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Research Article

A Bibliometric Evaluation of Global Research Trends in Microbial Silver Nanoparticle Synthesis and Medical Uses

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Abstract

Nowadays, scientists are getting highly interested in silver nanoparticles (AgNPs) made through microbes because they work amazingly well against bacteria and have huge medical benefits. Even though it is a hot topic, nobody had actually looked at how this specific study has grown and changed over time if we look only at the PubMed platform. So, we decided to do this research to find out where these publication trends are going, what the main topics are, who is writing them, and what new ideas are coming up in this field. To do this, we did a proper bibliometric search on PubMed on August 30, 2026. We found exactly 49 research papers in total, and we kept every single one of them to study them deeply. We used a software called VOS viewer (version 1.6.20) to make clean visual maps, and we looked at everything from author names, journals, countries, and institutions to keywords, citations, and core themes.The results were quite interesting. Words like silver, metal nanoparticles, and the actual size of the particles were everywhere. When it came to medical uses, the biggest focus was on anti-bacterial power, testing how sensitive microbes are, and checking how they fight bugs like E. coli and Staphylococcus aureus. But that is not all. Lately, researchers are talking a lot about things like cell survival, cytotoxicity, reactive oxygen species, apoptosis, and tumor cells. This clearly proves that people are now trying to use these nanoparticles to fight cancer and fix cell issues. When we looked at the visual maps, we saw that how these particles are made, their physical features, how they kill germs, and how cells react to them are all tightly connected to each other. In simple words, the PubMed data shows that research on microbial AgNPs is growing fast and getting very diverse. Fighting bacteria is still the number one job, but uses in cancer treatment, wound healing, and multi-tasking applications are developing quickly too. Our review gives a very clear picture of this field right now. It shows that in the future, we urgently need to make a standard way to produce these particles, test their safety properly, and do stronger medical trials to safely use them for real human treatments.

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KEYWORDS: Silver nanoparticles; microbial synthesis; biosynthesis; biomedical applications; antimicrobial activity; bibliometric analysis; PubMed; VOSviewer; nanotechnology.

1. INTRODUCTION

Nowadays, nanotechnology has grown into a very important field that connects many different subjects together, like materials science, microbiology, biotechnology, pharmacology, and medicine. Out of all the different materials, silver nanoparticles (AgNPs) are getting a huge amount of attention from researchers. This is mainly because their tiny size, high reactive surface, and the way they mix with living cells open up great doors for medical uses. So far, scientists have been testing their power in killing germs, fighting cancer, healing wounds, carrying medicines, and making medical tools (Naganthran et al., 2022). How well these silver nanoparticles work in real life depends heavily on features like their size, shape, surface charge, crystal structure, and how they stick together. All these physical features are completely decided by the way we manufacture them (Luo et al., 2018). Usually, old-fashioned physical and chemical ways of making them take up a lot of electrical energy and use dangerous chemical agents to stabilize the particles. Because of these safety issues, researchers are now shifting their interest towards green and natural methods that use tiny microbes, plants, and natural enzymes instead (Sampath et al., 2022).

Right now, using microbes to make silver nanoparticles has become a really hopeful method. This happens because these tiny living organisms have natural internal chemical systems that can easily break down silver ions and make the resulting particles stable. Over the years, scientists have been testing different kinds of bacteria, fungi, actinomycetes, and special hidden microbes as small biological factories. They discovered that things like microbial proteins, active enzymes, tiny peptides, natural sugars, and other chemical products inside them help a lot in creating and protecting these nanoparticles (Singh et al., 2015). However, the final look and size of these particles depend a lot on where the microbe comes from and the setup of the lab environment. Simple things like the liquid food you give them to grow, the acid levels, the room temperature, how many hours you keep them in the lab, the starting amount of silver, and the total weight of the microbes can totally change the final size, shape, and amount of the particles you get (Luo et al., 2018). Usually, bacterial systems are studied the most because they can survive and change their internal chemistry very quickly. On the other side, actinomycetes and fungi have their own special benefits. This is because they can produce a wide variety of strong enzymes and active chemical byproducts outside their cells, which makes the whole process even smoother (Chauhan et al., 2013).

When we look at the medical world, using microbes to create silver nanoparticles has shown immense value, especially in the fight against dangerous germs. These tiny silver particles work by attaching themselves directly to the outer surface of microbes. Once there, they cause heavy damage to the cell walls, build up internal oxidative stress, mess up the cell's normal chemical digestion, and attack core living components inside the bug. Because they can fight in all these different biological ways at the exact same time, they are incredibly tough for germs to handle (Rai et al., 2009). This powerful, all-round action is exactly why scientists are now testing them heavily against superbugs that resist normal medicines and stubborn sticky germ layers called biofilms, which are causing massive headaches in modern hospitals today (Saratale et al., 2022).However, their usefulness goes way beyond just killing regular bacteria. In laboratory testing models, these microbially made nanoparticles have also shown great power in attacking cancer cells and speeding up how fast open wounds heal. For instance, when researchers grew silver nanoparticles using a specific microbe called Talaromyces purpureogenus, the final particles successfully killed bad bacteria, fought off cancer targets, and helped fix damaged tissue all at once. This proves that we can create smart, multi-tasking natural nanomaterials for a variety of medical needs (Elamawi et al., 2019). Even with all these exciting laboratory results, we must remember that almost everything discovered so far is still stuck in the early experimental or animal-testing phase. Taking these discoveries out of the lab and turning them into real, approved medicines for human patients in clinics will still take a lot of deep research and careful testing.

Even though science has made great progress in this field, we still face massive roadblocks when it comes to making these particles the exact same way every time, increasing production size, testing their physical features, and proving they are safe for living beings, especially since using different families of microbes and unique setup conditions means the final nanoparticles often end up having completely different chemical faces and biological strengths, making it incredibly hard for researchers to compare results from one study to another (Luo et al., 2018). On top of that, just because these particles are made using natural biological methods does not automatically mean they are safe for humans, as these silver nanoparticles can attack mammalian cells and cross biological barriers in ways that depend entirely on how strong the dose is and what the particles look like (Xu et al., 2020). Because this field is growing so fast, it has created a massive, mixed-up mountain of research papers that use all kinds of different microbes, manufacturing tricks, tracking tools, animal models, and medical goals, which is exactly where bibliometric analysis comes in as a highly useful mathematical tool to help us sort through this rapidly changing field by pinpointing exactly where publication trends are heading, who the most important authors and journals are, which countries or colleges are doing the most work, how papers link together through citations, who is teaming up with whom, how keywords connect, what the main subject groups are, and what fresh ideas are popping up for the future (Donthu et al., 2021).

It is true that earlier bibliometric studies have looked at the wider world of research papers on silver nanoparticles and how they are used in medicine, but those old reviews usually lumped together all kinds of different manufacturing methods and completely different scientific fields instead of focusing on just one (Naganthran et al., 2022). Doing a tightly focused review specifically on silver nanoparticles made through microbes using only the PubMed-indexed medical papers can give us a much sharper and clearer look at how this exact subfield is growing and what its main medical focuses are. Because of this gap, our current research aims to do a thoroughly detailed bibliometric analysis of all PubMed-indexed papers dealing with microbially created silver nanoparticles and their medical uses, looking at every single publication printed up to August 30, 2026. This review deeply checks out where the publication trends are going, who the most important writers are, which journals and countries are leading, which colleges are doing the heavy lifting, how papers cite each other, who is teaming up in research networks, which keywords keep showing up together, what the biggest subject zones are, and where new ideas are heading, all with the main goal of finding out the biggest milestones, the hidden gaps in our current knowledge, and the best future paths in this incredibly fast-moving area of science.

2. METHODOLOGY

Database and Search Strategy: - A bibliometric study was conducted using the PubMed database to examine research on microbially synthesized silver nanoparticles and their biomedical applications. The literature search was performed on 30 August 2026 using relevant combinations of terms related to silver nanoparticles, microbial synthesis, and biomedical applications. The search retrieved 49 records, and all identified records were retained for the study.

Data Collection and Selection: - A bibliometric study utilizing the PubMed database was conducted on August 30, 2026, to examine research concerning microbially synthesized silver nanoparticles and their biomedical applications. The search strategy employed specific combinations of relevant terms, retrieving a total of 49 records which were all retained for subsequent analysis. You can access the PubMed database for further literature searches.

Bibliometric Analysis: - We deeply checked out the entire dataset to see how publication trends are moving, how productive different authors are, which journals are publishing the most, and how different colleges and countries are taking part in this research. We also looked at how papers cite each other and how scientists are teaming up across the world. To find out the main ideas and core subjects in this field, we carefully tracked which keywords keep popping up together. On top of that, we used a specific computer tool called VOSviewer (version 1.6.20) to build and draw clear visual maps of these connections, especially to show who is co-authoring with whom and how different research words link up. The entire study and all these visual maps were built completely by looking at the full group of 49 research papers that we retrieved from the PubMed database.

Thematic Analysis: - Authors did a proper thematic analysis by tracking the most common keywords and seeing how they connect with each other, which helped us point out the biggest subject zones and the freshest ideas coming up in this study. We paid very close attention to how these microbial silver nanoparticles are actually used in medicine, including their power to kill bacteria, fight off cancer cells, speed up wound healing, stop sticky germ layers called biofilms, and checking if they have any toxic side effects or other medical benefits. Finally, we explained all these findings to give a clear picture of how this field has grown, how the research is structured right now, and where it is heading next, using all the PubMed papers that were published up to August 30, 2026.

3. RESULTS

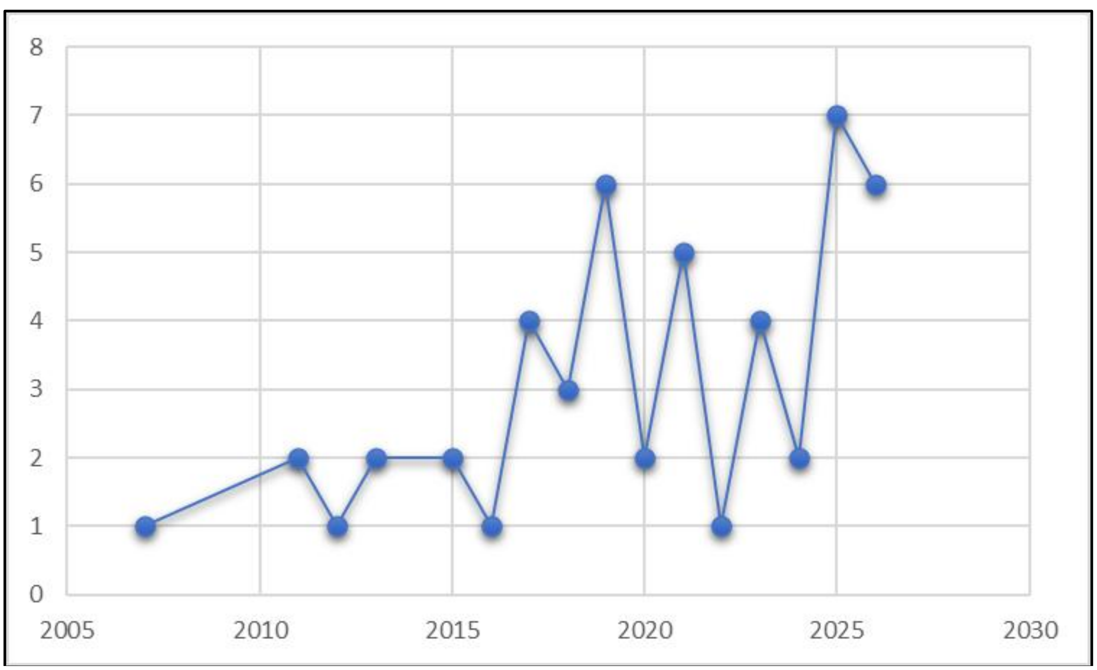

Figure 1: Annual publication trend of research related to microbially synthesized silver nanoparticles.

If you look closely at Figure 1, it shows exactly how the research papers we found on PubMed are spread out year by year. In the beginning, the number of papers coming out was quite small and limited, but then we can see a very clear jump in publications right after the year 2016. By the time we hit 2019, the count went up to six papers, and then the numbers kept going up and down a bit between the years 2020 and 2024. The highest number of papers printed in a single year happened in 2025 with exactly seven publications, and right after that, we recorded six publications in 2026. This whole chart clearly proves that scientists are getting more and more interested in silver nanoparticles as time goes on, especially over the last few years. This sudden rush of recent papers most likely shows that researchers worldwide are focusing heavily on using microbes and natural biological systems to build these nanoparticles and test their true medical powers.

Table 1. Most frequently occurring keywords and their total link strength related to microbially synthesized silver nanoparticles.

Selected	Keyword	Occurrences	Total link strength
☑	silver	24	160
☑	metal nanoparticles	21	139
☑	particle size	18	137
☑	anti-bacterial agents	14	118
☑	microbial sensitivity tests	10	97
☑	escherichia coli	9	89
☑	staphylococcus aureus	9	76
☑	humans	8	69
☑	cell survival	8	58
☑	green chemistry technology	5	54
☑	plant extracts	6	54
☑	antibacterial activity	7	52
☑	spectroscopy, fourier transform infrared	5	48
☑	animals	6	42
☑	silver nanoparticles	10	38
☑	antioxidant activity	4	35
☑	microscopy, electron, scanning	4	35
☑	antineoplastic agents	3	33
☑	cell line, tumor	3	30
☑	mice	4	30
☑	zinc oxide	3	30
☑	reactive oxygen species	3	28
☑	gold	3	26
☑	x-ray diffraction	3	26
☑	antioxidants	3	24
☑	nanoparticles	4	21
☑	surface properties	3	21
☑	nanocomposites	3	20
☑	apoptosis	3	18
☑	green synthesis	3	18
☑	cytotoxicity	5	13
☑	nanotechnology	3	9

Most frequently occurring keywords and their total link strength

Looking at the keyword analysis, we can get a very clear picture of the main ideas running through all the collected research papers. The word "Silver" turned out to be the absolute chart-topper here, popping up exactly 24 times and showing a massive total link strength of 160. Right behind it was the term "metal nanoparticles," which showed up 21 times with a link strength of 139, while "particle size" was found 18 times with a total link strength of 137. These heavy numbers clearly prove that the existing research focuses deeply on silver-based materials and how they look and behave physically. When we dive into the medical and bug-fighting words, "anti-bacterial agents" came up 14 times with a link strength of 118, while "microbial sensitivity tests" showed up 10 times. Next in line were the specific bacteria names, "Escherichia coli" and "Staphylococcus aureus," which appeared exactly nine times each. The fact that these terms are so high on the list proves that scientists are spending a huge amount of their time testing how well these particles kill germs. On top of that, other common words like "humans" and "cell survival" appeared eight times each, while terms like "antibacterial activity," "silver nanoparticles," "animals," and "plant extracts" also made a big appearance. Finally, seeing words on the list like "antineoplastic agents," "cell line, tumor," "apoptosis," and "cytotoxicity" is super important because it tells us that using these nanoparticles to fight cancer and tracking how living cells react to them has become a major piece of this entire scientific puzzle.

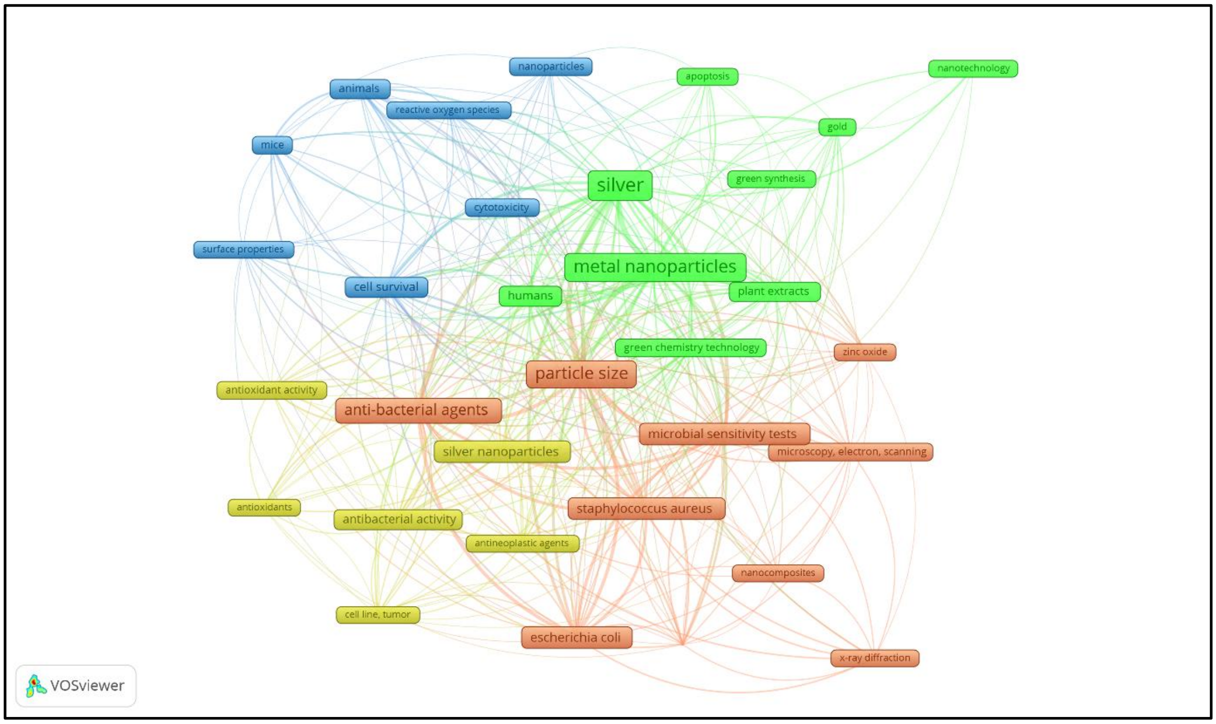

Figure 2: Keyword co-occurrence network of research related to microbially synthesised silver nanoparticles.

When you look at Figure 2, it displays the keyword co-occurrence network that we built using the VOSviewer software, and it really highlights the massive bonds shared between the main subjects of this study. Words like silver, metal nanoparticles, and the actual size of the particles stand right in the middle as the most common and central terms on the map. This whole network basically shows us that most papers are deeply focused on how these nanoparticles are manufactured and tested, how they kill germs, and how they react biologically, which is proven by keywords like green synthesis, plant extracts, antibacterial activity, Escherichia coli, and Staphylococcus aureus popping up everywhere. But if you look closer, you will also spot other important terms like cytotoxicity, reactive oxygen species, apoptosis, cell survival, and tumor cells, which clearly proves that scientists are now getting highly interested in using these particles for real disease therapies and cancer treatments. Looking at the big picture, this entire visual network acts as a proof that how we make these nanoparticles, how we test them against bacteria, and how they affect living bodies are all tightly wrapped and connected together.

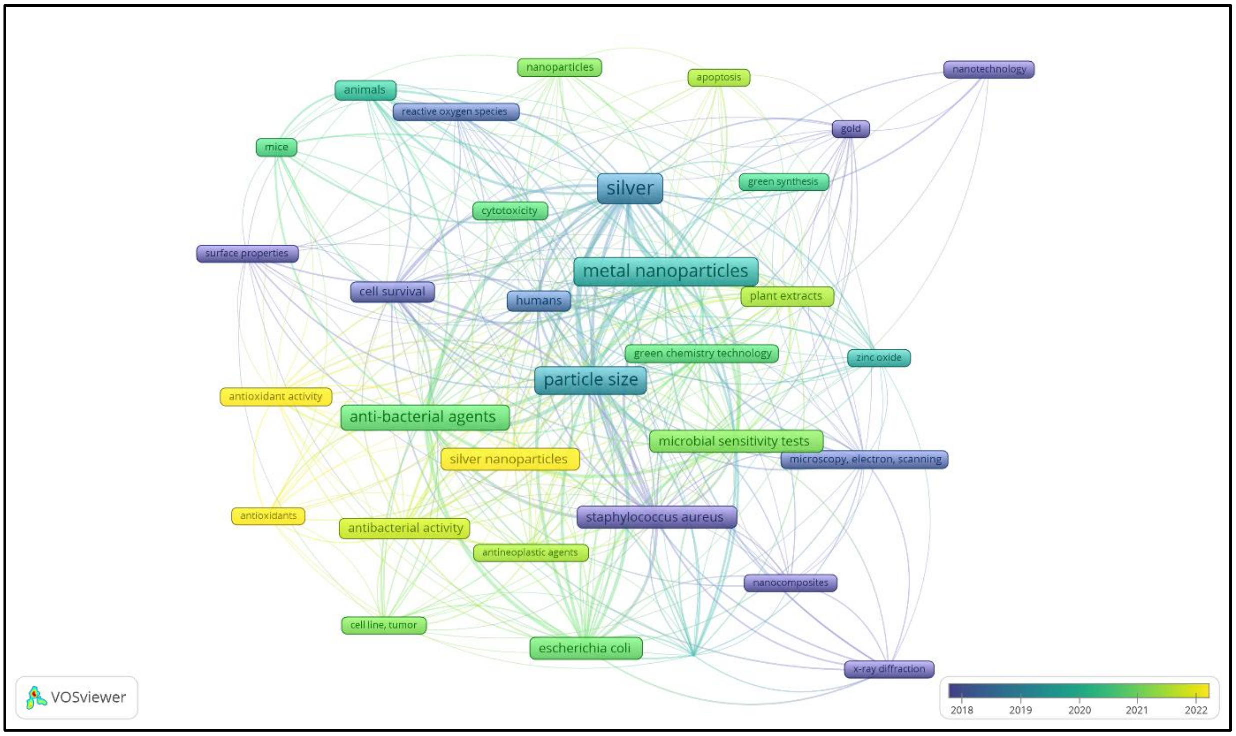

Figure 3: Overlay visualisation showing the temporal development of keyword research related to microbially synthesized silver nanoparticles.

Looking at Figure 3, it shows exactly how the research words are spread out over time using the overlay visual feature in VOSviewer, mapping out papers that came out roughly between the years 2018 and 2022. The chart makes it quite clear that words like silver, metal nanoparticles, particle size, and antimicrobial agents are the oldest and most deeply rooted topics in this field. On the flip side, newer words that have started popping up lately—like antibacterial activity, microbial sensitivity tests, green synthesis, cytotoxicity, apoptosis, and tumor cell lines—clearly show that scientists are now moving their attention towards cell reactions and actual medical treatments. Looking at the big picture, this changing timeline proves that the whole field is slowly shifting away from just basic particle making and physical testing, and is now running fast towards practical biomedical uses, while everyone still keeps a heavy focus on using green and natural biological ways to manufacture these particles.

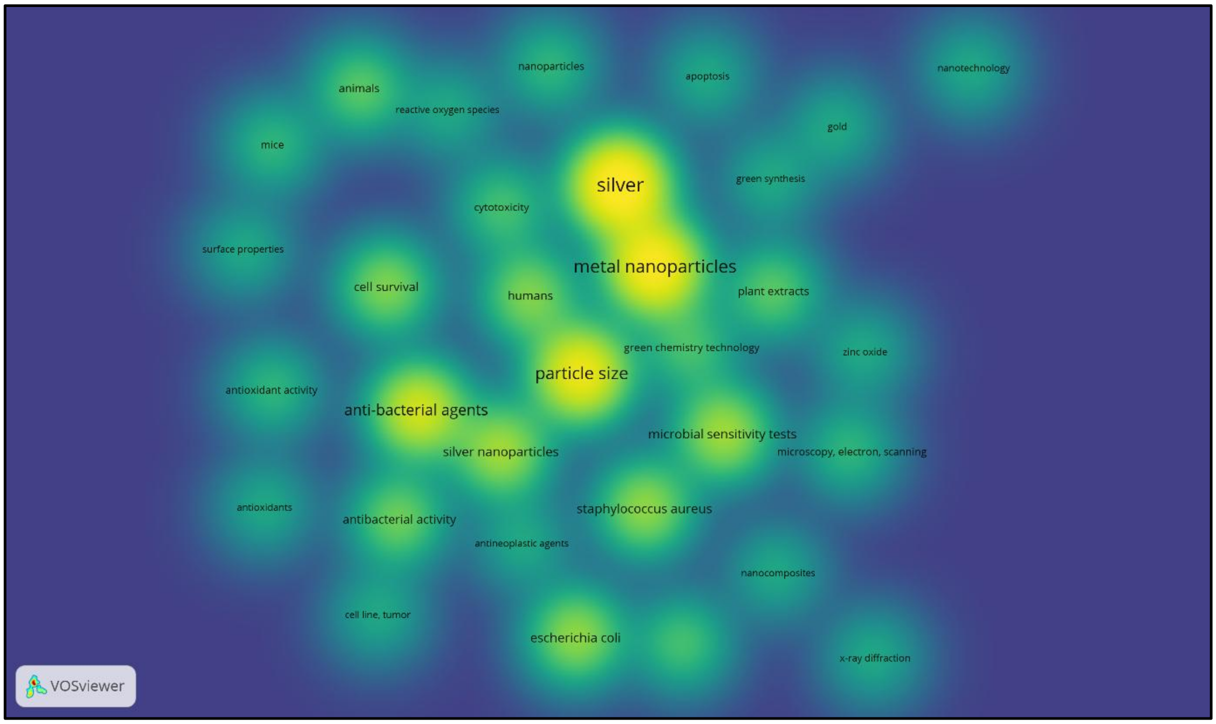

Figure: 4 Density visualisation of major research themes related to microbially synthesized silver nanoparticles.

If we look at the data in Figure 4, it becomes very clear that most of the research is heavily packed around words like silver, metal nanoparticles, particle size, and antibacterial activity, which tells us that the absolute heart of this whole field is making particles, testing their physical features, and using them to kill germs. At the same time, words like Escherichia coli, Staphylococcus aureus, cytotoxicity, cell survival, and reactive oxygen species show up as major zones where biological testing is happening, while things like nanocomposites, X-ray diffraction, zinc oxide, and surface properties stand out as more specialized or technical topics on the side. Looking at the big picture, this entire density map strongly underlines how much scientists worldwide are focusing on the way silver nanoparticles are synthesized, how well they fight off bacteria, and the way they behave inside living biological systems.

4. DISCUSSION OF FINDINGS

Our current bibliometric analysis clearly shows that scientific interest in making silver nanoparticles (AgNPs) through microbes is jumping up fast, with words like silver, metal nanoparticles, particle size, and antibacterial activity coming out as the biggest themes. Seeing words like Escherichia coli, Staphylococcus aureus, microbial sensitivity tests, and antibacterial activity show up so strongly confirms that killing bad germs is still the main job of this entire research field (Rai et al., 2009; Singh et al., 2015). On top of that, looking at the visual networks and changing timelines tells us that people are now paying way more attention to green synthesis, cytotoxicity, reactive oxygen species, apoptosis, anticancer activity, and wound healing, which proves that the field is slowly moving away from basic particle making and running towards practical medical treatments (Ahamed et al., 2010; Sampath et al., 2022). Of course, tracking the actual particle size and other physical features stays highly critical because these traits completely dictate how the final nanoparticles behave once they enter a living body (Luo et al., 2018). Looking at the big picture, these results prove that research on microbial AgNPs is mostly growing around manufacturing tricks, physical testing, germ-fighting power, and wider body reactions. Even though this whole field holds massive promise, the fact that different labs use unique setup conditions, different particle features, and mixed animal models makes it incredibly tough to copy results or compare one study to another smoothly (Luo et al., 2018). Also, because everyone is focusing more and more on cytotoxicity lately, it strongly underlines why we urgently need to test for real biosafety and do proper, step-by-step toxicity reviews before even thinking about using these particles on human patients in real clinics (Xu et al., 2020). Because of these gaps, future studies must put a heavy focus on creating standard manufacturing methods, checking features the exact same way every time, using trustworthy biological trials, and running strict safety tests to truly back up the medical powers of these microbially created silver nanoparticles (Donthu et al., 2021).

5. CONCLUSION

Our current bibliometric analysis gives a very clear and structured picture of the research happening around silver nanoparticles made through microbes and how they are used in medicine, looking specifically at the papers indexed in the

PubMed database. The data clearly shows that words like silver, metal nanoparticles, particle size, anti-bacterial agents, microbial sensitivity tests, Escherichia coli, and Staphylococcus aureus stand out as the absolute biggest and most discussed ideas in this field. At the same time, looking at the visual maps and density charts proves that killing harmful germs is still the main job of this research area, while other related topics like cytotoxicity, apoptosis, cancer treatments, green synthesis, and biological testing also form a massive and important piece of the puzzle. When we look at the timeline, it is obvious that publication numbers have jumped up fast over the last few years, which proves that scientists worldwide are staying highly interested in silver nanoparticles that are built using natural biological systems. The entire field has slowly grown from just understanding how to build these particles and test their physical features into running fast towards broader medical uses like fighting superbugs, managing cells, and creating real disease therapies. However, we still face heavy roadblocks when it comes to making these particles the exact same way every time, setting standard manufacturing methods, testing for real biosafety, and actually transforming these laboratory discoveries into practical medical tools for real human patients. Looking at the big picture, our study strongly underscores that research on microbial AgNPs is a highly mixed-up, multi-subject field that brings different sciences together while offering a perfect roadmap of its major milestones and where it is heading next. Because of this, future studies must put a massive focus on creating standardized ways to grow these particles using microbes, checking their physical traits very strictly, running reliable comparative tests, assessing long-term toxicity profiles, and doing real-world clinical validation to truly back up and strengthen the real human healing potential of microbially created silver nanoparticles.

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