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COMPREHENSIVE REVIEW ON GENERAL STRATEGIES USED IN WASTEWATER TREATMENT

V. Ragul[1] and M. I. Niyas Ahamed[1*]

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Abstract

The increasing pollutents concentration in the drinking water shows severe ecological threat to all living organisms. Numbers of conventional and non-conventional methods have been used to effectively eliminate wide range of heavy metals from contaminated water. The entire significant proposition will make future investigations dependent on the excluded relationship between the nanoconfinement impacts and the water purification innovations. The present review focused on some effective adsorbents which eliminate excessive amounts of heavy metals and it shows expressive elimination with basic, cost-effective adsorbent and easy availability as well as accessibility by the common people.

Keywords: Fluorosis, nanotechnology, defluoridation, nanoconfinement, adsorption.

1. Introduction

Water is world's wide resource and constituent lives. It acts chief role in the global economy, where about 70-80% of freshwater is used in cultivation of crops. Water pollution is one of the biggest environmental harms faced by the planet and has a tendency for affecting human health, plants, trees and livestock, as well as water shortages. Due to the shortage of fresh water supplies, waste management has become a elegant way to conserve and increase the water accessible sources. Recycle of polluted water posses wide range of applications, including agricultural soil management, environmental activities, manufacturing, recreational, aquaculture, and artificial groundwater recovery[1]. Waste water management provided proper processing is taken to restore its acceptable water quality for the intended use. Except for a small number of countries, the water supply is limited mostly to non-potable sources or to indirect, drinking water use. Any conditions and parameters including content of heavy metals, electrical conductivity and subsequent condensation organic matter should therefore be tested after application before wastewater[2]. Nanotechnology enables the production of new high-tech materials, such as functionalized surfaces, adsorption materials, coatings, nanocatalysts, membranes and reagents, for effective water and waste water repair processes[3-5]. Nanosorbent materials are nevertheless regarded as the most appropriate form of water and wastewater remediation due to their simple application and the wide variety of adsorbents available[6]. Nanomaterials historically had an unprecedented impact on the water and wastewater treatment process. Because of its special feats, such as increased surface area and enhanced adsorption potential, nanomaterials are the smartest way to handle both organic and inorganic pollutants. In addition, physisorption or chemisorption can rely on the functionalization of nanomaterials to communicate between nanoadsorbent materials and pollutants[7].

The relationship between organic and inorganic contaminants with materials containing nanosorbents. In order to extract methyl orange tint from water by the use of carbon nanotubes to remove diazinon pesticide[8,9]. The role of Cu\\Fe binary oxides in water removal of hexavelant chromium. The importance of new hybrid material in the removal of arsenic from water (III). However, by implementing potential activated alumina significantly modified by zirconium, fluoride and calcium removed[10].

In addition, experiments have been conducted to study the application of available nanoadsorbent materials in contaminated water management strategies. For example, eminent investigators applied various nanosorbents such as metal oxides and carbon, which were used to remove heavy metals from waste water[11]. Moreover, following the modification of mesoporous silica, synthetic superparamagnetic nanosorbents (iron oxide) have a major impact in removing of pollutants by by exceedingly increased surface area. investigation offer the impact and sources of different types of nanomaterials and adsorbents towards bioremediation of wastewater comparatively investigate with available literatures and research.

1.1 Effect of Toxic Dyes on Living Organisms

The availability of dyes (RB, MB, MV, CR & CV) and its structures and non-biodegradable existence, are major concerns for society and are harmful to living organisms. These dyes are carcinogenic and damage the environment. These dyes not only devastate aesthetic feature but also

*** Corresponding author: email** - driniyasahamed@shctpt.edu
[1]Department of Biochemistry, Sacred Heart College (Autonomous), Tirupattur Dt. Tamilnadu, India- 635601.

limit the dissemination of sunlight into water, which gives negative impact on organisms which living in water. Among different contaminents MV and MB are the most harmful to living creatures. Acidic dyes have adverse impact on the eyes, breathing system, skin and can increase the risk of cancer and human mutagenicity. Basic coloring dyes are also poisonous, can result in allergies, inflammation of the skin, mutations and even cutaneous cancer, improve heart health. Wastewater from different textile factories often includes metal ions that are impurities entirely depends on hexavalent chromium[12-15].
Chromium mediated multifarious dyes are generally severe carcinogenic and have damaging effects on marine organisms. The key explanation for the improved toxicity of azo dyes is the group of amines found in azo dyes. Reactive dyes in water soluble can be a reason for severe water problems[16,17]. Thus, the variety of dyes are a more hazardous organic pollutants in the atmosphere which are directly and indirectly exposed into water supplies, making polluted water or portable drinking water therapy a major ecological concern. The removal of fungi flocculation and anaerobic digestion, many methods are used, e.g. physical method, chemical, and biological methodology. These methods are effective and have accurate results to remove radioactive dyes from water[18]. They have however also some disadvantages, such as high processing loads, which are less efficient at low concentration and hard to manage. Adsorption, in terms of its ease, cost efficiency, simple handling protocol and service, is the best for the elimination of toxic dyes from contaminated water. Adsorption is a multi composition of fluids surface process in which a molecule (solute) is fixed by chemical and physical bonds to the surface of a solid material[19].

These surface compounds are known as adsorbents, whereas the molecule extracted from the liquid process is called as adsorption. Today, the adsorption phenomenon is useful for the purification of water. Dyes have the chromogenic group that makes the dye molecules adsorb easily on the adsorbent surfaces[20]. Schematic display of elimination of toxic dyes in the wastewater by adsorbent is shown in Fig (1).[21]

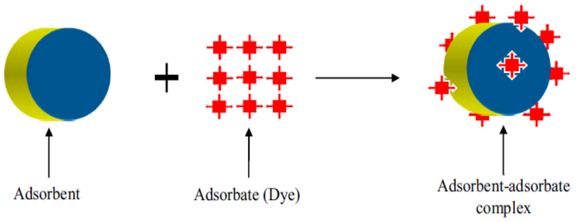

Figure 1: Dye adsorption process.

There are several factors responsible for the pollutant removal was represented in Fig. 2. Detailed studies of these tailored parameters will help to efficiently remove dyes and improve industrial water treatment processes. Recently, nanoparticles (NPs) are used as water adsorbents for water purification, which has a wide range of water treatment. These attractive NPs posses wide applications and properties, like improved surface-to-volume ratio, active surface characteristics in the treatment of toxic contaminants[22,23].

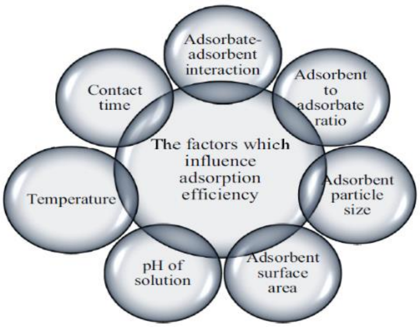

Figure 2: Factors influencing the adsorption efficiency

1.2 Nano Adsorbent (NA)

The cost and feature property such as the size of the particle, probability distribution of particles, shape, crystal structure, distribution of composite material, purity, aggregation checks, stabilisation, repeatability and higher NP increased manufacturing made it suitable for various applications such as sensor, biomedical, and water treatment in particular fig 3.[24,25]

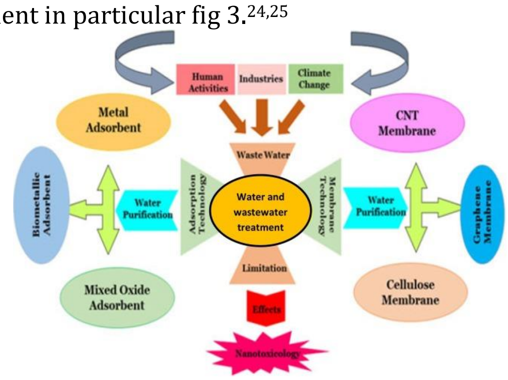

Figure 3: Water and wastewater treatment techniques

The present literature review has been carried out to upgrade nano adsorbent status in the water handling protocals and to examine the color sorption by a variety of nanomaterial, the sorption efficiency of which is described in Tables 1. Null-valent iron, iron oxides, hydroxides, aluminum oxide, zinc oxide, titanium oxide and Copper Oxide NPs are also used as an adsorbent in dye degradation[26].

2. General strategies used in wastewater treatment

2.1 Ion exchange

An "exchange site" of an immovable solid atom. Certain particles such as zeolites and clayminerals occur naturally, while others are synthesized. Ion exchange techniques in water and wastewater were successfully used to remove various heavy metal cations[27,28]. Some researchers have found that it is difficult to remove such heavy metals such as plum, given the rivalry between the active ion replacement sites and the naturally occurring sites. The efficacy of the removal of variety of heavy metals in 18 hours in batch containers with enhanced acidic pH removal efficiency (N95%)[29-31].

2.2 Chemical precipitation

The formed solid is indicated as a precipitate and can be pelleted by a centrifuge. Supernatal or supernatant is the fluid residual overhead of the solid[32,33]. Owing to its low cost and its efficiency, chemical precipitation methods are widely used to elimination of heavy metal ions from water and waste water[34]. The following steps usually include the reduction of heavy metals by chemical precipitation techniques:

2.3 Reverse osmosis (RO)

Reverse osmosis (RO) is a molecular filter technique that removes N99 percent of all soluble salts in a aqueous feedstock. Solvent mobility balances the concentration of solute on either side of the different membranes to produce a pressure called a "osmotic gradient." The reverse osmosis was named by the use membrane to pass water or wastewater, but the dissolved and particular substances are too big compared with the diameters of the membrane pores and stay behind[35-38]. This approach is extremely successful when all ionic forms are removed from the water and wastewater solution. The concentrated by-product solution (called retentate) is a major benefit of the technique, making the final recapture of metals cheaper[39]. Furthermore, this method has been used both in small scales and in large scales for heavy metal removal. The membranes are therefore relatively costly to purchase and maintain. And the high stresses needed to operate a device have led to the cost and sensitivity of this process[40,41].

The adsorption method has therefore been the most frequently used water treatment by the world's ecologists for removing toxic and poisonous inorganic and organic pollutants. However, adsorption produces a material, like other treatment systems, which may pose challenges to the responsible disposal. These achievements have led to many more studies to identify effective and cheap wastewater treatment techniques which mitigate these negative effects[42-45].

2.4 Classification of nano-adsorbents

Nanoadsorbents are generally categorized in different classes according to their adsorption process. Nanocarbonate (CNMs) has been the latest production, with carbon nanoparticles, carbon nanoparticles and nanocarbon sheets included[46]. In addition, nano-adsorbents were used for different types of silicone nano-materials, including silicone nanoparticles, silicone nano-nano-sheets and silicone nanosheets. Nanoclays, nanomaterials from polymers like nano-adsorbent controls two main nanoparticular features that function in another compound, including titanium dioxide and alumina, efficiently and efficiently. In addition, some reagents can change nanoparticles to boost their capacity before metal ions[47-50].

2.5 Oxide based nanoparticles

Nanoparticles based on oxide are usually made from variety of non metals & metals inorganic nanoparticles. These nano-particles are commonly used for wastewater treatment of dangerous contaminants. The elevated BET surface area and minimal environmental impact, the reduced solubility and no secondary contaminants are known as the oxide-backed nanoparticles[51-54].

2.6 Iron based nanoparticles.

Ferric oxide is a decreased material for adsorbing hazardous metals due to its natural appearance and its good biocompatibility. It is an ecological material that is readily available in a polluted area with a reduced likelihood of secondary exposure[55,56]. The pH, temperature, adsorbent dose and time of incubation of Fe_2O_3 nanoparticles are determined by the adsorption conditions for various heavy metals. Different researchers have developed the capability to absorb Fe_2O_3surface. Fe_2O_3 nano-particles with 3-aminopropyl trimethoxy silane to change their surface. The change in these nanoadsorbents shows a very near affinity to eradicate different wastewater contaminants[57].

2.7 Zinc oxide (ZnO) nanoparticles.

Zinc oxide (ZnO) has high-BET pore surface for heavy metal adsorption. The most frequent use of nano-adsorbents, for instance nano-assemblies, nanoplates, nano-plates and hierarchical znO nano-rubbers is to extract metal ions from wastewater. The updated nanoadsorbent compositions ZnO have a high deletion efficiency of heavy metals in comparison with Cu Wastewater Isolation (II)[58]. These modified ZnO nanoadsorbents are more efficient than conventional ZnO because of their special micro/nanostructures for removal. In addition, a variety of heavy metals have been removed using nano-assemblies. Because of their electropositive existence, adsorption in microporeous nanoassemblies of Pb^{2+}, Hg^{2+} and As^{3+} is higher. The use of mesoporous hierarchical nano-rods from elevated wastes is to strip Pb (II) and Cd (II)[59,60].

2.8 Magnesium oxide (MgO) nanoparticles.

Magnesium oxide (MgO) can be used in wastewater to eliminate various types of heavy metal. MgO microsphere is a modern structure that enhances adsorption affinity to eliminate heavy metals. The morphology of the NPs was modified to increase the adsorption potential of MgO by various forms. Nanotubes, nanobeads, nanostructures triggered by nanotubes, nanostructures, and 3D entities would be included. Fractal nanostructure of the fish bone Strong mesoporous Pb(II) and Cd floral adsorption (II)[61,62].

2.9 Electrospun nano-fiber membranes

The recent development of electrospun nanofibre membranes (ENMs) gives rise to a new approach to waste water management. The key benefits of this modern technology provide a reduced consumption of oil, lower costs and a lighter process than conventional methods. Moreover, increased porosity and volume-to-surface ratios are the key compensation of this process[63]. In order to generate fibers of less size, electrospinning is improved conventional spinning technique[64]. The fiber diameter regulates the surface area by volume and determines the porosity of the membrane. Several studies over the years have demonstrated that electrospun-nanofibers can be used. The nanofibre polymer protects the catalyst particles and helps to ensure electronic continuity in reactants, protons and fuel cells[65].

3. Algal membrane bioreactor (A-MBR) incorporated nanoparticles

Algae cultivation is one of the promising methods for the production and purification of energy in wastewater. A large number of algae species develop efficiently in wastes such as cyanocobalamine, thiamine and macronutrients (NO3, PO34, Ca, Na, K, NH4+) required to grow the species. Solutions are produced by the combining the materials needed for algal growth. The result is the elimination from waste water of nutrients and algal biomass for energy production[66,67]. Different techniques, such as sedimentation, flotation, and centrifugation, support the processing of algal biomass but these techniques cannot be offered to a broad range because of the high cost. The most sophisticated approach to development techniques is achieved by means of the simple membrane bioreactor[68]. The benefits of membrane technology include the lack of more chemicals, such as membrane filtering coagulants, which helps to promote water reuse and simplifies the separation of algal biomass after filtration[69].

Many techniques are available for increasing hydrophilicity and reducing membrane fouling, such as plasma processing, surface coverage and nano-installation. Studies have shown that nanoparticles improve hydrophilicity and reduce isolating membranes. For example, mixing carbon nano tubes with TiO_2 nanoparticles with hollow hollow fibre (HFMs) leads to better surface modification (hydrophilicity) and anti-fouling[70]. The reverse osmosis membrane's polyvinyl top layer is covered with the nano-parts of TiO_2, minimizing flowering under ultraviolet radiation through self-cleaning. In addition to self-cleaning, the TiO_2 particulate photocatalysis was also investigated in order to monitor emissions. The hydrophobicity and fouling of these nano-particles can be reduced by the membranes due to these properties[71-73].

3.1 Nano-adsorbents

Nanofilters are used to remove heavy metals from variety of polluted water. Numerous metal oxides are most often employed nanoparticles for removing heavy metals from aqueous solutions. It has qualities including high BET surfaces, microporous structure, and excellent dispersion capabilities. However, particle matter and issues in removal are associated with secondary pollution. Heavy metals also alter the bioavailability, mobility, and environmental toxicity. Economic re-use and have also altered the project to solve these issues[74,75].

3.2 Nano-catalysts

In the wastewater treatment for catalyst waste water, including photocatalysis, electro-catalysis and Fenton catalysis, the usage of nanoparticles would be extremely significant. The ubiquitous use of ZnO and TiO_2 catalysts for photocatalysis was subject to decreased demand for ultraviolet light as a result of their broadband energy ga[78]p. UV light, which poses a major health concern for people, including skin malignancies and DNA alteration, is exposed in industrial applications to these materials. TiO_2 is also a possible cancer agent that might cause human pneumoconiosis and pulmonary adenocarcinoma. Since high quality water must be generated by the drinking or safe disposal business, it is necessary to build dependable materials and procedures for these needs[79,80].

Another drawback that hampers photocatalytic activity is that of different types of Nano-catalysts, such as AgBr, that can not be recycled for reuse when disseminated into this solution. At present, the focus is on the synthesis with metal oxide and semiconductor oxides composite materials for new photocatalysts for the treatment of conventional catalyst issues. The major disadvantages in the Fenton catalytic fundamental reaction are recurring catalyst loss and acidic environments. The usage of the nano-based reagent of Fenton has been used as indicated in several investigations[81-85].

3.3 Nano-membranes

The most significant advantages of membrane filtering technologies are high-quality water treatment, effective desinfection, and reduced plant space requirements. The other sorts of care tend to be exceedingly expensive and difficult to create. Using a nano-membrane separator for dyes and heavy metals is a beneficial application of this technology[86]. When it comes to environmental considerations, the production phase of nano-membranes has a huge ecological footprint. Carbon nanofibers have 100 times the lifespan of normal materials, leading to more harmful chemicals in the environment, global warming, and ozone depletion. An additional problem is that the membrane can become fouled by an accumulation of organic compounds in the water coming into contact with the hydrophobic membrane[87,88]. The risk of membrane fouling increases if the particles are disposed on the membrane surface or inside the membrane pores. Fouling the membrane reduces water flow and thus requires a chemical or mechanical purification procedure, or even a complete membrane replacement for a certain time. To alleviate these issues, the researchers focus on membrane phase with a hydrophilic polymer layer, such as polyvinyl alcohol and chitosan. Nanoparticles such as TiO_2 may also be applied to eliminate foulings and increase membranes' permeate flow[89-91].

3.4 Integrated nano-particles and biological process

The need for a high degree of technological action, specialized biological agents to handle each pollutant (nutrients, dyes, organic compounds)[92] and the balance of each microbial and nano-particle, assembled in each technology, on a large scale constitute significant constraints. Likewise, these processes take time, such as pre-treatment, with biological-processed nano-particle, wastewater algae cultivation and nanofibre matting microbial immobilization[93,94].

3.5 Nano- and Micromotors

In recent years, nano/micro-motor-driven devices have been employed to deal with environmental challenges, such as wastewater treatment and environmental monitoring. Reactive nano-based material has the potential to help change hazardous contaminants into nontoxicity. In contrast to typical cleanup agents, nanomachines have different advantages. The establishment of smaller machines increases the prospect of in situ and ex situ nano-remediation rules that seek to help the environment while also reducing expenses. Nanoscale continuous movement is particularly advantageous in transporting and discharging reactive nanomaterials from polluted samples, and in supplying essential mixing processes with reactants[95,96].

Existing technologies, as defined in polluted water treatment, are inadequate to meet the demand for scaling, so further effort is needed. Before moving into commercial implementations, such issues must be clarified[97]. For example, the multifunctional nano/micromotor life cycle is restricted to residual physical materials used in locomotive reactions or oxidation responses. Pt layer poisoning is an other downside, as waste water compounds can chemically bind to other surface-active areas of the catalyst or large waste water based on viscosity, which prevents micro-engine movement. A host of environmental therapies will be used to introduce the latest nano/micro engine development to achieve versatile and challenging operations[98].

3.6 Nanosorbents

Nanosorbents have broad characteristics, such as high sorption, which make nanosorbents better suited and more effective for water treatment. These nanosorbents are very rare in the form of consumer products, but researchers and experts are working hard to produce nanosorbents at a higher quantity/commercial level. Carbon-based nanosorbents are the most known (e.g., carbon black, graphite, graphene oxide)[99]. There were also metal/metal oxides and polymer nanosorbents. The composition of various materials such as ag/polyaniline, ag/carbon, C/TiO2, etc. is essential in order to reduce the toxicity effect in wastewater treatment. For example, dendrimer-ultrafiltration reduced copper ions. They are regenerated simply by altering the pH, showing bioconsistency, biodegradability and toxic environment.

In addition, color removal or other chemical contaminants is almost 99%. Another effective nanosorbent are zeolites with an absorbent structure that can be implanted in numerous nanoparticles such as copper[100]. Zeolites have the advantage of regulating and acting as an anti-microbial agent the volume of metals. In addition, magnetic nanosorbents play an important role in water treatment and are a novel method of extraction from water of different organic pollutants. Filtration by magnet also eliminates some organic containments. Magnetic separation nanosorbents are synthesized with magnetic nanoparticles at a certain affinity[101-103].

3.7 Nanoadsorbents for water and wastewater remediation

Traditional sorbents like activated carbons, clay minerals, chelates, and natural zeolites can, however, remove water or wastewater cations from heavy metal, but their efficiency can be reduced by certain characteristics, such as low-sorption ability[104].

3.8 Synthesis of nanosorbent materials

The manufacture of nanosorbent materials is two fundamental approaches: the downgrading process and the downgrading process. A standard approach is used to synthesize non-absorbent materials during the top-down process. Corrosion and other techniques such as mechanical alloys, reactive friction and high energy ball friction reduce particle size. The downstream process is the newest. It depends on the building of the substance behind this process: atom by atom or molecular assembly, sol-gel and chemical/physical vapor.[105].

3.9 Advantages of Nano-Engineered Adsorbent

Activated carbon, clay minerals, garbage, and biomass are commonly utilized in the decoloring of colored water. However, isolating them from the water after equilibrium is a complex, expensive, and time-consuming procedure. Exhausted materials are normally filtered and centrifuged. Filtration is both affordable and quick, whereas centrifugation is both quick and expensive[106]. The low cost, fast separation, and convenience of handling afforded by NPs benefit the manufacture of magnetic NPs. By following a cycle of adsorption and desorption, this separation process improves the adsorption capability of a given magnetic adsorbent. Recently, adsorption-capable magnetic NPs have been made utilizing abundant materials such as active carbon, biomass, farm waste, and clay minerals[107]. Addition of NPs to the aforesaid materials modifies their porosity, while also enhancing the superficial field. Magnetic NPs are used to give these materials magnetic properties so that they can be distinguished from water, which exhibits higher adsorption capabilities after several adsorption-desorption cycles[108]. Functional nano adsorbents, which have several functional groups on their surfaces, have overtaken all other types of water purification methods as the most attractive and intelligent methods. At changing pH, the color components are held firmly within functionalized NPs. For waste water cleanup, a significant number of useful nano-sized adsorbents are used[109-112].

4. Conclusion and future perspectives

Several techniques exist for remediating water and wastewater, but suitable for extracting contaminants from a supply of water. Nanoadsorbent materials have recently been used because of their unusual adsorption properties. Where the properties of the nanoadsorbent increase its use and become more advantageous in many fields than older adsorbents. Nanoadsorbent materials are also considered to be an adsorbent of the next decade, and have many practices and are very effective in the purification of water and wastewater contaminants. These technologies are quick, efficient and solid wastewater treatments by eliminating specific types of water poisons. This paper focuses on the possible impact of nanotechnology on wastewater treatment. However, nanoparticles have another fundamental aspect to make them an acceptable all-round technique: their ability to recognize and to abstain from spoiling.

Conflict of Interest

The authors declare that there is no conflict of interest

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