Bibliometric Mapping Analysis of Scientific Publications in Chemistry on Cerium Oxide Nanoparticles Using Vosviewer

Anisa Klarasita [1*], Asep Bayu Dani Nandiyanto [2], Tedi Kurniawan [3]

[1,2] *Universitas Pendidikan Indonesia, Indonesia*
[3] *Community College of Qatar*

[*] E-mail: *anisaklarasita@upi.edu*

Abstract: This study aims to look at the advancement of scientific publications related to cerium oxide nanoparticles through a bibliometric approach using qualitative methods with descriptive statistics on literature studies on scientific articles. Two types of software are used: Publish or Perish and VOSviewer. Publish or Perish is used as a source to search for various relevant articles through the Google Scholar database, using the keyword "Cerium Oxide Nanoparticle," and obtained 997 articles from 2012 to 2022. The results show that 2012 and 2013 were fairly constant, increasing from 2014 to 2016, fluctuating from 2017 to 2020, and decreasing in 2021 and 2022. Data from Publish or Perish is inputted into VOSviewer to visualize and analyze mapping trends related to cerium oxide nanoparticles, obtaining 7 clusters of 189 items. The popularity of the terms used in scientific publications related to cerium oxide nanoparticles during the last three years has become less trending. This study concludes that there are still opportunities for future researchers to develop or even make discoveries related to cerium oxide nanoparticles.

Keywords: bibliometric, CeO_2, cerium oxide nanoparticle, VOSviewer.

INTRODUCTION

A science developing rapidly at this time can occur due to the results of the scientific research process carried out previously in various forms of publication media, one of which is scientific journals. Scientific journals are essential primary sources of information because they contain research results by experts in their fields (Rahayu & Saleh, 2017). Various scientific journal topics can be accessed through the features of Google called Google Scholar. One of the functions of scientific journals is to make it easier for further researchers to obtain specific data. Indonesian scientific journals have now been published in various scientific fields, one of which is in the field of science. The research results in science have resulted in various developments and discoveries. Chemistry is another field of science (Baffou & Quidant, 2014) that has attracted the attention of many researchers. Nanotechnology is a part of the field of chemistry (Jahangirian et al., 2017). Nanotechnology is proliferating due to its wide application in science and technology. Several rules have been used to produce nanoparticles because they have significant functions in various fields (Usman et al., 2019). Nanotechnology

129

is the study of particles with diameters ranging from 1 to 100 nm. These particles are known as nanoparticles, and they have distinct electronic, magnetic, optical, and mechanical properties that distinguish them from bulk materials (Singh et al., 2020).

Cerium oxide nanoparticles are part of the nanoparticles that have piqued the interest of researchers. Cerium (IV) oxide (CeO_2) is an oxide of the rare earth metal cerium. It is also known as cerium, ceric oxide, cerium dioxide, or cerium oxide has received a lot of attention in recent years, especially for the nanomaterial cerium oxide (nanoceria), which is widely used because of its high bioactivity and unique redox chemistry. (Pulido-Reyes et al., 2017). Nanoceria is used in cosmetics products, instruments, consumer products, and high-tech products for commercial purposes (Rajeshkumar & Naik, 2018). Several scientific journals have published publications on cerium oxide nanoparticles on various topics. A particular method is needed to determine the development of scientific journal publications known as bibliometric studies.

Bibliometrics is a branch of information science that was introduced in 1960. Bibliometric terminology comes from mathematics and calculus/statistics, which are then systematically used in the library field (Rahayu & Tupan, 2020). Bibliometrics has gotten to be an basic device for evaluating and analyzing the yield of researchers (Moral-muñoz et al., 2020). Bibliometric analysis is one way to observe research trends from various published articles (Mubarrok & Rahmawati, 2020). Bibliometric analysis about could be a procedure utilized to supply the structure of an arrangement that addresses questions, such as what the most subjects in a specific field of science are, how a specific point creates over time, and how these points relate to one another (Waltman et al., 2010).

A bibliometric analysis was carried out to discover the development of scientific journal publications regarding cerium oxide nanoparticles. The topics of articles that have published and discussed nanoparticles in their bibliometric analysis include Bibliometric Analysis of Magnetite Nanoparticles and Bibliometric Analysis of Titanium Dioxide Nanoparticles. Due to the absence of scientific publications discussing the bibliometric analysis of cerium oxide nanoparticles, the author tries to carry out a bibliometric analysis of cerium oxide nanoparticles. This study aims to examine the development of trends in scientific publications related to cerium oxide nanoparticles to be used as a reference for further researchers to develop or produce discoveries on cerium oxide nanoparticles.

METHOD

The research utilized a subjective strategy such as qualitative method, with descriptive statistics on literature studies on scientific articles (Mubarrok & Rahmawati, 2020) related to cerium oxide nanoparticles. Qualitative research is carried out to find the depth of a phenomenon and find a series of variables inductively (Raco, 2018). The main characteristics of qualitative research are problem exploration, factor identification, and theory formulation. Quantitative research is characterized by structuring the relationship between factors or clarifying the relationship between factors (Bimbingan & Konseling, 2016).

Meanwhile, descriptive statistics are used to present data in tables or graphs (Mubarrok & Rahmawati, 2020). Descriptive statistics are utilized to analyze information by portraying or depicting the information collected (Janna, 2020).

Scientific publication data related to cerium oxide nanoparticles are obtained by accessing Publish or Perish (POP) application. This application has experienced advancements and upgrades, it was presented in October 2006. This app is planned to assist scholastics (people) display research's affect indeed in case it has few citations. In expansion, it can moreover be utilized to choose which journals to submit, conduct literature reviews, plan for work interviews, and conduct bibliometric inquiries about (Aulianto et al., 2019). The Google Scholar database is used to find information related to published scientific journals discussing cerium oxide nanoparticles by entering the phrase "cerium oxide nanoparticle" in the keyword search field and setting the publication time range from 2012 to 2022.

The data was obtained in the format (*.csv) and (.ris). The contents of the file with the format (*.csv) include the author's name, title, year, journal name, publisher, number of citations, article links, and related URLs. The data is separated based on the year of publication. It is then plotted and visualized in a graph of the year of publication against the number of publications. The publication data file obtained in the format (.ris) is inputted into an application called VOSviewer, which is then analyzed for bibliometric mapping. Sifted terms will be included within the visualization of the network mapping (Nandiyanto et al., 2021) to make them more relevant. Three types of mapping were from the VOSviewer application: network visualization, density visualization, and overlay visualization. VOSviewer was used to visualize and analyze mapping trends related to cerium oxide nanoparticles. The target people of this research are future researchers who want to discuss cerium oxide nanoparticles.

RESULTS AND DISCUSSION
Publication data search results

Based on data search through the Publish or Perish reference manager application using the Google Scholar database, Google Scholar is used because it can be accessed for free. Google Scholar is a service that allows users to search for various information, especially scientific information related to lessons, in the form of texts in various publication formats through analysis of research themes/topics and research methods. Using the keyword "cerium oxide nanoparticle," 997 articles related to cerium oxide nanoparticles were obtained. The matrices include the 36021 total number of citations; 3602.10 citations per year; 36.13 citations per paper; 4.00 average writers per paper; h-index 91; g-index 143. The data is a Microsoft Excel file with format (*.csv) containing the author's name, title, year, journal name, publisher, number of citations, article links, and related URLs. The information is used to explore the influential researchers, the author's affiliation or institution, co-authorship, the most cited articles, and the most widely used keywords (Aribowo, 2019). Table 1 shows the five articles with the best citations that discuss cerium oxide nanoparticles.

Table 1. Best citations for cerium oxide nanoparticle

Title	Year	Cites	Ref.
Environmental geochemistry of cerium: applications and toxicology of cerium oxide nanoparticles	2015	290	(Dahle & Arai, 2015)
Effect of cerium dioxide, titanium dioxide, silver, and gold nanoparticles on the activity of microbial communities intended in wastewater treatment	2012	240	(García et al., 2012)
Cerium oxide nanoparticles: potential applications for cancer and other diseases	2013	226	(Wason & Zhao, 2013)
Effect of surface coating and organic matter on the uptake of CeO2 NPs by corn plants grown in soil: Insight into the uptake mechanism	2012	214	(Zhao et al., 2015)
Effect of cerium oxide nanoparticles on the quality of rice (Oryza sativa L.) grains	2013	204	(Rico et al., 2013)

Research development in the field of Cerium oxide nanoparticles

Based on information gotten from Publish or Perish, the number of published articles on cerium oxide nanoparticles from 2012 to 2022. Internet network is used when accessing Publish or Perish, that can run on Windows, Macintosh, Linux systems (Aulianto et al., 2019). Publish or Perish is used to conduct a literature review on the chosen theme to obtain a database with similar research themes (Al Husaeni & Nandiyanto, 2021). The data are separated by year of publication to facilitate the data analysis process. The number of publications each year can be determined by using the count number feature in Microsoft Excel software. Table 2 shows the development of publications on cerium oxide nanoparticles.

Table 2. Data on the development of the number of articles published on cerium oxide nanoparticles

Year of Publication	Number of Publication
2012	58
2013	58
2014	62
2015	85
2016	89

2017	83
2018	125
2019	101
2020	143
2021	126
2022	65
Total	995
Average	165,8

In 2012 and 2013, the number of articles published on cerium oxide nanoparticles was 58. In 2014, 62 articles were published. A total of 85 articles, 89 articles, 83 articles, 125 articles, 101 articles, 143 articles, 126 articles, and 65 articles were published from 2015 to 2022, respectively. The publication data are plotted and visualized with the graph shown in Figure 1. Figure 1 shows that the number of publications from 2012 to 2022 is not always constant. Only 2012 and 2013 have the same number of publications. The number of publications from 2014 to 2016 has increased, fluctuated from 2017 to 2020, and decreased in 2021 and 2022. In 2022 it has decreased because, in that year, it has not reached the end of the year.
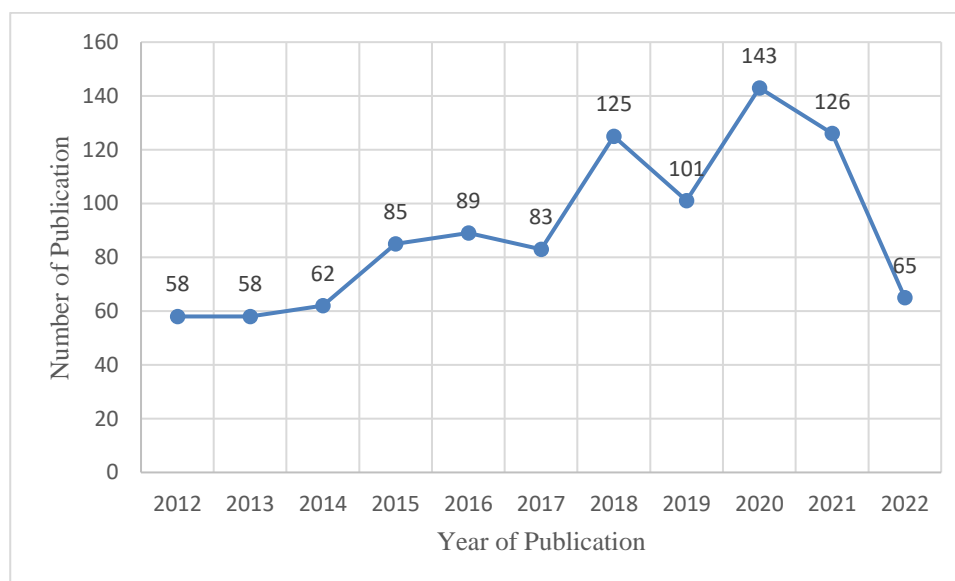
Figure 1. Number of published articles on cerium oxide nanoparticles

Visualization of Cerium Oxide nanoparticles topic area using VOS viewer

The trend of mapping scientific journal publications related to cerium oxide nanoparticles is visualized using VOSviewer with three mapping variations: network visualization, overlay visualization, and density visualization. The relationship between terms visualized by network visualization found in scientific publications related to cerium oxide nanoparticles which are described by an interconnected network with different colors (Al Husaeni & Nandiyanto, 2021).

133

From the mapping results, the terms often appear in scientific publications related to cerium oxide nanoparticles are divided into several clusters. Cluster 1 is marked in red, cluster 2 is marked in green, cluster 3 is marked in dark blue, cluster 4 is marked in yellow, cluster 5 is marked in purple, cluster 6 is marked in light blue, and cluster 7 is marked in orange (Nandiyanto et al., 2021). The mapping of research publications related to cerium oxide nanoparticles is divided into 7 clusters, as shown in Figure 2.
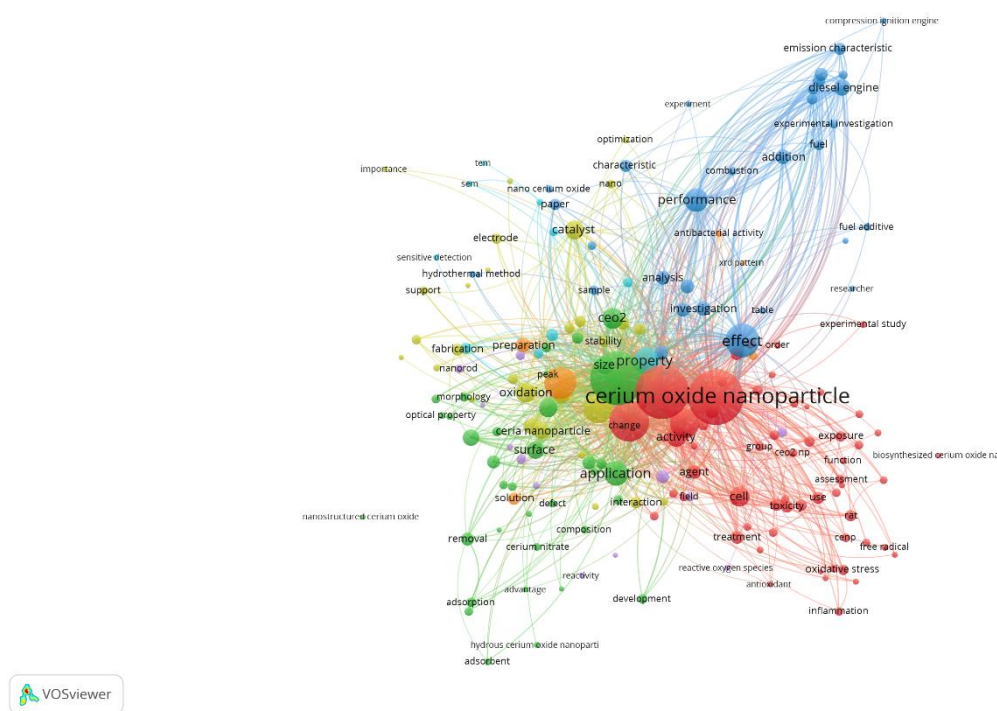

Figure 2. Network Visualization

Cluster 1 has 61 items and is marked in red. The 61 items are accumulation, activity, agent, antioxidant, antioxidant activity, antioxidant property, apoptosis, assessment, biomedical application, biosynthesized cerium oxide nanoparticle, cell, cenp, ceo, ceo2 np, cerium oxide nanoparticle, cerium oxide nanoparticles, cerium oxide np, cerium oxide surface, comparison, concentration, cytotoxicity, disease, efficacy, element, environment, example, experimental study, exposure, expression, form, free radical, function, group, impact, incorporation, inflammation, nanoceria, nanocerium, nanoparticle, order, oxidative stress, oxygen vacancy, potential application, potential use, present study, proliferation, protective effect, rare earth element, rat, ratio, review, role, sepsis, series, study, toxicity, treatment, uptake, use, variety, and vitro.

Cluster 2 has 37 items and is marked in green. The 37 items are adsorbent, adsorption, advantage, application, aqueous solution, catalysis, ceo2, ceo2 nanoparticle, cerium nitrate, cerium oxide, cerium oxide coating, cerium oxide particle, change, chitosan, coating, composition, defect, development, electrolyte, formation, hydrous cerium oxide nanoparticle, magnetic property, mechanism,

microstructure, morphology, nanocomposite, nanostructured cerium oxide, optical property, peak, photocatalytic activity, photocatalytic degradation, present work, removal, size, structural property, surface, and temperature.

Cluster 3 has 31 items and is marked in blue. The 31 items are addition, analysis, biodiesel, cerium oxide nano particle, characteristic, combustion, compression ignition engine, diesel, diesel engine, effect, emission, emission characteristic, engine, experiment, experimental investigation, fuel, fuel additive, growth, hydrothermal method, influence, investigation, nano additive, nano cerium oxide, paper, performance, pure cerium oxide, reduction, researcher, sample, table, and work.

Cluster 4 has 30 items and is marked in yellow. The 30 items are ability, article, catalyst, catalytic activity, catalytic performance, ceria, ceria nanoparticle, cerium, cerium dioxide, cerium dioxide nanoparticle, cerium oxidation state, cerium oxide catalyst, detection, efficient catalyst, electrochemical detection, electrode, fabrication, importance, interaction, nano, nanomaterial, optimization, oxidation, particle, precursor, reaction, stability, structure, support, and synergistic effect.

Cluster 5 has 12 items and is marked in purple. The 12 items are cerium oxide nanorod, cerium oxide nanostructure, degradation, enhanced photocatalytic activity, evaluation, facile synthesis, field, increase, nanorod, reactive oxygen species, reactivity, and research. **Cluster 6** has 11 items and is marked in sky blue. The 20 items are cerium ion, enhancement, inhibition, oxidation state, presence, property, sem, sensitive detection, strategy, tem, and xrd. **Cluster 7** has 7 items and is marked in orange. The 7 items are antibacterial activity, characterization, figure, preparation, solution, synthesis, and xrd pattern. Other visualizations that can be analyzed are overlay visualization shown in figure 3.
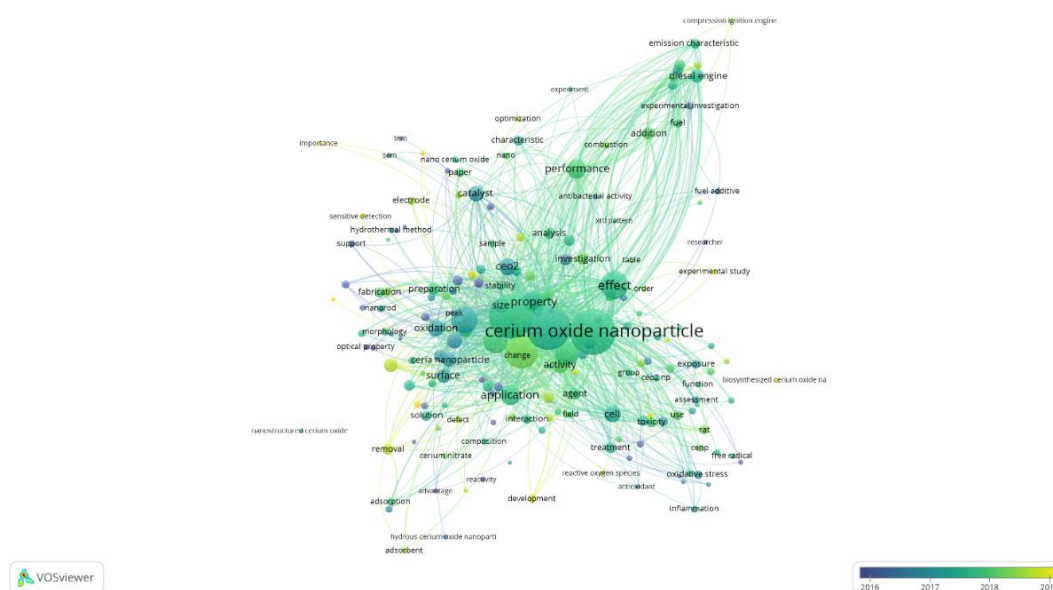

Figure 3. Overlay Visualization

The relationship between terms appears with overlay visualization accompanied by the trend of research time (Al Husaeni & Nandiyanto, 2021). The overlay visualization shows the time difference between each keyword in the dark blue to the yellow color range, with the numbers getting yellower the newer it is (Dhina et al., 2021). Figure 3 shows that scientific publications related to research on cerium oxide nanoparticles have been widely carried out from 2014 to 2019. It shows that during the last three years, the term's popularity in scientific publications of cerium oxide has become less trending. Thus, the next researcher still has the opportunity to do new research related to cerium oxide nanoparticles. Another visualization map obtained is the density visualization shown in Figure 4.

Figure 4. Density Visualization

The density visualization shows that the darker the yellow color and the larger the diameter of the circle, the more dense the keywords are, implying that there is more research on this topic. The number of studies decreases as the colors fade and blend into the green background (Nandiyanto et al., 2021). Figure 4 explains that if the subject has been studied a lot will displayed by larger font and yellower color of the image, it shows that the higher the density. On the other hand, lighter colors and smaller fonts indicate that the subject has not been well studied. (Hanif Batubara et al., 2022). Based on Figure 4, the yellow color is more accessible than the dark yellow color. It shows that scientific publications on cerium oxide nanoparticles can still be developed.

CONCLUSION

Two types of software are used, Publish or Perish and VOSviewer, to analyze the development of scientific publications related to cerium oxide nanoparticles with the Google Scholar database. The publication data were from 2012 to 2022, with cerium oxide nanoparticles as the keyword, and 997 articles were obtained. A

total of 58 articles were published in 2012 and 2013, respectively. They experienced an increase every year from 2014 to 2016, fluctuations from 2017 to 2020, and decrease in 2021 and 2022 (2022 has not yet reached the end of the year). Data from Publish or Perish was inputted into VOSviewer to visualize and analyze mapping trends on cerium oxide nanoparticles and obtained 7 clusters with a total of 189 items. Over the last three years, the term's popularity in scientific publications of cerium oxide has become increasingly popular. Lack of trend creates opportunities to develop or conduct new research related to cerium oxide nanoparticles.

REFERENCE

Al Husaeni, D. F., & Nandiyanto, A. B. D. (2021). 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*(1), 19–46. https://doi.org/10.17509/ajse.v2i1.37368

Aribowo E. (2019). Analisis Bibliometrik Berkala Ilmiah Names: Journal of Onomastics dan Peluang Riset Onomastik di Indonesia. *Aksara*, *31*(1), 91–111.

Baffou, G., & Quidant, R. (2014). Nanoplasmonics for chemistry. *Chemical Society Reviews*, *43*(11), 3898–3907. https://doi.org/10.1039/c3cs60364d

Bimbingan, B., & Konseling, D. A. N. (2016). Metode Penelitian Kualitatif dalam Bidang Bimbingan dan Konseling. *Jurnal Fokus Konseling*, *2*(2). http://ejournal.stkipmpringsewu-lpg.ac.id/index.php/fokus/a

Dahle, J. T., & Arai, Y. (2015). Environmental geochemistry of cerium: Applications and toxicology of cerium oxide nanoparticles. *International Journal of Environmental Research and Public Health*, *12*(2), 1253–1278. https://doi.org/10.3390/ijerph120201253

Dhina, M. A., Abdullah, A. G., Hadisoebroto, G., & Mubaroq, S. R. (2021). Visualization of performance assessment research to support education computing in the laboratory. *IOP Conference Series: Materials Science and Engineering*, *1098*(6), 062005. https://doi.org/10.1088/1757-899x/1098/6/062005

Dwi Ridho Aulianto, Pawit M Yusup, & Yanti Setianti. (2019). Pemanfaatan Aplikasi "Publish Or Perish" Sebagai Alat Sitasi Pada Jurnal Kajian Komunikasi Universitas Padjajaran. *Seminar Nasional MACOM III Universitas Padjajaran 2019*, *July*, 873–880.

García, A., Delgado, L., Torà, J. A., Casals, E., González, E., Puntes, V., Font, X., Carrera, J., & Sánchez, A. (2012). Effect of cerium dioxide, titanium dioxide, silver, and gold nanoparticles on the activity of microbial communities

intended in wastewater treatment. *Journal of Hazardous Materials*, *199–200*, 64–72. https://doi.org/10.1016/j.jhazmat.2011.10.057

Hanif Batubara, I., Saragih, S., Syahputra, E., Armanto, D., Sari, I. P., Lubis, B. S., Febri, E., & Siregar, S. (2022). Mapping Research Developments on Mathematics Communication: Bibliometric Study by VosViewer. *Jurnal Pendidikan*, *14*(3), 2637–2648. https://doi.org/10.35445/alishlah.v14i1.925

Jahangirian, H., Lemraski, E. G., Webster, T. J., Rafiee-Moghaddam, R., & Abdollahi, Y. (2017). A review of drug delivery systems based on nanotechnology and green chemistry: Green nanomedicine. *International Journal of Nanomedicine*, *12*, 2957–2978. https://doi.org/10.2147/IJN.S127683

Janna, N. M. (2020). Variabel dan skala pengukuran statistik. *Jurnal Pengukuran Statistik*, *1*(1), 1–8.

Moral-muñoz, J. A., Herrera-viedma, E., Santisteban-espejo, A., Cobo, M. J., Herrera-viedma, E., Santisteban-espejo, A., & Cobo, M. J. (2020). *77520-Texto del artículo-249046-3-10-20200304.pdf*. 1–20.

Mubarrok, U. S., & Rahmawati, Z. (2020). Analisis Bibliometrik Perkembangan Penelitian Bank Wakaf. *Malia (Terakreditasi)*, *12*(1), 17–28. https://doi.org/10.35891/ml.v12i1.1938

Nandiyanto, A. B. D., Al Husaeni, D. N., & Al Husaeni, D. F. (2021). A bibliometric analysis of chemical engineering research using vosviewer and its correlation with Covid-19 pandemic condition. *Journal of Engineering Science and Technology*, *16*(6), 4414–4422.

Pulido-Reyes, G., Martín, E., Gu. Coronado, J. L., Leganes, F., Rosal, R., & Fernández-Piñas, F. (2017). Physicochemical and biological interactions between cerium oxide nanoparticles and a 1,8-naphthalimide derivative. *Journal of Photochemistry and Photobiology B: Biology*, *172*, 61–69. https://doi.org/10.1016/j.jphotobiol.2017.05.009

Raco, J. (2018). *Metode penelitian kualitatif: jenis, karakteristik dan keunggulannya*. https://doi.org/10.31219/osf.io/mfzuj

Rahayu, R. N., & Tupan, T. (2020). Studi Bibliometrik Artikel Jurnal Perpustakaan Pertanian Periode 2013–2017. *Jurnal Perpustakaan Pertanian*, *27*(2), 44. https://doi.org/10.21082/jpp.v27n2.2018.p44-50

Rahayu, S., & Saleh, A. R. (2017). Studi Bibliometrik dan Sebaran Topik Penelitian pada Jurnal Hayati Terbitan 2012-2016. *Pustakaloka*, *9*(2), 201. https://doi.org/10.21154/pustakaloka.v9i2.1092

Rajeshkumar, S., & Naik, P. (2018). Synthesis and biomedical applications of Cerium oxide nanoparticles – A Review. *Biotechnology Reports*, *17*, 1–5. https://doi.org/10.1016/j.btre.2017.11.008

Rico, C. M., Morales, M. I., Barrios, A. C., McCreary, R., Hong, J., Lee, W. Y.,

Nunez, J., Peralta-Videa, J. R., & Gardea-Torresdey, J. L. (2013). Effect of cerium oxide nanoparticles on the quality of rice (Oryza sativa L.) grains. *Journal of Agricultural and Food Chemistry*, *61*(47), 11278–11285. https://doi.org/10.1021/jf404046v

Singh, K. R. B., Nayak, V., Sarkar, T., & Singh, R. P. (2020). Cerium oxide nanoparticles: Properties, biosynthesis and biomedical application. *RSC Advances*, *10*(45), 27194–27214. https://doi.org/10.1039/d0ra04736h

Usman, A. I., Aziz, A. A., & Noqta, O. A. (2019). Application of green synthesis of gold nanoparticles: A review. *Jurnal Teknologi*, *81*(1), 171–182. https://doi.org/10.11113/jt.v81.11409

Waltman, L., van Eck, N. J., & Noyons, E. C. M. (2010). A unified approach to mapping and clustering of bibliometric networks. *Journal of Informetrics*, *4*(4), 629–635. https://doi.org/10.1016/j.joi.2010.07.002

Wason, M. S., & Zhao, J. (2013). Cerium oxide nanoparticles: Potential applications for cancer and other diseases. *American Journal of Translational Research*, *5*(2), 126–131.

Zhao, L., Peralta-videa, J. R., Varela-ramirez, A., Castillo-michel, H., Li, C., Zhang, J., Aguilera, R. J., Keller, A. A., & Jorge, L. (2015). *mechanism*. *915*, 131–138. https://doi.org/10.1016/j.jhazmat.2012.05.008