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Mini Review

Use of Nanoparticles in Water Treatment: A review

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Abstract

A major role of water is for vitality for life on earth. Water is recognized as source of evolution from origin to degree of civilization .Since it is an essential resource its treatment becomes a necessity for day to day life .Several methods have been used for treatment of water so far some of which are very successful. In recent past development of silver and gold nanoparticles and their application in treatment of waste water is becoming a major area of research. It is mainly applicable to the removal of three major contaminants like pesticides, heavy metals and microorganisms. This article presents a is a mini review based on the application of nanoparticles for water and waste water treatment.

Keywords: Water treatment, silver nanoparticles, gold nanoparticles.

Introduction

Water is the largest part of essential substances for all existence on earth and a source of evolution of human civilization. Water is known as universal solvent and it easily dissolves other susbtances. During rain showers, surface water and flowing water various substances gases micro organisms are added into water which make it contaminated. The world running in 21[st] century is facing a major problem and a challenge as water contamination. Contaminated water contains unwanted substances and it adversely affects the quality and makes it unsuitable for use. Water resources become contaminated from various sources such as residential areas, commercial, industrial practices, agricultural practices etc. Parameters of wastewater vary widely and depend upon the source from which it is generated. Commonly they are pathogenic and non-pathogenic microorganisms, organic or inorganic. If waste water is disposed untreated these constituents create a great threat to living beings and the environment. A variety of physical, chemical and biological treatment processes are used for wastewater treatment. Nanotechnology has a great potential in enhancing water and wastewater treatment as it offers potential advantages like low cost, reuse and highly efficient in removing and recovering the pollutants.

Recently application of nanotechnology is increasing in water and wastewater treatment. Nanomaterials are typically defined as materials smaller than 100 nm in at least one dimension[1]. At nano scale, materials possess some new size-dependent properties such as large surface to volume ratio, reactivity, rapid dissolution and adsorption which are different from the bulk material. These properties are used for treatment of water efficiently[2-4] environment and sanitation[5-6]. A promising application of nanotechnology is in water purification[7-9]. Various applications of different nanomaterials can be stated in various stages.

Methodology

Adsorption: Use of nanomaterials in treatment of waste water is applicable in various forms like catalytic, absorptive, catalytic membrane, bioactive nanoparticles, biomemetic membrane, polymeric and nanocomposite membrane, thin film composite etc. Various organic chemicals[10] are absorbed more efficiently by using carbon nano tubes (CNT) than activated carbon .Organic compounds which have carboxylic, hydroxyl, amide functional groups also form hydrogen bond with the graphitic CNT surface which donates electrons[11].CNT have high adsorption competence for metal ions[12-14] and therefore are a good alternative for activated carbon.

Nanoscale metal oxides like iron oxides like ferrous oxide, TiO_2, Al_2O_3 are effective ,low cost adsorbants for heavy metals And radio nucleides[15-17]. Dendrimers [polymeric nanomaterials] are capable of removing both organics and heavy metals[18]. Nanoadsorbents are used as powder, beads or porous granules loaded with nanoadsorbants.

Nanomembranes: Membranes with nanofibres can remove micro-size particles from aqueous phase with a high elimination rate without considerable fouling[19]. Such membranes are used as pretreatment method used proceeding to ultrafiltration or reverse osmosis. Large number of studies on membrane nanotechnology has focused on creating multifunction membrane by adding nanomaterials into polymeric or inorganic membranes known as nanocomposite membranes. The addition of metal oxide nanoparticles including alumina[20], silica[21], zeolite[22] and TiO_2[23] to polymeric ultra filtration membranes has been shown to amplified membrane surface hydrophilicity, water permeability, or fouling resistance. Antimicrobial nanomaterials such as nanosilver is doped or surface grafted on polymeric membranes to inhibit bacterial attachment and bio-film formation[24,25] on the membrane surface It also as inactivates viruses[26] and can reduce membrane bio-fouling Development of Thin film Nanomaterial membrane mainly focuses on incorporating nanomaterials into the active layer of thin film composite [TFC] membranes via doping in the casting solutions or surface modification. The effect of nanoparticles on Membrane permeability and selectivity depends on the sort, dimension and quantity of nanoparticles added. Many biological inspired membranes are highly selective and permeable[27,28]

Nanocatalysts: Due to high surface to volume ratio and shape dependent properties nanocatalytic substances like zero-valent metal, semiconductor materials and bimetallic nanoparticles are widely used in water treatment as they increase the catalytic activity at the surface. It enhances the reactivity and degradation of environmental contaminants such as organochlorine pesticides, halogenated herbicides azo dyes, polychlorinated biphenyls and nitro aromatics[29]. The catalytic activity has been proved on laboratory scale for various contaminants. Reports are available which show that efficient for degradation of microbial contaminants in water and reusable particles[30] are silver nanocatalyst, N-doped TiO_2 and ZrO_2 nanoparticles.

Nanostructured catalytic membranes: Nanostructured catalytic membranes have more than a few advantages like they have homogeneous catalytic sites, require less contact time ,multiple ordered reactions can occur and they can be easily scaled for commercial purpose .To inactivate microorganisms and decompose organic pollutants nanostructured TiO_2 membranes and films are used[31]. With the advancement in nanotechnology several novel nanostructured catalytic membranes has been synthesized. These have with increased foul resistance, higher selectivity and higher rate of decomposition. The techniques of synthesizing these nanoparticles include many approaches for developing their multi functionality[32].

Bioactive nanoparticles: Silver nanoparticles can be biosynthesized extracellularly by bacteria *Bacillus cereus* which is having very high antibacterial potential. This strain was exposed to different concentrations of silver salt [$AgNO_3$] and studied with the help of various analytical instruments like High Resolution Transmission Electron Micrography [HRTEM], X-ray diffraction [XRD] and Energy Dispersive spectroscopy [EDS] Prakash et al.[33] found MgO nanoparticles and Cellulose acetate [CA] fibers embedded Ag nanoparticles effective against bacteria both positive and negative and spores as well. With the rapid increase in nanotechnology approaches for the detection of microbial pathogens is continuingly adding to the microbial and pathogen detection as well as in diagnostics.

Biomimetic membrane: Biomimetic membranes are chemically stable, have high permeability and selectivity[34] and show a great degree of removing salts.

A brief summary is shown in table-1 describing application of nanotechnology in water treatment

Table-1
Application of Nanotechnology in water and waste water treatment

Type of Nanoparticle	Type of pollutants removed
Carbon nano tubes	Organic Contaminant
Nano Scale metal Oxide	Heavy metals Radionucleides
Nano catalyst	PCB, Azodyes,Pesticides etc
Nano Structured catalytic	Decomposition of organic pollutant inactivation of micro organisms
Bioactive nanoparticle	Removal of Bacteria, fungi
Biomimetic membranes	Removing Salts

Conclusion

Nanotechnology for water and wastewater treatment is increasing day by day. The exclusive properties of nanomaterials show great opportunities for water and wastewater treatment. All three categories viz. nanoadsorbents, nanotechnology enabled membranes, and nanophotocatalysts have commercial products although they have not been applied in large scale water or wastewater treatment. Several other water treatment nanotechnologies have made immense enhancement in recent past for handling water contamination problems and are going to make additional advancements in coming future. Nanotechnology based treatment has offered very effectual, competent, resilient and eco friendly approaches. These methods are more commercial, less tedious with very less waste generation than conventional bulk material based methods.

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