WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Importance of Nanotechnology in Water and Waste Water Treatment

Daram Ajay Reddy [a] and Dr Mushini Venkata Subba Rao [a*]

[a] Student, JNTU number: 24345A0111, Department of Civil Engineering, G M R Institute of Technology, Rajam -532 127, Vizianagaram District, Andhra Pradesh. E mail: 24345a0111@gmrit.edu.in

a*Associate Professor, Chemistry Division, BS & H Department, G M R Institute of Technology, Rajam -532127, Vizianagaram District, Andhra Pradesh E- mail: subbarao.mv@gmrit.edu.in

ABSTRACT:

Clean and safe water is essential to human beings for survival of life and it should be considered as one of the national strengths. But it is a challenge in 21st century to meet the human needs to providing clean and safe drinking water to all across the globe. Due to increasing population, urbanization, industrlization, agriculture activities and including manmade activities around the world the ground and surface water quality undergo deterioration or contaminated or entry of different pollutants in to water bodies. Several conventional water purification processes are available for removal of pollutants or unwanted constituents from water. But at present nanotechnology plays a vital role in the purification of water waste water treatment. Nanomaterials like nano metal oxides, nano composites, nano fibers, nano carbon adsorbents, etc are presently using in the purification of water and waste water. In this paper briefly discussed about the importance of nanomaterials in water and waste water treatment by taking some published work.

Key words: Nanotechnology, water and waste water, nanomaterials

Introduction and Explanation:

Water is required for sustaining [1] all forms of life, food production, in industry should be considered as a good engineering material, agriculture and economy development is associated directly or indirectly with it. Availability of quality water is considered as a national strength and it is a most important constituent [2] of living beings. Assurance of drinking-water safety is a foundation for the prevention and control of waterborne related diseases [3-4] Drinking water affects the health of human beings and many diseases associated directly or indirectly due to the fact that presence of various chemical constituents in drinking water. It is reported that consumption of unsafe water and unhygienic practice, causes about 80% of common ailments, majority being due to contaminated water. Water pollution is the contamination of water bodies (i.e. Lakes, rivers, oceans, aquifers and ground water) and pollutants are directly or indirectly discharged into water bodies.

According to World Health Organization (WHO) report published in September 2023, approximately 1.7 billion of people suffer from poor drinking water quality. The major problem that the earth is currently facing is the freshwater being contaminated due to the disposal of untreated sewage, agricultural, domestic, and industrial wastes. Water from industrial and domestic sources often contains multiple contaminants, including heavy metals, organic pollutants, and pathogens, which pose significant.

The presence of excessive amounts of physical and chemical parameters are in the drinking water are creating problems [5] in human beings and are harmful to human health. Water pollution caused by heavy metal ions is becoming a serious intimidation to human beings and aquatic lives in present days. Consumption of excessive amounts of heavy metals [5] through drinking water by human beings, leads to may damage central nervous function, the cardiovascular and gastrointestinal (GI) systems, lungs, kidneys, liver, endocrine glands, and bones. Chronic heavy metal exposure [5] has been implicated in several degenerative diseases of these same systems and may increase the risk of some cancers. All these factors are considered into account fresh water is needed to be human beings to avoid water borne type diseases. Due to industrialization, increases in the urbanization and usage of plenty water in agriculture the demand of fresh water increases. But alternatively, only accessible fresh water is 0.5% of the world's 1.4 billion Km^3 of water which is furthermore poorly distributed across the globe [6] Due to population growth, demand of food and energy around the world increases and simultaneously changes happening in climate can create a lot of demand for requirement of water to the human beings. In addition to surface and ground water resources are polluted/contaminated due to several manmade activities due to it to reduce the fresh water supply [7-9].

Around the world the aquifers has been polluting due to several causes like saltwater intrusion, soil erosion, inadequate sanitation, contamination of ground/surface waters by algal blooms, detergents, fertilizers, pesticides, chemicals, heavy metals and so on[10-13]. Requirement of clean or fresh water throughout the world are depleting due to stretched drought, increase population, climate changes or threat with seasons and many more causes including manmade activities [14]

Safe drinking water is essential to the protection of public health and well-being of citizens. Clean and fresh drinking water is one of the major requirements for human beings and when our drinking water is polluted it is not only devastating to the environment, but also to human health. Ground water is one of the major sources of drinking and also which is widely used for domestic, irrigation and industrial purposes in urban and rural parts of India. Due to increased population, human activities, industrialization, dumping of industrial waste, increased use of fertilizers, changes in local topography, ineffective drainage system directly affects the quality of the groundwater or surface water in many areas. Based on the importance of the water to human beings we should properly follow the rules and regulations to avoid or minimize the entry of pollutants to water bodies as responsible persons. Even though man made activities the ground or surface water is polluting around the world. In this context due to demand of water can choose an appropriate water purification methods for removal of pollutants. Many conventional methods are available, but at present nano technology is one of the emerging fields in the purification of water and waste water treatment.

Importance of Nano Technology:

Traditional water purification methods are often ineffective to removal of organic pollutants, heavy metals, and bacteria from wastewater. Aquifers around the world are depleting due to several causes such as saltwater intrusion and contamination from surface waters. By using good purification technologies can reduce the contaminants in the water. Under these purification technologies at present nanotechnology has been proved to be one of the progressive methods for water and waste water treatment. The advantage of Nano scale research is environmentally eco-friendly and economically viable for effectively treating water/wastewater. Advances in nanotechnology have provided the opportunities to meet the fresh water demands of the future generations. It is suggested that nanotechnology can adequately address many of the water quality issues by using different types of nanoparticles and/or Nano fibers [15]

Nano materials [16] are considered to be very efficient and prominent in the elimination of pollutants. At present a huge research is going on Nano materials and has been studied for their potential to remove pollutants as adsorbents. Due to the large surface area of smaller size of Nano particles enhances the chemical activity and adsorption capacity of these particles and shows good adsorption capacity of the substances /pollutants on their surface. Adsorption process depends on adsorption coefficient and recitation partitioning of pollutant i.e. heavy metals or pollutants under equilibrium conditions. Oxide based nanoparticles (Al_2O_3, MgO, ZnO and Ag) are extensively used for removal of pollutants.

Nanotechnology has many successful applications in different fields but recently its application for water and wastewater treatment has emerged as a fast-developing and attractive area of concern. Due to unique characteristics of Nanoscale materials like their small size, large surface area, they have a greater number of active sites for interaction with different chemical species [17].

Nano materials having novel and appreciably properties such as physical, chemical, and biological, high reactivity and strong sorption due to their structure, higher surface area-to-volume ratio and contribution in the water and waste water treatment. Nano materials are use in the form of Carbon Nano Tubes or nano scale metal oxides and nano fibers which can be potentially apply to work in the form of adsorption, disinfection, photo catalyst and membrane forms for water or waste water treatment [18-20].In the following table some key potential applications of nano technology in ware and waste water treatment are given hereunder.

Applications	Few examples of nanomaterials	Some typical or novel properties
Adsorption	Carbon nano tubes, and nano fibers, Nano metal oxides like Fe_2O_3 and Fe_3O_4, Al_2O_3 , MgOetc..	Having high surface area, more accessible adsorption sites, easy reuse and so on
Disinfection	Nano silver, Nano Titanium dioxide	Having anti microbial and low toxicity activity, low cost and easy of re use
Photo catalyst	Nano Titanium dioxide and derivatives of fullerenses	Due to photo catalytic activity, pollutants are easily degraded
Membrane form	Nano silver, Nano TiO_2	Having anti microbial, chemical and mechanical stability, and so on

Tremendous work is going on at present in the field of nano technology for removal of pollutants from water and waste water and here under few published research papers are reviewed as the importance of nano technology.

Y.C.Sharma et.al [21] studied the nano-adsorbents for the removal of metallic pollutants like Cr, Cd, Hg, Zn, As, and Cu from water and wastewater; they have reported that nanoparticles are able to efficiently remove metallic species in particular and pollutant species in general from aqueous solutions. In addition to they have stated that the application of Nano particles/Nano adsorbents is gradually becoming popular for removal of various pollutant species.

Jayasri et al [22] reviewed the application of nano material in waste water treatment, in this paper they have discussed various types of available nanomaterials namely, nanoparticles, nanocomposites and nanostructures and the way they have been used in improving the treatment of wastewater. These nano materials are work under study process of adsorption, catalytic degradation, and membrane filtration for the removal of pollutants such as heavy metals, organic compounds and bacterial pathogens. In this review the authors have identified unique benefits of nanomaterials having the

properties like high specific surface area, activity and potential for regeneration, due that nano materials are highly capable and good with stand for effectively removal of pollutants from waste water.

Zakir et al [23] published a comprehensive review on recent progress in nanomaterials for water treatment. They clearly mentioned that conventional water purification methods are often ineffective to removal of organic pollutants, heavy metals, and bacteria from wastewater. At present in place of traditional water purification methods, nonmaterial are plays a vital role in the treatment of wastewater due to their unique characteristic properties. In this review thoroughly reviewed and examined the latest applications and advancements in nanomaterial-based water treatment. In this review paper mainly focused on the roles of nano materials as in the form of working in the treatment of water as membranes, adsorbents, and photo catalysts. They give detailed and elaborated discussion on the properties and performance of various nanomaterials, nano metal oxides like TiO_2, Nzo, Fe_2O_3, Go, and Coo, carbon-based materials, zealots, and MOFs materials. In this research paper they also quoted key challenges, limitations, and future perspectives for the large-scale application of nano materials in wastewater treatment applications.

References:

1. Vaddi Dhilleswara Rao and Mushini Venkata Subba Rao. (2022). Evaluation of Groundwater Quality by Water Quality Index During Successive Periodic Intervals in the Selected Villages of Gara Mandal of Srikakulam District in Andhra Pradesh, Asian Journal of Water, Environment and Pollution, Vol. 19, No., 63-72.
2. A.Mishra and V. Bhatt. (2008). Physico-Chemical and Microbiological analysis of underground water in V.V Nagar and nearby Places of Anand District, Gujarat, India, E-Journal of Chemistry, Vol.5 (3), 487- 492.
3. Guidelines for drinking-water quality, fourth edition. (2011). ISBN: 978 92 4 154815 1, World Health Organization (WHO), Geneva..
4. Global status report on water safety plans: a review of proactive risk assessment and risk management practices to ensure the safety of drinking-water, World Health Organization. , http://www.who.int/iris/handle/10665/255649, 2017.
5. D. D. Mara. (2003). "Water, sanitation and hygiene for the health of developing nations," *Public Health*, vol. 117, no. 6, 452–456.
6. H. El-Dessouky and H. Ettouney. (2002)."Teaching desalination—a multidiscipline engineering science,"*Heat Transfer Engineering*, vol. 23, no. 5, 1–3..
7. K. E. Kemper. (2004)., "Groundwater-from development to management,"*Hydrogeology Journal*, vol. 12, no. 1, 3–5.
8. J. A. Foley, R. DeFries, G. P. Asner et al.(2005). "Global consequences of land use," *Science*, vol. 309, no. 5734, 570–574.
9. S. E. Coetser, R. G. M. Heath, and N. Ndombe.(2007)., "Diffuse pollution associated with the mining sectors in South Africa:a first-order assessment," *Water Science and Technology*, vol. 55,no. 3, 9–16.
10. L. Ritter, K. Solomon, P. Sibley et al.(2002) "Sources, pathways, and relative risks of contaminants in surface water and groundwater: a perspective prepared for the Walkerton inquiry," *Journal of Toxicology and Environmental Health—Part A*, vol. 65, no. 1, 1–142..
11. J. Fawell and. J. Nieuwenhuijsen.(2003). "Contaminants in drinking water," *British Medical Bulletin*, vol. 68, 199–208.
12. S. Rodriguez-Mozaz, M. J. L´opez De Alda, and D. Barcel´o. (2004)."Monitoring of estrogens, pesticides and bisphenol A in natural waters and drinking water treatment plants by solid-phase extraction-liquid chromatography-mass spectrometry," *Journal of Chromatography A*, vol. 1045, no. 1-2, 85–92..
13. I. R. Falconer and A. R. Humpage. (2005). "Health risk assessment of cyanobacterial (blue-green algal) toxins in drinking water,"*International Journal of Environmental Research and Public Health*, vol. 2, no. 1, 43–50.
14. .E. J. Lee and K. J. Schwab. (2005). "Deficiencies in drinking water distribution systems in developing countries," *Journal of Waterand Health*, vol. 3, no. 2, 109–127.
15. N. Savage and M. S. Diallo. (2003). "Nano materials and water purification: opportunities and challenges," Journal of Nanoparticle Research, 7(4-5), 331–342,
16. Chen Xue Hu's. (2022).Research Progress on Adsorption of Water Pollutants by Nano Materials, Materials Science Forum 1058:33-38, DOI:10.4028/p-u8i5aj.
17. K. Hristovski, A. Baumgardener, and P.(2007). Westerhoff, Selecting metal oxide nanomaterialsfor arsenic removal in fixed bed columns: From nanoparticles to aggregated nanoparticles media*J. Hazard. Mater*. 147,265–274.
18. D. G. Rickerby and M. Morrison. (2007)."Nanotechnology and the environment: a European perspective," *Science and Technology of Advanced Materials*, vol. 8, no. 1-2, 19–24.
19. A. Vaseashta, M. Vaclavikova, S. Vaseashta, G. Gallios, P. Roy, and O. Pummakarnchana. (2007)."Nanostructures in environmental pollution detection, monitoring, and remediation," *Science and Technology ofAdvancedMaterials*, vol. 8, no. 1-2, 47–59, 2007.

20. X.Qu, P. J. J.Alvarez, andQ.Li.(2013). "Applicationsofnanotechnology in water and wastewater treatment," *Water Research*, vol. 47, no.12, 3931–3946..

21. Y.C. Sharma , V. Srivastava , V.K. Singh , S.N. Kaul and C.H. Weng. (2009). Nano-adsorbents for the removal of metallic pollutants from water and wastewater *Environmental Technology*, Vol. 30(6), 583–609.

22. Jayasri M , Shyamala G , Gurugubelli Thirumalarao. (2025). Nano Material Application in Wastewater Treatment, E3S Web of Conferences 619, 04011 (2025), ICSGET 2025, https://doi.org/10.1051/e3sconf/202561904011

23. Othmane Zakir, Aziz Ait-Karra , Said Khardazi , Rachid Idouhli, Mohy Eddine Khadiri, Burak Dikici, Abdelmaula Aboulaich, Abdelkader Outzourhit, Abdesselam Abouelfida. (2025). Recent progress in nanomaterials for water treatment: A comprehensive review of adsorption, photo catalytic, and antibacterial applications, Journal f water processing Engineering, vol 72, 107566, 2025.