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PROMISES AND CONS OF NANOBIOTECHNOLOGY : A CRITICAL REVIEW

Neha Shrivastava, Vikas Shrivastava, Anurag Jyoti* and Rajesh Singh Tomar

Amity Institute of Biotechnology, Amity University Madhya Pradesh,
Maharajpura Dang, Gwalior-474 005 (M.P.), India.

Abstract

Nanotechnology is a cutting-edge field of science, which allows the manipulation of materials having dimensions in nanometers. Nanotechnology has numerous applications in almost all the areas, including human health, environment, bio-diagnostics, drug delivery etc. Excessive and over-use of nanomaterials has led to the uncontrolled release of nanomaterials into the environments which are toxic to the living organisms. The present review has attempted to provide a detailed overview of the nanoparticles, their synthesis, classification, applications and toxic effects. Different methods of nanoparticles synthesis like physical, chemical and biological methods have been addressed. Physical and chemical methods for nanoparticles synthesis are less eco-friendly and contaminate the environment. Recently, biological methods have gained significant attention and are frequently used because they are eco-friendly and cost effective. Due to enormous properties of nanoparticles they are suitable for various commercial, domestic, medical and environmental applications exist in different forms. This paper also reviews exposures to toxic effects of nanoparticles on human and environment.

Key words : Nanotechnology, Nanoparticles, Synthesis, Applications, Toxicity.

Introduction

Nanotechnology is the grassland of research since last century. It is the manipulation of matter on an atomic, molecular and supramolecular scale. The major conception of nanotechnology was presented by Richard Feynman in 1959. Potential application of nanotechnology allows high exceptions of its ability to change the world. The word nanotechnology was introduced by Tokyo science University professor Norio Taniguchi. 'Nano' is a Greek word "nanos" identical to dwarf meaning extremely tiny (Chokriwal *et al*., 2014). Nanoparticles are the smallest particle that can exist in the chemical world with the size ranging from 1 to 100 nm. Nanoparticles perform as a link between the bulk material and the molecular and atomic structures. Unlike the bulk material, the nano form of the material has a completely different property. This is due to its huge volume/charge ratio present with the nanoparticles (Das *et al*., 2015; Tomar *et al*., 2018).

Nanotechnology has various applications in other fields of science such as optics, catalysis, magnetism, energy science, engineering and electronics since decades. Current study of nanotechnology in pharmaceutical and biomedical science results in successful improvement of conventional means of drug delivery system. Nanotechnology has created potential impact in various fields involving research and development of technology in various fields like biotechnology, molecular biology, medicine including immunology, oncology, endocrinology, cardiology, ophthalmology, pulmonary etc. In addition to these, brain targeting, tumor targeting and gene delivery (Bhatia, 2016). Silver nanoparticles are used as an antibacterial agent in the silk and textile technology. Nanoparticles coated with a peptide binds to a cancer tumor to decrease the cancer production in the nervous system of a living system (Kreuter, 2005). Nanoparticles widely used in anti-ageing cream, cosmetics, sunscreen, deodorants and many more. Nano calcium carbonate and nano silica dioxide can increase the rate of hydration and improve the early age mechanical properties of cementous materials. Metallic oxide nanoparticles are also used in different

****Author for correspondence :*** E-mail: ajyoti@gwa.amity.edu

types of electrochemical sensors and biosensors (Luo *et al*., 2006).

Now-a-days, increasing use of nanoparticles eventually leads to the prospective pressure towards plants, microbial population, aquatic life, water, soil, and most prominently humans as a part of natural environmental development. The extreme use of nanoparticle-based products also poses threat to the environment and human health. Nanoparticles show toxicity effects because of their tiny size and their ability to penetrate and internalize essential genetic structures and cell organelle disturbing their normal function.

Nanoparticles cause diseases like bronchitis, Alzheimer's, Parkinson's, asthma, lung cancer, and colon cancer etc. When these nanoparticles enter the circulatory system, they cause severe cardiovascular diseases and ultimately cardiac death. Excessive use of nanomaterial's in manufacturing and recycling industries pose unfavorable effects on water and soil. This needs a development of a cost-effective solution for minimizing the hazardous effects of nanoparticles from the environment and suitable measures should be adopted for the remediation of toxic effects of nanoparticles on human.

Branches of Nanotechnology

1. **Green nanotechnology-** The technology that is used to improve clean technologies to minimize environmental or human health risks.
2. **Nanoengineering** – Nanoengineering involves the manipulation of matter at small scales, usually cited as 1-100 nanometers.
3. **Wet nanotechnology -** Wet nanotechnology involves working up to large masses from small ones. These technologies require water in which the process occur (Gazit *et al*., 2007).

Classification of Nanoparticles

Nanoparticles can classify into various categories based on their Dimension, Particles size and Chemical properties.

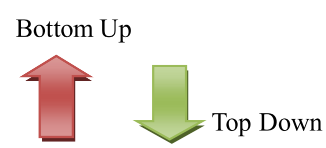
Zero Dimension (0-D) that holds critical range of 1-100nm-height, length and breadth are restricted at single point- (Example-Quantum Dots, Metal NPs) One Dimension (1-D) has only one parameter, either breadth or length (e.g.- nanowires and nanorods) Two Dimension (2-D) has two parameters. (E.g.-Nanofilms, nanosheets and nanowalls) Three Dimension (3-D) has all parameters of length, height, and breadth (e.g.-Crystal) (Acharya *et al*., 2009). On the bases of particle size & shape, nanoparticles are defined as a small object which is 1 to 100 nanometer in size. They have potential applications in biomedical, electronics and optical fields (Robert *et al*., 2013). The nanocapsules are made up of nontoxic polymer, which is vesicular system of a polymeric membrane these are encapsulated in inner liquid center at the level of nanoscale. Nanocapsules are widely used for food enhancement, nutraceuticlas and drug delivery and self-healing of materials (Ezhilarasi *et al*., 2012). Dendrimers are polymers, which are continually branched molecule with nano dimensions as well as controlled structure. Dendrimers are commonly used for targeted drug delivery. Quantum dots are semiconductor nanostructures that restrict the movement of valence band holes, excitations or conduction band electrons in all three spatial directions. On the bases of chemical properties, the metallic nanoparticles are nanosized metals having all the dimensions with in size range of 1-100nm. Different types of metal nanoparticles such as; Au, Zn, Cu, Mg, Ag, Ni, Fe, Si etc. have been synthesized by several co-precipitation and chemical methods (Mody *et al*., 2010). The polymeric nanoparticles are solid particles with size range of 10-1000 nm. They are extensively studied in pharmaceutical and medical fields. These are capable to increase the stability of volatile pharmaceutical agents. Most of the polymeric NPs are synthesized from biocompatible or biodegradable polymers. oftenly used in cancer treatment and delivery of vaccines. Carbon based nanoparticles *viz*. diamond, nanotube, grapheme, and nanofibers. Comprise high chemical stability, small dimension, low resistivity and high thermal conductivity (Bose *et al*., 2012). Metal Oxide nanoparticles having metallic, semiconductor or insulated character are often used in optoelectronics, memory devices, sensors, cells, fabrication of microelectronic circuits, fuel cells, and piezoelectric devices etc. There are numerous types of metal Oxide nanoparticles such as CuO, MgO, NiO, ZnO, and ZrO_2 nanoparticles etc.

Synthesis of Nanoparticles

Nanoparticles synthesis involves two major approaches:

Bottom up approach

Top down approach



In the Bottom-up approach, atoms buildup into new molecules which develop into clusters and then form particles of nano-scale (e.g. - growth of a crystal). The theory following bottom-up processing self-assembling is the synchronized action of self-determining entity to produce larger, controlled structures to get a desired shape originate in nature and create on the atomic scale.

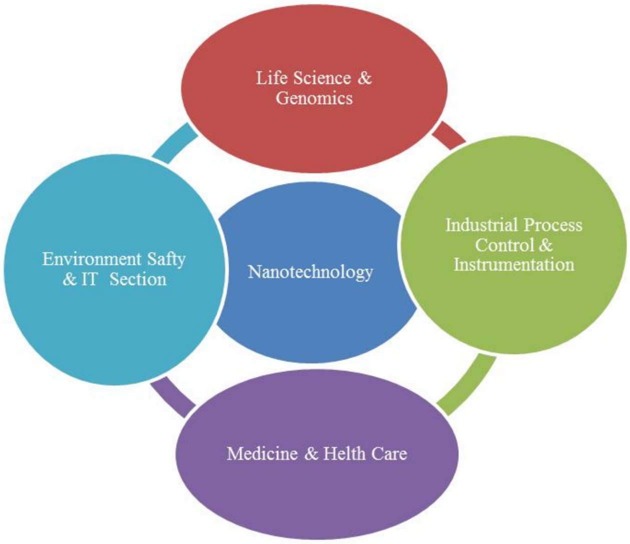


Fig. 1 : Diagrammatic representation branches of Nanotechnology.

chemical composition.

Nanoparticles can be synthesis by 3 methods :

1. Physical 2. Chemical 3. Biological

1. Physical Methods : These methods are advantageous over chemical methods due to minimum contamination of solvent during the synthesis process. Several physical methods are available for synthesis of nanoparticles (Mazhar *et al*., 2017).

High-energy ball milling process : A ball milling is a type of grinder used to grind and blend material. This method is used or synthesis of metallic nanoparticles. In these processes, a powder mixture placed in the ball mill is subjected to high-energy collision from the balls. It produces fine, uniform dispersions of oxide particles. This process can be carried out by using different apparatus, namely, attritor, vibratory, rod, tumbler, and planetary. The major drawback of this process is: - contamination of iron, low surface area, and high reactivity with oxygen, nitrogen and hydrogen (Rajput, 2015). Nanocrystals of Co, Al-Fe, Ag-Fe Cr prepared by using ball mill.

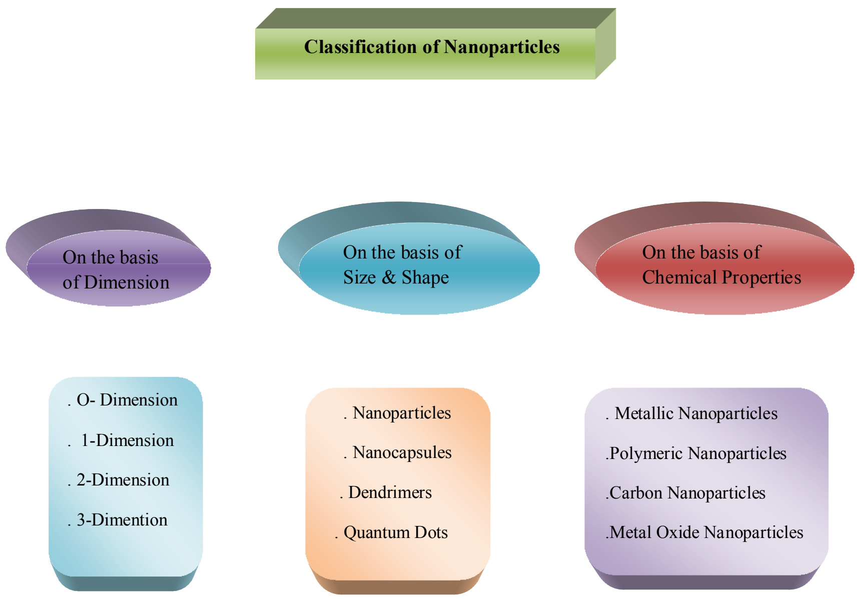


Fig. 2 : Flowchart representing classification of Nanoparticles.

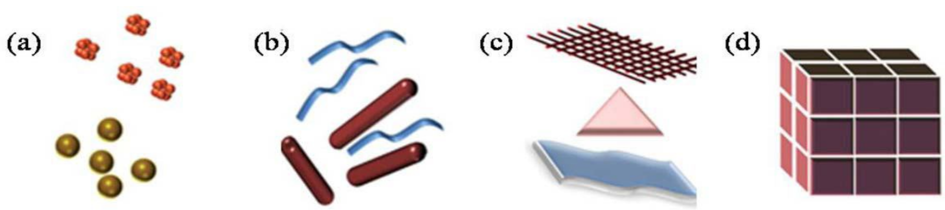


Fig. 3 : (a) 0-D spheres and clusters, **(b)** 1-D nanofibers, wires and rods, **(c)** 2-D films, plates, networks, **(d)** 3D Nanoparticles [https://nccr.iitm.ac.in/2011.pdf].

Whereas in the Top-down approach, bulk material gets converted into to nanosized particles.

Generally, bottom-up approach is more advantageous than top-down approach in nano fabrication. The main advantages of bottom-up approach are producing nanostructures with less defects and more homogenous

Laser ablation (Vaporization) : Vaporization of the matter is affected with pulses of high power laser beam.

This powerful beam evaporates atoms from a solid resource. Single wall carbon Nanotubes are commonly synthesized by this method.

Microwave Synthesis : The properties of nanoparticles are size dependent. Microwave irradiation provides rapid decomposition of metal precursors and ultimately synthesizes a wide range of metal oxide nanoparticles with various sizes, shapes and compositions. The area of use for these synthesized nanoparticles array from medical uses, in many industries, such as, manufacturing, cosmetics, textile production & electronics. Microwave assisted synthesis is faster, cleaner, and more economical than conventional methods (Shingh and Nakate, 2013).

2. Chemical Methods : There are various advantages of using chemical methods to synthesize nanomaterials. Using this method, large quantities of nanomaterials can be synthesized, having different shapes and dimensions. This is a low temperature synthesis process with economical instrumentation compared to other physical methods.

Sol-Gel method : Sol-gel method involves 2 types of materials, 'Sol" and 'Gel'. Sol acts as an originator of integrated network. Whereas, Gel polymers hold liquid. Sol-gel processing is a wet chemical method for the conversion of monomers into colloidal dispersions for the synthesis of organic & inorganic hybrid materials. This technique generally involves a low temperature. This process is eco and environment friendly. Synthesis of sol-gel involves hydrolysis, condensation, growth and agglomeration of particles (Rajput, 2015). These methods have been used to synthesize, nanorods, nanoparticles, and nanotubes. **Colloidal methods :** Involves synthesis of nanoparticles by chemical methods form "colloids". A Nanomaterial is a sub-class of colloids, in which dimensions of colloids is about 1 to 100 nm range. Smoke and fog are good examples of colloids. By these methods, Silver, Palladium, Copper and some other metal nanoparticles can be synthesized. **Reverse micelles :** reverse micelles are nanometer sized (1-100nm) water droplets isolated in organic media obtained by the exploitation of surfactants. Reverse micelles are present in water in oil micro-emulsions. Currently they are widely used in synthesis of numerous types of nanoparticles.

3. Biological Methods : The biological methods are advantageous over physical and chemical methods. These methods are environment friendly, bio-compatible, and avoid use of toxic chemicals. Nanoparticles synthesized from biological methods pose better specific surface area and higher catalytic reactivity (Seo *et al.*, 2006). Biological synthesis methods include bacteria, plants, or fungi which are valuable and easy approach to synthesize eco-friendly nanoparticles (Shrivastava *et al.*, 2018).

Microorganisms : Microorganisms can to reduce metal salts and convert them into nanoparticles. The communications of microbial cell-metal are complex, and many microorganisms have the capability to separate metal ions. On the other hand microorganisms can synthesize other nanoparticles like CdS, ZnS, PbS etc. using different routes (Niemeyer and Mirkin, 2004).

Plants – synthesis of nanoparticles by natural resources like plants are termed as 'Green Route'. Synthesis of nanoparticles with the use of plants is better than microbial mediated route because this synthesis method does not include any toxic chemicals and possess high reaction rate. Nanoparticles synthesized by green methods have better application in diverse fields, such as Copper NPs cover broad applications like antimicrobial materials, heat transfer system etc. (Wang *et al*., 2002; Jyoti *et al*., 2018). Titanium dioxide (TiO_2) has wide applications in photo catalysis, gas sensors, solar cell devices, and biomaterial as well as in pharmaceutical industries (Jha *et al*., 2009).

Characterization & Quantization of Nanoparticles

For the examination of diverse properties of the sample, there are number of characterization techniques available.

1. Structural Characterization
2. Optical Characterization

Structural Characterization

This technique is used to obtain accurate information about the surface morphology, size and crystal structure of the particle. Following characterization techniques are generally used :

- **XRD (X-ray Diffraction)**: This is a unique method of spectroscopy using X-ray, electron and neutron diffraction on powdered samples. This technique is used to identify the molecular as well as atomic structure of the crystal.
- **SEM (Scanning electron microscope) :** This technique uses focused high-energy electrons which generate a variety of signals at the surface of solid sample. SEM gives information of surface morphology and crystalline structure.
- **TEM (Transmission Electron microscope) :** TEM is a microscopic technique which is based on transmitted electrons. It gives the two-

dimensional image or provides 50 million magnifications. TEM is mainly used for nanoparticles size determination with high resolution and magnification.

Optical Characterization

Following techniques are used for the optical characterization of particles.

- **UV-Visible Spectroscopy :** UV-Visible Spectroscopy is also known as a reflectance or absorption spectroscopy. It utilizes the visible, near infra-red and, adjacent regions. UV-Visible Spectroscopy is based on the light absorption or reflectance spectroscopy in the UV region and chemical compounds undergo electronic transition.
- **IR (Fourier Transform Infrared Spectroscopy) :** In FTIR, the region of longer wavelength or low frequency can identify different types of chemical compounds.

Quantification of Nanoparticles

- **ICP-MS (Inductively coupled plasma mass spectrometry) :** ICP-MS is a type of mass spectroscopy. This is an advanced technology which can detect metals and non-metals at low concentrations on non-interfered low background isotopes. This technique involves ionizing the sample with inductively coupled plasma using a mass spectrometer to separate and quantify the material.
- **AAS (Atomic Absorption Spectroscopy) :** Atomic Absorption Spectroscopy was first used analytical technique for the quantitative determination of chemical elements using absorption of optical radiation (light) by free atoms in the gaseous state.

Applications of Nanotechnology

Nanoparticles comprise a significant class of different and innovative materials with several properties. Nanoparticles contribute a significant role in various applications because of their unique and important properties, such as high surface to volume ratio (Abhilash, 2010). Nanotechnology is being applied in various industries such as clothes, cosmetics, optics and a wide range of applications in optics, electronics, aerospace, computer industry, catalysis, bio-medicine, mechanics, energy science, environmental science, nutraceuticals etc. Nanotechnology is now used to improve Molecular diagnostics, drug discovery and drug delivery. Nanoparticles are widely used in anti-ageing cream, cosmetics, sunscreen, deodorants and many more.

'Nanomedicine' term has been coined by National Institute of Health (USA), to explain the its potential applications in human health. Tiny particles build up new materials from atoms and molecules to achieve latest molecular assemblies of individual organelles, cells and smaller components that give a modified medicine (Jain, 2005).

Nanotechnology in health and medicine

Several diseases like cancer, Alzheimer's, diabetes, cardiovascular diseases, Parkinson's and different serious infectious or inflammatory diseases comprise a major health problem for the mankind. Nano-medicine is applicable in the field of health and medicine. Nanotechnology helps in repaired and reproduced damaged tissues. Nanotechnology has given major contribution in the field of stem cell research,.e.g. - Magnetic nanoparticles are used to isolate and group stem cells (Nikalje *et al.*, 2015). Polymeric micelle nanoparticles are used to deliver drugs to tumors. The Cerium oxides NPs are used to eliminate oxygen free radicals and acts as potent antioxidant which are primarily present in a patient's bloodstream subsequent a traumatic injury. Use of carbon NPs in medical applications are as called Nano-diamonds. Nano-diamonds attached with the protein molecules are used to boost up bone growth around dental or joint implants. Researchers have also invented Chemotherapy drugs attached to the nano-diamonds to treat brain tumors, and leukemia (Godwin *et al.*, 2015). Ovarian cancer is one of the most dangerous forms of cancer. At present ovarian cancer patients undertake surgery followed by chemotherapy but after the therapy cancer may revert in many cases. Modern treatment approaches in humans comprise direct injection into the peritoneal space, targeted drugs to the ovaries and close to tissue where tumors possibly spread.

Nanotechnology in the Environment

Photo catalytic copper tungsten oxide nanoparticles are widely used to rupture oil into compounds that are non-toxic and eco-friendly. The NPs offer a large surface area for the reaction compilation which is activated by sunlight and works in water to make them clean-up in oil spills. Gold NPs implanted in a permeable manganese oxide acts as a room temperature catalyst, are highly applicable to reduce volatile organic pollutants in air. Iron NPs are also used to remove arsenic contamination from water wells. Elimination of heavy metals from soil and water such as Cu, Pd, As, Ni, Cd, Zn, etc. has gained attention because of their unfavorable effects on human

Table 1 : Possible risks pose by nanomaterials.

Types of Nanoparticles	**Possible Risks**	**References**
Carbon NPs, silica NPs	Fibrosis, granulomas, pulmonary inflammation.	Chou *et al.* (2008)
MnO_2, TiO_2	Cross the brain during epithelium neurons.	Hussain *et al.* (2006)
Silver, gold and carbon, NPs	Circulate into the central Nervous system and other organs.	Oberdorster *et al.* (2005)
TiO_2 NPs, Quantum Dots	Skin Penetration	Sharma *et al.* (2007)
Al_2O_3, carbon black, Ni NPs	More Toxic than micron sized particles	Sharma *et al.* (2007)

Table 2 : Uptake of different types of elements in different types of aquatic plants.

Aquatic plants species	**Toxicant(s)**	**References**
Bacopa monnieri (L.)	Cu, Cd, Hg2+, Cr, Mg, Lead	Hussain *et al.* (2011)
Pistia Stratiotes	Cd, Ca, Co, Fe, Mg, Mn, Zn	Lu *et al.* (2011)
Salvinia natans	Cr, Fe, Ni, Cu, Pd, Cd	Olkhovych *et al.* (2016)
Azolla Pinnata	Co, Cd,	Baudo *et al.* (2015)
Spirodela polyrhiza	Cd, Cr, Co, Cu, Ni, Pd, Zn	Baudo *et al.* (2015)

Table 3 : Uptake of different types of elements in different types of plants.

Plants species	**Toxicant (s)**	**References**
Indian mustard (*Barassica juncea*)	Gold, Cu, Hg, Cr	Su *et al.* (2008)
Beard grass (*Polypogon monospeliensis*)	Hg,	Su *et al.* (2008)
Chinese Brake Fern (*Pteris Vittata*)	Hg, arsenic	Su *et al.* (2008)

health and environment (Khan *et al*., 2017). Increasing concentration of engineered nanoparticles in soil and groundwater show most significant exposure for environmental risks (Golobic *et al*., 2012). Most important applications of nanoparticles in environment are :

- Sensors for environmental stages (Tratnyek and Johnson).
- Remediation process for contaminated materials or harmful substances.
- Eco-Environmentally products (e.g. pollution avoidance or green chemistry)

Several applications of nanoparticles related to biology or Environment is given below :

1. Antimicrobial assay (Sharma *et al*., 2013).
2. Bio detection of pathogens (Mahtab *et al*., 2013).
3. Food agriculture (Singh *et al*., 2015).
4. Textile (Kaushik 2014).
5. Electronics (Komatsu *et al*., 2005).
6. Renewable Energy.

Applications of Nanoparticles in Targeted Drug delivery

Accurate drug targeting into the cells and tissue of choice is one of the key application areas of nanotechnology. "Magic bullet" delivery technology has been anticipated by Poul Ehrlichat. In this technology, the drug is specifically targeted to the appropriate site in the accurate place at exact time with enhance therapeutic efficacy as well as reduce toxicity. Nanoparticles easily deliver drugs to minute areas within the body because of their unique size and area and can be easily manipulated under different conditions.

Toxicity of Nanoparticles

Nanoparticles are widely used in modern research community because of having unique properties compared to their bulk counterparts. They are being used in many areas such as medical, textile, industrial, electronics, agriculture etc. They are often associated with toxicities. They enter the environment and deteriorate the quality of air, water and soil at some stage (Bahadar *et al*., 2016). Nanoparticles are more toxic to human health in comparison to large-sized particles of the same chemical nature due to their tiny size. It is usually suggested that toxicity of nanomaterials is inversely proportional to their size. Metal oxide (MO) nanomaterials are most recurrently applicable in opto-electronics, spintronic, electronics, and memory devices (Jason and Eray, 2005). Piezo-electric devices, Photovoltaic's and solar cell (Karak *et al*., 2013). Several metal oxides viz, zinc oxide, titanium oxide etc. are widely used in cosmetics and sunscreens (Senatova *et al*., 2015 and Wu *et al*., 2009). Unavoidable releases of Nanoparticles to the environment are due to increased use and production of nanomaterials. In general, mostly used NPs are non-bio-degradable therefore remain in the environment. As a result, this may affect on the pH, salinity, and bio content of soil and water. Therefore, plants, humans, aquatic life and animals are directly affected by release of nanoparticles into the environment.

Toxicity due to nanoparticles into the environment

Engineered NPs may be present in the form of dust, metals or several compounds. Nanoparticles synthesized in industry or research laboratory are most common routes of their release in the environment (Bhaduri *et al*., 2013). Environmental reservoirs are exposed to nanomaterials

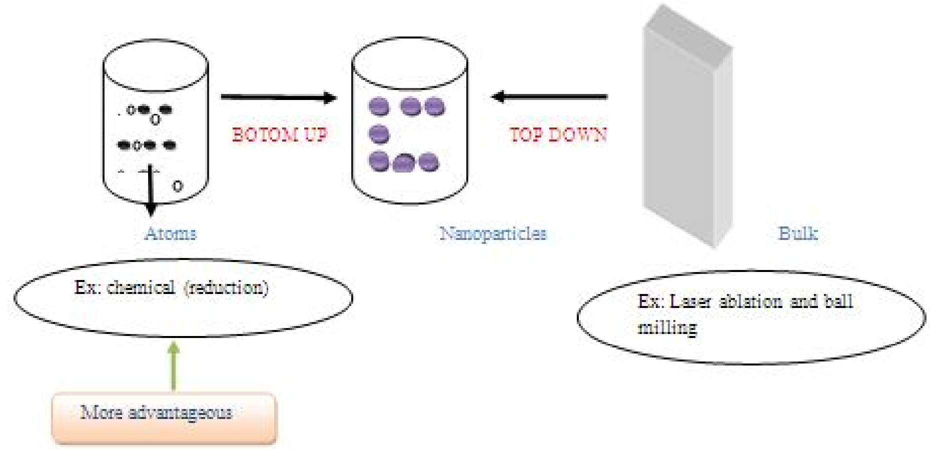


Fig. 4 : Schematic representation of the building up of Nanoparticles.

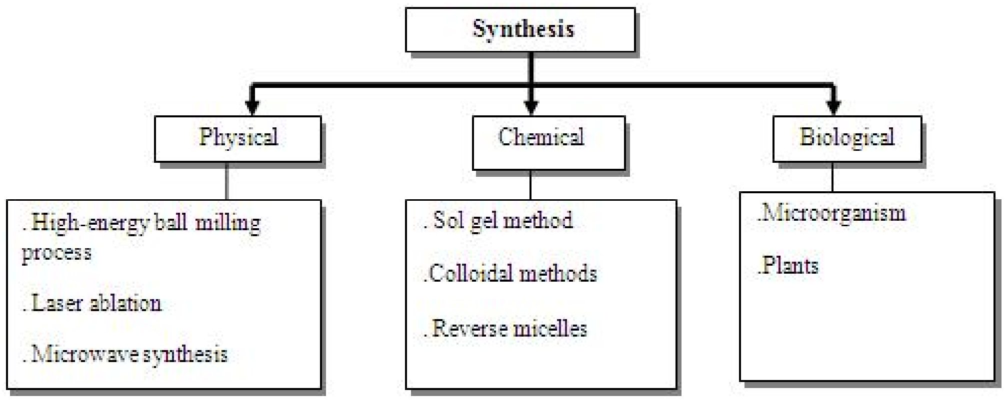


Fig. 5 : Flowchart representing Synthesis of Nanoparticles.

Table 4 : Biosorption of several algae to remove toxic elements from aqueous environment.

Toxic Elements	Algae used	Adsorption capacity	Permission level (mg/l)	References
Pb	*Gelidium amansii* (red algae)	100%	0.15	Naggar *et al.* (2018)
Pb	*Scenedesmus quadricauda* (green algae)	82%	0.15	Mirghaffari *et al.* (2015)
Cd(II)	*Chlorella Vulgaris* (green algae)	95.2%	0.06	Cheng *et al.* (2017)
Hg(II)	*Chlamydoonas reinhardtii* (green algae)	89.5%	0.01(Vapor)	Bayramoglu *et al.* (2006)
Cr(VI)	*Spirogyra* sp. (green algae)	14.7×103 mg metal/kg	0.05	Gupta *et al.* (2001)
Ni	*Sargassum glaucescens* (Brown macroalgae)	93%	0.1	Esmaeili *et al.* (2015)
Ar	*Sargassum wightii* (Brown algae)	90.2%	0.020	Chistobel *et al.* (2015) and Abdel *et al.* (2017)

on a regular basis. Most popular nanoparticles are metal oxide nanoparticles, which are used in various types of sunscreens, cosmetics, facial masking and glass coatings (Piccinno *et al*., 2012). They are directly exposed to the environment after utilization. ZnO_2 and TiO_2 having anti-bacterial activities are very commonly used (Tankhiwale *et al*., 2012; Awwad *et al*., 2014 and Varghese *et al*., 2015). After coming in direct contact with the beneficial microorganisms of water and soil they affect them directly. It has been reported that lots of NPs remain in sewage sledges.

Toxicity due to nanoparticles in human

The excessive use of nanoparticles-based products causes harmful affect when exposed to the environment. Nanoparticles show special chemical and physical properties because of their large surface area, & smaller size (Xiao *et al*., 2008). They enter these biological structures, and disturb their normal function causing diseases such as lung cancer, asthma, Parkinson's, Alzheimer's, colon cancer, bronchitis and many more.

Fig. 6 : Complete chart of Nanoparticles.

Nanoparticles also penetrate the circulatory system which affects blood clots, cardiac diseases, and arrhythmia. In future, for favorable effects of nanoparticles on human health should need to take more precautions for making manipulated engineered nanomaterials and need to improve lows and policies for safety management with respect of nonmaterial manufacturing, commercial, industrial used and recycling waste products (table 1).

Presence of nanoparticles in waste water

Accumulation of nanoparticles in the waste water which shows danger effects to the bacteria which are found in the waste water. The nanoparticles associated with the microorganisms it generates a potential gradient based layer of a nanoparticles inside and outside of the microbial cells. Therefore, a cost valuable solution to eliminate nanoparticles from the waste water phytoremediation process could be used.

Accumulation of metallic nanoparticles in the plants

Accumulation of toxic nanoparticles such as: cadmium, arsenic, manganese, copper, by the plant system through phytoremediation process. Phytoremediation is a natural technology in which uses of the living plants to elimination of hazardous substances from air, water and soil.

These approaches are more advantageous for the specific, selective and unique uptake capability of plant root systems. It is recent technology considered as a green substitute explanation with great potential for metal pollution (Weis *et al*., 2004). Some plants and aquatic plants are known for rapidly absorb water with different pollutants (tables 2 & 3). Therefore, they are commonly used in phytoremediation (Murithi *et al*., 2012 and Olkhovych *et al*., 2016).

Uptake and accumulation of Toxic elements from waste water by Algae

Toxic elements can be accumulating from waste water through Biosorption from algae. Natural sources are more economical, safer and more efficient for removing hazardous pollutants and other toxic metal ions from aqueous environments (table 4). Algae have various advantages such as:

- Naturally recyclable, renewable and easily available all year around.
- Superb preservation capacity.
- Minimum expenditure of harsh chemicals.
- Minimal preparatory steps require.
- Diverse multifunctional groups on their surface.
- Comparatively small and uniform distribution of binding sites on the surface (Bilal *et al*., 2018).

Conclusion

In this review paper, we provided a detail overview about nanoparticles, their branches, classifications, synthesis methods, characterization methods and their possible applications in different areas of science *viz*., agricultural, medical, drug delivery, waste water treatment, cosmetology etc. Nanotechnology provides several ways to deliberately make and engineer materials at the nanoscale. With the help of this technology, many diseases can be cured. But at the same time, the excessive use of nanoparticles showing the harmful effects on human and environment. Several hazardous substances releases to the environment by the workers engaged in nanotechnology activities which leading to the imbalance or destruction in ecosystem they possess toxic impacts on human and environment. Aquatic plants and some algae have the potential to uptake the nanomaterials and can be explored for the removal of harmful nanomaterials from environment.

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