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# ADVANCES OF NANOMATERIALS FOR ENVIRONMENTAL POLLUTANTS

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**ABSTRACT-**

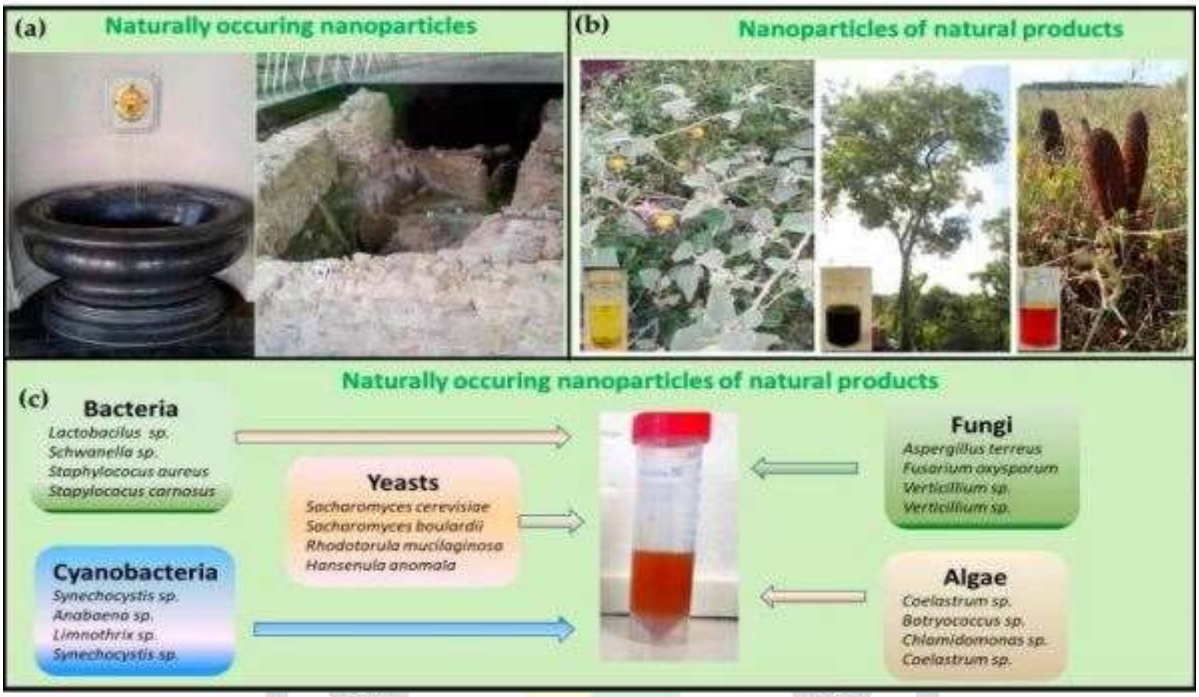
Environmental pollution has emerged as one of the most pressing challenges over the past several decades as a result of the contemporary industrialized sector's rapid rise. The problem of pollution is being addressed using a variety of contemporary methods and tools. The use of nanomaterials and nanotechnology in reducing environmental pollution as well as the concept of nanomaterials in resource recycling will be covered in this essay. There will be a variety of contaminants, their effects on the environment and human health, and how nanotechnology is being used to clean up soil, water, and air pollution. Physical and chemical characteristics of nanomaterials, as well as their sources, are further topics of study and we'll look at the negative effects of nanomaterials on the environment in addition to all the favourableones.Additionally, we look at the harm that nanoparticles do to the environment. A brief review on the use of nanomaterials as air pollution absorbers and water filters This essay has harmed the environment.Nanomaterials are widely used in many industries, including medical, electronics, sunscreens, and paints. Some of these have little or no impact on the environment, while others do.

**Keywords:** Nanoparticles (NPs), Nanomaterials, Environmental Pollution, Nanotechnology

**INTRODUCTION**

The words nanotechnology and nanoparticles have become popular because of their numerous usages in the field of science and technology. According to a market analysis report,**[1]** The global nanomaterials market size was valued at USD 9.39 billion in 2021 and is expected to register at a CAGR of 14.9% during the forecast period. The market is expected to be driven by increasing demand for the product in electronic applications owing to its increased surface area at the time of application coupled with its high super paramagnetic properties[1].the application of nanomaterials is also seen in the field of medicine in many in-vitro and in-vivo processes. Significantly, nanomaterial and nanotechnology offer a huge benefit through contaminant trace and handling to narrow environmental pollution. There is no as such published definition of nanomaterial but,**[2]** In ISO/TS 80004, Nanomaterials can be defined as materials possessing, at minimum, one external dimension measuring 1-100nm. On 18 October 2011, the European Commission adopted the following definition of a nanomaterial: "A natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm – 100 nm. In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50% may be replaced by a threshold between 1% to 50%." **[2]** The naturally occurring nanoparticles includes iron oxides/sulphides, silver, gold. Synthetic nanoparticles include carbon nanomaterials such as CNT and CNF. Metal based nanomaterial and dendrimers are also some synthetically produced nanoparticles.

NANOMATERIAL SOURCES [3] Products containing nanoparticles such as cosmetics, coatings, paints, and catalytic additives can release nanoparticles into the environment in different ways. There are three main ways that nanoparticles enter the environment. The first is emission during the production of raw materials such as mining and refining operations. The second is emission during use, like cosmetics or sunblock getting washed into the environment. The third is emission after disposal of nanoparticle products or use during waste treatment, like nanoparticles in sewage and wastewater streams [3].Sometimes nanoparticles are prepared accidentally while doing research as a by-product through combustion and vaporisation. Sources include exhaust engines, welding fumes, combustion processes from domestic solid fuel heating and cooking. For instance, the class of nanomaterials called fullerenes are generated by burning gas, biomass, and candle. [2] Natural sources of nanoparticles include combustion products forest fires, volcanic ash, ocean spray, and the radioactive decay of radon gas. Natural nanomaterials can also be formed through weathering processes of metal- or anion-containing rocks, as well as at acid mine and drainage sites [2].




PROPERTIES OF NANOMATERIALS The properties of nanomaterials include physical and chemical properties. Nanomaterials exhibit many unique properties one of the most important one is its small size. Nanomaterials are believed to be ten thousand times smaller than the width of a human hair. Nanomaterials' distinct properties are attributed to quantum effects, larger surface area, and self-assembly.

**Physical Properties**

Nanomaterials may occur in the form of Nanopowder, aerosols, emulsions, collide etc. [5] Nanoparticles consist of three layers: the surface layer, the shell layer, and the core. The surface layer usually consists of a variety of molecules such as metal ion, surfactants, and polymers. Nanoparticles may contain a single material or maybe consist of a Combination of several materials. Nanoparticles can exist as suspensions, colloids, or dispersed aerosols depending on their chemical and electromagnetic properties. The properties of nanoparticles are dependent their size. For instance, copper nanoparticles than are smaller than 50 nm are super hard materials and do not exhibit the properties of malleability or ductility of bulk copper. Other changes that are dependent on the size of nanoparticles are superparamagnetism exhibited by magnetic materials, quantum confinement by semiconductor Q-particles, and surface Plasmon resonance in some metal particles.[5]

**Chemical Properties**

Chemical properties can be determined based on the structure of the nanomaterial, it's boiling point, it's melting point, nature of stability, solubility etc. nanoparticles usually exhibit a significant decrease in melting temperature compared to their analogous bulk materials. . [6]The main reason for this phenomenon is that the liquid/vapour interface energy is generally lower than the average solid/vapour interface energy. When the particle size decreases, its surface-to-volume ratio increases, and the melting temperature decreases as a result of the improved free energy at the particle surface Metallic and semiconductor NPs possess interesting linear absorption, photoluminescence emission, and nonlinear optical properties due to the quantum confinement and localized surface Plasmon resonance (LSPR) effect. LSPR phenomena arise when the incident photon frequency is constant with the collective excitation of the conductive electrons .Due to this phenomenon; noble metal nanoparticles exhibit a strong size-dependent UV–visible extinction band that is not present in the spectra of bulk metals. Generally, the optical properties of nanoparticles depend on the size, shape, and the dielectric environment of nanoparticles [6].

NANOTECHNOLOGY IN AIR POLLUTION TREATMENT

Air contaminants have constantly been paid exceptional attention due to the fact that these contaminants are harmful and cause higher risk to life. As per the World Health Organization (WHO), air contamination kills about seven million people around the world every year. The WHO data indicates that almost nine out of ten people breathe air consisting of increased levels of contaminants. Therefore, it is essential to attain adequate information on the air contaminant sources and establish innovative technologies for the remediation of air. Nanotechnology helps develop better techniques for pollution control on a molecular level that can separate specific elements and molecules from a mixture of atoms and molecules. There are two major ways in which nanotechnology is being used to reduce air pollution: catalysts, which are currently in use and constantly being improved upon; and nano-structured membranes, which are under development. Nanoabsorbents:[7] Polymeric nanoadsorbents are repetitively branched molecules like dendrimers and are useful in removing heavy metal as well as organic pollutants. They are composed of tailor-made external branches which adsorb heavy metals and inner hydrophobic shells that can absorb the organic compounds.

[8]List of some nanomaterials with their pollution abatement capacity.

| **Nanomaterials** | **Adsorbate** | **Abatement capacity (mg•g−1)** |
|---|---|---|
| DESs-CNTs | Hg (II) | 186.97 |
| GO | Zn (II) | 246 |
| $NH_2$–SNHS | Pb (II), Cd (II) and Ni (II) | 96.79, 40.73 and 31.29 |
| Au | Hg (0) | 4065 |
| Nano-haematite | Cr (VI) | 6.33–200 |
| magnetite nanoparticle | Pb (II) and Cu (II) | 68.9 and 34.0 |
| magnetite nanoparticles | Pb (II), Cu (II), Zn (II), Mn (II) | 37.3, 10.8, 10.5 and 7.69 |

| | | |
|---|---|---|
| amino functionalized $Fe_3O_4$ NPs | Cr (VI) and Ni (II) | 232.51 and 222.12 |
| ZnO nanoparticles | Zn (II), Cd (II) and Hg (II) | 357, 387 and 714 |
| $TiO_2$ nanoparticles | Cd (II), Cu (II), Ni (II) and Pb (II) | 120.1, 50.2, 39.3 and 21.7 |
| $Al_2O_3$ nanoparticles | Cd (II), Cu (II), Ni (II) and Pb (II) | 118.9, 47.9, 35.9 and 41.2 |
| MgO nanoparticles | Cd (II), Cu (II), Ni (II) and Pb (II) | 135, 149.1, 149.9 and 148.6 |

**Metal Based Nanomaterials [**9]

Metals such as Ag and Au are considered excellent materials because they have high Plasmon resonance. The M-NPs have a higher surface area and thus brought higher activity to the surface plasmons. Therefore, this property of the Plasmon resonance phenomenon is being used for employing it as a sensor for identifying the diverse molecules present in the environment. Moreover, advancement in nanotechnology helps in the transport of Nanometallic compounds effectively in food products and ensures their quality via inhibiting the growth of food spoilage agents

**NANOTECHNOLOGY IN WATER POLLUTION TREATMENT**

Nanotechnology has a significant importance in wastewater treatment. Nanofilteration process is used wastewater management. Nano filtration is a pressure-driven membrane process with separation efficiency between reverse osmosis and ultrafiltration. NF is generally carried out by using asymmetric polymeric membranes consisting of a functionally active porous top layer with a low resistance support layer.in nanofiltration ultrafiltration occurs by reverse osmosis.[10] It is used to separate components of size close to the nanometre order. This type of membrane does not retain non-ionized organic compounds with a molar mass of less than 200 g/mol and monovalent salts. On the other hand, nonionized organic compounds with a molar mass greater than 250 g/mol and multivalent ionized salts (calcium, magnesium, aluminium, sulfates, etc.) are retained .here are some processes for waste water treatment

1. Disinfection: [11] Contamination from bacteria, protozoans, and viruses is possible in both ground and surface water. The toxicity of the standard chlorine chemical disinfection in addition to the carcinogenic and very harmful by-products formation is already mentioned. Chlorine dioxide is expensive and results in the production of hazardous substances like chlorite and chlorate in manufacturing process. [11] There are many different types of nanomaterials such as Ag, titanium, and zinc capable of disinfecting waterborne disease-causing microbes. Due to their charge capacity, they possess antibacterial properties. TiO2 photocatalysts and metallic and metal-oxide nanoparticles are among the most promising nanomaterials with antimicrobial properties. The efficacy of metal ions in water disinfection has been highlighted by many researchers [12]. This part of the paper covers the application of these antimicrobial nanomaterials for water disinfection

2. Nanosorbent Materials: Adsorption represents one of the most important water treatment methodologies for removing organic and inorganic water pollutants, due to its easy operation and design, usually low cost and the wide range of contaminants that can remove. During the adsorption process, the solutes present in the gas or the liquid sample are attached and accumulated in the absorbent, which is commonly a solid surface. Otherwise, nanosorbents are Nano scale structures characterized by a large reactive surface area, high porosity, catalytic potential, and high affinity. Carbon-based nanomaterials (CBNs) are composed entirely or mainly by carbon atoms and they are characterized by their useful properties for water treatment and desalination, including mechanical strength, electron affinity, and flexibility during functionalization. Even, CBNs can be integrated into membranes or other structural media for

enhancing its properties to remove aqueous pollutants. The most common CBNs include carbon nanotubes (single-walled and multi-walled), carbon nanofibers, graphene, fullerene, carbon-based composites, and derivatives. Highlighting that the most used kind of absorbent for water treatment are granular activated carbon and powdered activated carbon as a result of their broad-spectrum removal capability, low cost, high absorption properties, and easy disposal. However, they present slow adsorption kinetics and difficulty for regeneration. For overcoming those disadvantages, carbon nanotubes were developed as a new generation of carbonaceous adsorbents, and even, they demonstrated higher adsorption capability and efficiency.

## NEGATIVE IMPACT OF NANOTECHNOLOGY ON ENVIRONMENT

Everything which as a significant role in nature has some negative impact too. Similarly, nanotechnology along with providing waste water treatment and air pollution control also cause nanomaterial toxicity. Some metal based nanoparticles are harmful to environment and humans too. [11] There have been many previous cases of wastewater treatment methodologies which have resulted in unwanted after effects. Chlorination is one of the conventional wastewater treatment methods which had been anticipated to contribute in enhanced life expectancy across the world, but was later noticed to generate carcinogenic by-products like N-nitrosodimethylamine and trihalomethanes. This could also be related to the utilization of nanotechnology in wastewater treatment. The properties which are responsible for the usefulness of nanomaterials are the ones which also make them liable for the resulting toxicity. Toxicity depends on the molecular structure of components dictating the toxicity end point and size, which regulates cellular uptake. Due to its small size, Nanoparticles penetrate through epithelial and endothelial barriers into the lymph and blood to various organs and tissues, including the brain, heart, liver, kidneys, spleen, bone marrow and nervous system. Size- and shape-dependent toxicity is reported for Ag NPs, CNTs and many other metal NPs. The size of nanoparticles (from 1 to 100 nm) are akin to the size of protein globules (2–10 nm), DNA helix (2 nm) and thicknesses of cell membranes (10 nm), allowing easy entry to cells and cell organelles[11]

## CONCLUSION

To sum up the review the application of nanotechnology has been seen largely in the area of environmental pollution. Seeing the massive application of nanoparticles it seems that this technology will be having its roots in one of the largest influential industries in the coming future. Even though there is a significant advance in the investigation of nanomaterials and knowledge of their capability to remove compounds utterly, there is still the challenge of recycling these nanomaterials. Furthermore, in many cases, exists the problem of the stability of the nanoparticles, which tend to agglomerate with time.

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