Indian J. Applied & Pure Bio. Vol. 39(1), 366-393 (2024). **ISSN: 0970-2091**
A Web of Science Journal

Synthesis of Silver Nanoparticles by Green Approaches and their Various Applications: A Review

[1]Kinjal Gohil, *[1]Sureshkumar Dhakhda, [2]Khushbu Patel and [3]Rama Gaur

[1]Rai School of Sciences, Rai University, Ahmedabad-382260 (India)
[2]Inventa Systems, Ahmedabad-380006 (India)
[3]Department of Chemistry, School of Technology, Pandit Deendayal Energy University, Gandhinagar - 382007 (India)
*Corresponding Author: Email: sureshdhakhda@yahoo.com

Abstract

Nanoparticles of Silver are typically using in the field of medicine to cure or treatments of antimicrobial disease, used as adjuvant for vaccines, cancer treatments, anti-diabetic agent, applied on wounds, bone healing as well as used in biosensors. Based on these applications this reported review is focused on the green synthesis of silver nanoparticles and different types of applications are covered. Numerous efforts have been made in the last decade to develop green synthesis methods that avoid hazardous byproducts. Several eco-friendly processes for the rapid synthesis of silver nanoparticles using aqueous extracts of plant parts such as the leaf, bark, roots and other parts have been reported in recent years. Metal nanoparticle synthesis using plant extracts is one of the most concise, convenient, cost-effective and ecofriendly methods. AgNPs have been synthesized using natural sources such as plants, bacteria, fungi and biopolymers. These alternative causes act as reducers and capping agents. They have been used as antibacterial, antifungal and antioxidant in the fields of agriculture and medicine.

Key words : Silver nanoparticles, Green synthesis, Plant extracts, Applications.

The development of environmentally friendly methods for the synthesis of nanoparticles is an important in the field of nanotechnology. Silver nanoparticles are significant because of their remarkable chemical, physical and biological properties as well as their wide range of applications. In recent years, nanotechnology has appeared as a conventional and essential innovation. Nanotechnology is concerned with NPs, which are nuclear or atomic aggregates with a size of less than 100 nm. Nanotechnology refers to the assembly, representation, control and application of formations to stabilize the shape and size at the nanoscale. Nanotechnology is increasing in popularity as a new field of study concerned with the creation of nanomaterials and nanoparticles (NPs) for use in a variety of fields such as electro-catalysts, inorganic chemistry, biomedicines, pharmaceuticals, sensing, food technology, cosmetic products[58]. Metal and metal oxide nanoparticles have been widely researched using science and technology because of their excellent properties such as a high ratio of surface to volume. Metal and metal oxide nanoparticles have improved antimicrobial properties. Furthermore, the rapid increase in the number of microbes resistant to existing antibiotics has necessitated the creation of novel medicines in the form of bare NPs in a variety of medical fields[41].

Synthesis of silver nanoparticles :

Synthesis of AgNPs is a generally one-step procedure. The traditional methods for producing NPs are costly, toxic and unfriendly to the environment. To address these issues, researchers identified precise ecofriendly pathways, *i.e.*, naturally occurring resource and their products that are suitable for NP synthesis[19]. The Biosynthesized nanoparticles have gained focus due to their biologically active plant secondary metabolites that are useful in green synthesis. Silver nanoparticles are used extensively in nanomedicine and biomedical nanotechnology[115].

Moond *et al.*,[96] produced silver nanoparticles of 21nm size, monodispersed, and spherical in shape. The aqueous *Trigonella foenum-graecum L.* leaf extract from variety HM 444 was utilized as a reducing agent in the manufacture of silver nanoparticles (AgNPs). AgNPs were characterized by UV-Visible spectroscopy, Particle size analyzer (PSA), field emission scanning electron microscopy coupled to energy dispersive X-ray spectroscopy (FESEM-EDX) and high-resolution transmission electron microscopy (HRTEM). The production of metallic Ag has been verified by selected area electron diffraction (SAED)[96]. Plant leaf extract indicated a diverse and affordable process that might be used in the near future as a sustainable method for nanoparticle manufacturing. Nanoparticles have unique characteristics that are dependent on their size, shape, and morphology, which makes them compatible with plants, animals and microbes. Silver nanoparticles have demonstrated great bactericidal activity against a wide variety of microorganisms are organized from various angles, frequently to explore their own morphology or physical characteristics[156]. Basumatary *et al.* Investigated bio reduced silver nanoparticles by using *antidesma acidum* leaf extract and it was noticed that the reduced AgNPs were round in structure with a particle size of 10 nm. Application in the water pollution control is promising. Dyes like Congo red, methylene blue as well as methyl orange are extremely harmful and pollute the environment whenever discharged into waste water. At 18 and 20 minutes, the degradation percentage of MB (81%) was higher than the degradation percentage of CR (90%)[17]. Analysts have previously shown a strong interest in AgNPs. AgNPs are used in a variety of fields due to their unique properties, including biomedical (fast diagnosis, microscopy, tissue formation, and therapeutic agents, as well as the creation of novel medicine products), textile industry, food packaging, cosmetic industry, catalysis, sensors, biology, coatings, plasmonic

(SERS), optoelectronics, antimicrobial activities, DNA sequencing, SERS, climate change and pollutants control, clean water techniques, AgNPs are also used as anti-infection agents, tranquilizers, conveyance agents, water treatment, farming, and other applications due to their exceptional protection against a wide range of microorganisms and medicinal properties. Besides that, because of their conductivities, AgNPs have been observed use in electronic equipment, dyes, plasters etc[82]. Top-down and bottom-up approaches to NP synthesis are used. In the equipment, a suitable mixture is separated into small particulates through reduced size techniques such as pulse laser ablation, evaporation-condensation, ball milling and pulse wire discharge method. NPs were synthesized using chemical and biological methods in a bottom-up approach by the identity characteristic of atomic nuclei to new atoms, which grow into a nanoscale particle. Evaporation-condensation is the most general method for the synthesis of metal NPs in a top-down approach (Daniel and Astruc 2004; Swihart 2003)[60]. Autoclaving, gamma-ray radiation, applying microemulsions, electrochemical techniques, chemical reduction, laser ablation, microwave irradiation, and photochemical reduction are all used in the synthesis of AgNPs. Several characterization procedures (DLS, UV-vis, FT-IR, XRD, SEM, TEM, and EDX) have been used to explore the source, shape, size, and characteristics of AgNPs concerning various application areas[146]. Several different chemical and physical methodologies, such as chemical reduction, milling was used at the beginning of the twentieth century for the synthesis of NPs as well as to make them more effective. Moreover, these traditional techniques use expensive and toxic chemicals and cannot be considered eco-friendly. Taking this into consideration, researchers are now very involved in the synthesis of metal and metal oxide NPs using a bio-genic route, which uses aqueous plant extract and microbes, because they are eco-friendly, stable, clinically adaptable, biocompatible, and cost-effective[74]. As a result, bio-inspired technology for NPs synthesis has emerged as a significant group of nanoscience and nanotechnology. Multiple metals as well as metal oxide NPs have been synthesized to date using plant extracts, microbes, and other natural resources[92]. Plant biomass is being heavily researched by our team and others due to its widespread availability, renewability, and environmental responsibility, in addition to its numerous applications in the synthesis of NPs. AgNPs are formed by the oxidation of $Ag+$ to Ag^0 by biological molecules such as flavonoids, ketones, aldehydes, tannins, carboxylic acids, phenolic acids, and plant extract protein[16]. Green synthesis is more eco-friendly, cost-effective, and flexible for large-scale NP synthesis than physical and chemical methods, and it does not require extreme heat, power, pressure, or harmful chemicals. As a result, this review discusses the green-inspired synthesis of Ag-NPs, which has benefits placed above physical and chemical methods[92]. Metal nanoparticles (NPs) have unique properties that continue to intrigue researchers to study novel aspects of their value. Typically, AgNPs and AuNPs are synthesized using toxic chemicals that harm the ecosystem and the health of people. Plant-based biological substances in the form of extracts are the foundation of plant-mediated NP production, which beats traditional chemical approaches[53].

These based on plants metallic NPs also exhibit well-known biological properties such as anticancer, antioxidant, antibacterial and wound healing[101]. The tremendous advantages of this ecologically friendly technology have also paved the way for exciting advances in NP synthesis. To summarize, it is critical to focus on developing engineered NPs that are less hazardous, have adjustable size and form, provide enhanced health advantages, and broaden their scope of use in linked industries. The market for metal NPs is expected to reach $40.6 billion by 2027[117]. This reported review stimulate ideas for using different routes to produce silver nanoparticles that can benefit humans. There are few reports on their green synthesis, biocidal properties, and mechanism of action. Their antibacterial potential and mechanism of action have also been explored[98]. Gil-Korilis *et al.* have compared the silver nanoparticles and silver nanoparticles supported on clay minerals were tested for antibacterial activity and cytotoxicity. Silver nanoparticles were synthesized using $AgNO_3$ as the silver precursor, ascorbic acid as the agent for reduction, and sodium citrate as the stabilizer agent. They also discovered that utilizing nitric acid rather than citric acid for varying the pH of the silver nanoparticles while the synthesis process was more stimulating because more varied and larger nanoparticle sizes were obtained. Furthermore, as the pH of the samples raised the reduced size of the nanoparticles[49].

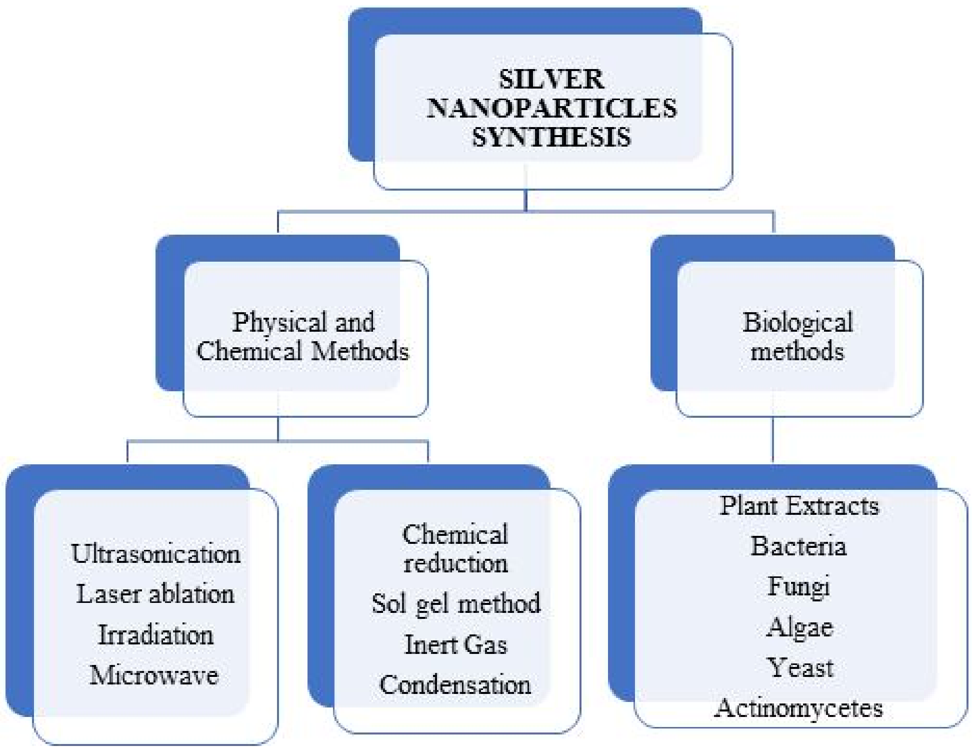

Figure 1. Synthesis of silver nanoparticles from different methods and their applications

Silver nanoparticles have a natural antibacterial activity against a variety of illnesses, such as pathogens, viruses, and yeast. Green synthesis can be divided into two categories: (a) the use of microorganisms such as fungi, yeasts (eukaryotes), bacteria, and actinomycetes (prokaryotes), and (b) utilizing plants and plant extracts. (c) Employing templates such as membranes, viruses, DNA, and diatoms. The subsequent sections describe green synthesis mostly through bacteria, fungi, plants, and plant extracts[154].

A. synthesis of AgNPs from microbes:

In the presented era, utilizing microbes for metal NP synthesis has proven to be an excellent method. Microbial cells become excellent bio industries for such production of AgNPs. NPs have been synthesized using natural resources and their components. Green synthesis can be divided into three types: (a) from bacteria, (b) from algae, and (c) from fungi[53]. For the synthesis of AgNPs, various reducing agents have been used. The cultures are initially given the opportunity to grow as culture suspensions in sterilized deionized water containing the culture medium. Finally, various concentration of AgNPs precursor is added to the cultured microbial, followed by constant mechanical stirring in the dark. The reaction's progress is monitored using a UV-vis spectrophotometer. Ultimately, the resultant AgNPs are separated from the rest of the mixture through the use of centrifugation at around 3000 rpm for 10–15 min[148].

Synthesis of AgNPs from Bacteria:

Bacteria produce inorganic materials either extracellularly or intracellularly. As a result, they are potential bio industries for the production of noble metal NPs such as gold and silver. Culture supernatants of numerous Enterobacteriaceae bacteria can be used to quickly synthesize Ag-NPs. Aside from the benefits, it is important to note that bacteria continued to grow after the establishment of Ag-NPs[78]. Aside from that, the major drawback of using bacteria as nano factories is the slow rate of synthesis and the limited range of shapes and sizes that can be obtained when compared to traditional methods. As a result, fungi-based nano factories and chemical reactions involving plant and plant extract-based components were studied for the synthesis of Ag-NPs. Correspondingly, there are numerous other bacteria that may be utilized to synthesize Ag-NPs[63]. The interaction of a bacterial strain S-27 from the Bacillus fexus group and 1 mM $AgNO_3$ in an aqueous medium resulted in the rapid synthesis of Ag NPs. The colourless cell suspension solution gradually turned yellow and then brown. Because of the surface plasmon resonance (SPR) of silver nanoparticles, its UV-vis spectrum had a sharp peak at 420 nm. Although slow degradation cannot be avoided, anisotropic nanoparticles of 12 and 65 nm size were constant in the dark for 5 months at room temperature. They had a crystalline structure with a face-centered cubic structure[78]. These nanoparticles are efficient against multidrug-resistant gram-positive and gram-negative bacteria. The intensity of the colour and the rate of interaction is determined by the concentration of the responding elements. Silver nanoparticles biosynthesized from *C. prophetarum* leaf extract indicated antibacterial activity capacity against cancer cell lines[109]. Four bacterial species investigated the silver nanoparticles produced by *Duranta erecta* leaves using the nutrient agar disc diffusion technique: *E. coli, Streptococcus aureus, Bacillus subtilis, and Pseudomonas aeruginosa*. AgNPs were tested for antibacterial activity against pathogenic organisms such as *Klebsiella pneumoniae* (ATCC® 13883TM), *Escherichia coli* (ATCC® 25922TM), *Acinetobacter baumannii* (ATCC® 19606TM), and *Pseudomonas aeruginosa* (ATCC® 27853TM). The ager-well analysis revealed inhibiting zones ranging from 7 to 15 mm with a MIC value of 250 g/ml, indicating that strains are susceptible to growth inhibitory circumstances[158].

Synthesis of AgNPs from Algae :

Researchers are interested in nanoparticles because of their high surface-to-volume ratio and capacity for interacting effectively with other particles. Silver nanoparticles (AgNPs) can be produced using a variety of methods, along with chemical, physical, and biological. The biological method is the cleanest and safest method because no harmful chemicals are utilized during the procedure[145]. For the biological method, bacteria, fungi, algae, and plant extract are utilized during synthesis. The high capacity of algae to take in metals and start reducing metal ions makes an algal synthesis of AgNPs particularly intriguing. Algae is a common and widespread species with easy availability; an added benefit is their development in lab conditions. These organisms can aid in low-cost large-scale production[155].

Synthesis of AgNPs from fungi :

The biosynthesis of AgNPs by pathogenic as well as nonpathogenic fungi has been widely studied. Silver ions have been observed to decrease extracellularly in the availability of fungi, resulting in consistent Ag NPs in water[143]. Fungi have the ability to synthesize metallic NPs due to their metal bioaccumulation capabilities and sensitivity, high binding capacity, and intracellular uptake similar to bacteria, which are easier to handle in a research laboratory. When compared to bacteria, switching from bacteria to fungi for generating normal nano factories provides the benefits of more simple and direct downstream processing, and biomass treatment, and produces far greater amounts of proteins, which it appears to significantly boost the earnings of this synthesis process[9]. Mycelia were dissolved in 100 mL of 1 mM $AgNO_3$ solution in an Erlenmeyer flask at 50 °C and mixed thoroughly for 96 hours at pH 9 to look for any changes in colour. Because of the formation of Ag NPs, the solution's color was observed from yellow to brown. *Candida albicans, Candida tropicalis, Candida glabrata, Candida sake*, and non-dermatophytic onychomycosis fungi have been investigated for antifungal activity[112].

B. Synthesis of AgNPs from plants :

Plant parts such as leaves, roots, flowers, fruits, rhizomes have all been effectively used in the synthesis of AgNPs[148]. various plant parts are taken from different places, washed thoroughly with ordinary water, and then distilled water to remove dirt particles and other waste items. After that, the portions are dried and ground to make powder or used as fresh to make the extract. To make the extract, the sliced pieces or ground powder of the plant parts are placed in deionized water or alcohol and typically heated below 60° C for a few hours because rising heating for an extended period can lead to the degradation of polyphenols in the biomass extract. The use of chemical stabilizers is avoided in this synthesis process because biopolymers introduce in the extract act as a reduction agent as well as a stabilizing agent in the synthesis of AgNPs. Visual colour changes or UV-vis spectroscopy can be used to monitor the progress of AgNPs formation, where a peak height due to surface plasmon resonance (SPR) of AgNPs at around 430-450 nm is usually observed[147].

Synthesis of AgNPs from leaf :

A large number of leaf extracts have been used in the biosynthesis of AgNPs. Spherical biogenic AgNPs are also produced using Aloe vera, Eclipta alba, Momordica charantia, and Leptadenia reticulata. Another study used tea leaf extract to synthesize AgNPs. The antibacterial effect of synthesized NPs against *S. aureus* and *E. coli* revealed that inhibitory activity is much more effective against S. aureus (89% inhibition rate) than *E. coli1*[106].

Synthesis of AgNPs from Seeds :

A plant seed extract has also been shown to be effective in the biosynthesis of nanoparticles. To date, numerous seed extracts have been used in the biosynthesis of AgNPs. AgNPs mediated by Sinapis arvensis seeds were found to inhibit the hyphal gains of the fungus N. parvum by more than 83%. Within 50 days of the reaction, inductively coupled plasma spectrometry (ICP) analysis revealed a 95% conversion of $Ag+$ to Ag^0. AgNPs with high antimicrobial activity were produced by extracting the seeds of plants such as Tectona grandis, Persea americana, Salvia hispanica L, and Trigonella foenum-graecum[20]. For the biosynthesis of AgNPs, the dried and roasted coffee seed (Coffea arabica) was used as a reducing and stabilizing agent[40].

Synthesis of AgNPs from roots :

Green synthesis of AgNPs and their use as antibiotics using plant root extract have recently attracted a great deal of interest. Potentilla fulgens root extract was found to be an excellent antibacterial agent against E. coli and B. subtilis, with ZOI values of 9.5 0.2 and 9.7 0.6, respectively[148]. *Alpinia calcarata* root extract was recently used as a bio-reducing and binding agent in the green synthesis of spherical AgNPs. The root extract was also reported to produce AgNPs with microbial activities[46].

Synthesis of AgNPs from stem :

Plant stem extracts have been commonly used as reducing agents in the green synthesis of AgNPs. Aqueous extracts of Moringa oleifera, waste grass, and Swertia paniculate were used to bio-synthesis AgNPs in order to test their antimicrobial activity against different bacterial strains.[148] Moteriya *et al.* reported the green synthesis of AgNPs using C. pulcherrima to stem extract and investigated their antimicrobial activity against various pathogenic microorga-nisms. Furthermore, green synthesis of AgNPs utilizing stem extracts of Garcinia mangostana, Dorema ammoniacum D., and Fumariae herba is observed[42].

Synthesis of AgNPs from bark :

Bark extract has been broadly utilized as a reduction agent and also as a stabilizing agent in the green synthesis of AgNPs in recent years. *Afzelia quanzensis, Syzygium alternifolium*, and Cochlospermum religiosum bark extracts were used in the green synthesis of AgNPs for antimicrobial activity[99]. Plant bark extracts from Plumbago zeylanica, *Helicteres isora, Terminalia arjuna, Butea monosperma, Prosopis juliflora, Garcinia mangostana*, and Solanum trilobatum were also used to green synthesis AgNPs and test their antimicrobial activity against various bacterial strains[113]. Butea monosperma, Syzygium cumini, and Diospyros montana bark extracts were recently used for the green synthesis of AgNPs and the research of their antibacterial properties[6].

Table-1. Different types of Applications of Silver Nanoparticles

No.	Plant extracts used for preparation of silver nanoparticles	Applications	Refe-rence No.
1.	*Cucumis prophetarum* L.	Increasing antibiotic resistance and antimicrobial activity against *Staphylococcus aureus, Salmonella typhi*	17
2.	*Trigonella foenum-graecum* L.	Dyes Degradation	41
3.	*Antidesma acidum* Retz.	Dyes Degradation	82
4.	*Allium sativum* L.	water recovery process	60
5.	*Aeonium haworthii* Webb. & Berthel.	Use in pharmaceutical and medical natural therapeutic drugs and antimicrobial activity against *Klebsiella pneumoniae, Escherichia coli, Salmonella typhi, Staphylococcus aureus*	146
6.	*Duranta erecta* L.	Human Healthcare	74
7.	*Moringa oleifera* Lam.	Applied in disinfection and antimicrobial activity against *Klebsiella pneumoniae, Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa*	92
8.	*Premna integrifolia* L.	Cytotoxic and antimicrobial candidates and antimicrobial activity against *Pseudomonas aeruginosa, Staphylococcus aureus and Escherichia coli.*	16
9.	*Eupatorium adenophorum* (Spreng.) King & H. Rob.	Degrading rhodamine dye and antimicrobial activity against *Escherichia coli, Staphylococcus aureus*	53
10.	*Ocimum canum* Sim.	Used in various industries and antimicrobial activity against *Escherichia coli*	101

11.	*Mangifera indica* L.	Antimicrobial activity against *Pseudomonas aeruginosa, Staphylococcus aureus* and *Escherichia coli.* It is used in antioxidant and anticancer agents.	117
12.	*Azadirachta indica* A. Juss.	Utilized in medicine, food and cosmetic industries and antimicrobial activity against *Escherichia coli*	98
13.	*Debregeasia salicifolia* (D. Don) Rendle	Finds a use for fabrication of silver NPs and antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli.*	49
14.	*Salvia verticillata* L.	Utilized in cancer therapy, degradation of azo dye Congo red and antimicrobial activity against *Enterococcus faecalis, Escherichia coli*, *Klebsiella pneumoniae, Pseudomonas aeruginosa, Bacillus subtilis, Salmonella enteritidis, Staphylococcus epidermidis* and *Staphylococcus aureus*	19
15.	*Banana leaves*	Anticancer activity	115
16.	*Eucalyptus globulus* Labill.	Solving various biological problems and antimicrobial activity against Gram-negative and Gram-positive bacteria	154
17.	*Eucalyptus corymbia* K.D. Hill & L.A.S. Johnson	Devoid of toxic chemicals either as reducing	148
18.	Bamboo Leaves	Different medical applications and antimicrobial activity against *Escherichia coli and Staphylococcus aureus*	78
19.	*Z. mays* L.	Utilized in nano-medicines, and targeted drug delivery. It is also used as an antimicrobial agent against *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli*	63
20.	*Carthamus tinctorius* L.	Antibacterial agents in food and medicine industry	109
21.	Corn silk	Applied in biomedical, antimicrobial and nanotechnological activity. It is also giving antimicrobial activity against *Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Salmonella enterica*	158
22.	*Murraya koenigii, Zea mays*	Utilized in bactericidal, wound healing and other medical and electronic applications and antimicrobial activity against *Escherichia coli and Staphylococcus aureus*	145

23.	*Zea mays* L.	Pharmaceutical industries	155
24.	*Melia azedarach* L.	Plant protection	143
25.	*Azadirachta indica* A. Juss	Used in biomedical, nanotechnology and antimicrobial activity against *Escherichia coli*	98
26.	*Azadirachta indica* A. Juss	Utilized in biomedical, nanotechnology and antimicrobial activity against Micrococcus, *Bacillus* and *Staphylococcus* species and Gram negative *Klebsiella* species and *Escherichia coli*	9
27.	*Azadirachta indica* A. Juss	Applied in Water purification and antimicrobial activity against *Escherichia coli*	112
28.	*Azadirachta indica* A. Juss	Utilized in nano-medicine and antimicrobial activity against *Escherichia coli* and *Staphylococcus aureus*	147
29.	*Kalopanax pictus* (Thunb.) Nakai	Rapid synthesis of AgNPs and antimicrobial activity against *Escherichia coli*	106
30.	*Azadirachta indica* A. Juss.	Applied in biocompatible green nanoparticles and Nanomedicine. It is also giving in antimicrobial activity against *Escherichia coli and Staphylococcus aureus*	20
31.	*Azadirachta indica and Camellia sinensis* (L.) Kuntze	Catalysis, medical application and antimicrobial activity against *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*	156
32.	*Musa balbisiana* Colla *Azadirachta indica and Ocimum tenuiflorum* L.	Make use in industrial and remedial purposes and antimicrobial activity against *Escherichia coli*	40
33.	*Chenopodium murale* L. S. Fuentes Uotila & Borsch.	Commercial application and antimicrobial activity against *Staphylococcus aureus*	46
34.	*Azadirachta indica* A. Juss	Stability of nanoparticles and antimicrobial activity against *Pseudomonas aeruginosa*	42
35.	*Hibiscus cannabinus* L.	Used as a Reducing agent and antimicrobial activity against *Escherichia coli, Proteus mirabilis and Shigella flexneri*	99
36.	*Berberis vulgaris* L.	Antibacterial agent to replace antibiotics and antibacterial activity against *Escherichia coli, Staphylococcus aureus*	113

37.	*Azadirachta indica* A. Juss	Utilized in catalysis and medical application	6
38.	*Rosmarinus officinalis* L.	Used in medicinal and industrial and antimicrobial activity against *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli*	26
39.	*Acacia leucophloea* (Roxb.) Willd.	Biomedical applications and antimicrobial activity against *Staphylococcus aureus, Bacillus cereus, Listeria monocytogenes, and Shigella flexneri*	124
40.	*Malus domestica* Borkh.	Utilized in green technology and antibacterial activity against of *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa*	45
41.	*Artocarpus heterophyllus* Lam.	Applied in nanomedicine and antibacterial activity against of *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa*	138
42.	Pine	Usages in stable nanoparticle and antibacterial activity against of *Bacillus cereus, Bacillus subtilis, Escherichia coli and Staphylococcus aureus*	43
43.	*Lysiloma acapulcensis* (Kunth.) Benth.	Maintaining low-cytotoxicity than the AgNPs produced chemically antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa*	153
44.	*Boerhaavia diffusa* L. nom. cons.	Applied in medicinal and industrial antibacterial activity against *Aeromonas hydrophila, Pseudomonas fluorescens and Flavobacterium branchiophilum*	78
45.	*Gymnema sylvestre* R. Br.	Find the use in fabrication of silver nanoparticles and antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*	103
46.	Olive leaf	Alternative therapeutic approach and antimicrobial activity against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli*	23
47.	*Combretum erythrophyllum* (Burch) Sond.	Utilized in dermatological infections and antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*	157

48.	*Coffea arabica* L.	Effective antibacterial agent and antibacterial activity against *Escherichia coli and Staphylococcus aureus*	123
49.	Carob leaf	Applied in medicinal and industrial field and antimicrobial activity against *Escherichia coli*	20
50.	*Datura stramonium* L.	Effective antibacterial agent and antibacterial activity against *Escherichia coli and Staphylococcus aureus*	83
51.	*Curcuma longa* L.	Utilized in Agricultural and food industries. It is also giving antimicrobial activity against *Escherichia coli and Listeria monocytogenes*	111
52.	*Persea americana* Mill.	Usages in biomedical and dye sensing areas and antimicrobial activity against *Escherichia coli*	119
53.	*Pistacia atlantica* Desf.	High potential for use in biological applications and antibacterial activity against *Staphylococcus aureus*	66
54.	*Pithophora oedogonia*	Nanomedicine applications and antimicrobial activity against *Escherichia coli, Pseudomonas aeruginosa, Vibrio cholerae, Shigella flexneri, Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus*	125
55.	*Melissa officinalis* L.	It is increasing antibiotic resistance and giving antibacterial effect against *Staphylococcus aureus and Escherichia coli*	136
56.	*Aloe vera* (L.) Burm. f.	Utilized in pharmaceutical, biotechnological and biomedical and antibacterial activity against *Pseudomonas aeruginosa*	130
57.	*Croton sparsiflorwus* Morong	Applied in pharmacology, cosmetics, drug delivery systems, biosensors, Cancer therapeutics and antimicrobial activity against *Staphylococcus aureus, Escherichia coli, Bacillus substilis, fungi Mucor* Spp, *Trichoderma* sp, *Aspergillus niger*	21
58.	*Pedalium murex* L.	Find a use for Antibacterial product and antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Micrococcus flavus, Pseudomonas aeruginosa, Klebsiella pneumoniae and Bacillus pumilus*	24

59.	*Malus domestica* Borkh.	Economic viability and antibacterial activity against *Staphylococcus aureus, Klebsiella pneumoniae and Escherichia coli*	1
60.	Myrtaceae family	Usages in bioactive potential and antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae*	134
61.	*Givotia moluccana* (L.) Sreem	Utilized in cancer treatment, drug delivery, sensors and commercial appliances and antimicrobial activity against *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa*	29
62.	*Nostoc linckia*	Applied in human pathogens and antimicrobial activity against *Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus*	27
63.	Saffron (*Crocus sativus* L.)	Utilized in biomedical field and antimicrobial activity against *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia, Shigella flexneri and Bacillus subtilis*	89
64.	*Musa paradisiaca* L.	Effluent treatment process for reducing the microbial load antimicrobial activity against *Escherichia coli*, *Bacillus subtilis and Staphylococcus aureus*	47
65.	*Calliandra haematocephala* Hassk.	Utilized in probe to detect the presence of H_2O_2 in various samples and antimicrobial activity against *Escherichia coli*	100
66.	*Gracilaria birdiae*	Applied in nano-medicines or drug delivery systems and antimicrobial activity against *Escherichia coli and Staphylococcus aureus*	4
67.	Oak fruit bark	Applied in green industrial production and antimicrobial activity against *Staphylococcus aureus and Bacillus subtilis*	62
68.	*Alpinia katsumadai* Hayata	Find a use as antibacterial and antioxidant agent and antimicrobial activity against *Staphylococcus aureus Escherichia coli and Pseudomonas aeruginosa*	96

69.	*Taraxacum officinale* (L.) Webber ex F.H.Wigg.	Applied in health care sector and antimicrobial activity against *Enterococcus faecalis and Pseudomonas aeruginosa*	137
70.	*Cocos nucifera* L.	Utilized in a treatment of human pathogens and antimicrobial activity against *Klebsiella pneumoniae, Bacillus subtilis, Pseudomonas aeruginosa and Salmonella paratyphi.*	137
71.	*Alternanthera dentata* (Moench) Sluchlik ex R.E.Fr.	Usages as a reducing and stabilizing agent and antibacterial activity against *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae* and, *Enterococcus faecalis*	73
72.	*Caulerpa racemosa*	Find a use for industrial and therapeutic needs and antibacterial activity against *Staphylococcus aureus and Proteus mirabilis*	67
73.	Tea leaf	Utilized as a catalysis, medical application and antibacterial activity against *Escherichia coli*	52
74.	*Acanthophora specifera* (Vahl) Bϕ rgesen	Applied as a sterilizing agent, coating medicinal devices and dental material and antimicrobial activity against *Staphylococcus aureus, Bacillus subtills, Salmonella* spp., *Escherichia coli*	7
75.	*Fritillaria flower*	It is used in eco-friendly and non-toxic protocol and antibacterial activity against *Bacillus subtilis, Enterococcus faecalis, Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, Klebsiella pneumonia*	50
76.	*Tectona grandis* L. f.	It is utilized in leakage of reducing sugars and proteins and antibacterial effects against *Bacillus cereus, Staphylococcus aureus,* and *Escherichia coli*	127
77.	*Rheum palmatum* L.	Find a use for antibacterial and antioxidant agents and antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*	141
78.	Pine cone	Agriculture and various applications. It is gives antimicrobial activity against *Bacillus cereus, Staphylococcus aureus, and Escherichia coli*	37

79.	*Talinum triangulare* (Jacq.) Willd.	Diverse clinical applications and gives antimicrobial activity against *Staphylococcus aureus and Escherichia coli*	69
80.	*Pelargonium/Geranium*	Applied in biomedical field and antimicrobial activity against *Aspergillus flavus and Aspergillus terreus*	11
81.	*Emblica officinalis* Gaertn.	Utilized at Nanomedicine and antimicrobial activity against *Escherichia coli and Klebsiella pneumonia, Staphylococcus aureus and Bacillus subtilis*	116
82.	*Piper nigrum* L.	Utilized in agricultural nanotechnology and antimicrobial activity against *Citrobacter freundii and Erwinia cacticida*	108
83.	*Mentha aquatica* L.	Applied in different types of dyes and antimicrobial activity against *Pseudomonas aeruginosa, Escherichia coli, Bacillus cereus, and Staphylococcus aureus*	131
84.	*Clitoria ternatea* L. and *Solanum nigrum* L.	It is utilized in large-scale synthesis of nanoparticles and antimicrobial activity against *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Klebsiella aerogenes*	149
85.	*Phlomis*	Nanomedicine area and antimicrobial activity against *Staphylococcus aureus and Bacillus cereus and Salmonella typhimurium and Escherichia coli*	22
86.	*Zingiber officinale*	*Antimicrobial activity* against *Bacillus subtilis and Staphylococcus aureus*. It is used in food industry.	59
87.	*Aloe vera* (L.) Burm. f.	*Antimicrobial activity* against *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa and Enterobacter* spp. It is also used in biomedical field.	118
88.	*Aloe vera* (L.) Burm. f.	Utilized as an antibacterial and antioxidant agents and antimicrobial activity against *Escherichia coli, Staphylococcus aureus.*	36
89.	*Aloe vera* (L.) Burm. f.	Medical field utilization and antimicrobial activity against *Rhizopus* sp. *and Aspergillus* sp.	150

90.	*Aloe barbadensis* Mill.	Study of nanotechnology and antibacterial activity against *Escherichia coli, Salmonella typhi, Staphylococcus aureus, Bacillus thuringiensis*	55
91.	*Aloe vera* (L.) Burn. f.	Synthesized antibiotic drugs and antibacterial activity against *Escherichia coli, Staphylococcus aureus.*	91
92.	*Thuja orientalis* (L.)Franco and *Aloe vera* (L.) Burn.f.	Medicine, textiles, and home appliances applications and antimicrobial activity against *Escherichia coli, Staphylococcus aureus*	90
93.	*Aloe vera* (L.) Burn. f.	Ideal alternatives in medicinal applications and antibacterial activity against *Pseudomonas aeruginosa and Escherichia coli,*	80
94.	*Cannabis sativa* L.	Applied as a water filtration and antibacterial activity against *Staphylococcus aureus, and Escherichia coli*	70
95.	*Rhamnus virgata*	Antimicrobial and antiviral applications and antibacterial activity against *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumoniae and Escherichia coli*	144
96.	*Aloe vera* (L.) Burn.f.	Utilized in Sterile textiles, antibacterial coatings, and useful health care products and antibacterial activity against *Escherichia coli, Staphylococcus aureus*	57
97.	*Allium cepa* L. & *Musa acuminata* Colla	Useful in biomedical and agricultural fields.	121
98.	*Aloe vera* (L.) Burn.f.	Ideal alternatives in medicinal applications and antimicrobial activity against *Escherichia coli, Bacillus Subtilis and Pseudomonas aeruginosa*	80
99.	*Strychnos potatorum* Linn.F.	Utilized as a multidrug-resistant and antimicrobial activity against *Staphylococcus aureus and Klebsiella pneumonia*	15
100.	*Aloe vera* (L.) Burm. f.	Better antibacterial agent and antibacterial activity against *Klebsiella pneumonia, Pseudomonas aeruginosa and Salmonella typhi strains. Against Escherichia coli*	152
101.	*Aloe vera* (L.) Burm. f.	Utilized as a Sterile textiles, antibacterial coatings, and useful health care and antibacterial activity against *Escherichia coli and Staphylococcus aureus*	105

102.	*Salvia spinosa* L.	Applied in the biomedical areas and antibacterial activity in the presence of *Escherichia coli, Bacillus subtilis and Bacillus vallismortis*	93
103.	*Aloe vera* extracts	Usages of medical entomology and parasitology and antibacterial activity in the presence of *Bacillus subtilis, Klebsiella pneumoniae, and Salmonella typhi*	120
104.	*Afzelia quanzensis* Welw.	Applied in the pharmacological properties and antibacterial activity against *Staphylococcus aureus, Escherichia coli*	114
105.	*Atalantia monophylla* (L.) Correa	Antimicrobial drugs and biosensors and antimicrobial activity against *Bacillus subtilis, Escherichia coli*	79
106.	*Aloe vera* extracts	Study of nanotechnology	120
107.	*Aegle marmelos* (L.) Correa	Utilized in new and effective herbal medicine and antibacterial activity in the presence of *Bacillus cereus, Pseudomonas aeruginosa and Escherichia coli*	79
108.	*Capsicum frutescens* L.	Find a use for Nanomedicine, biomedical field and antibacterial activity in the presence of *Escherichia coli, Bacillus subtilis*	5
109.	Maize *Zeamays* L.	Applied in the field of biomedical and industrial products, pharmaceutical Industry and antibacterial activity against *Escherichia coli, Staphylococcus aureus*	141
110.	*Aloe vera barbadensis* Miller	Usages in agricultural, biological, and pharmaceutical and antimicrobial activity against *Salmonella* spp., *Escherichia coli*	36
111.	*Aloe vera* (L.) Burm. f.	Find a use for functional textiles and antibacterial activity against *Escherichia coli or Staphylococcus aureus*	13
112.	*Hibiscus rosa-sinensis* L.	Applied in biomedical, cellular imaging, cosmetics, drug delivery, food, and agrochemical industries and antibacterial activity in the presence of *Pseudomonas aeruginosa, Staphylococcus aureus, Klebsiella pneumoniae, Enterococcus faecalis, and Escherichia coli*	32

113.	*Solanum indicum* L.	Wide therapeutic activity and antimicrobial activity against *Staphylococcus* sp. *and Klebsiella* sp.	91
114.	*Aloe vera* (L.) Burm. f.	Bio-coating, novel antimicrobial agents, and drug delivery systems and antibacterial activity against *Staphylococci aureus, Salmonella enterica, Bacillus cereus, and Escherichia coli*	72
115.	*Salacia chinensis* L.	Good alternative in treatment of bacterial infections and antimicrobial activity against *Staphylococcus aureus and Pseudomonas aeruginosa*	84
116.	*Moringa oleifera* Lam.	Utilized as a broad-spectrum antimicrobial agents and antibacterial activity against *Staphylococcus aureus, Enterococcus faecalis, Escherichia coli, Pseudomonas aeruginosa and Klebsiella pneumoniae*	31
117.	*Cissus quadrangularis* L.	Find a use for biomedical and Pharmaceutical and antibacterial activity against *Bacillus subtilis and Klebsiella pneumonia*	8
118.	*Butea monosperma* (Lam.) Taub	Biomedical applications and it gives an antimicro-bial activity against *Bacillus subtilis and Escherichia coli*	88
119.	*Ocimum canum* Sim.	Therapeutic uses and antibacterial activity against *Escherichia coli*	101
120.	*Ocimum canum* Sim.	Utilized in drug transportation and metabolism and antibacterial activity against *Escherichia coli and Staphylococcus aureus*	102
121.	*Ocimum sanctum* L.	Bio-medical and antibacterial activity against *Escherichia coli*	28
122.	sun dried Tulsi leaves	100% reduction of 4-NP to 4-AP by AgNPs	128
123.	*Ocimum tenuiflorum* L.	Applied in medical field, cosmetic industries and antimicrobial activity against *Escherichia coli, Salmonella typhi, and Klebsiella pneumoniae*	40
124.	*Kalanchoe pinnata*	Medical application and antibacterial activity in the presence of *Escherichia coli*	68
125.	*Achillea millefolium* L.	Alternative antibacterial and antioxidant agents and antimicrobial activity against *Staphylococcus aureus, Bacillus subtilis, Salmonella enterica, Escherichia coli, Pseudomonas aeruginosa*	12
126.	*Moringa oleifera*	Medical application and antibacterial activity against *Escherichia coli*	53

127.	*Limonia acidissima*	Utilized in the medical field, cosmetic industries and antibacterial activity against *Escherichia coli, Pseudomonas aeruginosa,and Bacillus subtilis*	86
128.	*Caralluma tuberculata*	Applied in Development of sustainable commercial and antibacterial activity against *Staphylococcus aureus, Bacillus cereus, Pseudomonas aeruginosa and Escherichia coli.*	39
129.	*Aegle marmelos*	Antimicrobial agent and gives an antimicrobial activity against *Streptococcus pyogenes, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus and Aeromonas hydrophila*	135
130.	*Trifolium resupinatum*	Better understanding of the antifungal efficiency and antifungal activity against *R. solani and N. Parvum (Fungi)*	44
131.	*Aloe barbadensis* Miller and *Ocimum tenuiflorum*	Alter the intracellular ROS levels and antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, and Escherichia coli.*	161
132.	*Ducrosia anethifolia*	Applied in Industry of humans & environment and antimicrobial activity against *Staphylococcus aureus, Bacillus cereus, Pseudomonas aeruginosa and Escherichia coli*	132
133.	*Borago officinalis*	Materials and biomedical applications and antibacterial activity against *Salmonella Typhi, Bacillus subtilis, and Staphylococcus aureus*	61
134.	*Ocimum gratissimum*	Medical application and antibacterial activity against *Escherichia coli, Klebsiella pneumonia, Staphylococcus aureus*	95
135.	*Muntingia calabura*	Utilized as a water treatment, medicinal purposes and antimicrobial activity against *Escherichia coli and Bacillus cereus*	87
136.	*Ocimum tenuiflorum, Mentha spicata, Azadirachta indica*	Therapeutic application and antibacterial activity against *Escherichia coli and Staphylococcus aureus*	25
137.	Pomegranate and Orange Peel	Applied in Medical science, healthcare, veterinary medicine, cosmetics, food industry, nanobiotechnology and various other fields	65

138.	*Trigonella foenum-graecum* L.	Excellent antifungal and antibacterial agent and antimicrobial activity against *Bacillus subtilis, Staphylococcus aureus, and Escherichia coli*	139
139.	*Fenugreek leaves*	Safety to human cells and antibacterial effect on *Escherichia coli and Staphylococcus aureus*	159
140.	*Fenugreek leaves*	Applied in animal husbandry, packaging, accessories, cosmetics, health and military & antimicrobial activity against *Pseudomonas aeruginosa*	18
141.	*Fenugreek seeds*	Utilized as a medical field, cosmetic industries and antibacterial activity against *Escherichia coli and Staphylococcus aureus*	14
142.	*Trigonella foenum-graecum*	Find a use for Photocatalytic, waste treatment and antibacterial activity against *Escherichia coli, Staphylococcus aureus and Bacillus cereus*	160
143.	*Crocus haussknechtii* Bois bulb	Utilized for water treatment, medicinal purposes and antibacterial activity against *Staphylococcus aureus and Pseudomonas aeruginosa*	110
144.	Maize, Fenugreek, and Onion	Improved the early growth characteristics	77
145.	*Polyalthia longifolia*	Utilized enhancing the growth of crops and antimicrobial activity against *Antifungal activity checked*	34
146.	Fenugreek seed	Applied in the field of nanomedicine and antibacterial activity against *Klebsiella pneumonia, Bacillus subtilis and Staphylococcus aureus & Escherichia coli*	75
147.	*Moringa oleifera* flower	Utilized in Water Purification and antimicrobial activity against *Klebsiella pneumonia and Staphylococcus aureus*	81
148.	*Dunaliella salina*	Bio-medical field and antimicrobial activity against *Escherichia coli, Bacillus subtilis, Enterobacter tobbaci.*	33
149.	*Azadirachta indica* A. Juss	Antimicrobial packaging material	2
150.	*Oxalis griffithii*	Developing new drugs and antibacterial activity against *Escherichia coli and Bacillus subtilis*	71

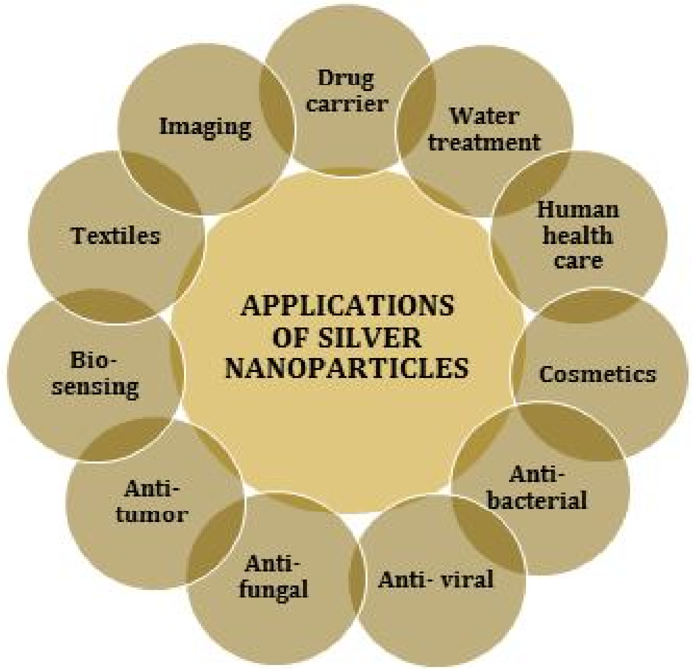

Figure 3. Applications of silver nanoparticle in different fields

Applications of Silver nanoparticles :

Based on special chemical and physical characteristics of silver nanoparticles, such as high surface area to volume ratio, excellent catalytic activity and antimicrobial properties, silver nanoparticles (AgNPs) have received a lot of attention in recent years.

These characteristics have led to a variety of AgNPs applications in various fields, as described below[85]. AgNPs have been widely used in medicine due to their antimicrobial properties. They have been demonstrated to be effective against a broad range of bacteria, viruses, and fungi, which makes them perfect candidates for wound dressing and implantable medical coatings[116]. AgNPs are additionally utilized in cancer therapy because they can selectively target cancer cells while sparing healthy cells, reducing chemotherapy side effects[56]. AgNPs have been used in the fabrication of conductive inks for printed electronics in the field of electronics. These inks are used to print conductive patterns on a variety of flexible substrates, including paper, plastic, and textiles. AgNPs have also been used to improve the electrical conductivity and mechanical properties of polymer composites[64]. AgNPs have been used in water treatment because of their extremely good catalytic activity in the degradation of organic pollutants. They've also been used as antimicrobial agents in water treatment systems, where they effectively control bacterial and viral growth[2]. AgNPs have been used as an antimicrobial agent in food packaging to enlarge the shelf life of food products. They can be mixed into packaging materials like plastics and paper to prevent the growth of bacteria and fungi that cause spoilage[94]. Finally, because of their unique physical and chemical properties, AgNPs have a wide range of applications in a variety of fields. Because of their antimicrobial properties, they are excellent candidates for use in medicine, water treatment, and food packaging, while their excellent catalytic behavior makes them appropriate to be utilized in electronics and environmental remediation[22].

Many initiatives have been taken for develop green synthesis. Green synthesis has an advantage over chemical and physical methods because it is less expensive, more environmentally friendly, and can be successfully expanded for large-scale synthesizing. Increased awareness of green chemistry and the use of ecofriendly pathways for the manufacturing of metal NPs, particularly Ag-NPs, fueled the interest in discovering sustainable and environmental methods. However, when compared to others, the development of microorganisms and large-scale formulation residue is difficult. Other benefits of synthesis from plant extracts include a sanitary working atmosphere, protection of health and the environment, reduced waste, and highly reliable products. Through a variety of applications, Ag-NPs synthesized via the green method have important factors of nanotechnology. Ag-NPs have appeared in the present as well as the future, with a wide range of applications including cardiovascular implants, dentistry, medicine, therapeutics, biosensors, agriculture, and many others. Green methods for synthesizing AgNPs utilizing bio renewable materials appear great promise because they need non-toxic chemical compounds for silver salt reduction. This review covers all natural resources used to produce AgNPs in the last ten years, including plants, bacteria, fungi, and biopolymers.

References :

1. Abdel-Aziz, M.S.; M.S. Shaheen, A. A. El-Nekeety, and M. A. Abdel-Wahhab (2014) *J. Saudi Chem. Soc. 18* (4): 356–363.
2. Ahmad, M. A.; S. Salmiati; M. Marpongahtun; M. R. Salim; J. A. Lolo; and Syafiuddin, (2020) *Biointerface Res. Appl. Chem.*, *10* (5): 6253–6261.
3. Ahmadi, O.; H. Jafarizadeh-Malmiri and N. Jodeiri, (2020) *Green Process. Synth. 7* (3): 231–240.
4. Ali, Z. A.; R. Yahya; S. D. Sekaran; and R. Puteh, (2016). *Adv. Mater. Sci. Eng.*, 2016.
5. Allafchian, A. R.; S. Z. Mirahmadi-Zare; S. A. H. Jalali; S. S. Hashemi, and M. R. Vahabi, (2016) *J. Nanostructure Chem.*, *6* (2): 129–135.
6. Almatroudi, (2020). *Open Life Sci*, *15* (1): 819.
7. Alsammarraie, F. K.; W. Wang; P. Zhou; A. Mustapha and M. Lin (2018). *Colloids Surfaces B Biointerfaces*, *171*: 398–405.
8. Alwhibi, M.S.; D.A. Soliman; M.A. Awad; A. B. Alangery; H. Al Dehaish, and Y. A. Alwasel, (2021) *Green Process. Synth.*, *10* (1): 412–420.
9. Alwhibi, M.S.; D.A. Soliman; M.A. Awad; H. Rizwana; and N. A. Marraiki, (2018) *J. Comput. Theor. Nanosci.*, *15* (4): 1255–1260.
10. Alwhibi, M.S.; D.A. Soliman; M.A. Awad; H. Rizwana; and N. A. Marraiki, (2018) *J. Comput. Theor. Nanosci.*, *15* (4): 1255–1260.
11. Anandalakshmi, K.; J. Venugobal; and V.

Ramasamy, (2016) *Appl. Nanosci.*, *6* (3): 399–408.

12. Anju, T. R.; S. Parvathy; M. Valiya Veettil; J. Rosemary; T. H. Ansalna; M. M. Shahzabanu, and S. Devika, (2021) *Mater. Today, Proc.*, *43*: 3956–3960.
13. Annavaram, V.; V. R. Posa; V.G. Uppara; S. Jorepalli; and A. R. Somala, (2015) *Bionanoscience*, *5* (2): 97–103.
14. Arokiyaraj, S.; S. Vincent; M. Saravanan; Y. Lee; Y. K. Oh; and K. H. Kim, (2017) *Artif. cells, nanomedicine, Biotechnol.*, *45* (2): 372–379.
15. Arshad, H.; M. Saleem; U. Pasha and S. Sadaf, (2022) *Electron. J. Biotechnol.*, *55*: 55–64.
16. Aryan; Ruby; and M. S. Mehata, (2021). *Chem. Phys. Lett.*, *778*: 138760.
17. Asif, M.; R. Yasmin; R. Asif; A. Ambreen; M. Mustafa; and S. Umbreen, (2022) *Dose. Response.*, *20*(1).
18. Aswani, R., and E. K. Radhakrishnan, (2021) *Green Funct. Nanomater. Environ. Appl.*, 129–154.
19. Awad, M. A.; A. Hendi; K. M. Ortashi; B. Alzahrani; D. Soliman; A. Alanazi; W. Alenazi; R. M. Taha; R. Ramadan; M. El-Tohamy; N. AlMasoud and T.S. Alomar (2021) *Sensors Actuators A Phys.*, *323*: 112670.
20. Awwad, A. M.; N. M. Salem; and A. O. Abdeen (2013) *Int. J. Ind. Chem. 41*,*4*(1): 1–6.
21. Bagherzade, G.; M. M. Tavakoli; and M. H. Namaei, (2017) *Asian Pac. J. Trop. Biomed.*, *7*(3): 227–233.
22. Balčiūnaitienė, A.; M. Liaudanskas; V. Puzerytė; J. Viškelis; V. Janulis; P. Viškelis; E. Griškonis; and V. Jankauskaitė, (2022) *Plants (Basel, Switzerland)*, *11* (8).
23. Banerjee, P.; M. Satapathy; A. Mukhopahayay; and, P. Das (2014) *Bioresour. Bioprocess.*, *1* (1): 1–10.
24. Baruah, K.; M. Haque; L. Langbang; S. Das; K. Aguan; and A. Singha Roy, (2021) *J. Mol. Liq.*, *337*: 116422.
25. Basumatary, S.; K. J. Kumar; J. Daimari; A. Mondal; S. Kalita; K.S. Dey; and A.K. Deka, (2023) *Environ. Nanotechnology, Monit. Manag.*, *19*: 100769.
26. Behravan, M.; A. Hossein Panahi; A. Naghizadeh; M. Ziaee; R. Mahdavi; and A. Mirzapour, (2019) *Int. J. Biol. Macromol.*, *124*: 148–154.
27. Beigoli, S.; A. Hekmat; F. Farzanegan; and M. Darroudi, (2021) *J. Sol-Gel Sci. Technol. 983*, *98*(3): 508–516.
28. Bindhu, M. R.; and M. Umadevi, (2013) *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, *101*: 184–190.
29. Bindhu, M. R.; M. Umadevi; G.A. Esmail; N. A. Al-Dhabi; and M. V. Arasu, (2020) *J. Photochem. Photobiol. B Biol.*, *205*: 111836.
30. Burange, P. J.; M. G. Tawar; R. A. Bairagi; V.R. Malviya; V.K. Sahu; S.N. Shewatkar; R. A. Sawarkar; and R. R. Mamurkar, (2021) *Bull. Natl. Res. Cent. 451*, *45* (1): 1–13.
31. Chikdu D., P. Pal, A. Gujar, R. Deshmukh and S Kate; (2015); *Journal of Global Biosciences*, 24,7.
32. Chouhan, S.; and S. Guleria, (2020) *Mater. Sci. Energy Technol.*, *3*: 536–544.
33. Das, R.; P. Deb; H. Pandey; P. Shyam; and D. Singh, (2022) *J. Agric. Food Res.*, *10*: 100390.
34. Dashora, A.; K. Rathore; S. Raj; and K. Sharma, (2022) *Biochem. Biophys. Reports*, *31*: 101320.
35. De Aragão, A.P.; T. M. de Oliveira; P.V. Quelemes; M.L.G. Perfeito; M.C. Araújo;

Santiago, J. de A. S.; Cardoso, V. S.; Quaresma, P.; de Souza de Almeida Leite, J. R.; da Silva, D. A. (2019) *Arab. J. Chem.*, *12* (8): 4182–4188.
36. De Jesús Ruíz-Baltazar, Á.; S. Y. Reyes-López; D. Larrañaga; M. Estévez; and R. Pérez, (2017) *Results Phys.*, *7*: 2639–2643.
37. Deshmukh, A. R.; A. Gupta; and B. S. Kim, (2019) *Biomed Res. Int.*.
38. Devi, M.; S. Devi; V. Sharma; N. Rana; R. K. Bhatia; and A. K. Bhatt, (2020) *J. Tradit. Complement. Med.*, *10* (2): 158–165.
39. Dhand, V.; L. Soumya; S. Bharadwaj; S. Chakra; D. Bhatt; and B. Sreedhar, (2016) *Mater. Sci. Eng. C*, *58*: 36–43.
40. Dizaj, S. M.; F. Lotfipour; M. Barzegar-Jalali; M. H. Zarrintan; and K. Adibkia, (2014) *Mater. Sci. Eng. C*, *44*: 278–284.
41. Donga, S.; and S. Chanda, (2021), *49* (1): 292–302.
42. Dua, T. K.; S. Giri; G. Nandi; R. Sahu; T. K. Shaw; and P. Paul, (2023) *Chem. Pap.*, *77* (6): 2947–2956.
43. Eren, A.; and M. F. Baran, (2019) *Appl. Ecol. Environ. Res.*, *17* (2): 4097–4105.
44. Essghaier, B.; R. Dridi; F. Mottola; L. Rocco; M. F. Zid and H. Hannachi (2022) *Nanomater. (Basel, Switzerland)*, *13* (1):
45. Garibo, D.; H. A. Borbón-Nuñez; J.N.D. de León; E. García Mendoza; I. Estrada; Y. Toledano-Magaña; H. Tiznado; M. Ovalle-Marroquin; A. G. Soto-Ramos; A. Blanco; J. A. Rodríguez; O. A. Romo; L. A. Chávez-Almazán; and A. Susarrey-Arce, (2020) *Sci. Rep.*, *10* (1):
46. Ghaedi, M.; M. Yousefinejad; M. Safarpoor; H. Z. Khafri; and M. K. Purkait, (2015) *J. Ind. Eng. Chem.*, *31*: 167–172.
47. Ghoshal, G.; and M. Singh, (2022) *Mater. Sci. Energy Technol.*, *5*: 22–29.
48. Gil-Korilis, A.; M. Cojocaru; M. Berzosa; C. Gamazo; N.J. Andrade; and K.J. Ciuffi (2023) *Appl. Clay Sci.*, *240*: 106968.
49. Girón-Vázquez, N. G.; C. M. Gómez-Gutiérrez; C. A. Soto-Robles; O. Nava; E. Lugo-Medina; V.H. Castrejón-Sánchez; A. R. Vilchis-Nestor; and P. A. Luque, (2019) *Results Phys.*, *13*: 102142.
50. Gomathi, M.; A. Prakasam; P.V. Rajkumar; S. Rajeshkumar; R. Chandrasekaran; and P. M. Anbarasan, (2020) *South African J. Chem. Eng.*, *32*: 1–4.
51. Gomathi, M.; P.V. Rajkumar; A. Prakasam; and K. Ravichandran, (2017) *Resour. Technol.*, *3* (3): 280–284.
52. Habeeb Rahuman, H. B.; R. Dhandapani; S. Narayanan; V. Palanivel; R. Paramasivam; R. Subbarayalu; S. Thangavelu; and S. Muthupandian, (2022) *IET nanobiotechnology*, *16* (4): 115–144.
53. Haleem, A.; M. Javaid; R.P. Singh; S. Rab; and R. Suman, (2023) *Glob. Heal. J.* 02.008.
54. He, Y.; F. Wei; Z. Ma; H. Zhang; Q. Yang; B. Yao; Z. Huang; J. Li; C. Zeng; and Q. Zhang, (2017) *RSC Adv.*, *7* (63): 39842–39851.
55. Hemlata; P. R. Meena; A. P. Singh; and K. K. Tejavath; (2020) *ACS Omega*, *5*(10): 5520–5528.
56. Hemmati, S.; A. Rashtiani; M.M. Zangeneh; P. Mohammadi; A. Zangeneh and H. Veisi (2019) *Polyhedron*, *158*: 8–14.
57. Herdiana, Y.; N. Wathoni; S. Shamsuddin; and M. Muchtaridi, (2022) *OpenNano*, *7*: 100048.
58. Ibrahim, H. M. M. (2015) *J. Radiat. Res. Appl. Sci.*, *8* (3): 265–275.
59. Iravani, S.; H. Korbekandi; S. V. Mirmohammadi and B. Zolfaghari, (2014)

Res. Pharm. Sci., *9* (6): 385.

60. Jadhav, K.; D. Dhamecha; B. Dalvi; and M. Patil (2015) *Part. Sci. Technol.*, *33*(5): 445–455.
61. Jagtap, U. B.; and V. A. Bapat, (2013) *Ind. Crops Prod.*, *46*: 132–137.
62. Jain, A. S.; P. S. Pawar; A. Sarkar; V. Junnuthula; and S. Dyawanapelly, (2021) *Int. J. Mol. Sci.*, *22* (21):
63. Jain, D.; H. K. Daima; S. L. Kothari; D. Jain; H. Kumar Daima; S. Kachhwaha; and S. L. Kothari, (2009) *Artic. Dig. J. Nanomater. Biostructures*, *4* (3): 557–563.
64. Jain, S.; and M. S. Mehata, (2017) *Sci. Rep.*, *7* (1):
65. Jebril, S.; R. Khanfir Ben Jenana; and C. Dridi, (2020) *Mater. Chem. Phys.*, *248* : 122898.
66. Jemilugba, O.T.; E.H.M. Sakho; S. Parani; V. Mavumengwana; and O. S. Oluwafemi (2019) *Colloid Interface Sci. Commun.* 9, *31*: 100191.
67. Kagithoju, S.; V. Godishala and R.S. Nanna (2015) *3 Biotech*, *5* (5): 709–714.
68. Kathiravan, V.; S. Ravi; S. Ashokkumar; S. Velmurugan; K. Elumalai; and C. P. Khatiwada, (2015) *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, *139*: 200–205.
69. Kathiraven, T.; A. Sundaramanickam; N. Shanmugam; and T. Balasubramanian, (2015) *Appl. Nanosci.*, *5* (4): 499–504.
70. Kavitha, A.; S. Shanmugan; C. G. Awuchi; C. Kanagaraj and S. Ravichandran (2021) *Inorg. Chem. Commun.*, *134*: 109045.
71. Kazlagić, A.; A. Lagumdžija; B. Borovac; S. Hamidović; O.A. Abud and E. Omanović-Mikličanin, (2020) *IFMBE Proc.*, *78*: 335–341.
72. Khalil, M. M. H.; E. H. Ismail; K. Z. El-Baghdady and D. Mohamed (2014) *Arab. J. Chem.*, *7* (6): 1131–1139.
73. Khan, I.; K. Saeed; and I. Khan, (2019) *Arab. J. Chem.*, *12* (7): 908–931.
74. Khan, J.; I. Naseem; S. Bibi; S. Ahmad; F. Altaf; M. Hafeez; M. M. Almoneef; and K. Ahmad, (2023) *Materials (Basel).*, *16* (1):
75. Khan, J.; I. Naseem; S. Bibi; S. Ahmad; F. Altaf; M. Hafeez; M.M. Almoneef; and K. Ahmad, (2023) Materials, *16:* 129.
76. Khatami, M.; M. S. Nejad; S. Salari; and P. G. N. Almani, (2016) *IET nanobiotechnology*, *10* (4): 237–243.
77. Khwaja S. S, H. Azamal, and Rao Rifaqat A. K. (2018) *Journal of Nanobiotechnology,* (14): 16.
78. Krithiga, N.; A. Rajalakshmi; and A. Jayachitra, (2015) *J. Nanosci.*, 1–8.
79. Kumar, D. A.; V. Palanichamy; and S.M. Roopan, (2014) *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, *127*: 168–171.
80. Kumavat, S. R.; and S. Mishra, (2021) *Int. Nano Lett.*, *11* (4): 355–370.
81. Lee, S. H.; and B. H. Jun, (2019) *Int. J. Mol. Sci.*, *20* (4):
82. Li, R.; Y. Pan; N. Li; Q. Wang; Y. Chen; M. Phisalaphong; and H. Chen, (2020) *Colloids Surfaces a Physicochem. Eng. Asp.*, *598*: 124827.
83. Logaranjan, K.; A. J. Raiza; S. C. B. Gopinath; Y. Chen; and K. Pandian (2016) *Nanoscale Res. Lett.*, *11* (1): 1–9.
84. Loo, Y. Y.; Y. Rukayadi; M. A. R. Nor-Khaizura; C. H. Kuan; B. W. Chieng; M. Nishibuchi; and S. Radu, (2018) *Front. Microbiol.*, *9* (JUL).
85. Mahadevan, S.; S. Vijayakumar; and P. Arulmozhi, (2017) *Microb. Pathog.*, *113*: 445–450.

86. Mahendran, N.; B. Anand; M. Rajarajan; A. Muthuvel; and V. Mohana, (2022). *Mater. Today, Proc.*, *49*: 2620–2623.
87. Mandal, S.; S. B. Marpu; R. Hughes; M. A. Omary; and S. Q. Shi, (2021) *Green Sustain. Chem.*, *11* (01): 28–38.
88. Mankad, M.; G. Patil; D. Patel; P. Patel; and A. Patel, (2020) *Arab. J. Chem.*, *13* (1): 2865–2872.
89. Mariselvam, R.; A. J. A. Ranjitsingh; A. Usha Raja Nanthini; K. Kalirajan; C. Padmalatha; and P. Mosae Selvakumar, (2014) *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, *129*: 537–541.
90. Medda, S.; A. Hajra; U. Dey; P. Bose; and N.K. Mondal, (2015) *Appl. Nanosci.*, *5* (7): 875–880.
91. Mihailović, V.; N. Srećković; Z. P. Nedić; S. Dimitrijević; M. Matić; A. Obradović; D. Selaković; G. Rosić; Katanić and J. S. Stanković, (2023) *Molecules*, *28* (2):
92. Mohammadlou, M.; H. Jafarizadeh-Malmiri and H. Maghsoudi (2017) *Green Process. Synth.*, *6* (1): 31–42.
93. Mohanta, Y.K.; S.K. Panda; A. K. Bastia; and T. K. Mohanta, (2017) *Front. Microbiol. 8*: 626.
94. Moodley, J. S.; S. B. N. Krishna; K. Pillay; Sershen; and P. Govender, (2018) *Adv. Nat. Sci. Nanosci. Nanotechnol.*, *9* (1):
95. Moond, M.; S. Singh; S. Sangwan; P. Devi; A. Beniwal; J. Rani; A. Kumari; and S. Rani, (2023) *Mol. 28* (3): 951.
96. Mosaviniya, M.; T. Kikhavani; M. Tanzifi; M. Tavakkoli Yaraki; P. Tajbakhsh and A. Lajevardi, (2019) *Colloid Interface Sci. Commun.*, *33*: 100211.
97. Mostafa, Y.S.; S.A. Alamri; S.A. Alrumman; M. Hashem; and Z. A. Baka, (2021) *Plants (Basel, Switzerland)*, *10* (11):
98. Moyo, M.; M. Gomba; and T. Nharingo, (2015). *Int. J. Ind. Chem.*, *6*(4): 329–338.
99. Murugan, K.; B. Senthilkumar; D. Senbagam; and S. Al-Sohaibani, (2014) *Int. J. Nanomedicine*, *9* (1): 2431–2438.
100. Nadaf, S.J.; N.R. Jadhav; H.S. Naikwadi; P. L. Savekar; I. D. Sapkal; M.M. Kambli; and I. A. Desai, (2022) *OpenNano*, *8*: 100076.
101. Naikoo, G.A.; M. Mustaqeem; I.U. Hassan; T. Awan; F. Arshad; H. Salim; and A. Qurashi, (2021) *J. Saudi Chem. Soc.*, *25* (9): 101304.
102. Narasimha, R.; L. V. Hublikar; S. M. Patil; and P. Bhat, (2021) *J. Water Environ. Nanotechnol.*, *6* (1): 49–61.
103. Nouri, A.; M. Tavakkoli Yaraki; A. Lajevardi; Z. Rezaei; M. Ghorbanpour and M. Tanzifi (2020) *Colloid Interface Sci. Commun.*, *35*: 100252.
104. Ojo, O. A.; B. E. Oyinloye; A. B. Ojo; O. B. Afolabi; O. A. Peters; O. Olaiya; A. Fadaka; J. Jonathan; and O. Osunlana, (2017) *J. Bionanoscience*, *11* (4): 292–296.
105. Otunola, G. A.; A. J. Afolayan; E. O. Ajayi; and S. W. Odeyemi, (2017) *Pharmacogn. Mag.*, *13*.
106. Pandian, H.; Senthilkumar; M, V. Ratnam; M, N.; and S, S. (2023) *Environ. Res.*, *216*: 114641.
107. Paosen, S.; J. Saising; A. Wira Septama; and S. Piyawan Voravuthikunchai, (2017) *Mater. Lett.*, *209*: 201–206.
108. Patel, S. G.; and N. K. Patel (2023) *Egypt. J. Agric. Res.*, *101* (1): 4–12.
109. Patil S., S. Rajeswari, V. Rajendran, and R. Seenivasan (2017) *Int J Pharm Pharm Sci.*, 7, 6, 169.
110. Patil, P. S. (2014) *Int. J. Pharm Tech Res.;* (1): 21–28.
111. Patra, J. K.; and K. H. Baek, (2017)

Frontiers in Microbiology, 8:

112. Pattanayak, S.; M.M.R. Mollick; D. Maity; S. Chakraborty; S.K. Dash; S. Chattopadhyay; S. Roy; D. Chattopadhyay; and M. Chakraborty, (2017) *J. Saudi Chem. Soc.*, *21* (6): 673–684.
113. Paulkumar, K.; G. Gnanajobitha; M. Vanaja; S. Rajeshkumar; C. Malarkodi; K. Pandian and G. Annadurai (2014) *Scientific World Journal*.
114. Prem Raj Meena, Arvind Pratap Singh, and Kiran Kumar Tejavath; (2020) *ACS Omega*, 5 (10): 5520-5528.
115. Rafique, M.; I. Sadaf; M. S. Rafique; and M.B. Tahir (2017) *Artif. Cells, Nanomedicine Biotechnol.*, *45* (7): 1272–1291.
116. Raj, S.; R. Trivedi; and V. Soni, (2021) *Surfaces*, *5* (1): 67–90.
117. Raja, S.; V. Ramesh; and V. Thivaharan, (2017) *Arab. J. Chem.*, *10* (2): 253–261.
118. Rajkumar, T.; A. Sapi; G. Das; T. Debnath; A. Z. Ansari; and J. K. Patra, (2019) *J. Photochem. Photobiol. B Biol.*, *193*: 1–7.
119. Ramesh, P. S.; T. Kokila; and D. Geetha, (2015) *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, *142*: 339–343.
120. Rautela, A.; J. Rani and M. Debnath (Das) (2019) *J. Anal. Sci. Technol.*, *10* (1): 1–10.
121. Rizwana, H.; M.S. Alwhibi; H.A. Aldarsone; M. A. Awad; D. A. Soliman; and R. S. Bhat, (2021) *Green Process. Synth.*, *10*(1): 421–429.
122. Rodríguez-Félix, F.; A.G. López-Cota; M.J. Moreno-Vásquez; A.Z. Graciano-Verdugo; I. E. Quintero-Reyes; C. L. Del-Toro-Sánchez; and J. A. Tapia-Hernández, (2021) *Heliyon*, *7* (4): e06923.
123. Rohaizad, A.; Z. A. Mohd Hir; U.A. A.M. Kamal; Z. Aspanut; and A. A. Pam, (2023) *Results Chem.*, *5*: 100731.
124. Roy, P.; B. Das; A. Mohanty; and S. Mohapatra, (2017) *Appl. Nanosci.*, *7* (8): 843–850.
125. S, S.; M, P.; KK, U.; MS, V. Das; S, N.; K, G.; and A, M. (2023) *Appl. Surf. Sci. Adv.*, *13*: 100377.
126. Sadeghi, B.; A. Rostami and S. S. Momeni (2015) *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, *134*: 326–332.
127. Sahni, G.; A. Panwar; and B. Kaur, (2015) *Int. Nano Lett. 52*, *5* (2): 93–100.
128. Salata, O. V. (2004) *J. Nanobiotechnol.*, *2* (1): 3.
129. Salunke, B. K.; J. Shin; S. S. Sawant; B. Alkotaini; S. Lee; and B. S. Kim, (2014) *Korean J. Chem. Eng.*, *31* (11): 2035–2040.
130. Sana, S. S.; and L. K. Dogiparthi, (2018). *Mater. Lett.*, *226*: 47–51.
131. Sengottaiyan, A.; R. Mythili; T. Selvankumar; A. Aravinthan; S. Kamala-Kannan; K. Manoharan; P. Thiyagarajan; M. Govarthanan; and J. H. Kim, (2016) *Res. Chem. Intermed.*, *42* (4): 3095–3103.
132. Senthil, B.; T. Devasena; B. Prakash; and A. Rajasekar, (2017) *J. Photochem. Photobiol. B Biol.*, *177*: 1–7.
133. Senthilkumar, P.; S. Rashmitha; P. Veera; C. Vijay Ignatious; C. SaiPriya and A. V. Samrot, (2018) *J. Pure Appl. Microbiol.*, *12* (2): 969–974.
134. Shankar, T.; P. Karthiga; K. Swarnalatha; and K. Rajkumar (2017) *Resour. Technol.*, *3* (3): 303–308.
135. Sharma, A.; V. D. Diwevidi; S. Singh; K. Kumar Pawar; M. Jerman; L. B. Singh; S. Singh; and D. Srivastawa, (2013) *Int. J. Biotechnol. Bioeng. Res.*, *4* (3): 175–180.
136. Siddiqui, M. N.; H. H. Redhwi; D. S. Achilias; E. Kosmidou; E. Vakalopoulou; and M. D. Ioannidou, (2018) *J. Polym.*

Environ., *26* (2): 423–433.

137. Singh, C.; S. K. Anand; R. Upadhyay; N. Pandey; P. Kumar; D. Singh; P. Tiwari; R. Saini; K. N. Tiwari; S. K. Mishra; and R. Tilak, (2023) *Materials Chemistry and Physics,* 297: 127413.
138. Singh, J.; A. Mehta; M. Rawat and S. Basu (2018) *J. Environ. Chem. Eng.*, *6* (1): 1468–1474.
139. Singla, S.; A. Jana; R. Thakur; C. Kumari; S. Goyal and J. Pradhan (2022) *OpenNano 7*: 100047.
140. Sinha, S. N.; D. Paul; N. Halder; D. Sengupta; and S. K. Patra, (2015) *Appl. Nanosci.*, *5* (6): 703–709.
141. Soliman, M.; S. H. Qari; A. Abu-Elsaoud; M. El-Esawi; H. Alhaithloul and A. Elkelish (2020) *Acta Physiol. Plant.*, *42* (9):
142. Sulochana, M.B.; and A. B. Parameshwar (2022) *CIBTech Journal of Biotechnology*; *11*: 1.
143. Sun, Q.; X. Cai; J. Li; M. Zheng; Z. Chen; and C. P. Yu, (2014) *Colloids Surfaces a Physicochem. Eng. Asp.*, *444*: 226–231.
144. Tailor, G.; B. L. Yadav; J. Chaudhary; M. Joshi; and C. Suvalka, (2020) *Biochem. Biophys. Reports*, *24*: 100848.
145. Tarannum, N.; Divya; and Y. K. Gautam, (2019) *RSC Adv.*, *9* (60): 34926–34948.
146. Tippayawat, P.; N. Phromviyo; P. Boueroy; and A. Chompoosor, (2016) *Peer J, 4*(10):
147. Vanlalveni, C.; S. Lallianrawna; A. Biswas; M. Selvaraj; B. Changmai; and S. L. Rokhum, (2021) *RSC Adv.*, *11* (5): 2804–2837.
148. Vanlalveni, C.; K. Rajkumari; A. Biswas; P. P. Adhikari; R. Lalfakzuala; and L. Rokhum, (2018) *Bionanoscience*, *8* (2): 624–631.
149. Veisi, H.; S. Hemmati; H. Shirvani and H. Veisi, (2016) *Appl. Organomet. Chem.*, *30* (6): 387–391.
150. Velmurugan, P.; K. Anbalagan; M. Manosathyadevan; K. J. Lee; M. Cho; S. M. Lee; J. H. Park; S. G. Oh; K. S. Bang; and B. T. Oh, (2014) *Bioprocess Biosyst. Eng.*, *37* (10): 1935–1943.
151. Velmurugan, P.; S.-M. Lee; M. Iydroose; K.-J. Lee; and B.-T. Oh, (2012) *Appl. Microbiol. Biotechnol. 971*: *97* (1), 361–368.
152. Verma, A.; and M. S. Mehata, (2016) *J. Radiat. Res. Appl. Sci.*, *9* (1): 109–115.
153. Vijay Kumar, P. P. N.; S. V. N. Pammi; P. Kollu; K. V. V. Satyanarayana; and U. Shameem, (2014) *Ind. Crops Prod.*, *52*: 562–566.
154. WA, F. (2016) *J. Nanomed. Nanotechnol.*, *07* (06):
155. Xu, L.; Y. Y. Wang; J. Huang; C. Y. Chen; Z.X. Wang; and H. Xie (2020) *Theranostics*, *10* (20): 8996.
156. Yasin, S.; L. Liu; and J. Yao, (2013) *J. Fiber Bioeng. Informatics*, *6* (1): 77–84.
157. Younas, M.; M. H. Rasool; M. Khurshid; A. Khan; M. Z. Nawaz; I. Ahmad; M.N. Lakhan, (2023) *Biochem. Syst. Ecol.*, *107*: 104605.
158. Yousaf, H.; A. Mehmood; K. S. Ahmad; and M. Raffi, (2020) *Mater. Sci. Eng. C*, *112*: 110901.
159. Zarei, Z.; D. Razmjoue; and J. Karimi, (2020) *J. Inorg. Organomet. Polym. Mater.*, *30* (11): 4606–4614.
160. Zhou, Q.; J. Lv; Y. Ren; J. Chen; D. Gao; Z. Lu; and C. Wang, (2017) *Text. Res. J.*, *87* (19): 2407–2419.