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Exploration of Nano-material and Thin Film Technologies for Wastewater Analysis: An Overview

VANDANA RATHORE[1]* and RAMAKANT BHARDWAJ[2]

[1]School of Engineering and Technology, Jagran Lakecity University, Bhopal, India.
[2]Department of Mathematics, Amity University, Kolkata, India.

Abstract
Nano-materials and thin films have immense potential in supporting various applications such as purifying water resources, treating water-borne diseases, detecting pollutants through sensors, and most importantly, preventing water contamination. However, providing contamination-free water for healthy living remains a challenging issue, as many parts of the world are facing severe water scarcity and pollution problems. This could lead to reduced food production, an increase in water-borne diseases, and fewer freshwater resources. Therefore, there is an urgent need for innovative approaches that can provide safe drinking water and reduce global water pollution by enhancing natural water resources and creating new opportunities. This article provides a comprehensive review of the role of nanotechnology in remedying toxic aqueous waste, focusing on three major categories of nano-materials: catalysts, membranes, and filtration. Emerging technologies such as thin films, thin film composites, thin film dryers, and hybrid membranes are discussed in detail for their potential in wastewater management. The review includes nano-photocatalysts, membranes, adsorbents, and dryers, along with an analysis of their risks and future prospects. As there are limited resources available on these techniques, this overview aims to provide maximum coverage and promote further advancements in existing technologies.

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Introduction

The treatment of wastewater is critical for protecting public health and the environment, as untreated wastewater can lead to the spread of disease, pollution of waterways, and harm to aquatic life. Wastewater treatment is the process of removing contaminants from wastewater, including domestic sewage and industrial wastewater, before it is

CONTACT Vandana Rathore drvandana@jlu.edu.in School of Engineering and Technology, Jagran Lakecity University, Bhopal, India.

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discharged into the environment. The sewerage processing generally has the following treatment stages.

Prefatory Process

This stage involves the removal of large objects and debris such as sticks, stones, and rags using screen and grit chambers.

Foremost Process

This juncture is mainly used for elimination of settle able and turbidity through sedimentation and skimming. The contaminants are endorsed to settle, and the solids that settle to the bottom are removed instantly.

Subordinate Process

This phenomenon is used for the removal microorganism and nutrients by using biological processes. The wastewater is mixed with microorganisms in aeration tanks, where the microorganisms consume the organic matter and convert it into carbon dioxide and water

Advance Treatment

This operation utilizes the removal of any remaining pollutants and disinfection of the wastewater using advance technologies (nano-materials and thin films). Various methods are used for tertiary treatment, including sand filtration, carbon adsorption, and chemical disinfection using chlorine or ultraviolet light.

Overall, wastewater treatment plays a crucial role in protecting public health and the environment by removing contaminants from wastewater before it is discharged into the environment. Nano-material and thin film technologies are emerging as powerful tools for wastewater analysis, offering the potential for improved accuracy, sensitivity, and efficiency compared to traditional methods. This overview will explore the use of these technologies in wastewater analysis and their potential applications. Nano-materials exhibit exceptional characteristics specially surface-volume (SA:V) ratio, which make them attractive for use in wastewater analysis. For example, carbon nano-tubes (CNT), (SWCNTs), (MWCNTs) and activated carbon oxide have been used for the revelation of hard core rock, organic compounds, and other pollutants in wastewater. Thin film technologies involve the deposition of a thin layer of material onto a substrate. These films can be used for sensing applications, such as the detection of pollutants in wastewater. For example metal oxide thin films, including titanium dioxide ($TiO2$) and zinc oxide (ZnO), have been utilized in the identification of unprocessed compounds present in wastewater. Overall, the use of nano-material and thin film technologies for wastewater analysis shows great promise for improving the accuracy, sensitivity, and efficiency of wastewater analysis. With further development and refinement, these technologies are committed towards ensuring the safety of water resources and protecting public health in broad spectrum.

In a globalized world, commercial enterprise has been updated and highly developed. Our surroundings are packed with different types of hazardous waste discharged from human performance or industrial processes. Such venomous wastes include chlorofluorocarbons (CFCs), carbon monoxide (CO), significant metals (chromium, arsenic, cadmium, lead, zinc, and mercury), ($N2O$), organic compounds (dioxins and volatile organic compounds), and particulates. Anthropogenic activities, like coal, lubricating material, and ignition, have vast potential to change production from natural sources of water.[1] There is also pollution caused by a variety of things, such as oil spills, waste disposal of insecticides, weed killer, triazine, pesticides, and fungicide, by-products of industrial practices, incineration, fertilization, and abundant use of natural gases. In the world, twenty nine percent of all water is not treed within the glaciers and merely eight percent of its healthful water,[2] an analogy of ladle of water against a five-cubic-decimetre container of drinkable liquids. In the current interval, obtaining purified water has become an imperative subject and is relatively complicated to solve the coupled issues.[3,4]

Remediation is the procedure to take away, neutralize or minimize the aqueous adulteration which has harmful effects on the health of living organisms and simultaneously restrains the effect on ecosystems. Remediation automation can be put together mainly in three groups, explicitly (A) physicochemical (B) biological methods & (C) thermal techniques. Generally, conventional modes such as adsorption, extraction and oxidation are gradual, inefficient, and pricey, whereas the supplementary environment-friendly biological degradation is low-cost, but especially stagnant. Nanotechnology provides the facility to manage matter at the nano-scale and assemble materials in such a way that they have specific properties (size, temperature, resistance, etc.,) with a unambiguous function of nano materials.[6] Nano-materials are extremely tiny structures having dimensions (1-100nm), and the surface-volume ratio (SA:V) is very special and unique (107:1) that may be used to stimuli contaminants in aqueous pollutants.[7] The pace of advancement in nano-science could be utilized to avoid further adulteration simply by applying nano tools, advancement in industrialization processes, and importantly, by creating awareness. Therefore, the foremost requisitions of this technology in the given vicinity can be classified into three major parts as shown in the given (Figure 1). The first one is restoration: the ratio of surface area to volume is very high in nano-materials, hence they can be utilized to detect nano-contaminations as well as antibiotics in pure water. Secondly, sanctification of pollutants: the use of nanotechnology on specific structures at the nano-scale (1-100) nm for nano-materials and (100-200) nm for thin films. Lastly, detection by sensing techniques for pollution prevention techniques. By way of the speedy addition of adulterants group and their deliberation, the growth of the mechanism that is capable of indulgence and evasion when it is needed.[8,9,10]

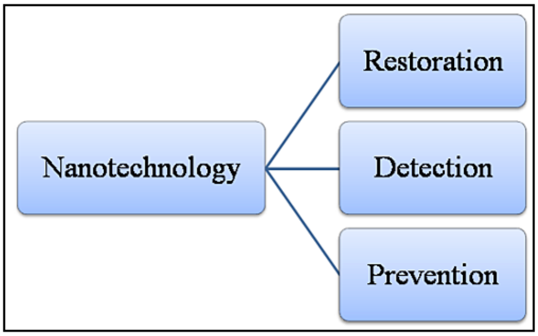

Fig. 1: Important areas of nanotechnology in waste water treatment

In this article authors are presenting comprehensive study regarding the role of nanotechnology in aqueous pollution remediation's and focused on foremost categories of nano-materials and thin film technologies their relevance in wastewater treatment. Most importantly nano-adsorbents like metal based, carbon nano-tubes and polymerization, nano-photocatalyst, nano-membranes their scope and futuristic application are discussed as shown in (Figure 2).

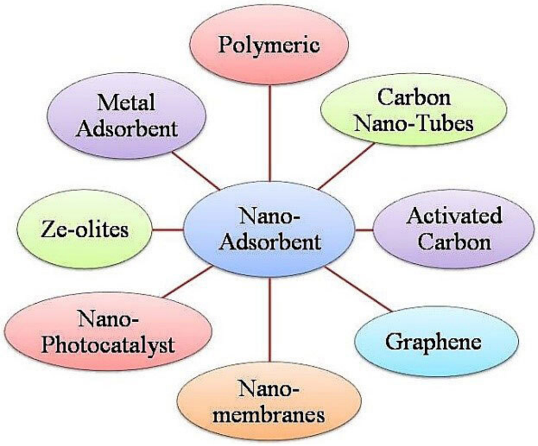

Fig. 2: Types of nano-technologies for waste water treatment

Materials and Methods

Nanotechnology for Aqueous Pollutants

The variation of tremendously advanced nanotechnology to standard system nanotechnologies gives new possibilities for improvement of superior water and wastewater technology techniques. Nanotechnology (1-100nm) simplifies the water cleansing methodology as a result of size and area, enlarging underground water sources in a very economic way.[11] The de-photo ionization techniques of exploitation nano-sized fibres as associate conductor don't seem to be solely low price, likewise further energy economical.[12] Ordinary hydrous filtering tactic use semi-permeable membranes for reverse electro-dialysis. Drop-off the pore size of the integument to the micro millimetre variation would enhance the property of the molecules allow to exceed from commencing to finish. The membranes that may still filter viruses square measure currently existing.[13] Engineering is what is more loosely employed in purification, separation, and removal processes square measure particle replace resins, that square measure untreated chemical compound membrane with nano-sized pores on the surface wherever ions square measure fascinated and changed for alternative ions.[14] Adsorption of Pollutants Sorbents square measure wide employed in aqueous adulteration and purification to get rid of organic and inorganic contaminants, for examples square measure carbon and ion-exchange resins. The utilization of nanoparticles could have the blessings over standard materials attributable to a lot of the larger expanse of nanoparticles on a mass basis. Additionally, the singularity of structural, electronic and optical properties of these nanoparticles will build them particularly powerful adsorbents. Many materials have properties that square measure captivated with size 15.

Nano-Materials for Wastewater Treatments

Nano-materials have exceptional dimension-dependent characteristics, allied to their specific surface area (SSA) being elevated, which results in strong sorption, accelerated suspension, and inflated reactivity, as well as irregular properties. These properties include super-paramagnetism, restricted surface quasi-particle resonance, development of quantum confinement effect.

The unique properties of nanostructure make them ideal for the creation of advanced high-tech substances which are utilized in more effective way for the treatment of water and contaminants. Such materials include pellicle, surface assimilation materials, functionalized surfaces, coatings, and reagents. Figure 3 illustrates the various functions of nano-materials and their applications in these areas.

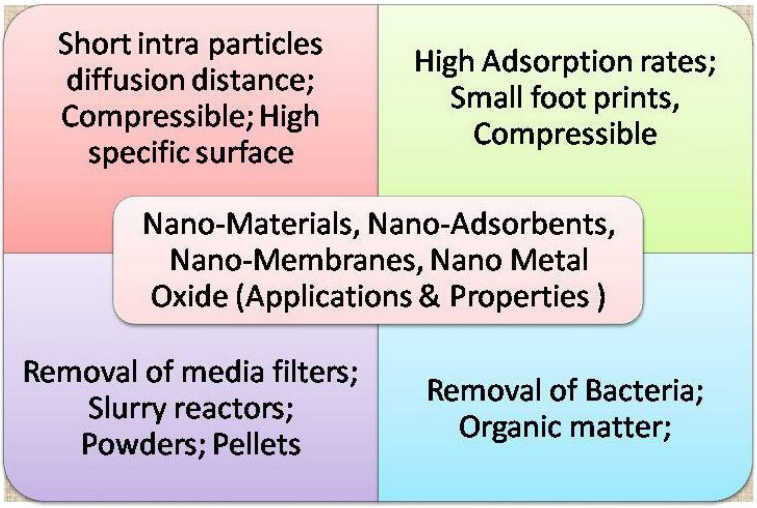

Fig. 3: Functions of Nano-materials and Properties

Result and Discussions

Nano-Materials as Adsorbents

In the current scenario, nanoparticles are being considered for their potential application as adsorbents. Present research mechanism is to investigate the following types of nano-adsorbents: carbon activated nano-adsorbents, such as carbon nano-tubes (CNTs), metal-based nano-adsorbents; polymeric nano-adsorbents; and zeolites. Gubin and Kalfa et al. have found in their work that the smaller size of nanoparticles increases their surface area, which may enhance their chemical activity and ability to adsorb.[16,17,18] Significant nano-materials used in this technology for transporting of trash metals in aqueous solutions include CNTs, activated carbon (AC), zinc oxide (ZnO), magnesium oxide (MgO), inorganic compounds such as manganese oxide (MnO), ferric oxide (Fe_2O_3), and titanium oxide (TiO2), and graphene oxide ($C_{140}H_{42}O_{20}$).[19]

Inorganic nanoparticles are oxide-based nanoparticles that are generally prepared via metals and non-metals. These nanoparticles are ubiquitous used for the elimination of harmful adulterants from liquids. There include titanium oxides,[20] magnesium oxide,[21] manganese oxides,[22] ferric oxides,[23,24] and zinc oxides.[25] Graphene exists in many different forms and has unique characteristics that make it extremely favourable for numerous environmental and wastewater applications. The main characteristic of graphene that makes it extremely valuable and suitable as a surface assimilative for the subtraction of heavy metals is its high specific surface area (0.6 m2/g), light weight (~ 0.77 mg), mechanical strength (~150 Gpa), chemical stability, and elasticity.[26,27] Furthermore, the occurrence of graphene oxide as a functional material also affects the adsorption quality, process, and their future scope.[28] Table 1 represents the comparable values and percentage of removal of pollutants along with the types of metals, pH value, and adsorbent doses. Zinc sulphide,[29] graphene,[30] zeolite,[31] and magnetic Nanomaterials have been taken into consideration as nano-adsorbents for the comparison of the removal of pollutants.[32,33,34]

Table 1: Type of absorbents and amount of removal pollutants

				Experimental Setting				
S.N	**Nano-Absorbents**	**Nano-Materials**	**Heavy Materials**	**pH**	**Time (min)**	**Absorbent does (g/L)**	**Removal Pollutants (%)**	**Ref.**
1	Zinc Sulphide	Nano-Crystals	Hg (II)	1-6	5	10	99.99	[19]
2	Graphene (GNS)/d-MnO2	Nano-Sheets	Ni (II)	NR	20	5	77.04	[20]
3	Magnet Coated Zeolite	Coated Nano-Particles	As (III)	2.5	15	0.5	95.6	[21]
4	Magnetic Nanomaterials	Nano-adsorbents	Pb^{2+}	6	10	20	80	[22]
5	Magnetic Zeolite	Cinders by products & sludge	Cadmium and Lead (II) Ion	5.49-7.48	89	5.99	>85.7	[23]
6	Magnetic Nanoma terials	(MNPs) Resorbent	Fe_2O_3 ferrites & Zn+2	5.48	89.5	2.49	>95.6	[24]

The use of nano-materials as adsorbents has several advantages over traditional adsorbents. For example, nano-materials can remove pollutants at lower concentrations and in shorter contact times, reducing the overall treatment time and energy consumption. Additionally, the high surface area of nano-materials provides a greater number of adsorption sites, which can strength the chemisorptive capacity of the material. Advance carbon resources such as fullerenes, carbonise source, activated charcoal and hierarchical-carbon are widely used due to their excellent adsorption performance for numerous toxic waste, along with organic compounds, heavy metals, and dyes. Crystalline solids analogous to titanium dioxide and iron oxide have also shown promising results as adsorbents due to their broad area of surface and surface reactivity. These materials can remove pollutants through various mechanisms such as adsorption, precipitation, and photocatalysis Despite the promising potential of nano-materials as adsorbents, there are still some challenges associated with their use. One of the main challenges is the cost of synthesis and functionalization of these materials additionally, the potential release of nano-materials into the environment is a concern that needs to be addressed. Overall, the use of nano-materials as adsorbents holds great promise for the elimination of contaminant from water and wastewater. With further development and optimization, these materials could become an essential component of water treatment processes, helping to ensure the safety and sustainability of water resources.

Nano-Materials as Catalyst

Nano catalyst plays a very important role in environmental protection and aqueous treatments. Important techniques which are used as a catalyst are: electro-catalysis and photo-catalyst. For organic compounds Fenton catalysis is used at large scale. Nano-materials which are highly considerable for purification and are gaining special attention in inorganic materials along with characteristics are shown in figure 2. Nano-catalysts are distinctive in nature and are used for wastewater treatment such as photo-catalysis, electro-catalysis.[35] and catalysts typically consist of a solid support material, such as activated carbon or silica, that is functionalized with Fe2+ ions (Fenton catalysts)[36] for improved decomposition of organic contaminants[37] and germ destroying actions.[38] In photocatalysis the extensively used Titanium (IV) oxide and Zinc oxide have experienced lot of inconvenience due to their high band gap of these materials (~3.39 eV) during ultraviolet radiation activity process, which need to be researched further.

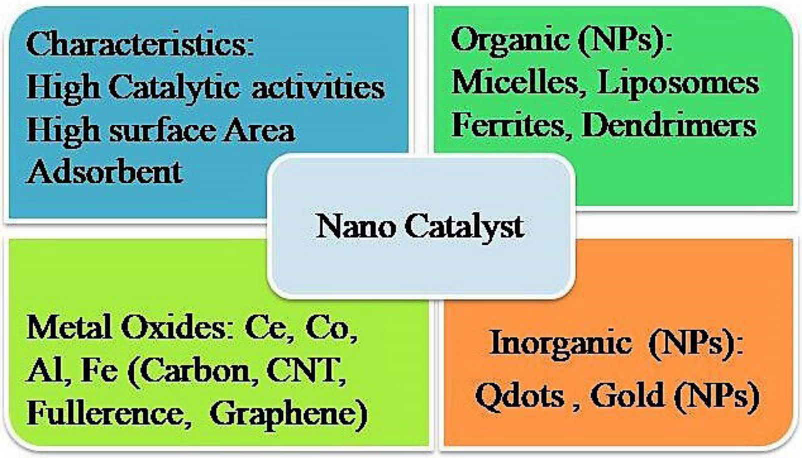

Fig. 4: Nanoparticles as a catalyst

Titanium dioxide (TiO2) (IV) is extensively used in photo-catalysis, anticipated its reactivity in response to imperceptible radiations (~k<400 nm), stability, substantial characteristics.[39] Similarly, another biodegradable material, zinc oxide (ZnO), which is insoluble in water, has been extensively studied as a transducer and photo-catalytic agent because of its distinctive photoluminescence similar to titanium oxide.[40] The separation of bands VB and CB describe energy level of considered materials and plays significant role at nano-scale atomic structures i.e. (forbidden energy gap) in cadmium sulfide (CdS) is ~2.42 eV, making it an appropriate semiconductor that can operate at a wavelength range of ~<495 nm.[41] CdS nanoparticles have received intensive attention as a photo cathode for managing and purifying industrial pigments in sewage.[42] Although titanium, zinc, and cadmium oxides are popularly acknowledged for their photocatalytic activity, they exhibit functional characteristics only under the ultraviolet range up to a wavelength range of [100-400 nm]. Importantly, due to the broad superlattice hetero-structured energy level ~[3.2-3.65] eV in titania, additional amendments are required for optimal catalytic analysis and to enhance their activities under visible light spectra stretching around [340-700 nm] for the degradation of natural aqueous pollutants. Figure 4 represents the scope of nano-catalysts in organic and inorganic nanoparticles. The effectiveness of various nano-catalysts for treating aqueous pollutants, their outcomes, conditions, and types of contaminants are represented in Table 2.

Table 2: Type of Nano-catalysts for finding aqueous impurity

S.N.	Catalyst	Spectrum	Status	Pollutant	Outcome	Ref.
1	TiO2 (tri-titanate)	Ultraviolet spectrum region	quantity ~1 g/L, interval ~2 h	Chemical Compound and dye C4H12CIN	Dilapidation competence achieved up to 90%	[33] [34]
2	Silver Bromide /Zinc Oxide	~410 nm Visible region	Dose 1 g/L, pH 6.85 Irradiation of sample 240 mins	Methylene blue (MB)	Confiscation of MB ~87%, decomposed by silver bromide/ zinc oxide	[35]
3	Semicon ducting ZnO nano-rods	~370 nm Ultra violet spectrum region	Catalyst quantity 1 g/L, for 45 min	RhB	Improved photo -catalytic degradation of RhB	
4	Zero-valent nano Copper	Visible light spectrum [380-700]nm	Catalyst dose = 0.16 g/L, for 80 min	$C_{14}H_{14}N_3NaO_3S$ (MO)	Process of irradiation was used to degrade methyl orange ~ 82 minutes and efficiency up to ~36%.	[36]
5	ZnO–FeO clino-ptilolite	Electrom agnetic radiation solar rays	pH=8.3, mechanism dose = 0.1 g/L	Polluted Fish pond water	Approx 80-85% efficient	[37]
6	Graphene-CoxZn1-x Fe_2O_4	Radiations from the zone of visibility	Concentration of Methylene blue (60 min) = 5 mg/L, vehicle dose 7=100 mg/L	Methylthionine chloride	Compared to cobalt doped zinc ferrite nano particles,the photo-catalytic efficiency of grapheme -cobalt doped zinc ferrite hetero-structures was found to be higher.	[38]
7	3D SnO2	Ultra violet region ~[100-400] nm	Measured value =1.99 g/L, interval =2.52 h	spell =2 g/L, interval =2.5 h	Irradiation of sample up to 160 min, degradation of methyl orange may be achieved by 85%	[39]

TiO_2 and silver bromide catalyst are effective in removing chemical compounds and dyes up to 90%.[43,44] ZnO nano-roads have improved photo catalytic degradation of RhB compound.[45] Catalyst used for removal of methyl orange (MO),[46,49] fish pollution,[47] methylthionine chloride,[48] catalyst used are respectively ZnO-FeO, graphene and tin Oxide. Nano-materials have shown great potential in catalyzing reactions with high selectivity and efficiency, reducing reaction time and energy consumption. One of the most significant advantages of using nano-materials as catalysts are their surface area compared to volume is quite high, authorize for a greater number of active sites, enabling the catalytic reaction to occur more efficiently. Additionally, the tunable surface chemistry of nano-materials allows for the optimization of catalytic activity and selectivity. Due to their exceptional photo-catalytic properties, catalysts such as titanium dioxide, iron oxide, and zinc oxide have been studied extensively. These materials can catalyze reactions under visible or ultraviolet light, making them suitable for applications such as water treatment and air purification. The unique electronic properties and high surface area of carbon found materials, such as grapheme oxide and grapheme nanoplateles, have demonstrated encouraging outcomes as catalysts. These materials can catalyze reactions such as hydrogen evolution and oxygen reduction. Despite the significant advantages of nano-materials as catalysts, there are some challenges associated with their use. One of the primary challenges is the cost of synthesis and functionalization of these materials. Additionally, there may be concerns about the potential environmental impacts of these materials, especially if they are released into the environment. Overall, the use of nano-materials as catalysts shows great promise for improving the efficiency and selectivity of chemical reactions, reducing reaction time and energy consumption, and enabling the development of sustainable and environmentally friendly processes.

Nano-Materials as Membranes

Membranes play a very important role in waste water treatment. In addition, Nano filtration is a membrane filtration technique, synthetic structures where size of pores is approximately ~0.5-15nm, particularly used for wastewater treatment and usually known as nano-materials membranes.

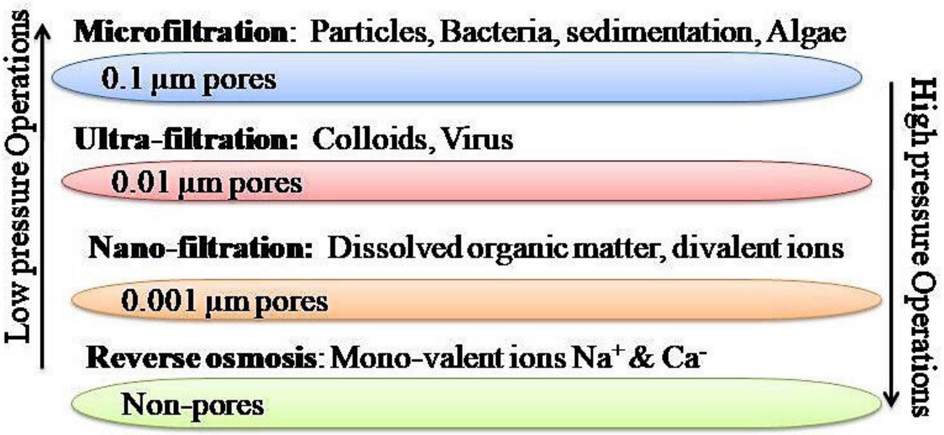

Fig. 5: Different types of nano-membranes

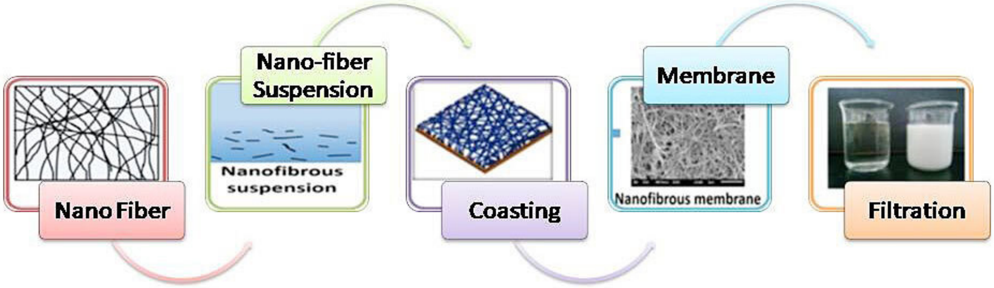

Fig. 6: Process of filtration for Nano-materials as membranes

Nano membranes are found very efficient for eradication of different types of contaminants mainly obtained from textile industry includes blue and red dyes. They have also found efficient for removing heavy metals like Co, As, Cr, Ni etc.,.[50] Figure (5, 6) represents different types of membranes and process of filtration. Along with the existing advance wastewater handling procedure, thin flexible tissues filtration technology made-up by Nano-materials known as membranes is one of the most scientific approaches due to its valuable properties.[51] Nano membrane technology have many benefits due to its quality of treated water, highly disinfection ratio, acquiring less space for plants specially in for the use of irrigation and agricultural areas.[52] Furthermore, it is very much economical, resourceful and comfy design compared to other techniques for water treatment.[53] Particle filtration of liquid adulterants are novel membranes (1000 - 0.0001) microns and plays fundamental responsibility in the chemical disintegration of organic fouling materials.[54] The One-dimensional structures of nano-materials encompass nano-tubes Carbon nano tubes (CNTs), Single wall carbon nano tubes (SWCNTs) like honeycomb structure, (NR) nano-ribbons (1D, 2D), and nano-fibres (synthetic polymers) are the compositions of these types of membranes made up from different nano-material have been found potential application in waste water treatments at very crucial stages.[55] Under high pressure carbonaceous nano-fibres (CNFs) fabricated membrane showed exceptional selective filtration and removal efficiency in aqueous pollutants.[56] The authors have reported the use of electro-spun membranes for the transportation of heavy metals contaminated with substances such as As, Ni, Cd, Cu, and Cr.[57] Moreover, a review and competence of a variety of nano-membranes for treatment of adulterated water along with type of pollutants, nano-membrane efficiencies, prominent results and important remarks are presented in Table 3 by the author. With the help of nano-membranes microorganism,[58] lubricants,[59] Amputation,[60] metal oxides,[61] Total Suspended Solids,[62,63] and degradation of dairy effluents[64] can be removed up to 90-100%.

Table 3: Type of nano-membranes for investigation of adulterants in water

S.N.	Nano-Membranes	Core Material & Major Pollutants	Efficacy	Result	Ref.
1	Nano-membrane	c-alumina and titania nano-crystallites Pathogens and pigeons	Microorganism up to99% & pigeons 25%	Elimination of ions may be improved by pH corrections and pathogens can be removed 100%.	[48]
2	Microstructures of nano scale	(PBM) Polymer Membranes	99.75% of lubricants	Coupling of nano-filtration and floatation eliminates grease in	[49]

		Propylene Oil removal		aqueous purity, de-emulsification, augmented; weight absorption and adsorption capacity is high due to its porous structure.	
3	Polymer Composite Membrane with Polyvinyl Alcohol Layer, CNT	Macro-molecule membranes Treatment of adulterated water with lubricants	Amputation up to 94.9%	Incorporation of CNT with polymer composite augment suitability of membrane, definitive tensile strength & toughness, amplified CNT concentration increases membrane flux.	[50]
4	Carbon nano-fiber membrane	nanoparticles and metal oxides	Removal up to 95%	Involuntarily well-built and malleable membrane, tolerate filtration with high pressure, knack to manufacture cost efficient nano-rods by electro spinning	[51]
5	Nano-porous membrane filtration	Total Suspended Solids, Total dissolved solids, Biological contaminants, lubricants, COD, BOD	Removal of adulterants up to TSS 99%, lubricants 80-90%, amount of oxygen, dissolved 76% & TDS 44%	Most favourable situation, feed temperature ~450C, velocity ~1.3 m/s, salt concentration ~11.2 g/L, trans-membrane pressure of 4 bar & pH 10, utilization of treated water for cultivation purposes .	[52]
6	Micro-filtration membrane (ZrO_2)	(CH3)2NC(O)H Pre treatment of dimethyl formamide (DMF)	Opaqueness 99.6%, (TSS) Total suspended solids 99.98%.	The process of removing fine particles of TSS and recovering flux can be accomplished through a combination of ultrasonic cleaning, chemical cleaning, and flushing in DFM.	[53]
7	Nano fiber membranes as photo-catalysts	Milk products vanished in technological cycle	Removal up to 75–95%	The use of nano-materials (AgTiO2) incorporated into nano-fiber membranes is crucial for the photo- catalytic degradation of dairy effluents.	[54]

A membrane is a thin layer of material that separates two or more substances, and it is commonly used to filter, purify, or separate different types of substances. Nano materials that are used as membranes include graphene oxide, carbon nano-tubes, nano-porous ceramics, and polymeric nano-fibres. These materials have been used in various applications, such as water filtration, gas separation and drug delivery. In conclusion, nano materials have the potential to be highly effective as membranes due to their small size, unique properties, high selectivity, and efficiency.

Nanotechnology and Threats

Nanotechnology has a plethora of potential uses and has seen rapid advancements. However, it also has the potential to unintentionally harm human health and the environment. Materials that are non-toxic in their bulk form can become highly toxic at the nano-scale. This is especially concerning if these particles enter the food chain or drinking water supplies and do not biodegrade, as they can cause various diseases in humans upon intake. The Royal Commission on Environmental Pollution (RCEP)[65] and the European Union[66] acknowledge the potential risks associated with some nano-materials based on laboratory tests. However, research on the toxicity and health risks associated with nano-materials is currently limited and requires further exploration.[67] This is a challenging task since monitoring the vast volume of diverse nanoparticles being produced and used and their subsequent impact is difficult. While the effectiveness of using nano-materials in water treatment has been demonstrated, the technique's drawbacks need to be examined, as nano-particles may release harmful gases or particles during preparation and treatment that are highly toxic and can accumulate for years, posing significant risks to health and the environment.

However, there are also some challenges associated with the use of nano-material and thin film technologies for wastewater analysis. For example, the synthesis and functionalization of these materials can be complex and time-consuming. In addition, there may be concerns about the potential environmental impacts of these materials, especially if they are released into the environment.

Health Risks

The small size of nanoparticles makes them potentially hazardous to human health. They can easily cross the threshold and through oneself into different parts of the body, liver, lungs, absorption through the skin and accumulate in organs and tissues, potentially leading to health problems such as lung damage, cancer, and neurological disorders.

Ethical Concerns

The use of nanotechnology raises ethical questions, such as the potential for human enhancement, surveillance, and privacy concerns.

Security Risks

Nanotechnology can also be used for malicious purposes, such as developing new weapons or spy devices, which could pose a threat to national security.

To address these potential threats, researchers and policymakers must work together to develop appropriate safety guidelines and regulations for the development and use of nanotechnology. This will ensure that the benefits of nanotechnology are maximized while minimizing potential risks to living organism, the ecosystem and national security

Conclusion and Future Aspects

There is a growing need for advanced water treatment technologies to ensure the provision of high-quality drinking water, mitigate micro-contamination, and enhance industrial production through the implementation of versatile water treatment systems. Nano-particle materials, such as nano-adsorbents/zeolites, nano-metals, photo-catalysts, and nano-membranes, hold promise for developing novel water technologies that can be easily customized to meet specific customer requirements. However, a major technical challenge associated with using nano-particle materials in water treatment is that they are often not adaptable to large-scale processes and are currently not cost-competitive with conventional treatment technologies. To overcome this limitation, further research is needed to develop nano-catalysts that are minimally toxic to the environment and reduce the health risks to living organisms.

Further work is required to reconsider the effect of toxic chemicals on biological organisms (eco-toxicity) prospective for all new adaptation in nano-catalyst and for existing nano-technology with zero toxicity. In spite of that nano-particles put forward huge potential for novelty in the upcoming decades in purification of adulterated water but in particular for distribution of functions and powers decentralized treatment systems, location based devices, size dimensions, cost and heavily degradable pollutants play a crucial role for further development. Novel findings of the present work may be concluded as follows.

Zn Sulphdie Nanomaterials acts as good absorbents may remove pollutant up to 99.99 % including heavy materials form the pollutants. Nano membranes are effective to investigate and remove microorganisms, pathogens and lubricants from the water pollutants up to 100%.

Nano catalyst are helpful in removal of chemical compound specially dyes up to range of 90% with the help of tri-titanate.

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