ISSN No:-2456-2165

Nanomaterials used for Water Purification

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Abstract— Nano-substances have received unique interest in water-pollutants mitigation researches on account that ultimate decade. Two important properties make nanoparticles especially beneficial as sorbents. On a mass basis, they have much large floor regions as compared to macro particles. They also can greater with numerous reactor businesses to boom their chemical affinity closer to target compounds. Nano filtration strategies extensively used to eliminate cations, herbal natural matter, organic contaminants, natural pollution, nitrates and arsenic from groundwater and floor water. Nano-membranes used to treat infected water via way of means of filtration or separation strategies. Nano sorbents extensively used as separation media in water purification to eliminate inorganic and natural pollution from infected water. During the ultimate decade, titanium dioxide (TiO2) nanoparticles have emerged as promising picture graph catalysts for water purification. Consequently, extraordinary people had followed the methods which include chemical precipitation, sol–gel, vapour deposition, solvo thermal, solid-state response etc. for the synthesis of a few nanostructured combined oxides, which can be efficaciously use for groundwater treatment.

Keywords:- *Nanomaterials, Pollutants, Sorption, Filtration, Adsorption.*

I. INTRODUCTION

A. Introduction

Water is a legendary substance whose material life is secondary in comparison to the symbolic fee because it manifested in our thoughts because the image of existence. Sustainable resources of easy water are vital to the world's health, surroundings and economy. Currently the human society is dealing with a fantastic crunch in assembly growing needs of potable water because the to be had resources of freshwater are lowering because of prolonged droughts, populace growth, decline in water excellent mainly of groundwater because of growing groundwater and floor water pollution, unabated flooding and growing needs from a whole lot of competing users. Water being a prime herbal resource, a primary human want and a treasured countrywide asset, its use wishes suitable planning, improvement and management. Increasing populace coupled with overexploitation of floor and groundwater during the last few many years has ended in water shortage in numerous components of the world. Wastewater is growing substantially and withinside the absence of right measures for treatment and management, the prevailing freshwater reserves polluted. Increased urbanization is riding a boom in according to capita water intake in towns and cities. Hence, there is a want to understand the requirement to manage current water reserves on the way to keep away from destiny water strain. Today availability of secure consuming water is a concern. For nearly all of the water wishes of the country, groundwater is through a long way the maximum critical water resource. Worldwide, in line with a United Nations Environment Programmed (UNEP) study over 2 billion human beings rely on aquifers for his or her consuming water [1]. Forty according to cent of the world's meals is produce through irrigated agriculture that predicated largely on groundwater [1].

Groundwater constitutes approximately ninety-five according to cent of the freshwater on our planet (discounting that locked withinside the polar ice caps), making it essential to human existence and economic improvement. Clean water is the worldwide want and want of existence for all of the human kinds. However, the easy water assets infected in gift time. Nanotechnology is a smooth and realistic technique to easy wastewater through the usage of special methods. Different varieties of bacteria, poisonous chemical compounds like arsenic, mercury etc., and sediments may be eliminated through the usage of nanotechnology. Nanomaterial based gadgets are getting used for water purification. Nano filtration technique has blessings over different traditional technique as low strain is needed to pass the water via filters and those filters may be wiped clean without difficulty through back flushing. Smooth indoors of carbon nanotubes cause them to handy for the elimination of just about all varieties of water contaminants. Because of large floor place nanostructured, substances have blessings over traditional micro dependent substances.

II. METHODS FOR WATER TREATMENT

Adsorption is a very common techniques used for water treatment. Nanomaterials can be use adsorbents for water treatment in various forms such as catalytic membranes, biomimetic membranes and thin film nanocomposite membrane etc. Carbon nanotubes (CNT) absorb chemicals more efficiently than activated carbon. Organic compounds having functional groups like carboxylic, hydroxyl and amide has tendency to form hydrogen bond with CNT surface which donates electrons and CNTs have high capacity to adsorb metal ions that's why good substitute of activated carbon. Nano adsorbents are used in the form of either as powder or porous granules encumbered with nano-adsorbants.

- *Nano membranes*

Nano membranes modified with nanofibers are being utilized for the removal of micronized particles. These membranes are used in pretreatment method of reverse osmosis. Inorganic Nano membranes doped with titanium

oxide have been reported for the degradation of chemicals specially chlorinated compounds. Polymeric membranes immobilized with titanium oxide are very effective for the degradation of chlorinated compounds. Polymeric membranes doped with nanosilver are applied to inhibit biofilm formation on the membrane surface and to incapacitates viruses so can reduce bio fouling. Because of unique properties nanocatalysts are very effective for the removal of contaminants from water shrieks. These catalysts are capable to degrade environmental contaminants halogenated pesticides, herbicides and nitrogenous aromatic compounds. Biological nanoparticles show great potential for waste water treatment. MgO nanoparticles and Cellulose acetate (CA) fibers implanted with Ag nanoparticles have been reported as antibacterial against gram positive as well gram negative bacterial so can also be used in water treatment.

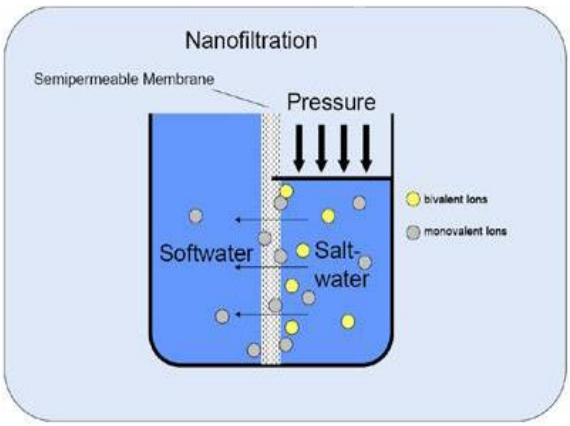

Fig 1. Nano-filtration Process

III. NANOMATERIALS FOR WATER TREATMENT

A. Metal Nanoparticles

➢ *Silver Nanoparticles*

Silver nanoparticles are strong antibacterial agents and highly toxic to different bacteria, viruses and fungi. This antimicrobial properties of silver nanoparticles make them useful as disinfectant for water. Now days silver nanoparticles are successfully applied as disinfectant in water treatment. Although direct application of these silver nanoparticles reduce their proficiency in long-term use and may cause problems as they have tendency to aggregate in aqueous mediumlenhar, still filter materials incorporated with silver nanoparticles are used as water disinfectant because of their antimicrobial properties and cost-effectiveness.

From last two decades, silver nanoparticles doped membranes or ceramic materials are frequently used for the treatment of household water due to their disinfecting and antifouling behavior. For example ceramic filters prepared by clay and doped with silver nanoparticles are capable to enhance efficiency of removing *E.coli*. It was also observed that filters having high porosity have greater tendency to remove bacteria than filters with low porosit. It was reported that silver nanoparticles upgraded the filter enactment and increased the removal rate of E.coli up to 97.8% and 100%.

➢ *Iron Nanoparticles.*

Nano zero valent iron (nZVI) due to their small size and large surface area have excellent absorption and reducing properties. These properties make these nano zero valent iron (nZVI)effective agents for the removal of large range of contaminants like halogenated, nitrogenous compounds, dyes, phenols, inorganic ions ,heavy metals and radioactive components. When these nano zero valent iron (nZVI) and contaminants come in contact, oxidation-reduction reaction takes place which oxidize Fe2+ to Fe3+ so ferric hydroxide, Fe(OH)3 will form and this Fe(OH)3 will facilitates the removal of heavy toxic metals

B. Metal Oxides Nanoparticles

➢ *Titanium oxide Nanoparticles (TiO2 NPs)*

Photocatalytic degradation method is the best method now a days for the removal of contaminants from waste water. Titanium oxide nanoparticles are using as an efficient catalyst because of their photocatalytic activity, cost effective and stability. These catalyst when come in the contact of contaminants, gradually oxidize them into low molecular weight products like CO2, H2O, NO3-, Cl- etc.. Titanium oxide nanoparticles are selective degradation agents and used for the degradation of heavy metals, cyanides, polycyclic aromatic hydrocarbons, chlorinated organic compounds, dyes and phenols. These nanoparticles are also effective antimicrobials against a wide range of gram-negative and gram-positive bacteria, fungi and viruses.The coupling technology of titanium oxide nanoparticles,(TiO2 NPs) with membrane such as polyvinylidene fluoride, polyethersulfone, polymethyl methacrylate, and polyamide-imide is much more promising to resolve the recovery problem of titanium oxide nanoparticles (TiO2 NPs). By this coupling, titanium oxide nanoparticles can easily be separated just using simple filtration method.

➢ *Zinc Oxide Nanoparticles (ZnO NPs)*

ZnO NPs are also very efficient photocatalysis agents for waste water treatment due to their specific characteristics like band gap in the near-UV spectral region, and oxidizing power. Biocompatibility of these nanoparticles make them suitable for waste water treatment.

➢ *Iron Oxides Nanoparticles*

As iron oxides nanoparticles are simple and can easily be synthesized so these are frequently being used now a days for the removal of heavy metals. This is typical to recover nanosorbent materials from contaminated water because of their small size but magnetite and maghemite can be used as adsorbents because of their magnetic behavior. Because of magnetic behavior these iron oxide nanoparticles as a nanosorbants can be recovered from solution by applying external magnetic field. Therefore these nanoparticles are being magnificently working as nanosorbents for removing heavy metal ions from water.

ISSN No:-2456-2165

C. Carbon Nanotubes (CNT)

Carbon nanomaterials (CNMs) are interesting adsorption agents because of their structural and electronic properties. Because of large surface area and selective nature for aromatics CNMs have advantages in wastewater treatment. CNTs, due to their structure are more efficiently being used than other carbon nanomaterials. CNTs show specific adsorption capacity for cations, dyes and ethyl benzene etc. Functionalization of CNTs enhance their adsorption capacity by increasing surface area and dispersibility. Nanocomposite adsorbent formed by the combination of CNTs having adsorption properties and iron oxide having magnetic properties, are capable in removing chromium from water.

D. Nanocomposites

Among nanomaterials, nanocomposites are the most prominent materials now days because of their magnetic properties and these properties make them easy to separate from the solution. Nano filtration membrane can be prepared by incorporating titanium oxide nanoparticles including the fabrication of co-polyamide network on a polyimide backing. Nanocomposites also have specific binding capacity through chelation, ion exchange and play active role in the different forms like polymer nanocomposites, carbon nanocomposites and metal oxide nanocomposites.

E. Dendrimers

Dendrimers are monodispersed Nano sized distinct 3-D macromolecules having symmetric core, inner shell and outer shell. More complex nano-structured materials can be synthesized by using dendrimers as nanoscale building blocks, e.g., dendrimer encapsulated NPs find use in materials engineering applications. Other materials can also be functionalize with dendrimers to enhance recovery rate of different metal ions from water. Dendrimers can also be used as chemical sensors and removal of heavy metals for water treatment. Dendrimers are water soluble ligands and this property make these useful for the absorption of toxic heavy metal ions in water purification[90]. Different nanomaterial can be represented by flow diagram given in Figure 2.

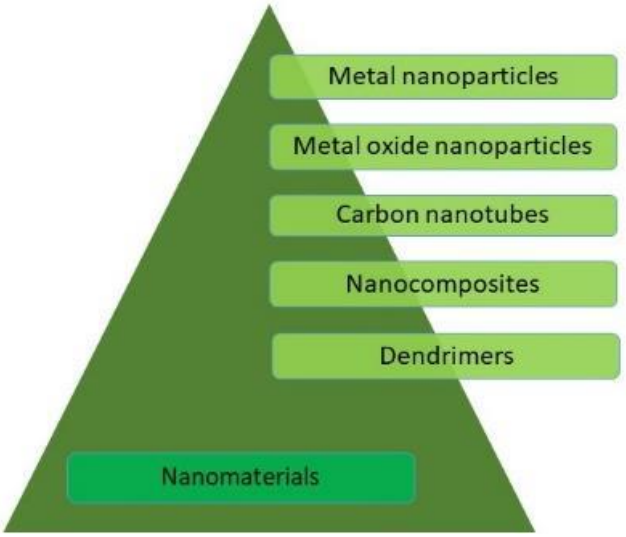

Fig 2. Different Nanomaterials used in water purification

IV. NANOFABRICATION

Nanomaterials can be fabricated by using basic two methods, one is bottom- up and other is top-down. Bottom-up is a single step approach while top- down is a twostep method. One of the popular one-step approach is direct evaporation. Chemical reaction method can also be used for the same purpose. Two-step method is commonly use for the fabrication process due to the low cost of material. In this twostep, method nanoparticles are dispersed in base fluid. This process is most popular method for producing large scale of Nano fluids.

V. CONCLUSION

Although risks are involved with nanomaterials of high reactivity due to large surface area to volume ratio but in case of water purification done by nanotechnology no problem related to human health and environment has reported. These nanotechnology based chlorine free methods of water purification have advantage because chloramine or chlorine used in chlorine method produce carcinogenic byproducts. By improving water, quality economy of any developed country can grow, as techniques of water purification like chlorination, filtration and disinfection can give profit of 5-10 dollars for 1-dollar investment.

ACKNOWLEDGMENT

I am thankful to my parents and friends who helped me a lot in this research within limited time.

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