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A Review on- A future Prospectus of Nanotechnology and Its Useful in Water Purification

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ABSTRACT

Providing clean and affordable drinking water is one of the modern-times challenges. The world's growing population causes water scarcity, and pollutants contaminate whatever water sources are left. Nanotechnology has provided innovative solutions for water purification. This chapter reviews nanotechnology-enabled water-treatment processes, showing how they transform our water supply and wastewater treatment.

Keywords: Nanotechnology, Pollutants, Nanomaterials, Population

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INTRODUCTION

The worldwide population is growing at an exponential rate of 83 million people each year, and is expected to reach 7.9 billion by 2020. The challenge of a rapidly growing population combined with an unpredictable climate has further pushed researchers towards developing innovative technologies that can ensure human beings and animals have access to safe drinking water. In an effort to ensure that the human population is not deprived of clean water, various nanotechnology methods have been developed to remove potentially toxic contaminants from drinking water supplies.

CONTAMINANTS IN WATER

The United States Environmental Protection Agency (EPA) broadly defines a water contaminant as anything that is not a water molecule. These contaminants can be organic and/or inorganic chemicals, or biological, radiological or physical substances that can potentially cause adverse effects upon consumption.

The following table provides some examples of these types of contaminants that can be present in any water supply:

Table 1: Description and examples of commonly found water contaminants

Class of Contaminant	Description	Examples
Physical	Affects the physical appearance or related properties of water	Sediment Organic material Soil erosion products
Chemical	Can be natural or man-made	Nitrogen Bleach Salts Pesticides Metals Toxins produced by bacteria, human or animal drugs
Biological	Organisms in water Also known as 'microbes' or 'microbiological' contaminants Responsible for several waterborne diseases (e.g., cholera)	Bacteria Viruses Protozoa Parasites
Radiological	Chemical elements with an unbalanced number of neutrons and protons Resulting atoms can emit ionizing radiation	Cesium Plutonium Uranium [1]
Heavy Metals	Released into the environment through natural and industrial processes	Arsenic Cadmium Chromium Lead Zinc Nickel Copper [2]

LIMITATIONS OF CONVENTIONAL WATER PURIFICATION METHODS

Some of the most commonly used water purification methods include screening, filtration, sedimentation, gravity separation, reverse osmosis, ion exchange, neutralization, remineralization, micro- and ultrafiltration and several others [3]. Despite the usefulness of these techniques, they are often costly methods that require high amounts of energy and water to complete and/or the use of excess reagents.

THE ADVANTAGE OF NANOTECHNOLOGY FOR WATER FILTRATION

Nanotechnology-derived water filtration processes are much more efficient as compared to traditional techniques, as these solutions can be fabricated with features that can enhance the adsorption of materials from water. For example, properties such as reactivity and pore volume, as well as both hydrophilic and hydrophobic interactions, can be manipulated at nanolevel in water treatment solutions to exhibit high performance at an affordable cost.

Table 2 provides an overview of the types of nanomaterials that have already been successful in water treatment systems.

Table 2: Nanomaterials used for water filtration and their applications

Nanomaterial	Pros	Cons	Contaminants Removed
Nanoadsorbents	High specific surface High adsorption rate	High production costs	Heavy metals Organic materials Bacteria
Nanometals and Nanometal Oxides (e.g., nanosilver, nano titaniumdioxide (TiO_2), magnetic nanoparticles, etc)	Abrasion-resistant Supramagnetic – facilitates separation Short intraparticle diffusion distance compressible Photocatalytic Low cost	Not as reusable as compared to other nanomaterials	Heavy metals Radionuclides Media filters Powders Pellets
Membranes and Membrane Processes (e.g., nanofiltration, nanocomposite, self-assembling, aquaporin-based and nanofiber membranes)	Provide a physical barrier for substances depending on their pore and molecule size Reliable Automated	Requires a high amount of energy	Can be incorporated into any type of water and / or wastewater treatment systems[4]

LIMITATIONS

Nanotechnology is a highly effective alternative method to removing a wide range of contaminants from any type of water supply. Despite their high specificity in eliminating certain contaminants, nanomaterials exhibit certain limitations, especially when considering the potential uptake of these materials into wildlife. For example TiO_2 and silver nanoparticles, some of the most commonly used nanoparticle species, can have particularly harmful effects on aquatic organisms including bacteria, algae, invertebrates, fish and plants [4]. To combat the potential adverse effects associated with the use of certain nano-water filtration systems, it is imperative that both national and international efforts are made to develop highly efficient systems capable of monitoring the levels of nano engineered materials within our water supplies.

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