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# APPLICATIONS OF NANOMATERIALS IN ENVIRONMENTAL PROTECTION

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**ABSTRACT**

Innovating new approaches, instruments, and strategies to address particular quantitative and qualitative environmental issues is a major task for science and technology. Nanotechnology is highly effective at removing and detecting pollutants in the fields of air, water, and wastewater. Some of the techniques created utilizing nanotechnology to treat water and wastewater, air, and detect pollutants include nano-adsorbents, nano-filtration, nano-photocatalysts, magnetic nanoparticles, and nanosensors. This paper discusses how nanotechnology can be used in environmental applications such as the remediation of polluted water and air, the development of self-cleaning materials, energy-related uses, the development of novel functionalized adsorbents for industrial and environmental applications, and the development of nonmaterials for the production of sustainable energy. By supplying their position in monitoring, pollution prevention, and cleanup approaches, nanotechnology can significantly improve. Through a thorough literature review, this paper seeks to identify the well-researched benefits that this new technology can provide for the environment. The study's findings indicate that nanotechnology has a wide range of possible environmental advantages when applied correctly. An example of non-material application of nanotechnology in the environmental field is the restoration of soil and ground water using nanoparticles. Applications of nanotechnology to the environment focus on developing remedies for current environmental issues as well as safeguards against future issues brought on by the interactions of materials and energy with the environment.

**Keywords**; Nanotechnology, environmental applications, remediation of polluted water and air,

## 1. INTRODUCTION

The impact of nanotechnology on the environment and air pollution, both direct and indirect, can be evaluated from a variety of angles [1]. Due to the transdisciplinary nature of nanotechnology, numerous traditional fields of research must pay direct attention to it. Nanotechnology, despite its catchy moniker, is actually incredibly useful for underdeveloped nations. Greek words for "nano," which mean "dwarf," allude to dimensions of the magnitude 10-9. Nanotechnology is defined in a wide variety of ways [2]. The majority of them are technical and usually have to do with making structures that are smaller than 100 nm, or 100 times a millionth of a millimeter.The design, synthesis, characterisation, and usage of materials and technologies on the nanoscale are the main goals of the applied scientific discipline of nanotechnology. This field of research encompasses the investigation of nanoscale phenomena and the tinkering with of materials, and it is a subclassification of technology in colloidal science, biology, physics, chemistry, and other scientific fields.

Physics, chemistry, biology, engineering, and other fields of study are all used in nanotechnology. Examples of how nanotechnology is used to create systems and have important applications in environmental challenges include the creation of nanomaterials, nanotubes, nano composites, nanofillers, and nanoparticles [3]. Polymer composites enhanced with nanoparticles are being developed by a number of chemical companies [4]. The creation of nanocomposites through the use of nanotechnology has produced extremely resilient and light-weight raw materials that can replace heavy metal components, significantly reduce the weight of machinery and automobile parts, and ultimately reduce energy consumption and air pollution [5]. The use of semiconductor manufacturing technologies has also had the positive side effects of reducing the release of 2 million tons of carbon compounds and saving billions of dollars in energy. Lighting uses nanotechnology, which will help to minimize air pollution [6]. The direct conversion of biological energy to electrical energy is possible with biofuel cells that are manufactured using nanotechnology [7]. The purpose of this study was to examine how nanotechnology affects the environment, particularly through examining contaminants and nanotechnology-based remediation techniques. For the sake of both environmental preservation and human health, it is crucial to be able to identify pathogens and harmful substances in soil, water, and air. Nanotechnology holds the promise of incredibly quick and sensitive systems.

## 2. METHODOLOGY

A survey of the available literature was conducted to identify papers that specifically addressed the advantages of adopting nanotechnology now or in the future in the environmental sciences. The World Wide Web's scientific databases were looked up. This essay discusses the use of nanomaterials in the environment. The primary sort of nanomaterial, contaminants that can be addressed using nanomaterial, is described. (shows in fig. 1.)

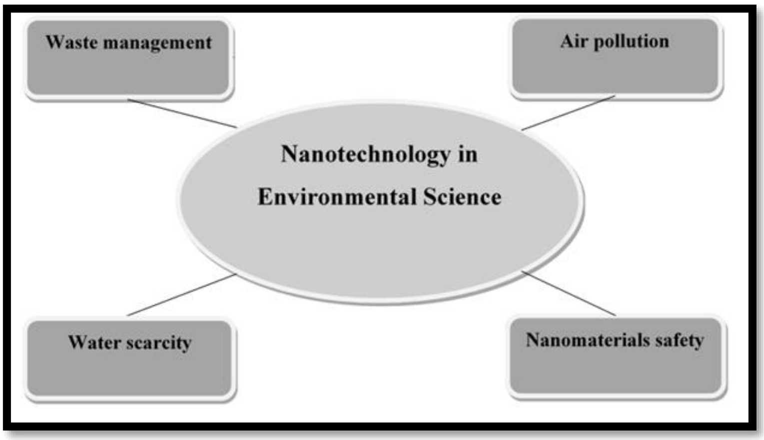

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**Fig. 1. Application of Nanotechnolgy in Enviromental Science**

## 2.1 AIR POLLUTION

Air pollution is the result of any particle, biological molecule, or dangerous solid, liquid, or gas entering the atmosphere and posing a threat to the environment, harming or ill treating living things, or having an impact on the ecosystem of a place. There are two main and secondary categories for this kind of pollution, which might come from either human or natural resources. Continuous monitoring of air pollution is one of the most crucial and fundamental requirements in regard to reducing environmental contamination [8]. Effective advancements have been made in the control of air pollution thanks to the use of nanosensors (demonstratein fig 2.) [9]. The development of such sensors drew nearer to the point of scientific use with the creation of the first samples of smart dust [10]. The primary goal of creating smart dust is to create a collection of sophisticated sensors in the form of tiny nanocomputers [11]. These nanosensors can effortlessly float in the air for several hours [12]. These small silicon particles have their own wireless capability and can transmit the data gathered to a central base. The prototypes have a data transfer rate of around one kilobyte per second [13].

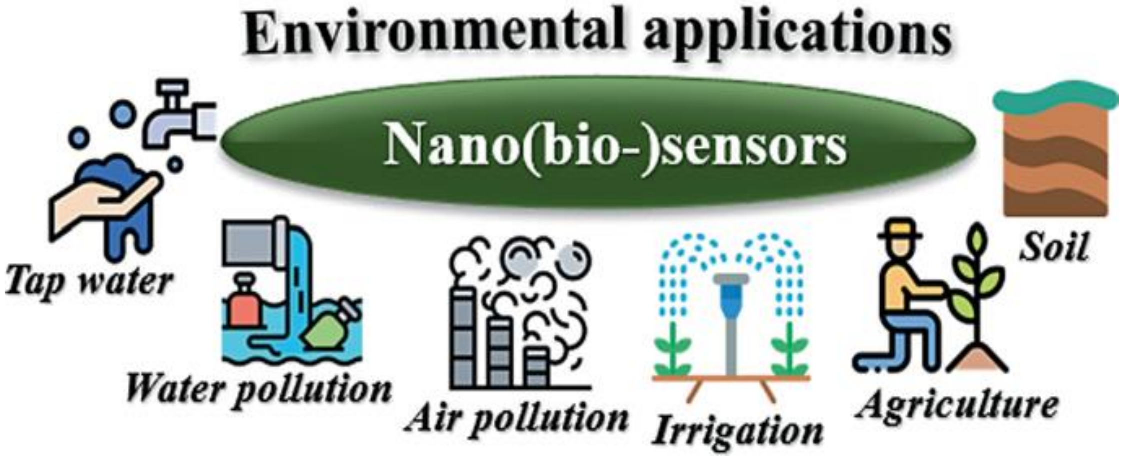


**Fig. 2. Nanobiosensor Application in Enviroment**

## 2.2 ADSORPTION OF TOXIC GASES

Nanotechnology enables the eradication of environmentally harmful gases. Using CNTs that have been treated with gold or platinum nanoparticles as an example [14]. The graphene layer surrounding the tube axis is where the carbon atoms in CNTs are arranged in a hexagonal pattern. CNTs are one-dimensional nanotubes of special molecules with outstanding chemical characteristics, thermal stability, and both single- and multi-walled nanotubes [15]. The atmosphere in industrial locations contains a variety of harmful chemicals, including benzene dioxin, toluene, ethyl benzene, and -xylene [16]. The two benzene dioxin rings and the nanotube's surface have a close relationship. A porous wall 2.9 nm in diameter connects the dioxin molecule to the entire surface of the nanotube, and overlap occurs. This increases the adsorption potential inside the pore. A. Aghababai Beni and H. Jabbari Results in Engineering 15 (2022) 100467 3. Furthermore, CNTs' excellent resistance to oxidation makes them useful for regenerating adsorbent at high temperatures [17].

## 2.3 ADSORPTION OF NOX AND $CO_2$

Pollutants such as carbon monoxide (CO), unburned hydrocarbons (HC), and nitrogen oxides (NOx) are produced during complete combustion of the fuel-air mixture [18]; The majority of unburned hydrocarbons in gas engines comprise methane since methane makes up a large portion of natural gas [19]. Because methane has a lower carbon to hydrogen (C/H) ratio than any other hydrocarbon, less carbon dioxide and carbon monoxide are released when methane is burned [20]. The absorption and storage of CO2 produced by fossil fuel power plants has attracted a lot of attention recently. Adsorption, cryogenic adsorption, membranes, and other techniques are used among the many CO2 recycling technologies. Adsorption-desorption processes are thought to be the most advanced of these technologies. The adsorption of amines or ammonia is the basis for this procedure. The adsorption process in these technologies, however, consumes a lot of energy. In order to reduce greenhouse gas emissions, scientists are creating membranes based on CNT, nano-silica, and zeolite [21]. These membranes can collect CO2 from factory chimneys on a massive scale.

## 2.4 WATER AND WASTEWATER TREATMENT

Ceramic and polymer membranes are being created using nanotechnology for the purification of water [22]. In addition to organic-inorganic hybrid nanocomposite membranes and biomimetic membranes, these nanoscale membranes also comprise ceramic membranes coated with nanoscale catalytic and zeolite particles. Membranes made of carbon nanotubes, block copolymers with a similar porosity, and biopolymer membranes incorporating protein molecules are all examples of bio-mimic membranes. Based on the water permeability, pollutant molecular selectivity, and mechanical strength of these membranes, performance is enhanced. Biomimetic membranes are often not very commercialized. despite outstanding performance, potential. While nanocomposite mem branes are already mass-produced and have a great efficiency in the purification of water. There is very little utility for zeolite and catalytic membranes in water treatment, save from slight to moderate enhancements in the efficiency of traditional membranes.

## 2.5 NANOFILTERS

Another important application of nanotechnology in the environment is the use of nanofilters in the handling of sewage and water. The membrane employed in the nanofiltration technique often repels big molecules and can cleanse well water or surface water with less energy than previous methods. Numerous bacteria, viruses, pesticides, organic contaminants, and calcium and magnesium salts can all be eliminated from the water using this procedure [23]. Another finding from research is that using nanotechnology to clean water can significantly lower treatment costs [24]. In the industrial sector, alcohols like ethanol are frequently employed as detergents or solvents. While being consumed, these chemicals absorb a lot of different contaminants. It is necessary to treat them for reuse because throwing them away after usage harms the environment. Conventional techniques, such distillation, pollute the environment and waste a lot of energy [25].

## 2.6 ENVIRONMENTAL CATALYSTS

The term "environmental catalysis" refers to the creation of catalysts to either break down environmentally undesirable molecules or offer alternate catalytic syntheses of significant substances without the production of undesirable environmental byproducts. One of the most significant water contaminants is halogenated organic compounds (HOCs). In numerous industries, including the pharmaceutical industry, these chemical compounds are useful as solvents and additives. These substances are poisonous and hazardous, and they can result in conditions like cancer. The full decomposition of these chemicals in water and wastewater is therefore necessary [26]. Three types of air contaminants in particular include carbon monoxide, hydrocarbons, and nitrogen monoxide. Catalytic converters can lower these pollutants' emissions. A specific stoichiometry must be maintained for current catalytic converters, which use pricey metal catalysts. There is hence a tremendous motivation to create low-cost, high-efficiency catalysts [27],

## 3. CONCLUSION

Nanotechnology has drawn a lot of interest in the present and the future. Researchers, governments, and artists all have high hopes for this technology's ability to solve today's challenges. Energy supply and environmental protection are two of the biggest issues facing the globe today. Both the availability of fossil fuels and the environmental damage they have caused are issues. Using nanotechnology is one of the most promising solutions to regulate and mitigate pollution as well as offer clean, sustainable energy. Reduced pollutant sources are referred to as pollution prevention.

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