Nanoparticles Synthesis and Applications: A Green and eco friendly Approach

Prajapati N. B[1] , Raval A. A[2]
[1.] Ph.D scholar, [2]. Asst. Professor Department of Microbiology, Arts, Science and Commerce College, Kamrej Cross Roads, Surat- 396445 INDIA

Abstract

In this modern era the use of nanoparticles has increased in biomedical science, drug delivery, food industry, and agriculture. This has led to the development of various approaches for the synthesis of nanoparticles. But the conventional methods used for the fabrication of nanoparticles have some limitations such as high energy consumption, high cost, and environmental hazards. Hence the need for the development of alternative approaches is in demand. Green synthesis is a promising approach that is clean, nontoxic, cheaper, and ecofriendly for the synthesis of nanoparticles.

Keywords: 1. nanoparticles 2.fabrication 3. Green synthesis

1. Introduction

Nanoscience is the basis for the development of nanotechnology. Nanotechnology is an emerging field of science, which deals with nano scale objects. It allows the production and manipulation of atoms and molecules at nanoscale dimensions. The term nanotechnology was first given by the Professor Noro Taniguchi of Tokyo University of Science in 1974. (Singh et al., 2010). Nanotechnology is an auspicious field dealing with the synthesis and applications of nano size particles of 1 – 100 nm. Nanotechnology has two crucial aspects (1) To synthesize nano size materials and (2) Use of nanomaterials for the desired purpose. Nanotechnology has founduse in various disciplines like physics, biology, chemistry, material science, and engineering. (Khan and Rizavi., 2014). Recently, astonishing success was observed in the research due to nanotechnology. (Ghozali et al., 2015).

2. Nanoparticles

Nanoparticles are particles of nanometer size that has a large surface to volume ratio which increases their reactivity and biochemical activity. Nanoparticles have unusual and novel properties and as result applied in the fields of biotechnology, medical, sensors, catalysis, optical devices, DNA labeling, and drug delivery. Due to the small size nanoparticles show different properties such as sensitivity, stability, high reactivity, strength, surface area, etc. Nanoparticle synthesis is not a simple process as it requires specific skills and facilities according to the method chosen for its synthesis (Khan and Rizvi, 2014) (Ghozali et al., 2015).

3. Classification of Nanoparticles

Nanoparticles are classified into three categories organic, inorganic, and carbon based nanoparticles.

3.1.Organic nanoparticles mean they are made up of carbon plus other atoms. They are also known as polymers. Examples of organic nanoparticles are liposomes, dendrimers, micelle, ferritin, etc. Mostly these are used in the biomedical field for drug delivery.

3.2.Inorganic nanoparticles are particles that do not contain carbon atoms. They are further classified into two categories (1) Metal based nanoparticles and (2) Metal oxide based nanoparticles.

3.2.1. Metal based nanoparticles mean the nanoparticles fabricated from the metal and mostly used metals are aluminum (Al), silver (Ag), zinc (Zn), gold (Au), cobalt (Co), lead (Pb), copper (Cu), and iron (Fe).

3.2.2. Metal oxide based nanoparticlesare synthesized because of their high reactivity and efficiency which is achieved by the changing of the properties of the relevant metal based nanoparticles.

3.3. **Carbon based nanoparticles** are those which only contain carbon atom, for example, carbon nanotube, carbon nanofiber, and Carbon black. (Ealia and Saravanakumar , 2017) (Xu et al., 2006).

4. Approaches For Synthesis of Nanoparticles

Specifically, two approaches Top down approaches and Bottom up approaches are used for the synthesis of nanoparticles. Figure 1 shows the schematic representation of the top-down and bottom-up approaches for the fabrication of nanoparticles.

4.1. **Top down approaches** are the procedures in which some parts of the bulk materials are removed and this removal is done by chemical, mechanical, electrochemical, etc., depending upon requirements. Most of the conventional methods are top down approaches like milling, grinding, etc. (Singh et. al., 2010).

4.2. **Bottom up approaches** are to make material from atoms to clusters to particles. Different methods used to achieve this are sol-gel, spinning, pyrolysis, chemical vapor deposition, biosynthesis methods, etc.

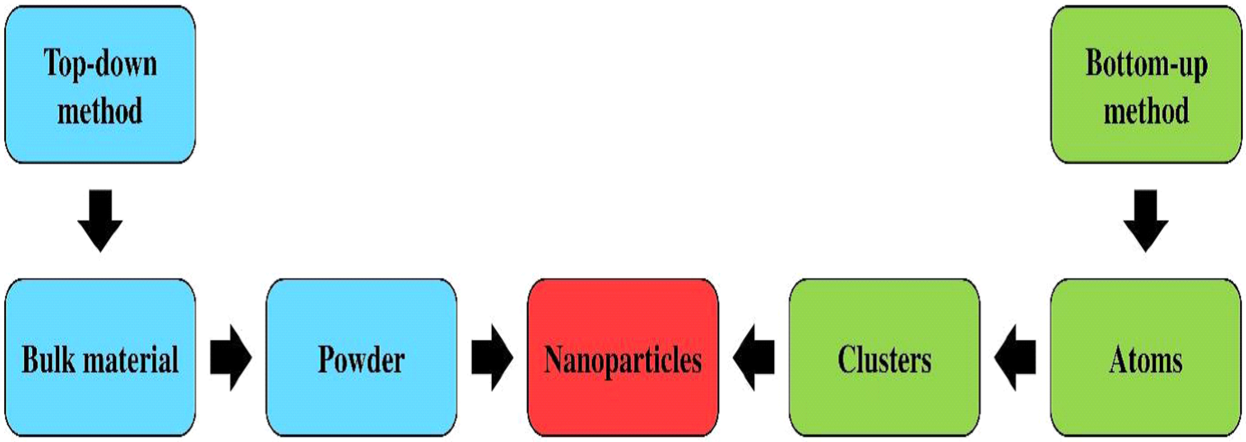

Fig. 1 Top down and Bottom up approaches for nanoparticle synthesis (Ealia and Saravanakumar, 2017)

5. Methods for nanoparticle synthesis

Nanoparticles used for commercial purposes are mostly synthesized by conventional methods. Physical and chemical methods are the conventional methods widely used but are found too expensive. Physical methods such as ultrasonication, irradiation, laser ablations, etc are used for nanoparticle synthesis. Chemical methods used for nanoparticle synthesis are chemical reduction, condensation, sol-gel method, etc. These approaches are not eco friendly and sometimes toxic compounds are released during their formation. These compounds have an adverse effect on human health as well as on the environment (Sandhu et al., 2019).Green nanotechnology are an alternative approach that minimizes human health and potential environmental risk. This method synthesizes nanoscale material through green chemistry and green engineering (Eckelman et al., 2008). A green synthesis is a biological approach for the synthesis of nanoparticles using environmentally benign materials like plants, bacteria, actinomycetes, fungi, algae, etc. The biological approach is eco friendly, cost effective and can be easily scaled up. Figure 2 shows the different types of Physical, Chemical, and biological methods used for nanoparticle synthesis.

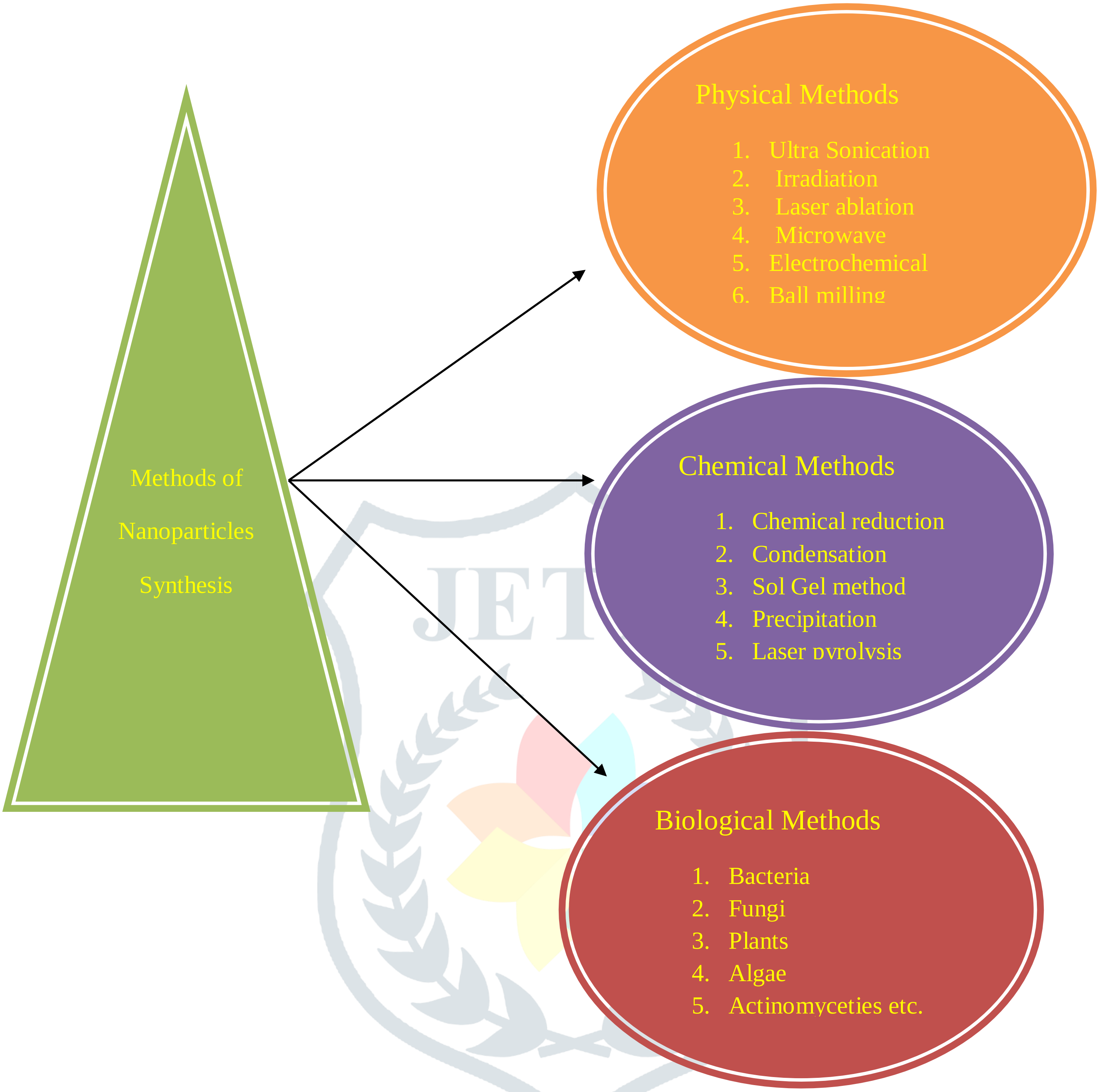

Fig. 2. Different methods used for Nanoparticles synthesis

6. Green Synthesis of Nanoparticles

There are numerous methods used for the synthesis of nanoparticles, physical, chemical, and biological methods. The drawback of the physical method is high energy consumption for maintenance of temperature and pressure during its synthesis. (Chen, 2003). Chemical methods require a short time and produce large amounts of nanoparticles but are expensive, outdated, inefficient, and produce hazardous toxic waste as byproducts that are not environmentally benign. Apart from these, the biogenic approach is the most convenient for the production of nanoparticles as it produces notoxic substances. Also,the advantage of using this method is the omni presence of the materials used in the production of nanoparticles and easily available in sufficient quantities. The green route is more reliable as compared to the other methods as it is not energy intensive. (Xiangqian et al., 2011, Vithiya and Sen 2011). Nanoparticles synthesized from biological methods are classified into two categories based on their locations synthesized (1) Intracellular nanoparticles and (2) Extracellular nanoparticles (Mann, 2001). Plants, bacteria, algae, fungi, etc are used for biological methods (Table 1). Biological approaches for the fabrication of nanoparticles are bottom up approaches due to the results of reduction or oxidation reactions.

Table1: Green synthesis of Nanoparticles

Sources	Name of the organisms	Type of nanoparticles produced	References
Bacteria	*Escherichia coli*	Ag	Divya et al., 2016
	Desulfovibrio desulfuricans	Pd	Deplanche et al., 2008
	Pseudomonas aeruginosa	Au	Husseiny et al. 2007
	Desulfovibrio desulfuricans NCIMB 8307	Pt	Yong et al., 2002
Fungi	*Candia albicans*	Au	Chuhan et. al., 2011
	Aspergillus niger	Ag	Jaidev and Narasimha, 2010
	Aspergillus terreus CZR-1	Ag	Raliya and Tarafdar, 2012
	Fusarium oxysporum	TiO_2& SiO_2	Bansal et al., 2005
Plant	*Ocimum gratissimum*	Ag	Lakshmana prabhu et al., 2017
	Sageretia Thea	ZnO	Mayedwa, Khalil, Mongwaketsi, et al., 2017
	Pterocarpus marsupium	Ag	Bagyalakshmi and Haritha, 2017
	Solanum Lycopersicum	Cu	Batoool and Masood, 2017
Algae	*Phaeodactylum tricornatum*	CdS	Scarano & Morelli, 2003
	Shewanella algae	Pt	Konishi et al., 2007
Actinomycete	*Streptomyces viridogens* strain HM10	Au	Balagurunathan et al., 2011
	Streptomyces hygroscopicus	Ag	Sadhasivam et al., 2010
	Rhodococcus sp.	Au	Ahmad et al., 2003a and 2003b

6.1 Biosynthesis of Nanoparticles from Bacteria

Bacteria are widely used for the green synthesis of nanoparticles due to their fast growth and ease of genetic manipulation. *Pseudomonas stutzeri* isolated from silver mines are used for the synthesis of metal nanoparticles (Mohanpuria et al., 2008) (Klaus et al., 1999). Extracellular biosynthesis of silver nanoparticles using *Escherichia coli*was reported by Manonmani and Juliet, 2011.Silver nanoparticles synthesized from *Escherichia coli* by reduction of Ag+ shows antimicrobial activity against *Salmonella typhi, Bacillus subtilis, Klebsiella pneumonia,* and *Vibrio cholera* as studied by Shaikmoideen et al., 2016. Gold nanoparticles are used in imaging, as drug transporters, and in thermo treatment of biological targets (Cheon and Horace, 2009).Hybrid polymer-silver nanoparticle is an important functional tool in optical, thermal, mechanical, electrical, and antimicrobial applications (Ananth et al., 2011). Silver nanoparticles have many applications like therapeutics, catalysts, sensors, microelectronics and filters, high sensitivity biomolecular detection and diagnosis and antimicrobial agents (Raiet al., 2009). Sunkar and Nachiyar, 2012 reported the green synthesis of silver nanoparticles using *Bacillus cereus* isolated from the *Garcinia xanthochymus.* Extracellular gold nanoparticles synthesized from *Pseudomonas aeruginosa* was reported by Husseiny et al. 2007. Bacterial strain *Aeromonas hydrophila* formed spherical and oval shaped ZnO nanoparticles with an average diameter of 57.72nm (Jayaseelan et al., 2012). Bacterial isolate retrieved from the soil identified as *Agrococcus sp*. was used for the green synthesis of silver nanoparticles. Ag NPs are characterized through TEM which reveals that the particle size ranges from 5 to 80nm was reported by (Jangra et al., 2014). Dhandapani et al., 2014 reported the biological approach of ZnO NPs synthesis from *Serratia ureilytica* (HM475278). Probiotic bacterium *Lactobacillus plantarum* VITES07 was used by Selvarajan and Mohanasrinivasan, 2013 for the green synthesis of zinc oxide nanoparticles.

6.2 Biosynthesis of Nanoparticles from Plants

Different parts of plants like fruits, leaves, seeds, flowers, peels, bark, roots, etc are used for the synthesis of the nanoparticles. Santhoshkumar et al., 2014 discussed the synthesis of titanium dioxide nanoparticles from *Psidium guajava*. Biosynthesized TiO_2 nanoparticles showed maximum antibacterial activity against *Staphylococcus aureus*as compared to *Escherichia coli*. *Camellia sinensis* aqueous leaf extract was used for iron oxide nanoparticle synthesis and the particles obtained were of 116 nm sizes as studied by Gottimukkala et al., 2017. Silver nanoparticles synthesized from *Acalypha indica* plant leaf effectively control water borne pathogenic bacteria (Krishnaraj *et al*. 2010). Copper nanoparticles were synthesized from the *Punica granatum*and reported by Kaur et al., 2016. Particle size ranging between 15-20 nm and evaluated to determine antibacterial activity against *Micrococcus luteus*, *Pseudomonas aeruginosa*, *Salmonella enteria*,and *Enterobacter aerogens*. Biosynthesis of copper nanoparticles by using a mixture of *Zingiber officinale, Piper nigrum*, and *Piper longum* was carried out and characterization was done using FEG-SEM with EDS, FTIR, HR-TEM, XRD, and was confirmedby UV-visible spectroscopy. Synthesized copper nanoparticles exhibited antimicrobial activity against *Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa*,and *Staphylococcus aureus* and showed high stability after six months at room temperature (Shah et al., 2019). Stable Au nanoparticles were synthesized by using Almond (*Terminalia Catappa*) leaf extract as a reducing agent and the size of biosynthesized gold nanoparticles ranging from 10 to 35 nmwith average size of 21.9 nm (Ankamwar., 2010). Green synthesis of silver nanoparticles synthesized from the *Citrullus lanatus* fruit peel extract was reported by Ndikau et al., 2017. TEM analysis reveals that the particles were spherical and average diameterof 17.96 ± 0.16nm.*Sesbania grandiflora* leaf extract was used as a reducing agent for the green synthesis of zinc oxide and iron oxide nanoparticles. SEM analysis of zinc oxide nanoparticles reveals that particles were spherical in shape and size ranged from 15 to 35 nm while iron oxide nanoparticles were nonspherical and ranged from 25 to 60 nm. Biosynthesized nanoparticles are used for the treatment of seafood industry effluent for the efficient removal of organic pollutants. (Sorna and Kandasamy., 2018). Drumstick (*Moringa oleifera*) leaves are used for the production of ZnO nanoparticles. Formation and characterization of the particles was done by UV-VIS spectroscopy, FTIR, XRD, and SEM. Studies performed by Pal, et al 2018 using biosynthesized nanoparticles revealed their antibacterial activity against gram positive bacterium *Bacillus subtilis* and gram negative bacteria *Escherichia coli*. Plant-mediated synthesis of AuNPs was performed using *Chenopodium formosanum* shell extract as a reducing and stabilizing agent and was reported by Chen et al., 2019. The synthesized Au NPs exhibit antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*.The green ZnO nanoparticles of *Catharanthus roseus* synthesized under different physical conditionsrevealed its significant antibacterial activity against both gram positive and gram negative organisms, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, and *Escherichia coli*. (Gupta et al., 2018)

6.3 Biosynthesis of Nanoparticles from Fungi

Fungi are important in the biogenic approach due to the easy scale up process and as they produce extracellular enzymes which are easily recovered. Silver nanoparticles synthesized from *Aspergillus flavus*, which size ranged from 8.92 ± 1.61 nm (Vigneshwaran et al., 2007). *Trichoderma viride* was used for the study of the influence of reaction temperature on the synthesis of silver nanoparticles. In this, the particle size decreased when an increase in temperature (Fayaz et al., 2010). Xue et al., 2016 mixed silver nitrate solution with *Arthroderma flavum* for the synthesis of silver nanoparticles. Ag NPs are confirmed by the UV- Vis analysis and characterization was done by XRD which revealed the diameter of particles of 15.5 ± 2.5 nm. They also reported the antifungal activity of AgNPs against *Candida* spp., *Aspergillus* spp., and *Fusarium* spp. Helar et al., 2015, observed that gold nanoparticles synthesized from *Fusarium oxysporum* have a good effect on seed germination and enhances seed viability in the agricultural field. Four *Aspergilli* species named *A. fumigatus, A. clavatus, A. niger*,and *A. flavus*were used for the biological synthesis of silver nanoparticles by Zomorodian et al., (2016). Ag NPs from different fungal spp. were exhibit different particle sizes, 5 - 95 nm size for *A. fumigatus*, 25 - 145 nm for *A. clavatus*, 25 - 175 nm for *A. niger*, and 45 - 185 nm for *A. flavus*. A white rot fungus named *Stereum hirsutum*was used for the fabrication of copper and copper oxide nanoparticles was documented by Cuevas et al., 2015. FTIR study suggests that the extracellular protein of fungus was responsible for the green synthesis of nanoparticles. TEM analysis exhibit that the particles are spherical in shape and size was 5 to 20 nm. The biological synthesis of gold nanoparticles using intracellular protein extracts of *Pycnoporus sanguineus* was reported by Shi et al., 2015. Biosynthesized Au NPs show catalytic activity and degrade 12.5 µmol of 4-nitroaniline within 6 min. Shamsuzzaman et al., 2017 used Candida albicans as a capping and reducing agent for the fabrication of ZnO nanoparticles . Abdel Rahim et al., 2017 used *Rhizopus stolonifer* aqueous mycelium extract for the green synthesis of silver nanoparticles. Confirmation and characterization of nanoparticles was done XRD, FTIR, and TEM.

6.4 **Biosynthesis of nanoparticles from Actinomycetes**

Streptomyces are commonly found in the soil and belong to the order *Actinomycetales*. Actinomycetes are transitional forms between fungi and bacteria. The culture supernatant of *Streptomyces albogriseolus* was used for the production of silver nanoparticles. Only a few studies are done on the usage of actinomycetes such as *Thermomonospora* sp. (Ahmad et al., and Sastry et al., 2003) and *Rhodococcus* sp. (Otari et al., 2012) for the synthesis of nanoparticles. *Thermomonospora sp*., and *Rhodococcus sp*., has been utilized for gold nanoparticle synthesis by extracellular and intracellular modes respectively (Ahmad et al., 2003a & 2003b).

6.5 Biosynthesis of nanoparticles from Algae

Algae are also widely used in biogenic methods to decrease the side effects of the physical and chemical methods. Algae possess functional groups and enzymes in their cell wall which act as a reducing agent for the reduction reaction. (Gade et al., 2008). Copper nanoparticles synthesized from the brown algae *Sargassum polycystum* display anticancer and antibacterial activity (Ramaswamy et al., 2016). Studies conducted by Jayashree and Thangaraju., 2015 on *Sargassum plagiophyllum* usingsilver nanoparticles showed antibacterial activity against *Escherichia coli, Proteus vulgaris, Proteus mirabilis, Pseudomonas aeruginosa, Bacillus subtilis, Staphylococcus aureus, Vibrio cholera*,and *Enterococcus aerogens*. Biological synthesis of copper and silver nanoparticles by using green Algae *Botryococcus braunii* has been reported by Arya et al., 2018. Characterization of nanoparticles was carried out by FTIR, SEM, XRD, and UV visible spectroscopy. Biosynthesized nanoparticles exhibit antibacterial and antifungal activity against *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Klebsiella pneumonia,*and *Fusarium oxysporum*. Silver nanoparticles synthesized from the red algae *Laurencia papillosa* revealed the antibacterial and antifungal activity against *Bacillus subtilis* and *Aspergillus flavus* (Omar et al., 2017). Sharma et al., 2014a used dried biomass of green alga, *Prasiola crispa* for the fabrication of extracellular Au NPs and characterization done by the FTIR. Red seaweed *Gracilaria edulis* was used for the green synthesis of copper oxide nanoparticles and was confirmed by UV spectroscopy. The synthesized nanoparticles characterization was done using different techniques X-ray spectrometry (EDX), Field emission scanning electron microscopy (FESEM), X-ray diffraction (XRD), and UV-visible absorption spectroscopy (Niji et al., 2018).

7 Applications of Nanoparticles

Due to novel physical, chemical, and biological properties, nanoparticles have incredible applications in different filedsof biology, medicine, environment, agriculture, and commercial industries.

7.1 **Pharmacological**

Nanoparticles have various effects on human health related to bulk material from which it fabricated (Albrecht et al., 2006).Due to theirsmall size nanoparticles has access to the skin, brain, and lung. (Koziara et al., 2003). Nanomedicines have applications in the diagnosis and treatment of human disease. Other applications of nanoparticles are play important role in drug delivery, imaging, and cancer therapies. Silver nanoparticles are widely used in the medical field due to their antimicrobial activity. A lower concentration of silver nanoparticles ruptures the cell wall of bacteria (Kasthuri *et al*., 2009). Silver and gold nanoparticles inhibit the cell cycle functions of the bacteria. (Kim *et al*., 2007). Metallic nanoparticles show antibacterial, antifungal, antiplasmodial, and anti-inflammatory actions. This novel property increases the use of nanoparticles in different areas of the medical field. Diabetes mellitus is a medical condition in which blood sugar level is uncontrolled. Metallic nanoparticles are used as anti diabetic agents. Synthetic drugs have some drawbacks like liver damage; renal failure while nanoparticles develop as a drug that effective against microbes.Daisy and Saipriya, 2012 reported that gold nanoparticles have good therapeutic effects against diabetic models. Iron, zinc oxide, selenium nanoparticles have antibacterial applications (Goswami et al., 2018) (Shah et al., 2015). Nanoparticles play important role in imaging. ZnO NPs are used as anticancer and antibacterial agents. Zinc oxide nanoparticles have a good ability to trigger excess ROS production and release zinc ions and induced cell apoptosis. Also, it is used for diabetic treatment because zinc is responsible for keeping the structural integrity of insulin. Another application of ZnO nanoparticles is bioimaging because of its excellent luminescent properties. (Jiang et al., 2018). ZnO nanomaterial has some properties like biosensing, strong adsorption capability, high isoelectric point, and high catalytic activity which are helpful for the adsorption of proteins like antibodies and enzymes. (Kalpana and Devi Rajeswari., 2018). Nanoparticles are an important tool for the biomedical field. Medical devices coated with the biosynthesized Ag NPs inhibit the biofilm of *Staphylococcus aureus*. (Raja et al., 2013). CONPs (Copper Oxide Nanoparticles) synthesized from the brown alga, *Bifurcaria bifurcata* exhibit antibacterial activity against *Enterobacter aerogenes* and *Staphylococcus aureus* (Abboud et al., 2013). Tilia extract is used for the biogenic synthesis of copper nanoparticles, which exhibit antibacterial and antifungal activity against *Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, and Candida albicans*. Also shows potent cytotoxic activity against Caco-2, HepG2 and Mcf-7 cell. Their result suggested that nanoparticles can find usage in the treatment of cancer also (Reda et al., 2018).

7.2 Environment

Some harmful chemicals are released into the environment due to industrial and household activities. Biosynthesized nanoparticles absorb these contaminants on their surface and eliminate them. (Swadeshmukul et al., 2001) Also nanoparticles are helpful for the removal of heavy metals like mercury, lead, cadmium, arsenic from natural waters (Mueller and Nowack, 2008). Biosynthesized nanoparticles also performed noteworthy activities like remediation and biosensoring. (Tratnyek and Johnson, 2006). Nanoparticles are used for water purification and also for the reduction of air emissions. The conventional techniques used for the remediation purpose are costly and require a longer period time to achieve the goals (Salipira et al., 2007). Nanoparticles are easily transported with the flow of water because of their small size (Karn et al.ṁ, 2009) and useful for the treatment of underground water. Due to their small size nanoparticles enter into small space and remain active for a long time (Zhang, 2003).Continuous monitoring and sensing of pollutants are important to protect environments. Biological contaminations generally occur due to the *Enterobacteriaceae* family, which are toxic for humans. Lin et al., 2002 developed mannose encapsulated gold nanoparticles for the detection of the *Escherichia coli*. Mannose was used due to the good affinity of it for the type I pili of *Escherichia coli.* A sensor for Pb detection was developed by Liu and Lu in 2004. The sensor consists of the gold nanoparticles coated with the lead dependent DNA enzymes. Titanium dioxide nanoparticles possess photocatalytic properties which were helpful for the reduction of pollution they work as oxidizing agents when exposed to UV radiation, andbreakdownpollutants to less harmful compounds (Parkin and Palgrave, 2005).

7.3 Agriculture

In agricultural fields nanoparticles are used to increasecrop yields. Biosynthesized nanoparticles increase growth of plants like root, shoot, leaves, etc. and can also be used for the coating of the plant seeds. ZnO possesses pesticidal activity when it is sprayed on tomato and eggplant, ZnO reduces disease by 28% as compared to control (Kalpana and Devi Rajeswari., 2018). Nanoparticles are used as a biosensor in the agricultural field. The biosensors are small, portable, rapid in response, stable, accurate, and real time processing sensor by using this farmer get proper information about soil and plant in agricultural fields. (Sharon et al., 2010). Green synthesis of MgO nanoparticles from *Aspergillus flavus* shows a positive effect on clusterbeans. The synthesized nanoparticles enhance root shoot growth and chlorophyll pigments in clusterbeans (Raliya et al., 2014). ZnO nanoparticles synthesized from *Aspergillus fumigates* increases rhizospheric microbes populations, acid phosphatase, alkaline phosphatase, and phytase activity in clusterbeans. (Raliya and Tarafdar., 2013).Nanoparticles of ZnO NPs are used for the seed coating of several plants (*Z. mays*, *G. max*, *Cajanus cajan*, and *Abelmoschus esculentum*) . When germination was carried out it indicated that the seeds coated with ZnO NPs germinated better as compared to uncoated seeds (Adhikari et al., 2016). Jeyasubramanian et al., 2016, reported the positive effect of iron oxide (Fe_2O_3) nanoparticles on spinach (*Spinacea oleracea*) . The nanoparticles increased the growth of spinach in terms of root and stem length as well as biomass.

7.4 Commercial Industry

Nanoparticles are widely used in the food industry for the packaging of food and also protect food from spoilage. Zinc and titanium nanoparticles are used in cosmetics for the preparation of sunscreen. Nanoparticles have a high surface to mass ratio due to which they have high catalytical activity. Because of their high catalytical activity nanoparticles are widely used in water purifications and dye degradation. Silver nanoparticles show good activity against azo dyes. Zinc oxide nanoparticles are mainly used for industrial products like rubber, paint, coating, and cosmetics.(Jiang et al., 2018). ZnO NPs possess some properties like semiconducting, piezoelectric, and pyroelectric and have versatile applications in spin electronics, transparent electronics, UV light emitters, personal care products, catalysts, coating and paints. ZnO NPs are also used in the food preservation and packing industry. It improved food quality and packing in three ways (1) by releasing antimicrobial ions (2) By destroying the integrity of the bacterial cells and (3) By producing ROS due to light radiation. (Kalpana and Devi Rajeswari., 2018). ZnO enhanced the sun protection factor (SPF) so it can be used in cosmetics for the whitening of the skin and foot care and ointment preparations (Osmond and McCall, 2010(Singh and Nanda, 2014). Biosynthesized ZnO nanoparticles show photocatalytic activity and degrade the organic dye. ZnO NPs degrade 96% titan yellow dye. (Pal et al, 2018)

Conclusion

The main aim of this review was to explore the potentials of nanoparticles regarding the different fields like agriculture, pharmacology, Environment, etc. The green approach for the fabrication of nanoparticles is an eco accommodating and cost adequate compared to other physical and chemical approaches. However, Green sources used for nanoparticles synthesis act as both reducing and stabilizing agent. Nanoparticles due to their properties have acceptable solutions to the global sustainability challenges facing the society.

References:

1. AbdelRahim K, Mahmoud S. Y, Ali A. M, Almaary K. S, Mustafa A. E. Z. M. Aand Husseiny S. M. (2017). Extracellular biosynthesis of silver nanoparticlesusing Rhizopus stolonifer. Saudi journal of biological sciences., 24: 208-216.
2. Adhikari T, Sarkar D, Mashayekhi H, Xing BS. Growth and enzymatic activity of maize (*Zea mays* L.) plant: solution culture test for copper dioxide nano particles. J Plant Nutr.39:102–118.
3. Ahmad, A., P. Mukherjee, S. Senapati, D. Mandal, M. I. Khan, R. Kumar and M. Sastry (2003). Extracellular biosynthesis of silver nanoparticles using the fungus Fusarium oxysporum, *Colloids. Surf B*, Vol. 28, No. 4, pp. 313-318.
4. Ahmad, A., S. Senapati, M. I. Khan, R. Kumar and M. Sastry (2003a). Extracellular biosynthesis of monodisperse gold nanoparticles by a novel extremophilic actinomycete, Thermomonospora sp, *Langmuir*, Vol. 19, No. 8, pp. 3550-3553.
5. Ahmad, A., S. Senapati, M. I. Khan, R. Kumar, R. Ramani, V. Srinivas and M. Sastry (2003b). Intracellular synthesis of gold nanoparticles by a novel alkalotolerant actinomycete, Rhodococcus species, *Nanotechnology*, Vol. 14, No. 7, pp. 824-82
6. Albrecht M. A., Evans C. W., Raston C. L., *Green Chem*. 8 (2006**)** 417-420.
7. Ananth**,** A. N., S. Umapathy, J. Sophia, T. Mathavan and D. Mangalaraj (2011). On the optical and thermal properties of in situ/ex situ reduced Ag NP's/PVA composites and its role as a simple SPR-based protein sensor, *Applied Nanoscience*, Vol. 1, No. 2, pp. 87-96.
8. Ankamwar B., 2010. Biosynthesis of Gold Nanoparticles (Green-Gold) Using Leaf Extract of Terminalia Catappa E-Journal of Chemistry , 7(4), 1334-1339
9. Arya A., Gupta K., Chundawat T.S. and Vaya D.,2018. Biogenic Synthesis of Copper and Silver Nanoparticles Using Green Alga Botryococcus braunii and Its Antimicrobial Activity.Bioinorganic Chemistry and Applications Volume 2018, Article ID 7879403, 9 pages.
10. Bagyalakshmi J. and Haritha H., 2017. Green Synthesis and Characterization of Silver, Nanoparticles Using *Pterocarpus marsupium* and Assessment of its *In vitro* Antidiabetic ActivityAJADD[5][03] 118-130.
11. Balagurunathan, R., M. Radhakrishnan, R. Babu Rajendran and D. Velmurugan (2011).Biosynthesis of gold nanoparticles by actinomycete Streptomyces viridogens strain HM10, *Indian J. Biochem. Biophys*, Vol. 48, No. 5, pp. 331.
12. Bansal V, Rautaray D, Bharde A, Ahire K, Sanyal A, Ahmad A, Sastry M, 2005. Fungus mediated biosynthesis of silica and titania particles. Journal of Materials Chemistry 15: 2583-2589
13. Batoool M and Masood B (2017) Green Synthesis of Copper Nanoparticles Using *Solanum Lycopersicum* (Tomato Aqueous Extract) and Study Characterization. J Nanosci Nanotechnol Res Vol.1: No.1: 5.
14. Chen M. N., Chan C. F., Huanga S. L., and Lina Y. S., 2019. Green biosynthesis of gold nanoparticles using *Chenopodium formosanum* shell extract and analysis of the particles' antibacterial properties. J. Sci. FoodAgric.99:3693–3702
15. Chen, J., Z. Lin and X. Ma (2003). Evidence of the production of silver nanoparticles via pretreatment of Phoma sp. 3.2883 with silver nitrate, *Lett.appl. microbiol*, Vol. 37, No. 2, pp. 105-108
16. Cheon, J. and G. Horace (2009).Inorganic nanoparticles for biological sensing, imaging andtherapeutics.*J Mater Chem*, Vol. 19, pp. 6249- 6250.

17. Chuhan, A.; Zubair, S.; Tufail, S.; Sherwani, A.; Sajid, M.; Raman, S.C.; Azam, A.; Owais, M., 2011. Fungus-mediated biological synthesis of gold nanoparticles : Potential in detection of liver cancer. *Int. J. Nanomed.*, *6*, 2305–2319.
18. Cuevas R., Duran N., Diez M. C., Tortella G. R., and Rubilar O., 2015. Extracellular Biosynthesis of Copper and Copper Oxide Nanoparticles by Stereum hirsutum, a Native White-Rot Fungus from Chilean Forests. Journal of Nanomaterials. Volume 2015, Article ID 789089, 7 pages.
19. Daisy, P., Saipriya, K. (2012). Biochemical analysis of *Cassia fistula* aqueous extract and phytochemically synthesized gold nanoparti- cles as hypoglycemic treatment for diabetes mellitus. *Int. J. Nanomed*, (7), 1189–1202.
20. Deplanche K., Woods R. D., Mikheenko I. P., Sockett R. E., Macaskie, L. E., 2008. Manufacture of stable palladium and gold nanoparticles on native and genetically engineered flagella scaffolds. Biotechnology and Bioengineering 101: 873-880.
21. Dhandapani p., Siddarth A. S., Kamalasekaran S., Maruthamuthu S., and Rajagopal G.,2014. “Bio-approach: ureolytic bacteria mediated synthesis of ZnO nanocrystals on cotton fabric and evaluation of their antibacterial properties,” Carbohydrate Polymers, vol. 103, pp. 448–455.
22. Divya K., Kurian L. C., Vijayan S., Jisha M. S., 2016. Green synthesis of silver nanoparticles by *Escherichia coli*: Analysis of antibacterial activity. J. Water Environ. Nanotechnol.,1(1): 63-74,
23. Ealia A. M. S. and Saravanakumar M. P., 2017. A review on the classification, characterisation, synthesis of nanoparticles and their application. *IOP Conf. Ser.: Mater. Sci. Eng.* 263 032019
24. Eckelman MJ, Zimmerman JB, Anastas PT (2008). Toward green nano. J Ind Ecol 12(3):316–328.
25. Fayaz, M., C. Tiwary, P. Kalaichelvan and R. Venkatesan (2010). Blue orange light emission from biogenic synthesized silver nanoparticles using Trichoderma viride, *Colloids. Surf B*, Vol. 75, No. 1, pp. 175-178
26. Gade A. K, Bonde P, Ingle A. P, Marcato P. D, Durán N and Rai M. K: Exploitation of *Aspergillus niger* for synthesis of silver nanoparticles. Journal of Biobased Material Bioenergy 2008; 2: 243-47.
27. Ghozali S. Z, Vuanghao L and Ahamad N. H. (2015). Biosynthesis and characterisation of silver nanoparticles using Catharanthus roseus leaf and its proliferative effects of on cancer cell line. Nanomedicine & naotechnology., 6 (4): 1 6.
28. Goswami G. K., Mehta P and Soni A., 2018. Green nanoparticles: synthesis and applications. IOSR journal of biotechnology and biochemistry, volume 4, pp78-83.
29. Gottimukkala K. S. V, Harika Reddy P and Zamare D. (2017). Green synthesis of iron nanoparticles using green tea leaves extract. Journal of nanomedicine & biotherapeutic discovery. 7 (1): 1 4.
30. Gupta M, Tomar R. S, Kaushik S, Mishra R. K and Sharma D (2018) Effective Antimicrobial Activity of Green ZnO Nano Particles of Catharanthus roseus. Front. Microbiol. 9:2030.
31. Hanan H. Omar, Fatmah S. Bahabri and Adel M. El-Gendy, 2017. Biopotential application of synthesis nanoparticles as antimicrobial agents by using Laurencia papillosa . Int. J. Pharmacol., 13: 303-312.
32. Helar G and Chavan A. Synthesis, characterization and stability of gold nanoparticles using the fungus *Fusarium oxysporum* and its impact on seed germination. International Journal of Recent Scientific Research 2015; 6: 3181-85.
33. Husseiny M.I, El-Aziz M. A, Badr Y, Mahmoud M. A (2007) Biosynthesis of gold nanoparticles using Pseudomonas aeruginosa. Spectrochim Acta A: Mol Biomol Spectrosc 67:1003–1006
34. Jaidev, L.R.; Narasimha, G., 2010. Fungal mediated biosynthesis of silver nanoparticles, characterization and antimicrobial activity. *Colloids Surf. B Biointerfaces*, *81*, 430–433.
35. Jangra S., Sethi N., Jangra R., and Kaura S., 2014. Microbial Synthesis of Silver Nanoparticles by Actinotalea sp. MTCC 10637 AJPCT[2][8]1016-1023
36. Jayaseelan C. Rahuman A. A., Kirthietal A. V. 2012. “Novelmicrobial route to synthesize ZnO nanoparticles using Aeromonas hydrophila and their activity against pathogenic bacteria and fungi,”SpectrochimicaActaPartA:MolecularandBiomolecular Spectroscopy,vol.90,pp.78–84
37. Jayashree S and Thangaraju N: Biosynthesis and characterization of silver nanoparticles using marine macro algae *Sargassum Plagiophyllum* C. Agardh. Journal of Pharmaceutical and Biomedical Science 2015; 5: 705-12.

38. Jeyasubramanian K, Thoppey UUG, Hikku GS, Selvakumar N, Subramania A, Krishnamoorthy K. Enhancement in growth rate and productivity of spinach grown in hydroponics with iron oxide nanoparticles. RSC Adv. 2016;6:15451–15459.
39. Jiang J., Jiang Pi. And Cai J., 2018. The Advancing of Zinc Oxide Nanoparticles for Biomedical Applications. Bioinorganic Chemistry and Applications Volume 2018, Article ID 1062562, 18 pages.
40. Karn, B., Kuiken, T., & Otto, M. (2009). Nanotechnology and in Situ Remediation: A Review of the Benefits and Potential Risks. *Environmental Health Perspective, 117*, 1823-1831.
41. Kaur P, Thakur R and Chaudhury A. (2016). Biogenesis of copper nanoparticles using peel extract of Punica granatum and their antimicrobial activity against opportunistic pathogens. Green chemistry letters and reviews., 9 (1): 33 38.
42. Khan Mujeebur Rhaman and Rizvi Tanveer Fatima. (2014). Nanotechnology: Scope and applications in Plant Disease management. Plant Pathology Journal. 13 (3): 214-231.
43. Kim, J.S., Kuk, E., Yu, K.N., Jong-Ho, K., Park, S.J., Lee, H.J & Kim S.H. (2007). Antimicrobial effects of silver nanoparticles *Nanomedicine*,(3), 95–101.
44. Klaus T., Joerger R., Olsson E., and Granqvist C. G.,1999. "Silver based crystalline nanoparticles, microbially fabricated," *Proceedingsof the National Academy of Sciences of the UnitedStates of America*, vol. 96, no. 24, pp. 13611–13614.
45. Konishi Y., Sukiyama T., Tachimi T., Saitoh N., Nomura T., and Nagamine S.,2007. "Microbial deposition of gold nanoparticles by the metal-reducing bacterium *Shewanella algae*," *Electrochimica Acta*, vol. 53, no. 1, pp. 186–192
46. Koziara J. M., Lockman P. R, Allen D. D., Mumper R. J., *Pharm. Res*,20 (2003) 1772-1778.
47. Krishnaraj, C., Jagan, E.G., Rajasekar, S., Selvakumar, P., Kalaichelvan, P.T & Mohan, N. (2010). Synthesis of silver nanopar- ticles using *Acalypha indica* leaf extracts and its antibacterial activity against water borne pathogens. *Colloid Surf, B* (76), 50–56.
48. Lakshmana Prabu S., Umamaheswari A., Rajakumar S., Bhuvaneswari P. L., and Muthupetchi S., 2017. Development and Evaluation of Gel Incorporated with Synthesized Silver Nanoparticle from *Ocimum gratissimum* for the Treatment of Acne Vulgaris American Journal of Advanced Drug Delivery(5)(03j)107-117
49. Lin, C. C., Yeh, Y. C., Yang, C. Y., Chen, C. L., Chen, G. F., Chen, C. C., & Wu, Y .C. (2002). SelectiveBinding of Mannose-Encapsulated Gold Nanoparticles to Type 1 Pili in *Escherichia coli*. *Journal of theAmerican Chemical Society*, *124*(14), 3508-3509
50. Liu, J., & Lu, Y. (2004). Accelerated Color Change of Gold Nanoparticles Assembled by DNAzymes for Simple and Fast Colorimetric Pb2+ Detection. *Journal of the American Chemical Society*, *126*(39), 12298-12305.
51. Mann, S. (2001); Biomineralization: principles and concepts in bioinorganic materials chemistry. Oxford University Press
52. Manonmani, V. and V. Juliet, 2011. Biosynthesis of Ag nanoparticles for the detection of pathogenic bacteria. Proceeding of the 2nd International Conference on Innovation, Management and Service, September 16-18, 2011. Singapore, pp: 307-311.
53. Mayedwa N, Khalil AT, Mongwaketsi N, et al., 2017. The Study of Structural, Physical and Electrochemical Activity of Zno Nanoparticles Synthesized by Green Natural Extracts of Sageretia Thea. Nano Res Appl., 3:2.
54. Mohanpuria P., Rana N. K., Yadav S., 2008. Biosynthesis of nanoparticles: technological concepts and future applications J Nanopart Res 10: 507–517.
55. Mueller, N.C., Nowack, B., 2008. Exposure modeling of engineered nanoparticles in the environment. *Environ. Sci. Technol.* 42, 4447– 4453
56. Ndikau M., Noah N. M., Andala D. M., and Masika E., 2017.Green Synthesis and Characterization of Silver Nanoparticles Using Citrullus lanatus Fruit Rind Extract. *International Journal of Analytical Chemistry* Volume 2017, Article ID 8108504, 9 pages.
57. Niji A., John V. S., and Ranjini P. S. P., 2018. Green Synthesis And Characterization Of Copper Oxide Nanoparticles Using A Red Seaweed Gracilaria Edulis . *IJESI*. Vol. 7 Issue 10 (3), pp 09-13.
58. Osmond M. J. and McCall M. J. 2010. "Zinc oxide nanoparticles in modern sunscreens: an analysis of potential exposure and hazard,"*Nanotoxicology*,vol.4,no.1,pp.15–41.
59. Otari, S., R. Patil, N. Nadaf, S. Ghosh and S. Pawar (2012).Green biosynthesis of silver nanoparticles from an actinobacteria Rhodococcus sp, *Mater. Lett*,Vol. 72, pp. 92-94.

60. Pal S., Mondal S., Maity J., and Mukherjee R., 2018.Synthesis and Characterization of ZnO Nanoparticles using M oringa O leifera Leaf Extract: Investigation of Photocatalytic and Antibacterial Activity. *Int. J. Nanosci. Nanotechnol*., Vol. 14, No. 2, pp. 111-119
61. Parkin, I. P., & Palgrave, R. G. (2005). Self-cleaning coatings. *Journal of Materials Chemistry, 15*, 1689
62. Rai, M., A. Yadav and A. Gade (2009).Silver nanoparticles as a new generation of antimicrobials, *Biotechnol.adv*,Vol. 27, No. 1, pp. 76-83.
63. Raja K, Namashivayam S, Christo BB, Karthigai Arasu SM, Arum Muthukumar K, Deepak K (2013). Anti biofilm effect of biogenic silver nanoparticles coated medical devices against biofilm of clinical isolate of S. aureus. *GJMR 13* (3): 25–30.
64. Raliya, R., and Tarafdar, J. C. (2013). ZnO nanoparticle biosynthesis and its effect onphosphorous-mobilizingenzymesecretionandgumcontentsinclusterbean (Cyamopsis tetragonoloba L.). *Agric. Res*. 2, 48–57.
65. Raliya, R., Tarafdar, J. C., Singh, S. K., Gautam, R., Choudhary, K., Maurino Veronica, G., et al. (2014). MgO nanoparticles biosynthesis and its effect on chlorophyllcontentsinthe leavesofClusterbean(CyamopsistetragonolobaL.). *Adv.Sci.Eng.Med*.6,538–545
66. Raliya, R.; Tarafdar, J. C., 2012. Novel approach for silver nanoparticle synthesis using *Aspergillus terreus* CZR-1: mechanism perspective. *J. Bionanosci*., *6*, 12–16
67. Ramaswamy S. V. P, Narendhran S and Sivaraj S: Potentiating effect of eco-friendly synthesis of copper oxide nanoparticles using brown alga: antimicrobial and anticancer activities. *Bulletin of Material Science* 2016; 39l: 361-64.
68. Reda Hassanien, Dalal Z. Husein, Mostafa F. Al-Hakkani. Biosynthesis of copper nanoparticles using aqueous Tilia extract: antimicrobial and anticancer activities. *Heliyon* 4 (2018) e01077.
69. Sadhasivam, S., P. Shanmugam and K. Yun (2010). Biosynthesis of silver nanoparticles by Streptomyces hygroscopicus and antimicrobial activity against medically important pathogenic microorganisms, *Colloids Surf B., Biointerfaces*.Vol. 81, No. 1, pp. 358-362.
70. Salipira, K., Mamda, B. B., Krause, R. W., Malefetse, T. J., & Durbach, S. H. (2007). Carbon nanotubes and cyclodextrin polymers for removing organic pollutants from water. *Environmental Chemistry Letters, 5,* 13-17.
71. Sandhu Repudaman Singh., Aharwal Ravindra Prasad., Kumar Suneel. (2019). Green synthesis: A novel approach for nanoparticle synthesis. *IJPSR, Vol. 10(8): 3550-3562.*
72. Santhoshkumar T, Rahuman A. A, Jayaseelan C, Rajakumar G, Marimuthu S, Kirthi A. V, Velayutham K, Thomas J, Venkatesan J and Kim S. K. (2014). Green synthesis of titanium dioxide nanoparticles using *Psidium guajava* extract and its antibacterial and antioxidant properties. Asian pacific journal of tropical medicine., 7 (12): 968 976.
73. Scarano G. and Morelli E, 2003. Properties of phytochelatin-coated CdS nanocrystallites formed in a marine phytoplanktonic alga (*Phaeodactylum tricornutum*, Bohlin) in response to Cd. *Plant Science* 165: 803- 810.
74. Selvarajan E., and Mohanasrinivasan V., 2013. "Biosynthesis and characterization of ZnO nanoparticles using Lactobacillus plantarum VITES07," *Materials Letters,* vol. 112, pp. 180– 182.
75. Shah M., et al. "Green Synthesis of Metallic Nanoparticles via Biological Entities" Materials 8(2015): 7278–7308.
76. Shah R., Pathan A., Vaghela H., Ameta S.C., and Parmar K., 2018. Green Synthesis and Characterization of Copper Nanoparticles Using Mixture (Zingiber officinale, Piper nigrum and Piper longum) Extract and its Antimicrobial Activity . *Chemical Science Transactions.*, 8(1), 63-69.
77. Shaikmoideen J. M., Koilparambil D., Kurain L. C., Vijayan S., 2016. Green synthesis of silver nanoparticles by *Escherichia coli*: Analysis of antibacterial activity J. Water Environ. Nanotechnol., 1(1): 63-74
78. Shamsuzzaman A., Mashrai A., Khanam H., and Aljawfi R. N., 2017. "Biological synthesis of ZnO nanoparticles usingC.albicansandstudyingtheircatalyticperformancein the synthesis of steroidal pyrazolines," Arabian Journal of Chemistry, vol. 10, pp. S1530–S1536.
79. Sharma, B., Purkayastha, D. D., Hazra, S., Gogoi, L., Bhattacharjee, C. R., Ghosh, N. N., Rout, J., 2014a. Biosynthesis of gold nanoparticles using a freshwater green alga, *Prasiola crispa* . Mater Lett. 116, 94-97.
80. Sharon, M., Choudhary, A.K. and Kumar, R. (2010) Nanotechnology in Agricultural Disease and Food Safety. J. Phytology, 2(4): 83–92

81. Shi C., Zhu N., Cao Y., and Wu P., 2015. Biosynthesis of gold nanoparticles assisted by the intracellular protein extract of *Pycnoporus sanguineus* and its catalysis in degradation of 4-nitroaniline. *Nanoscale Reaserch Letters*. 10: 147
82. Singh Manoj., Manikandan S., And Kumaraguru A. K., 2010. Nanoparticles: A new technology with wide Applications. *Research journal of nanoscience and nanotechnology*.
83. Singh P. andNanda A., 2014. "Enhancedsunprotectionofnano-sized metal oxide particles over conventional metal oxide particles: aninvitro comparative study,*"InternationalJournal of Cosmetic Science*,vol.36,no.3,pp.273–283.
84. Sorna P.R. and KandasamyS., 2018. Synthesis and Characterization of Zinc Oxide and Iron Oxide Nanoparticles Using Sesbania grandiflora Leaf Extract as Reducing Agent.Journal of Nanoscience Volume 2017, Article ID 8348507, 7 pages.
85. Sunkar S. and Nachiyar C. V., "Biogenesis of antibacterial silver nanoparticles using the endophytic bacterium *Bacillus cereus* isolated from *Garcinia xanthochymus*," *Asian Pacific Journal of Tropical Biomedicine*, vol. 2, no. 12, pp. 953–959, 2012.
86. Swadeshmukul, S., Peng, Z., Kemin, W., Rovelyn, T., Weihong, T., 2001. Conjugation of biomolecules with luminophore-doped silica nanoparticles for photostable biomarkers. *Anal. Chem*. 73, 4988– 4993
87. Tratnyek, P.G., Johnson, R.L., 2006. Nanotechnologies for environmental cleanup. *Nano Today* 1, 44–48
88. V. N. Kalpana and V. Devi Rajeswari., 2018. A Review on Green Synthesis, Biomedical Applications, and Toxicity Studies of ZnO NPs.*Bioinorganic Chemistry and Applications* Volume 2018, Article ID 3569758, 12 pages
89. Vigneshwaran, N., N. Ashtaputre, P. Varadarajan, R. Nachane, K. Paralikar and R. Balasubramanya (2007).Biological synthesis of silver nanoparticles using the fungus Aspergillus flavus, *Mater.lett*,Vol. 61, No. 6, pp. 1413-1418.
90. Vithiya K., and Sen S., 2011. Biosynthesis of nanoparticles. IJPSR.Vol. 2(11): 2781-2785
91. Xiangqian Li., Huizhong Xu., Zhe-Sheng Chen, Guofarng Chean., Biosynthesis of nanoparticles by microorganisms and their applications. Journal of nanomaterials. Volume 2011, Hindawi Publishing Corporation.
92. Xu, Z. P., Q. H. Zeng, G. Q. Lu and A. B. Yu (2006). Inorganic nanoparticles as carriers for efficient cellular delivery, *Chem. Eng. Sci*,Vol. 61, No. 3, pp. 1027-1040.
93. Xue B, He D, Gao S, Wang D, Yokoyama K and Wang L: Biosynthesis of silver nanoparticles by the fungus *Arthroderma fulvum* and its antifungal activity against genera of *Candida*, *Aspergillus* and *Fusarium*. International J of Nanomedicine 2016; 4: 1889-06.
94. Y. Abboud. ,T. Saffaj .,A. Chagraoui ., A. El Bouari ., K. Brouzi .,O. Tanane., B. Ihssane., 2013. Biosynthesis, characterization and antimicrobial activity of copper oxide nanoparticles (CONPs) produced using brown alga extract (Bifurcaria bifurcata).Appl Nanosci (2014) 4:571–576.
95. Yamamoto, O. (2001). Influence of particle size on the antibacterial activity of zinc oxide, *Int. J. Inorg. Mater*,Vol. 3, No. 7, pp. 643-646.
96. Yong, P., N. A. Rowson, J. P. G. Farr, I. R. Harris and L. E. Macaskie (2002). Bioreduction and biocrystallization of palladium by Desulfovibrio desulfuricans NCIMB 8307, *Biotechnol.bioeng*,Vol. 80, No. 4, pp. 369-379.
97. Zhang, W. X. (2003). Nanoscale iron particles for environmental remediation: An overview. *Journal of Nanoparticle Research*, *5*, 323-332.
98. Zomorodian K, Pourshahid S, Sadatsharifi A, Mehryar P, Pakshir K, Rahimi M. J.and Monfared A. A. (2016). Biosynthesis and characterization of silvernanoparticles by Aspergillus species. Biomed research international. 1- 6.