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ARTICLE

A Bibliometric Analysis with Computational Mapping Using VOSviewer: Research Development on Anti-Bacterial Activity of Selenium Particles

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A B S T R A C T

This study aims to analyze research trends in the antibacterial activity of selenium particles through a bibliometric approach using VOSviewer. Journal data that is used as a reference is obtained from the Google Scholar database using the publish application or perish reference manager. The title and abstract of the journal used as a guide in the search process by referring to the keyword "antibacterial activity of selenium particles". A total of 993 journals obtained are relevant to the keywords used. The study period used is the last 10 years (2012 to 2022). The results show that the use of selenium particles as anti-bacterial can be divided into 4 terms, namely "selenium particles", "selenium nanoparticles", "antibacterial activity", and "chemistry". The keywords “selenium particle” were associated with 39 links with a total link strength of 212. The keywords “selenium nanoparticles”, “antibacterial activity”, and “chemistry” were associated with 51 links, 53 links, and 40 links, respectively with the total link strength of 875, 1349, and 303. The results of the analysis of the development of the publication of the antibacterial activity of selenium particles in the last 10 years showed a significant increase in the past 3 years (2019-2021). In 2012-2016 there was an increase from 10 publications to 43 publications (in order of 10, 19, 30, 30, 43 each year), although in 2014-2015 there was no increase. In 2017-2019 there was an increase from 63 publications to 94 publications (annual order 63, 91, 94). In 2020-2021 has increased from 204 publications to 233 publications. While the most popular research on the anti-bacterial activity of selenium particles occurred in 2021, as many as 233 studies. The authors examined the published journals on the anti-bacterial activity of selenium particles and their relationship to problems using VOSviewer. This review can be a starting point for research related to other topics.

Keyword: Anti-bacterial activity of selenium particles; Bibliometric; VOSviewer.

INTRODUCTION

Selenium is an element with atomic number 34, has semi-metallic properties. The inorganic forms of selenium are selenate (SeO_4^{2-}) and selenite (SeO_3^{2-}), while the organic forms are selenomethionine and selenocysteine [29]. Selenium can increase production of lymphokine-activated killer cells, macrophages, cytotoxic T cells, and natural killer cells (NK cells) [2].

In the health sector, selenium has been widely studied for its antioxidant, antimicrobial, and antitumor activity [11]. In its antimicrobial activity, selenium can inhibit infections from broad-spectrum bacteria such as E. coli [36], S. aureus [22], P. aeruginosa, and Proteus mirabilis [25]. The mechanism of inhibition of bacterial activity by selenium can be in several ways, namely reduction of oxidative stress [13], non-oxidative mechanism [14], or release of metal ions [24]. Selenium particles and nanoparticles can be synthesized by several methods, namely physical methods (laser ablation [30], ultraviolet radiation [38], and hydrothermal [31]); chemical methods (catalytic reduction, decomposition by acids) [32]; and biological methods (using bacteria [7] or fungi [33]).

One of the analytical techniques that can be used to determine the development of research on the antibacterial activity of selenium particles is through bibliometric analysis. Bibliometric analysis is a form of meta-analysis of research data that can assist researchers in studying

bibliographic content and citation analysis of articles published in journals and other scholarly works.

There have been many studies on bibliometric analysis, including bibliometric analysis in the field of nanoparticle production [21], bibliometric analysis of nanoparticles for medical purposes [26], bibliometric analysis in Covid-19 research [8], bibliometric analysis in pharmaceuticals [28], and bibliometric analysis of selenium removal in drinking water [1].

However, research on computational mapping of bibliometric analysis of published data in the field of anti-bacterial activity of selenium particles that has been carried out specifically to determine research development has not been carried out. Bibliometric analysis for the last 10 years of research in the period 2012 to 2022 by the VOSviewer application.

Therefore, this study was conducted to conduct computational research on mapping bibliometric analysis of articles indexed by Google Scholar using VOSviewer software. This research was conducted with the hope that it can be a reference for researchers to conduct and determine the research themes to be taken, especially those related to the application of selenium particles as anti-bacterial.

METHODS

2.1 Tools

The software used in this research are Microsoft Excel, Publish or Perish reference manager, and VOSviewer.

2.2 Procedure

Journal data used in this study is based on research from publications that have been published in Google Scholar indexed journals. The author chose Google Scholar in this study because the Google Scholar database is an open source for free. To obtain research data, a reference manager application, namely Publish or Perish, is used. The Publish or Perish software was used to conduct a literature review on the selected topic. Detailed information for using and installing software and the process for obtaining data is described in Al Husaeni and Nandiyanto (2022) and detailed information on library search in searching for data on Google Scholar is described in a previous study conducted by Azizah et al. (2021).

The research was conducted through several stages, namely as follows.

a) Collection of publication data using the publish or perish application
b) Processing of bibliometric data for journals that have been obtained using the Microsoft Excel application
c) Computational mapping analysis of bibliometric published data using the VOSviewer application
d) Analysis of computational mapping analysis results

Journal data search in Publish or Perish was used to select publications using the keyword "selenium particles antibacterial activity" based on the requirements of the publication title. The journals used were published from 2012 to 2022. All data were obtained in September 2022. Journals that had been collected and matched the research analysis criteria were then exported into two types of files: research information system (.ris) and comma-separated value (*.csv).

Next, the VOSviewer application is used to visualize and evaluate trends using bibliometric mapping. Journal data from the database is then mapped. VOSviewer is used to create 3 variations of mapping publications, namely network visualization, overlay visualization, and density visualization based on the network (co-citation) between existing items. When creating a bibliometric map, the keyword frequency is set to be found at least 3 times. Therefore, 56 terms and keywords that are less relevant are omitted.

RESULTS AND DISCUSSION

3.1. Publication search results

Based on data searching through the publish or perish reference manager application from the Google Scholar database, 993 journal data were obtained that met the research criteria. The data obtained is in the form of journal metadata consisting of the author's name, title, year, journal name, publisher, number of citations, journal links, and related URLs. Table 1 shows some examples of published data used in the VOSviewer analysis of this study. The data samples taken are the 15 best journals that have the highest number of citations. The number of citations from all journals used in this study is 38047, the number of citations per year is 3804.70, the number of citations per journal is 38.05, the average author in the journals used is 3.92, all journals have an h-index the mean is 90, and the g-index is 159.

3.2. Research development in the field of anti-bacterial activity of selenium particles

Table 2 shows the development of research in anti-bacterial activity of selenium particles published in the Google Scholar indexed journal. Based on the data shown in Table 2, the number of studies on the anti-bacterial activity of selenium particles was 993 journals from 2012-2022. In 2012 there were 10 journals. In 2013 there were 19 journals. In 2014 there were 30 journals. In 2015 there were 30 journals, 2016 there were 43 journals, 2017 there were 63 journals, 2018 there were 91 journals, 2019 there were

Table 1. Data published on the antibacterial activity of selenium particles

No.	Author	Title	Year	Number of publications	Reference
1	Shakibaie et al.	Nano-selenium and its nanomedicine applications: a critical review	2018	307	[9]
2	Shakibaie et al.	Anti-biofilm activity of biogenic selenium nanoparticles and selenium dioxide against clinical isolates of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Proteus mirabilis*	2015	211	[25]
3	Mittal et al.	Quercetin and gallic acid mediated synthesis of bimetallic (silver and selenium) nanoparticles and their antitumor and antimicrobial potential	2014	190	[17]
4	Ramya et al.	Biomedical potential of actinobacterially synthesized selenium nanoparticles with special reference to anti-biofilm, anti-oxidant, wound healing, cytotoxic and anti-viral activities	2015	167	[23]
5	Hosnedlova et al.	A summary of new findings on the biological effects of selenium in selected animal species—a critical review	2017	144	[10]
6	Akar et al.	Investigation of characterization and biofouling properties of PES membrane containing selenium and copper nanoparticles	2013	140	[4]
7	Shoeibi et al.	Biosynthesis of selenium nanoparticles using Enterococcus faecalis and evaluation of their antibacterial activities	2017	134	[27]
8	Lampis et al.	Selenite biotransformation and detoxification by *Stenotrophomonas maltophilia* SeITE02: novel clues on the route to bacterial biogenesis of selenium nanoparticles	2017	118	[12]
9	Zhu et al.	Selenium nanoparticles decorated with *Ulva lactuca* polysaccharide potentially attenuate colitis by inhibiting NF-κB mediated hyper inflammation	2017	112	[39]
10	Li et al.	Inhibitory activity of selenium nanoparticles functionalized with oseltamivir on H1N1 influenza virus	2017	111	[15]
11	Mahmoudvand et al.	Scolicidal effects of biogenic selenium nanoparticles against protoscolices of hydatid cysts	2014	109	[16]
12	Wang et al.	Nanostructured selenium for preventing biofilm formation on polycarbonate medical devices	2012	107	[35]
13	Wadhwani et al.	Green synthesis of selenium nanoparticles using *Acinetobacter sp.* SW30: Optimization, characterization and its anticancer activity in breast cancer cells	2017	105	[34]
14	Zare et al.	Isolation and characterization of a fungus for extracellular synthesis of small selenium nanoparticles	2013	105	[37]
15	Ahmad et al.	Anticancer activity of biostabilized selenium nanorods synthesized by *Streptomyces bikiniensis* strain Ess_amA-1	2015	104	[3]

94 journals, 2020 there were 204 journals, 2021 there were 233 journals, and 2022 there were 176 journals. From the number of publications, research on the antibacterial activity of selenium particles is quite often carried out every year, especially in the last 10 years (2012-2022).

Table 2. Research developments on the antibacterial activity of selenium particles

Year	Number of publications
2012	10,0
2013	19,0
2014	30,0
2015	30,0
2016	43,0
2017	63,0
2018	91,0
2019	94,0
2020	204,0
2021	233,0
2022	176,0
Total	**993,0**
Average	**90,3**

Figure 1 shows the development of research on the antibacterial activity of selenium particles during the last 10 years in the range from 2012 to 2022. Based on Figure 1, it is known that research developments related to the antibacterial activity of selenium particles has increased almost every year, except in 2015. This increase can be seen from the number of publications in 2012 was 10, in 2013 as many as 119, in 2014 as many as 30, in 2016 as many as 43, in 2017 as many as 63, in 2018 as many as 91, in 2019 as many as 94, in 2020 as many as 204, and in 2021 as many as 233. But in 2022 as many as 176. The data shows that the popularity of research on the antibacterial activity of selenium particles tends to increase every year, except in 2015.

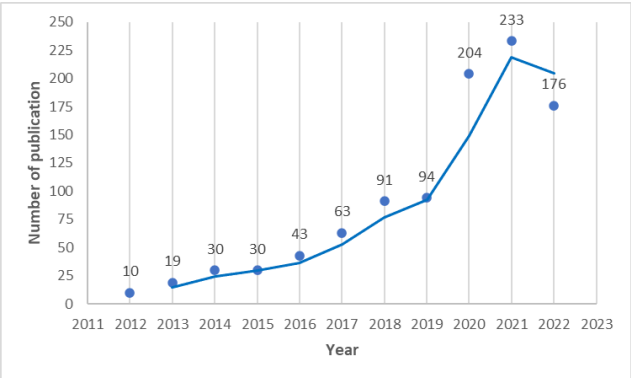

Figure 1. Level of research development of anti-bacterial activity of selenium particles.

3.3. Visualization of the topic area of anti-bacterial activity of selenium particles using VOSviewer

Computational mapping is performed on journal data. VOSviewer is used in computational mapping. From the computational mapping, 56 items were found. Each item found related to the anti-bacterial activity of selenium particles in the data mapping was divided into 7 clusters, namely:

a) Cluster 1 has 14 items and is marked with red color, the 14 items are anti inflammatory activity, antibacterial property, anticancer, anticancer activity, anticancer property, biosynthesis, chemical composition, chemical method, inhibition, medical application, nanocomposite, selenium nanoparticle, toxic chemical, and vitro antibacterial activity.

b) Cluster 2 has 11 items and is marked in green, the 11 items are anti bacterial activity, antibacterial property, antimicrobial effect, application, cell, chemical, nanotechnology, particle, review, treatment, and use.

c) Cluster 3 has 10 items and is marked in blue, the 10 items are antibacterial effect, antitumor activity, characterization, chemistry, combination, selenium, selenium particle, size, structure, and synthesis.

d) Cluster 4 has 8 items and is marked in yellow, the 8 items are antifungal activity, antimicrobial activity, bacterium, catalytic activity, extract, green synthesis, nanoparticle, and pathogenic bacterium.

e) Cluster 5 has 6 items and is marked with purple color, the 6 items are activity, antimicrobial property, evaluation, photocatalytic activity, property, and selenium dioxide.

f) Cluster 6 has 5 items and is marked with a sky blue color, the 5 items are antibacterial activity, antibacterial performance, chemical property, effect, and particle size.

g) Cluster 7 has 2 items and is marked with orange color, the 2 items are study and wound healing application.

The relationship between one term and another is shown in each existing cluster. Labels are assigned to each term with colored circles. The size of the circle for each term varies depending on the frequency of occurrence of the term [19]. The size of the label circle shows a positive correlation with the occurrence of terms in the title and abstract [20]. The more often the term is found, the larger the label size [5]. The mapping visualization analyzed in this study consists of 3 parts: network visualization (see Figure 2), overlay visualization (see Figure 3), and density visualization (see Figure 4).

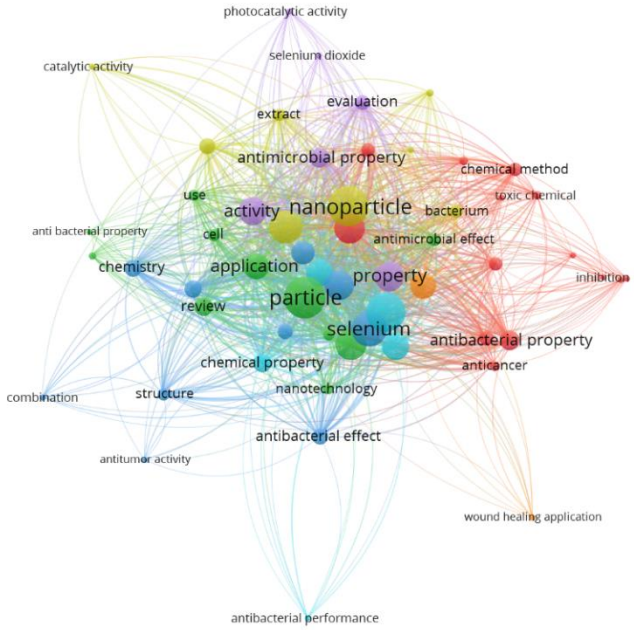

Figure 2. Network visualization keywords anti-bacterial activity of selenium particles.

Figure 2 shows the relationship between the terms. Relationships between terms are defined in a network of interconnectedness. Figure 2 shows the clusters of each term that is frequently researched and related to the topic of research on the antibacterial activity of selenium particles. From the clusters contained in the network visualization, the anti-bacterial activity of selenium particles can be separated into 4 areas, namely the term particle which is included in cluster 2 with a total of 54 links, 1643 total link strength, and 401 events (see Figure 5). The second term is selenium which belongs to cluster 3 with a total of 51 links, a total link strength of 1174, and 289 events (see Figure 6). The third term is nanoparticle which belongs to cluster 4 with a total of 53 links, a total link strength of 1658, and 365 occurrences (see Figure 7). And the fourth term is antibacterial activity which is included in cluster 6 with a total of 53 links, a total link strength of 1349, and 346 events (see Figure 8).

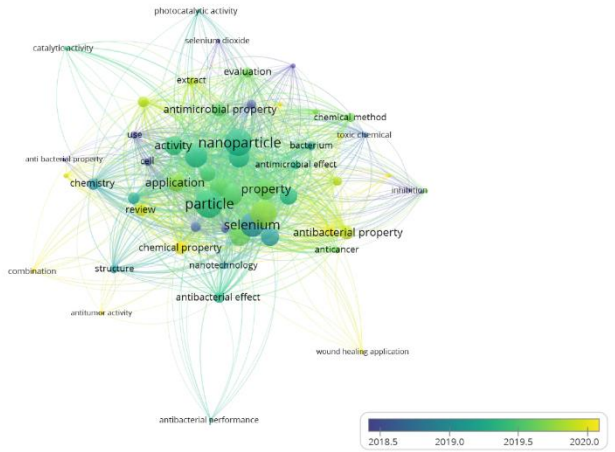

Figure 3. Overlay visualization keywords anti-bacterial activity of selenium particles.

Figure 3 shows the visualization of the overlay in the study of the antibacterial activity of selenium particles. This visualization overlay shows the novelty of research on related terms [5]. Figure 3 which is explained in Figure 9 shows that research on the antibacterial activity of selenium particles has been carried out from 2019 to 2020. The time for the popularity of the term anti-bacterial activity of selenium particles in research has been quite long. Thus, we can easily make new research on the antibacterial activity of selenium particles.

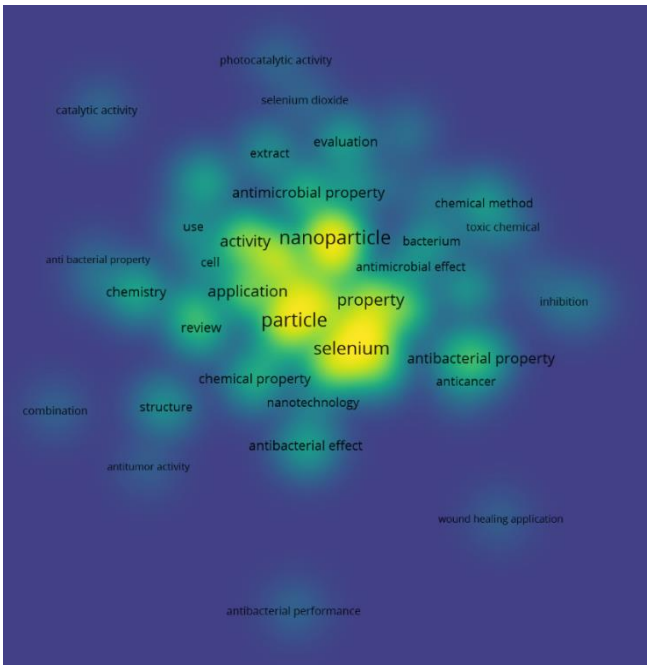

Figure 4. Density visualization keywords anti-bacterial activity of selenium particles.

Figure 4 shows the density visualization. Density visualization means that the brighter the yellow color and the larger the circle diameter of the term label, the more often the term appears [18]. This means that a lot of research on related terms has been done. On the other hand, if the color of the term fades closes to the background color, then the number of studies on the term is small. Based on Figure 4, research related to the term, selenium, particle, property, application, activity, and nanoparticle has a high number of studies.

Figure 5 shows a network of particle relationships with other terms, namely nanotechnology, use, anti-bacterial property, chemistry, and review. Figure 6 shows the network of relationships between the term selenium and existing terms, including antibacterial effect, antitumor activity, structure, combination, and chemistry. Figure 7 shows the network of relationships between the term nanoparticle and existing terms, including antimicrobial property, extract, and catalytic activity. While Figure 8 shows a network of relationships between the antibacterial activity term, which are related to the terms, effect, structure, combination, size, antibacterial effect, chemical property, and antibacterial performance.

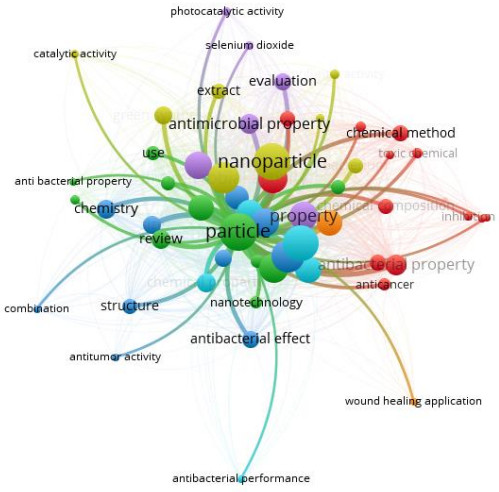

Figure 5. Network visualization of particle term.

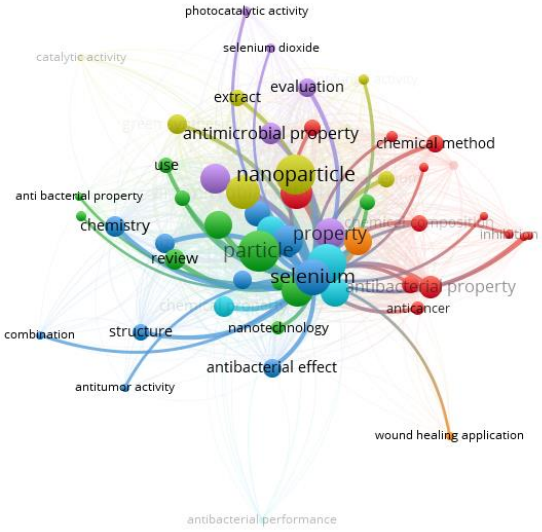

Figure 6. Network visualization of selenium term.

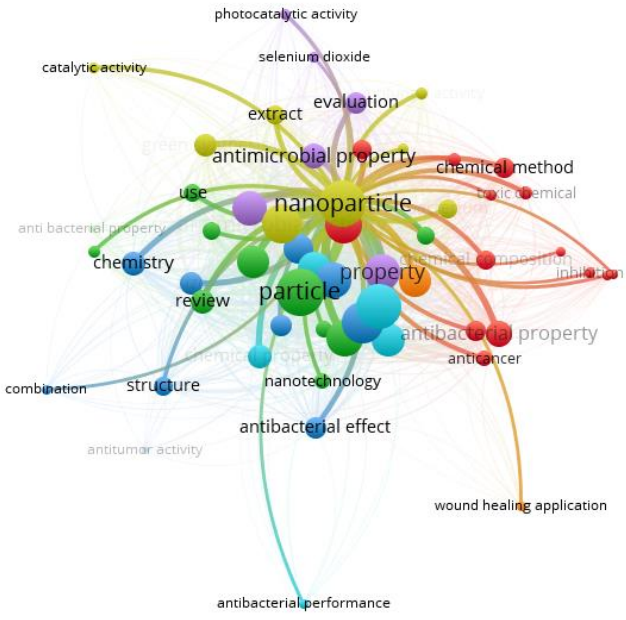

Figure 7. Network visualization of nanoparticle term.

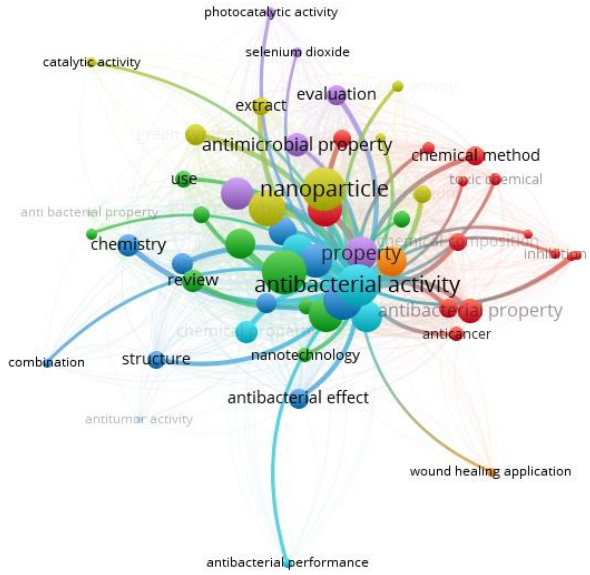

Figure 8. Network visualization of antibacterial activity term.

From these data, the antibacterial activity of selenium particles is still slightly associated with other terms. From the mapping results, the antibacterial activity of selenium particles only has 78 links and is connected to 16 terms. In contrast to the fields of particle, selenium, and nanoparticles, which tend to have a high degree of relevance and are often associated with various terms. It can be concluded that the field of anti-bacterial activity of selenium particles is still very likely to be researched and associated with other terms, this will have a higher impact on the novelty of research.

Based on the results of mapping the collected article data, the keyword anti-bacterial activity of selenium particles is still rarely used in research. Most studies only use terms or fields related to selenium particle and selenium nanoparticle. From the results of this study, we can look for research on the anti-bacterial activity of selenium particles that is newer and up to date.

CONCLUSION

The purpose of this study was to analyze the antibacterial activity of selenium particles using a bibliometric approach using VOSviewer. The publication topic taken in this study is "antibacterial activity of selenium particles". The journals used are taken from the Google Scholar database via Publish or Perish. The library data used in this study include titles and abstracts. From the search results, as many as 993 relevant articles were published in the range of 2012 to 2022. The results showed that the antibacterial activity of selenium particles increased significantly from 2016 to 2021, experienced a less significant increase in 2012 to 2015, and did not experience a change in the number of in 2015 to 2016. The results show that research opportunities on the anti-

bacterial activity of selenium particles still have a high enough chance and are related to other terms.

AUTHOR'S CONTRIBUTION

TDV conducts literature studies, analyses data using software, and compiles articles. ABDN guides in the preparation of articles and teaches how to operate the publish or perish reference manager and VOSviewer.

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