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A Review on Green Synthesis of Nanoparticles and Evaluation of Antimicrobial Activity

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Abstract

Nanoparticles and their compounds have potent inhibitory and antimicrobial properties against bacteria, viruses, and fungus. In contemporary society, the emergence of infectious illnesses caused by various harmful bacteria and the rise of antibiotic resistance have prompted pharmaceutical corporations and researchers to seek novel antimicrobial agents. The synthesis, characterization, and use of biologically produced nanoparticles have become a significant aspect of nanotechnology. Nanoparticles are produced globally in substantial volumes for various applications. The green synthesis of metal and semiconductor nanoparticles is a growing research topic due to its potential uses in the creation of revolutionary technologies. Recent advancements in research on metal nanoparticles. A nanoparticle has significant potential for healthcare items, including burn dressings, antibacterial applications, medical devices, and scaffolds. Diverse methods used for the creation of nanoparticles include chemical reduction, photochemical processes, electrochemical procedures, and green chemistry approaches. This research reports on several plants, fungi, bacteria, and actinomycetes used in this technique, including the synthesis methods, nanoparticle morphology, dimensions, and their applications as antimicrobials in an elaborate way. We also elucidated the fundamental process by which nanoparticles engage with microorganisms and provided future suggestions.

Keywords: Nanoparticles, biological method, antimicrobial activities, bioassay.

Introduction

Nanotechnology is one of the most dynamic fields of study in contemporary materials science. This rapidly evolving discipline is significantly influencing several aspects of human existence and generating increasing enthusiasm in the life sciences, particularly in biotechnology and biomedical science. Nanoparticles display entirely novel features determined by distinct variables including form, size, and distribution. Nanocrystalline particles have significant applications in high-sensitivity biomolecular detection and diagnostics, medicines and antimicrobials, catalysis, and microelectronics. [1-3]

Nonetheless, there is a need for a financially feasible and ecologically sustainable biological method for synthesizing nanoparticles. [4] Various methodologies exist for the synthesis of nanoparticles, including solution reduction, photochemical and chemical reactions in reverse micelles, thermal decomposition of nanoparticle compounds, [5] radiation-assisted techniques, electrochemical processes, microwave-assisted methods, and more recently, green chemistry approaches. [6].

The utilization of environmentally benign materials such as plant extracts (leaves, flowers, bark, seeds, peels, etc.), fungi, bacteria, and enzymes for nanoparticle synthesis provides numerous advantages in terms of eco-friendliness and compatibility for pharmaceutical and biomedical applications, as these methods do not involve toxic chemicals in the synthesis protocol. [7] Nanoparticles have long been acknowledged for their inhibitory effects on microorganisms in medicinal and industrial processes. [8]

Utilization of nanoparticles in genomics, improvement of immune responses, biosensor technology, clinical chemistry, microbial control, and targeted medication delivery and detection. The biosynthesized nanoparticles were shown to be very lethal against several multidrug-resistant human pathogens. [9]

Nanoparticles are metallic in nature and may serve as antimicrobicides. Furthermore, nanoparticles exhibit significant differences from their bulk counterparts in several aspects, which enhances their use in the development of diagnostic instruments and antimicrobials. [6]

Certain nanoparticles serve as appealing probes for biological markers due to their diminutive size (1-100 nm) and substantial surface-to-volume ratio. Biological and chemical properties concerning size and shape exhibit a strong affinity for targets, particularly proteins, alongside structural robustness despite atomic granularity. Particle aggregation may be enhanced or delayed based on the nature of surface modification, with increased photoemission, high electrical and thermal conductivity, and improved surface catalytic activity. [10]

Silver nanoparticles have garnered significant study attention due to their crucial applications in antibacterial activity, catalysis, and surface-enhanced Raman scattering. [7] Numerous concepts exist to elucidate the antibacterial properties of silver nanoparticles.

The fast degradation of silver nanoparticles liberates ionic silver, which deactivates crucial bacterial enzymes by engaging with key thiol groups. Silver ions may impede bacterial DNA replication, compromise bacterial cytoplasmic membranes, deplete intracellular adenosine triphosphate (ATP) levels, and ultimately induce cell death. [11]

The high surface-to-volume ratio of silver nanoparticles boosts their interaction with microorganisms, enhancing silver ion dissolution and biocidal efficacy. Silver nanoparticles' antibacterial effectiveness depends on their silver ion release [12]. Silver nanoparticles are most often produced via borohydride reduction of silver salts. Capping agents such water-soluble polymers, oligosaccharides, polysaccharides, sodium dodecyl sulphate, and glycolipid [13] stabilize nanoparticles and increase water solubility to avoid aggregation.

Strains resistant to bacteriocides and antibiotics have improved silver nanoparticles resistance. Some antimicrobial agents are toxic and irritating, thus there is interest in developing safe and cost-effective biocidal materials [12].

Biological and chemical nano silver manufacturing is costly and uses toxic chemicals that may offer biological and environmental risks, which is a major issue. For successful use, silver nanoparticles must be handled by humans and accessible at a lower cost. An economically and ecologically viable approach to synthesis them is unavailable[14]. Biosynthesis of nanoparticles has garnered interest due to the necessity for ecologically friendly material synthesis.

Biosynthesis of silver nanoparticles by fungus and bacteria. Fungi, plant extract, and bacteria synthesize silver nanoparticles by reduction/oxidation reactions. Microbial enzymes or plant phytochemicals with antibacterial or reducing agents form nanoparticles from compounds [15].

A biological technique employing milky latex of Galotropisprocera as a reducing material and surface stabilizing agent was employed for the first time to synthesize spherical zinc oxide nanoparticles. The synthesized product's phase and shape were characterized using conventional methods. Aloe vera extract synthesizes stability, shape, and size zinc oxide nanoparticles. [6].

Eco-friendly nanoparticle synthesis. Due to their high surface area to volume ratio, zinc oxide nanoparticles are new antimicrobials. Recently, researchers found antibiotic-resistant strains due to microbial metal ion resistance[16]. Zinc oxide nanoparticles are being used in non-conventional porous and nanometric materials. Solar cells, ceramics, catalysts, cosmetics, gas sensors, and varistors use zinc oxide nanoparticles as semiconductors [12]. The precipitation method was followed by controlled and freezing drying, and the material was thermally treated at various temperatures to study its textural, morphological, and structural properties by powder SEM, TEM, thermal analysis, etc [16].

Gold nanoparticles: Biocompatible nanoparticles are widely used in microorganisms. Biologically intended gold nanoparticles may be created for photochemical and chemical functions [17]. Gold nanocages, nanospheres, and nanorods that absorb near-infrared irradiation may photothermally kill cancer cells and bacteria [18].

Gold nanoparticles linked with photosensitizers kill MRSA using photodynamic antimicrobial chemotherapy and NIR photo thermal radiation [19]. Fungi and bacteria have created gold nanoparticles. Selective photothermal death of bacteria and protozoa uses gold nanoparticles with antibodies and drugs. Because novel antibiotic-resistant bacteria are a severe public health issue, there is a strong motivation to discover new bactericides [9]. However, antibiotic resistance and its spread are serious health issues, causing therapeutic difficulties for many medications. Combination treatment with antibiotic resistance inhibitors is gaining popularity[20]. Gold nanoparticles' biological activities have been studied, however their impacts on antibiotics have not. Application of nanoparticles to genomics, immune response augmentation, biosensorics, chemical chemistry, microbe control, drug detection, and targeted delivery.

Copper Oxide Nanoparticles: Antimicrobial copper oxide nanoparticle biosynthesis is a key bionanotechnology study topic. This new ecofriendly science has well-defined structure, size, and regulated monodispersity. Researchers have presented a green copper oxide nanoparticle extracellular manufacturing technique. Stabilized copper nanoparticles from isolated soil of Penicillium aurantiogriseum, citricum, and waksmanii [21]. Copper nanoparticles are attractive owing to their unique biological, chemical, and physical characteristics and inexpensive preparation cost. Copper oxide forms quickly from copper nanoparticles. Carbon and silica are used to enclose copper nanoparticles to prevent oxidation [22]. If the application demands green copper nanoparticle manufacturing, bacteria, actinomycetes, fungus, yeast, and plants are used. In green nanoparticle production, microorganisms synthesize internal or extracellular inorganic compounds with biological and chemical properties [23].

here is no biological method for nanoparticle production, although several biomolecules may be involved. In intracellular and extracellular production of nanoparticles employing fungus, several capping and reducing agents may be involved, and their effects on nanoparticle size and form need to be clarified [24]. Titanium Dioxide Nanoparticles: Plant extract-based nanoparticle manufacturing is being used to prevent biological side effects. Indian Gooseberry, Aloe vera, Lemon, Grass, Neem, Corriandrum, Tulsi, and others are green chemistry-compatible plant extract employers [25]. Size, shape, morphology, crystalline phase, and composition affect nanoparticles. Titanium dioxide nanoparticles' potential oxidation strength, high photostability, and non-toxicity make them useful in air and water purification and DSSC. Titanium oxide nanoparticles have optical, chemical, antibacterial, and antimicrobial properties, making them useful as pigments, catalyst supports, and photo catalysts [26]. The solvent medium, reducing agent, and non-toxic substance used to stabilize nanoparticles are ecofriendly and green. Recently, bacteria, actinomycetes, and fungi synthesized nanoparticles. Next, a simple and green titanium dioxide nanoparticle production utilizing nyctanthes leaf extract. Nyctanthes picked it for its antinoceptive, antioxidant, anti-inflammatory, antidiabetic, antifungal, and antibacterial properties. Titanium dioxide nanoparticle biosynthesis, notably with nyctanthes [25], has not been expanded. Iron Oxide Nanoparticles: Most inorganic compounds produced by microorganisms are nanoparticles. These biological creatures' cellular extracts may be utilized to synthesize nanoparticles of various sizes, shapes, and chemical compositions [27]. Iron is reduced by plant extract polyyols. Irons and water-soluble heterocyclics stabilize nanoparticles. Plant extracts may be reduced with ferric chloride [28]. Nanoparticle production reduces ferric ions in plant extracts. After a 45-plant screening method, the 10 best plants for iron nanoparticle production were mango, clove, tea, green tea, coffee, rose, cumin, origano, thymol, and curry [29].

Cadmium oxide nanoparticles: Biosynthesis employing Achillea wilhelmsii flower extract as reducing agents. Flower extract reduced aqueous cadmium ions to nanoparticles [30]. The manufacturing of nanoparticles using ecologically friendly materials as plant leaves, floral extract, fungus, and bacteria without harmful chemicals has several advantages for medicinal and biological applications [31]. Toxic nanoparticle production has low-productivity. Biological methods involving microorganisms (bacteria, fungus, yeast, etc.) enzyme and plant extracts are offered. Scientists are interested in plant-based nanoparticle manufacturing because it is fast, eco-friendly, cheap, and a single-step biosynthesis process [32].

Green synthesis: why? Green synthesis is cheaper, more environmentally friendly, readily scaled up for large-scale synthesis, and does not need high pressure, temperature, energy, or harmful chemicals [6].

The green nanoparticle biosynthesis route: Various procedures for the synthesis of nano and micro-scaled inorganic materials have led to a new and uncharted field of nanoparticle biosynthesis [33]. Eco-friendly, non-toxic reagents are used to synthesize nanoparticles. Phytomining exploits hyperaccumulating plants to extract metals from biomass for profit [34].

Hyper accumulation species control metal soil solution concentrations physiologically. Plants' nanoparticle biosynthesis may be linked to phyto-remediation [35].

The biological method: Bio-organism extract may reduce and cap nanoparticles. Protein/enzymes, polysaccharide, vitamin, and amino acid bimoleculars in these extracts reduce metal ions in a chemically complicated, ecologically friendly way. Nanoparticles made from bioorganic substances are widely reported [10]. Nanoparticle production using biological techniques is safe, cost-effective, sustainable, and environmentally friendly [9]. Biological synthesis of nanoparticles is becoming more popular due to its ecofriendliness and simplicity. Plants like Alfalfa, Emblica officianalis, Lemongrass, Aloe vera, Tamarindus indica, and Cinnamomum camphora have been reported to synthesize nanoparticles, but their potential is still unexplored [36].

Comparative study on biological synthesis of nanoparticles with their size, shape, and citation

S.No.	**Material**	**Natural Resource**	**Part used**	**Component**	**Rpm/min.**	**Size**	**Shape**	**Citation**
1-	AgNps	Ocimum sanctum	Leaves	$AgNO_3$	10,000/15min	20nm	Spherical	Malikarjuna et al.,2011
2-	AgNps	Onion (Allium cepa)	Onion (bulb)	$AgNO_3$	-	33.6 nm	Spherical	Saxena et al., 2010
3-	AgNps	Castusspeciosus	Callus culture	$AgNO_3$	10,000/20min	420nm	Spherical	Malabadi et al.,2012
4-	AgNps	Oryza sativa, Vigna radiate, Brassicalcampertris	Seeds	$AgNO_3$	10,000/15min	25nm	Spherical	Mazumdar and Ahmed, 2011
5-	AgNps	Tridaxprocumbens	Leaves	$AgNO_3$	20,000/25min	55nm	-	Dhanalakshmi and

								Rajendran, 2011
6-	AgNps	Euphorbia hitra	Leaves	$AgNO_3$	18,000/25min	50nm	Spherical	Elunalai,2010
7-	AgNps	Ficusbenghalensis	Leaves	$AgNO_3$	-	44nm	Spherical	Tripathi et al.,2010
8-	AgNps	Syensoniahyderobadensis ,Boswelliaovalifoliolata, Shoreatumbuggaia	Leaves, Bark	$AgNO_3$	18,000/25min	430nm	-	Savithramma et al., 2011
9-	AgNps	Withania somnifera	Leaves	$AgNO_3$	15,000/10min	40nm	Spherical	Nagati et al.,2012
10-	AgNps	Ocimum sanctum	Leaves	$AgNO_3$	18,000/25min	50nm	-	Rout et al., 2011
11-	AgNps	Ocimum sanctum	Leaves	AgNO3	15,000/15min	30nm	Spherical	Singhal et al.,2011
12-	AgNps	Euphorbia prostrats	Leaves	AgNO3	60,000/40min	80nm	Rod Shape	Zahir et al.,2012
13	AgNps	Trianthemadecandra	Roots	AgNO3	5000/10 min.	50nm	Hexagonal	Geethalakshmi and Sarada,2010
14-	AgNps	Mulberry	Leaves	AgNO3	35,000/10min	40nm	Spherical	Awwad and Salem, 2012
15-	AgNps	Cassia auriculata	Leaves	AgNO3	5000/20 min	-	Spherical	Praveen et al.,2012
16-	AgNps	Solanum xanthocarpum	Berry	AgNO3	4000/30 min.	406nm	Spherical	Amin et al., 2012
17-	AgNps	Vitexnegundo	Leaves	AgNO3	-	30nm	Spherical	Zargar et al.,2011
18-	AgNps	Elaeognuslatifolia	Leaves	AgNO3	8000/15 min.	50nm	Spherical	Phanjom et al.,2012
20-	AgNps	Cleome viscosa	Leaves	$AgNO_3$	10,000/15min	50nm	Spherical	Lakshmi et al.,2011
21-	AgNps	Saururuschinenis	Leaves	$AgNO_3$	18,000/25min	54nm	Spherical	Nagajyoti et al.,2011
22-	AgNps	Ocimumbasillicum	Leaves	$AgNO_3$	10,000/20min	89nm	Spherical	Sivaranjani and Sundaram, 2013
23-	AgNps Au-Nps	Memecylonumbellatum	Leaves	$AgNO_3$ $HAuCl_4$	10,000/15min	20nm	Spherical	Arunachalam et al., 2011
24-	AgNps Au-Nps	Punicagranatum	Peels	$AgNO_3$ $HAuCl_4$	10,000/15min	25nm	Spherical	Ahmed et al., 2012

25-	CdO-Nps	Achilleawilhelmsii	Flowers	$CdCl_2$	14,000/5 min.	10nm, 35nm	Spherical	Andeani and Mohsenzadeh, 2012
26-	ZnO-Nps	Calotropisprocera	Milky latex	$\{(CH_3CO)_2Zn2.H_2O\}$	10,000/15min	40nm	Sphercial	Singh et al., 2011
27-	AgNps	Punica granatum	Seeds	$AgNO_3$	10,000/15min	400nm	Spherical	Chauhan et al., 2011
28-	AgNps	Punica granatum, Rosa domascena	Peels, Petals	$AgNO_3$	10,000/20min	21nm	Spherical	Solgi and Taghizadeh, 2012
29-	AgNps	Punica granatum	Seeds	$AgNO_3$	10,000/15min	20nm	Spherical	Chauhan and Upadhyay, 2012
30-	AgNps	Loquat	Leaves	AgNO3	15,000/5 min.	18nm	Spherical	Ramesh et al., 2012
31-	Cr2O3-Nps	Arachishypogoea	Leaves	K_2CrO_4	-	80nm	Hexagonal	Awwad et al., 2013
32-	Au-Nps	Putranjivaroxburghi	Leaves	$HAuCl_4$	-	38nm	Spherical	Badole and Dighe, 2012
33-	Au-Nps	Caesalpiniapulcherrima	Flowers	$HAuCl_4$	15,000/20min	50nm	Spherical	Nagaraj et al., 2012
34-	AgNps	Nerium oleander	Leaves	$AgNO_3$	10,000/15min	67nm	-	Suganya et al., 2012
35-	Au-Nps	Tagetesarecta	Flowers	$HAuCl_4$	15,000/20min	10nm	Spherical	Krishnamurthy et al., 2012
36-	AuNps	Allium cepa (Onion)	Bulb	$HAuCl_4$	10,000/15min	54nm	Spherical	Parida et al.,2011

Nanoparticles as microbicides: Biology includes DNA sequencing and antimicrobials. Nanoparticles are harmful to many microorganisms. Nanoparticles have been tested for antimicrobial activity against Staphylococcus aureus, Pseudomonas aeruginosa, and E. coli [12]. The nanoparticles were harmful to E. coli. That nanoparticle size affected antibacterial activity. Silver nanoparticles 1-10nm bind to cell membranes and disrupt respiration and permeability [37]. The luminous bacteria were employed to test nanoparticle antibacterial capabilities. Green fluorescent proteins were modified for these investigations. General consensus is that nanoparticles linked to bacterial cell sulfur proteins kill microorganisms. The complete area cent measurement of the cell-free supernatant showed how nanoparticles affected bacterial recombination [38]. Silver ions and nanoparticles were tested for their antifungal activity against Bipolarissoro kiniana and Magnaporthegrisea, two grass-pathogenic fungus. Silver ions and nanoparticles increased Bipolarissoro kiniana colony growth by 50% compared to Magnaporthe grisea [39]. Silver cations neutralized with chloride ions reduced colony development inhibition. Growth chamber inoculation experiments confirmed that ionic and nanoparticle silver suppressed two fungal illnesses. Colloidal silver nanoparticles were made by reducing silver nitrate solution with glucose and capping it with gelatin [40]. Govindaraju et al. use agar well diffusion to test Solanum torvum-mediated silver nanoparticles against silkworm Bombyxmori harmful bacteria and fungus such Pseudomonas aeruginosa, Staphylococcus aureus, Aspergillusflavus, and Aspergillusniger.

Antimicrobial activity: Atomic and molecular matter control unites them in applied science and technology. Metal-microbe interactions are significant in biotechnology, biomineralization, bioremediation, and microbial corrosion [14]. Recent investigations show that carefully designed metal oxide nanoparticles are antibacterial. From ancient times, its components have powerful inhibitory and bactericidal properties and wide antibacterial actions against fungus, viruses, and bacteria [41]. The evolution of resistant strains has enhanced bacterial bactericide and antibiotic resistance [15]. Some antimicrobial compounds are quite toxic, therefore developing safe and cost-effective biocidal materials is crucial8. Silver nanoparticles' antibacterial efficacy against microorganisms is assessed using multiple methods [41]. The medical industry uses nanoparticles largely for their antibacterial properties [42]. Nanoparticles' unique biological and chemical features make them promising medicinal and pharmacological candidates [43]. Dental resin composites, ion exchange fibbers, and medical device coatings include antibacterial compounds [44].

Nanoparticle-amphiphilic hyper branched macromolecule hybrids with antibacterial surface coating [13]. Recent studies have shown that nanoparticles accelerate wound healing by reducing local metalloproteinase (MMP) activity and increasing neutrophilic apoptosis. Silver nanoparticles reduced pro-inflammatory cytokines in a burn damage animal model. In 1995, Dr. Robert Burrell invented nano silver-based wound dressing. He created Acticoat to expedite healing and eliminate scars. Nanoparticles' antibacterial properties make them promising disinfectants. Intravenous catheters, endo tracheal tubes, wound dressing, and bone are also regarded to be typical medical treatments.

Bioassays used: Various methods have been used to investigate bio-nanoparticle antibacterial activity.

Comparative study on antimicrobial activities biosynthesis of nanoparticles using with botanical and reference

S.No	Biological entity	Test microorganism	Impact	Material	Concentration	Reference
1-	Sagassum wightii	S.aureus, B. rhizoids, E.coli	Highly effective against test microbes	$AgNO_3$	50µg/ml, 100µg/ml	Govindaraju et al., 2008
2-	Gliricidiasepium	S.aureus, E.coli, K. pneumoniae	Highly active against S. aureus	$AgNO_3$	27µg/ml, 50µg/ml	Rajesh et al., 2009
3-	Ocimum sanctum	S.aureus,V.cholerae, P.vulgaris	Active againstP.aeruginosa	$AgNO_3$	100µg/ml	Prabhu et al., 2010
4-	Argimonemexicana	E.coli, Aspergillusflavus	Highly active against test microorganism	$AgNO_3$	100µg/ml, 250µg/ml	Khandelwal et al.,2010
5-	Aloe vera	E.coli	100% inhibition bacterial growth	$AgNO_3$	200µg/ml	Zhang et al., 2010
6-	Trianthemadecandra	E.coli, P.aeruginosa	Highly effective against test microbs	$AgNO_3$	50µg/ml, 150µg/ml	Geethalakshmi and Sarada, 2010

7-	Solanustorvum	S.aureus, E.coli, Aspergillusflavus, A. niger,	Highly active against S. aureus	$AgNO_3$	100µg/ml, 250µg/ml	Govindaraju et al., 2010
8-	Svensoniahyderabadensis	A. niger, Fusarium oxysporum, Curvularialunata	Antibacterial & antifungal activity	$AgNO_3$	100µg/ml, 200µg/ml	LingaRao and Savithramms, 2011
9-	Desmodiumtriflorom	E.coli, Bacillus subtilis	Highly active for E.coli	$AgNO_3$	27µg/ml	Ahmed et al., 2011
10-	Euphorbia hirta	E.coli, S. aureus, K. pneumoniae	Highly effective against , S. aureus	$AgNO_3$	50µg/ml	Elumalai et al., 2010
11-	Ocimumteniiflorum, Solanum tricobatum	P.aeruginosa, S. aureus, E.coli	Highly active against test pathogen	$AgNO_3$	50µg/ml, 75µg/ml, 100µg/ml	Logeswari et al., 2012
12-	-	S.typhi, K. pneumonia,	Highly active against	$AgNO_3$	100µg/ml	Nithya et al., 2011
		P.aeruginosa	test organism			
13-	Foeniculumvulgare	E.coli, S.aureus	Show the highly activity against test organism	AgNO3	20µg/ml,50µg/ml	Shitalbonde, 2012
14-	Garlic, Onion	Proteus sp., E.coli, Klebsiella sp., Bacillus sp., Pseudomonas sp.	Very highly active against pathogen	AgNO3	100µg/ml, 200µg/ml, 30µg/ml, 400µg/ml, 500µg/ml	Lekshmi et al., 2012
15-	Cabbage	E.coli, Bacillus subtilis,.	Highly effective in their activity against test organism	AgNO3	100µg/ml	Veerona et al., 2012
16-	-	Staphylococcus aureus	Maximum activity against test organism	AgNO3	5,10,15,25,20µg/ml	Ansari et al., 2011
17-	Cassia tora L.	E.coli, Salmonella sp.	Very effective against E.coli	AgNO3	50µg/ml	Sathya and Ambikapathy, 2012
18-	Vitexnegundo	Staphylococcus aureus, E.coli	-	AgNO3	50µg/ml	Zargaret al., 2011
19-	Solanum xanthocarpam	Anti helicobactor pylori	Highly active against test organism	AgNO3	100µg/ml & 125µg/ml	Amin et al., 2012
20	Guava, Red grape, Green grape, Tomato,	S.aureus, E.coli, P. aeruginosa	Highly effective against E.coli	AgNO3	5, 20, 50, 200µg/ml	Phuphansri et al., 2012
21-	Arachishypogaea	E.coli	-	Cr2O3	50, 100µg/ml	Ramesh et al., 2012
22-	Loquat	Shigella, Lesteriamonocytog	Highly active test	AgNO3	200, 100, 50, 10µg/lit.	Awwad et al., 2012

		enes	microbes			
23-	Cleome viscosa	E.coli, S.aureus	-	AgNO3	50,100µg/ml	Lakshmi G. et al., 2011
24-	Neem, Triphala	K.pneuomoniae, S. typhi	Highly effective against test pathogen	AgNO3	100, 250µg/ml	Govhane et al., 2012

Conclusion

Rapid biological agents including microorganisms, plants, and algae can synthesize nanoparticles. This nanoparticle production is cheaper and easier. Nanoparticle synthesis kills viruses, algae, bacteria, and fungus. Its agricultural usage, However, if nanoscaled emerging sewages exceed the permissible limits for microbial populations in waste water treatment facilities, environmental infrastructure may be affected. Evidence suggests nanoparticles have a variety of genotoxic effects on higher organisms. This raises concerns regarding human and other higher organism consequences. Nanoparticle toxicity mechanisms have advanced, but more research is needed to fully understand them and safely use their powerful antimicrobial properties without endangering human health, critical infrastructure, and the environment. More thorough in-vitro, in-vivo, and environmental research should examine aquatic chemistry's influence on nanomaterial destiny and toxicity.

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