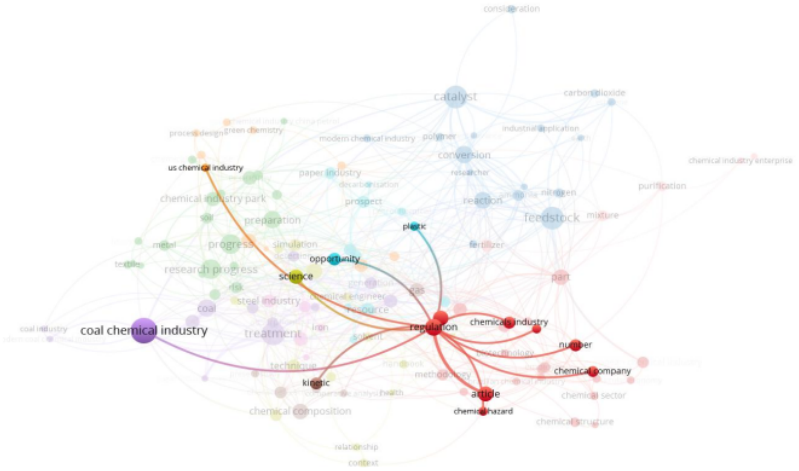

Figure 3. Network visualization of cluster 1.

Cluster 2 has 20 items, which are automotive industry, chemical enterprise, chemical industry china, chemical industry park, chemical product, development trend, economy, environmental impact, heavy chemical industry, heavy industry, implementation, metal, petroleum, preparation, progress, research progress, risk, risk assessment, soil, and textile. As shown in Figure 4, "progress" is the major node in Cluster 2.

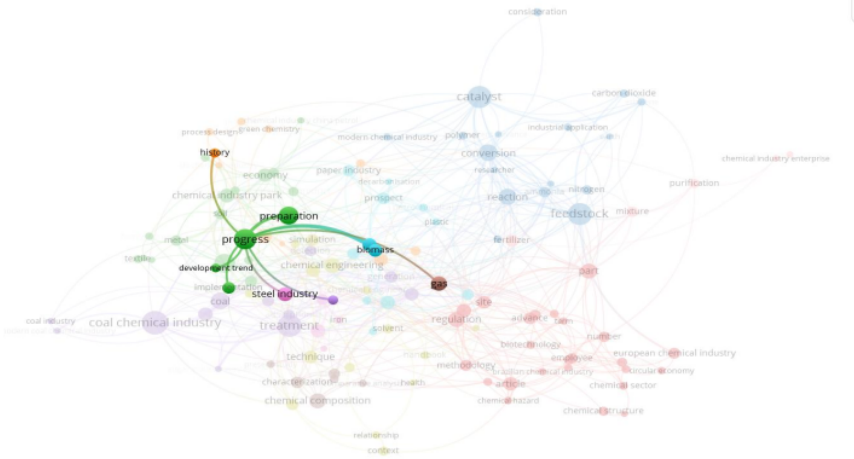

Figure 4. Network visualization of cluster 2.

Cluster 3 has 17 items, which are ammonia, carbon dioxide, catalyst, consideration, conversion, earth, ethylene, feedstock, industrial application, methane, methanol, modern chemical industry, nitrogen, polymer, reaction, recent advance, and researcher. Figure 5 shows the network visualization of cluster 3. As shown in Figure 5, "feedstock" is the major node in Cluster 3. Cluster 4 has 15 items, which are chemical engineer, chemical engineering, context, handbook, hazardous chemical, health, investigation, modeling, platform, pollution, relationship, science, simulation, solvent, and technique. As shown in Figure 6, "chemical engineering" is the major node in Cluster 4 and it connects to a total of 15 nodes.

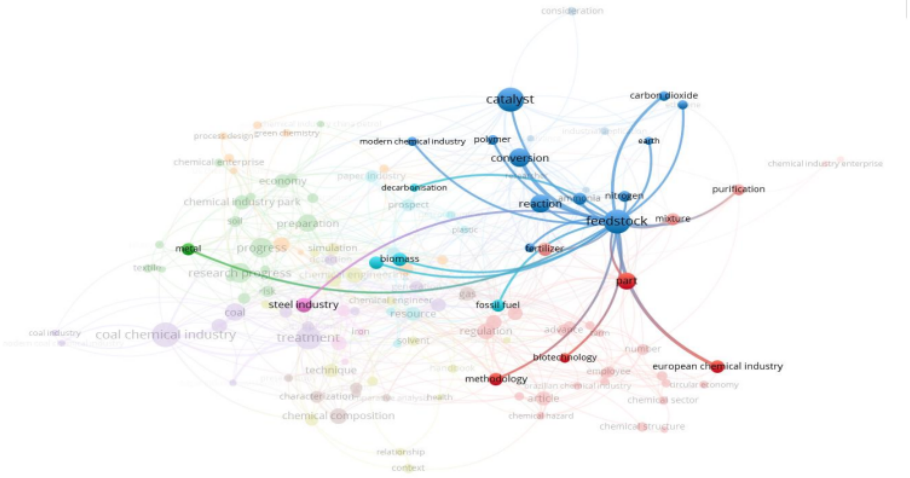

Figure 5. Network visualization of cluster 3

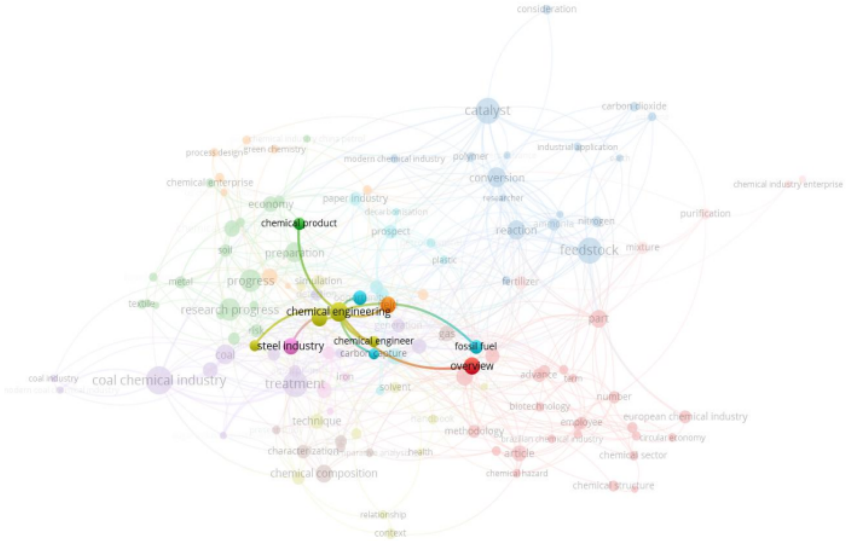

Figure 6. Network visualization of cluster 4

Cluster 5 has 13 items, which are adsorption, amount, chemical oxygen demand, chemical treatment, coal, coal chemical industry, coal industry, detection, generation, modern coal chemical industry, removal, sugar industry wastewater, and treatment. As shown in Figure 7, “chemical engineering” is the major node in Cluster 5. Cluster 6 has 12 items, which are biomass, carbon capture, chemical plant, decarbonisation, fossil fuel, global chemical industry, opportunity, paper industry, petro chemical, plastic, prospect, and resource. Figure 8 shows the network visualization of cluster 6. As shown in Figure 8, “chemical plant” is the major node in Cluster 6. Cluster 7 has 10 items, which are cellulose, evolution, field, green chemistry, history, principle, process design, sustainable development, textile industry, and US chemical industry. As shown in Figure 9, “chemical plant” is the major node in Cluster 7.

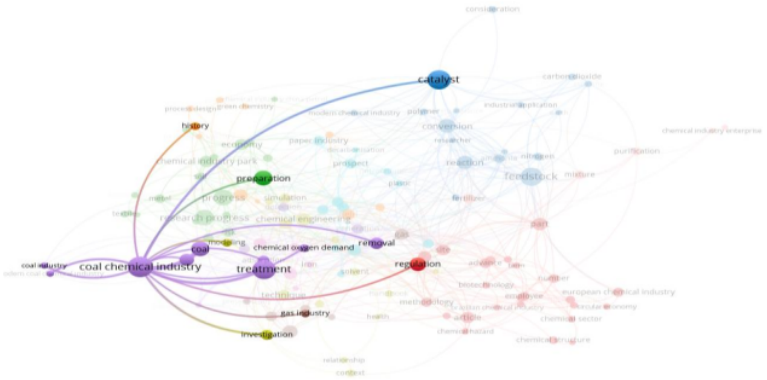

Figure 7. Network visualization of cluster 5

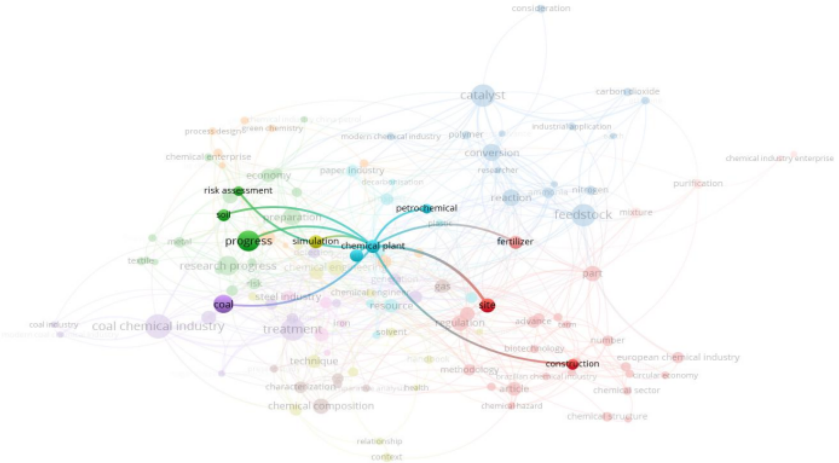

Figure 8. Network visualization of cluster 6

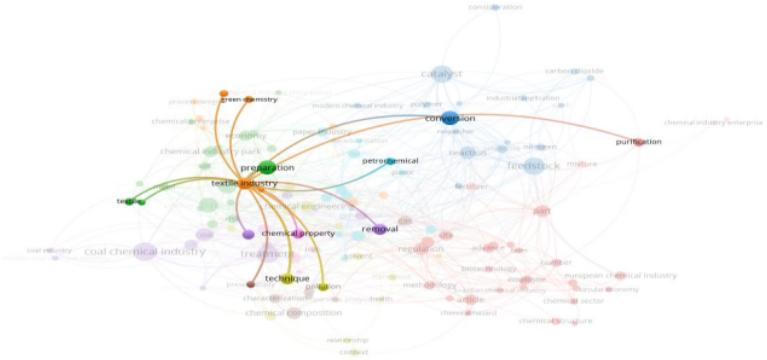

Figure 9. Network visualization of cluster 7

Cluster 8 has 7 items, which are characterization, chemical composition, comparative analysis, gas, industrial gas, kinetic, and the present study. Figure 10 shows the network visualization of cluster 8. As shown in Figure 10, "chemical composition" is the major node in Cluster 8. Cluster 9 has 5 items, which are chemical property, influence, iron, physicochemical property, and steel industry. Figure 11 shows the network visualization of cluster 9. As shown

in Figure 11, “influence” is the major node in Cluster 9. Cluster 10 has 5 items, which are chemical industry enterprise, fertilizer, mixture, profitability, and purification. Figure 12 shows the network visualization of cluster 10. As shown in Figure 12, “influence” is the major node in Cluster 10.

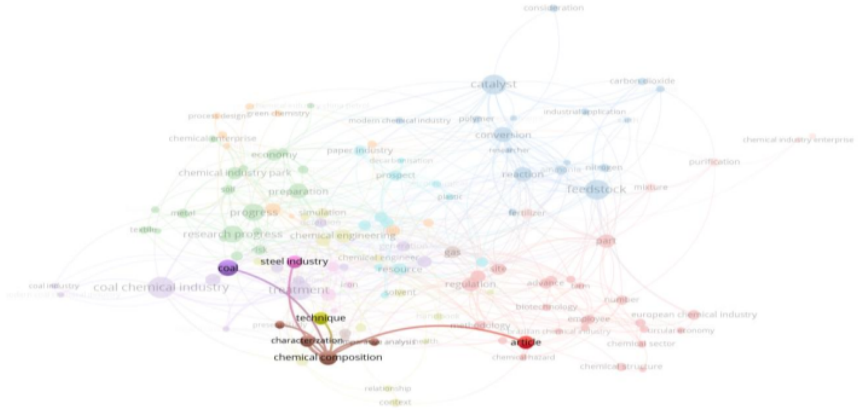

Figure 10. Network visualization of cluster 8

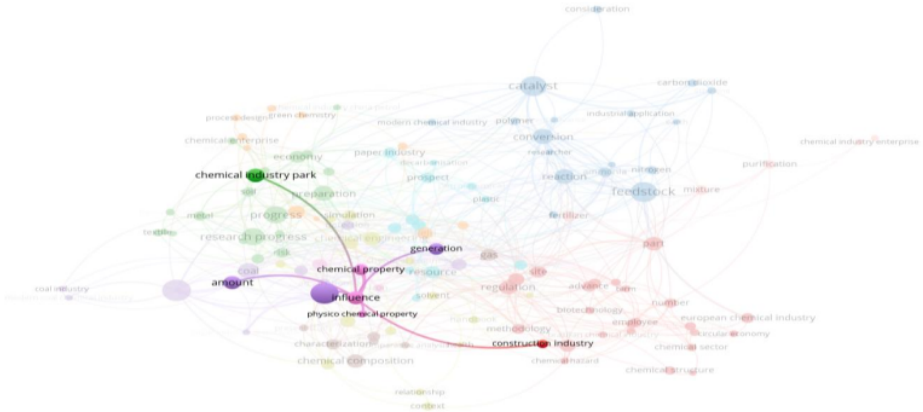

Figure 11. Network visualization of cluster 9

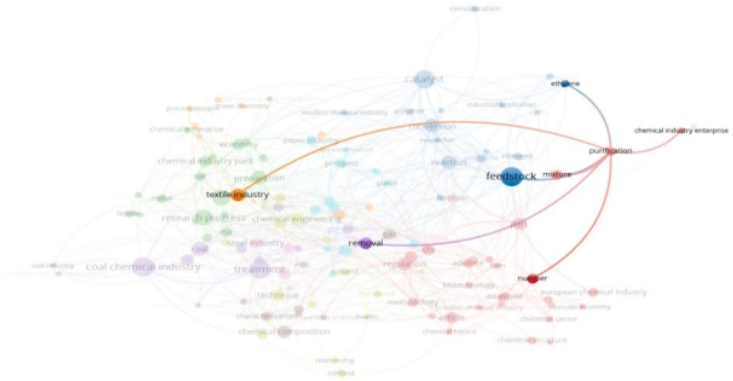

Figure 12. Network visualization of cluster 10

3.2.2. Overlay visualization of chemical industry keyword

Overlay visualization describes the relationship between terms that are categorized based on the time the research was conducted [5]. Figure 13 shows research trends related to the chemical industry in the range of 2017 – 2021.

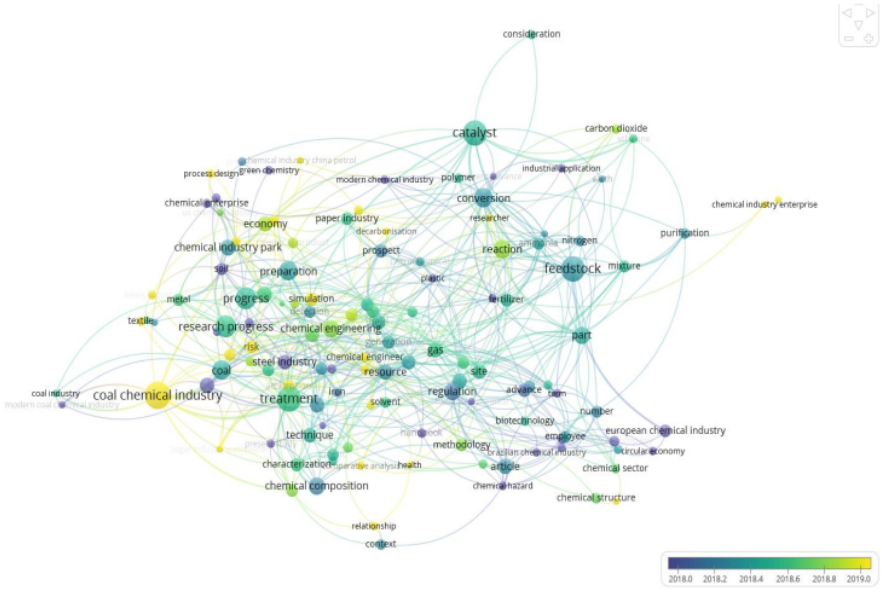

Figure 13. Overlay visualization of chemical industry Keyword

3.2.3. Density visualization of chemical industry keyword

The density visualization in Figure 14 shows the lighter the yellow color, the larger the diameter of the circle, and the denser the keywords, the more often the research is carried out. On the other hand, if the color fades, the fewer the number of studies conducted [5]. This result also confirms the effectiveness of bibliometric analysis [37-53] to explore and visualize the current literature that can be used for deciding whether further research be done. Figure 14 shows the materials that have the most number of studies carried out, such as the keywords chemical engineering, feedstock, coal chemical industry, research progress, and others.

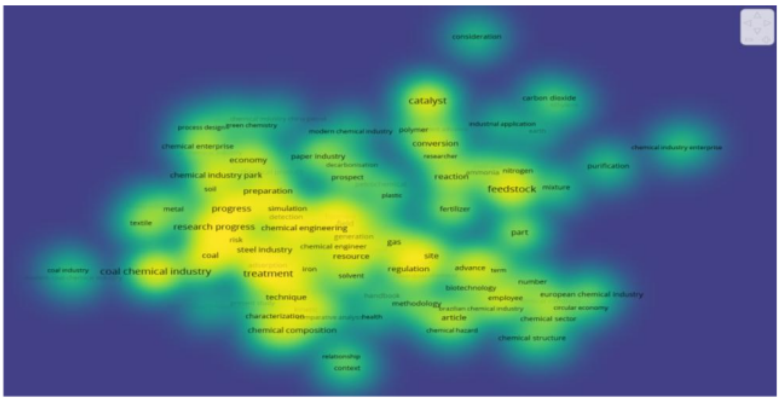

Figure 14. Density visualization of chemical industry keyword

Conclusion

The goal of this study is to conduct bibliometric research in the chemical business by integrating mapping visualization analysis using VOSviewer software and Publish or Perish. Data collection focused on a topic area including titles, abstracts, and keywords based on the keyword "chemical industry." Based on the search results, 988 relevant publications published between 2017 and 2021 were found. Following that, the visualization process is divided into three forms of visualization utilizing VOSviewer, namely network visualization, overlay visualization, and density visualization. According to the mapping results, research on the chemical sector continues to decline from 2017 to 2020. This research is expected to help and become a reference for other researchers to conduct and choose related research topics.

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