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Conventional and Advanced Nanotechnological Approaches for Wastewater Treatment

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Abstract

The industrialization, urbanization and economic growth have placed a much higher demand of clean water and energy worldwide. The human activities have constantly been contaminating the reservoirs of fresh water which as a result, has triggered a global challenge to keep up the demand and supply of the fresh water for an optimal human survival. Wastewater effluents generated through commercial and industrial activities have been released to the freshwater resources either directly or indirectly. The severe contamination of the drinking water has resulted into generation of growth abnormalities and serious health implications including diseases like hemorrhage, nausea, irritation and ulceration of skin, dermatitis etc. among others. The stagnant bodies of the waste water usually serve as the breeding ground for the malarial parasite and several other species of mosquitoes which unleash severe diseases including dengue, yellow fever, and chicken guinea in tropical and subtropical countries annually. An effective management of the wastewater is the need of the hour to combat these situations. In this review, we have compiled the conventional as well as advanced nanotechnological based wastewater treatment methods which would provide an overview of the technological intervention in wastewater management.

Keywords: Wastewater Effluents; Water Pollution Sources; Human Diseases; Conventional Wastewater Treatment Methods; Advanced Nano technological Approaches for Wastewater Treatment

Introduction

As per World Water Development Report 2020 of the United Nations, the 3.6 billion populations (47% of total world population) were suffering from water scarcity and this number would further increase up to 6 billion by 2050. Reduction of water resources, increasing water demand and water pollution are some of the major challenges observed due to uncontrolled growth of population and high industrial growth. Utilization of earth's resources in dwindling way and urbanization has further exacerbated these challenges. According to a report, approximately 85% of the total sludge produced in China was being dumped into water bodies inappropriately [1]. Textile industry is known as a major pollutant of water bodies which releases chemical effluents containing dyes, organic matter, toxic chemicals, detergents, and salts among the industrial wastes [2]. These industrial effluents have been deemed responsible for different types of chronic diseases including cancer and represent serious threats towards environment, aquatic organisms and human health [3,4]. Conservation of natural water resources, wastewater treatment, and recycling of the wastewater are some of the practical approaches to adopt to overcome the challenges of water contamination and scarcity. Generation and effective execution of policies and guidelines for conservation of natural water resources would be helpful to cease the ongoing deterioration of the water resources. One of the major challenges in this approach would be addition of the extra cost associated with wastewater treatment. Recovery of precious materials, nutrients, energy and water is the only way to compensate the cost of wastewater treatments.

This review article has described the pollutant status along with the challenges related to the available and emerging technological advances to combat the alarming situation of water resources. The article focuses on the major sources of water pollution (e.g. textile, sewage, dairy, beverages, tannery, pharmaceutical wastewater effluents etc.) and their treatment methods. The integration of advanced technology available today would be the way forward to secure a sustainable recycling plan for meeting an ever increasing demand of clean water and energy in modern times.

Major sources of water pollution

Utilization of water was increasing continuously at the rate of 1% per year since the 1980s which was driven by a combination of economic and social developments and population growth. At this rate the global domestic and industrial water uses will increase up to 20 to 30% by 2050. After using water for industrial or domestic's applications, a large amount of discharge or effluent is generated and added into water bodies without treatment. We must first understand major sources of water pollution in detail for devising effective water treatment options. Different sources of water pollution are mentioned in Figure 1.

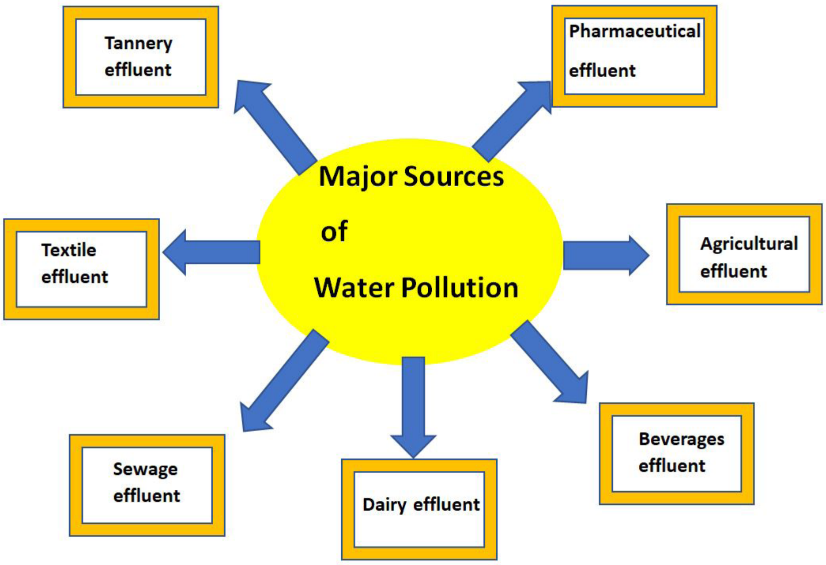

Figure 1: Major sources of water pollution

Textile effluents

Demand for reactive dyes in textile industries has increased from 60,000 tons to 178,000 tons since the year 2004 [5]. The large production of textile dyes is based on market demand but their release in the environment without treatment has caused serious issues for human and animal health. As per an observation of Pagga and Brown, daily processing of 12-20 tons of textile dyes produces almost 1,000-3,000 m3 of waste water [6]. This textile effluent contains different types of organic toxic chemicals, nanoparticles [7], detergents, dyes, and salts [8]. These toxic materials made textile wastewater most polluting agent which poses major threat to the human lives (in form of different disease like hemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis) as well as to the aquatic environment (in form of high biochemical oxygen demand (BOD), chemical oxygen demand (COD), reduce light etc).

Sewage effluents

As population and urbanization increased, annual sewage sludge production has also been increased up to 10 million tons for Europe, 20 million tons for China and 49 trillion litres for USA. Currently, China dumps approximately 85% of its total industrial sludge into water bodies without treatment [1,9].

Dairy effluents

With an overwhelming increase in human population globally, the demand for milk and milk-based products has also increased which as a result, flourished the dairy industry [10]. India stands first among largest milk producing countries with 94.5 million tones annual production of milk (Reference). Approximately 4 - 11 million tons/year of dairy waste is generated globally which then is released into the environment without treatment. A recent study has demonstrated the implications of such practices on the human health and ecosystem biodiversity (Reference).

Beverages Industrial effluents

The population growth and urbanization have resulted into industrialization of Asian and South American countries, alcohol production from sugar molasses are among major industries in these continents. Global production of alcohol from cane molasses was evaluated to be more than 13 million m^3/annum. During alcohol production a dark brown organic effluent known as spent wash is generated in quantity of 12-15 times the volume of the main product. The spent wash requiring high demand of COD and BOD added into water without treatment has posed serious environmental threats for terrestrial as well as aquatic animals.

Tannery effluents

The tannery industry belongs to one of the most polluting industry. Globally, every year 300–400 million tons of heavy metals, solvents, toxic sludge and other wastes were discharged in form of tannery effluent into aquatic environment [11]. According to a study's, tannery effluents could carry large amounts of leather coloring agents, sodium chloride, sulphates, various organic and inorganic substances, toxic metallic compounds, different types of tanning materials and putrefying suspended matter [12]. Mismanagement of tannery wastewater effluents could damage the normal life of water bodies and land surface [13]. Leather can absorb only 20%

chemicals in tanning process and the remaining amount is discarded in form of tannery wastewater effluent. Alkaline pH, large amount of organic matter, suspended solids, organic nitrogen and ammonia are the components of tannery effluents [14].

Other effluents

After using pesticides by farmers, they became integral part of soil/water bodies and harmed to ecosystem [15]. Presence of chemicals like urea, nitrate, sulphate etc. in agricultural effluents were major cause for algal blooming, eutrophication and river/pond toxicity.

Effluents from pharmaceutical drug industries were also major concern for modern society. In India, Patancheru, Hyderabad, a well-known pharmaceutical drugs manufacturing hub, was evaluated in the year 2007 for their large amount of pharmaceutical industrial effluent and their impact on local people's health and found more concentration of drugs in their body as compare to normal person [16]. Industrial drug effluent generating companies were not only harming local people but also presenting danger towards aquatic organism [17].

Wastewater Treatment Methods

Different wastewater treatment methods were mentioned in Figure 2 and their pros and cons were mentioned in Table 1. Based on their development, wastewater treatments methods could be categorized into two major categories: 1. Conventional treatment methods and 2. Advanced nanotechnological approaches.

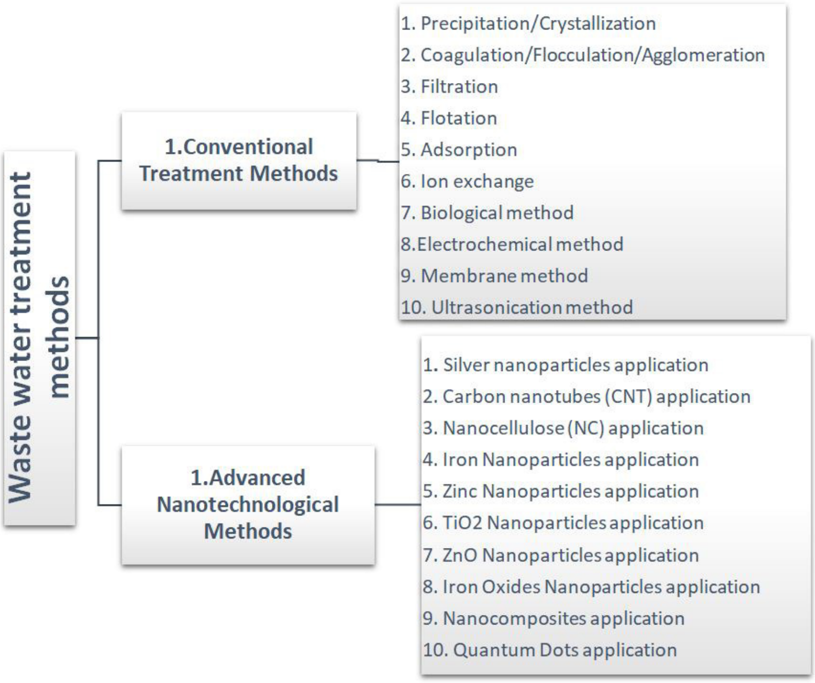

Figure 2: Waste-water treatment methods

S. No.	Treatment methods	Pros	Cons
1.	Precipitation/ Crystallization	Simple and economical process Very efficient for metal separation Fluoride toxicity can also reduce Significant reduction in COD	Chemical consumption, Monitoring of pH, Ineffective at low concentration for removal of metal ions, Handling and disposal problems for produced large amount of sludge
2.	Coagulation/flocculation	Simple procedure, Cost effective method, Efficient method for reduction in BOD and COD demands, Capable for removing organic carbon from polluted water and enhance sludge settling, Rapid and efficient method for removable of non-soluble pollutants. Availability of plenty commercial chemicals in market as coagulant and flocculent	Requirement of chemical as flocculant and coagulant, Non reusability of chemicals, Increased sludge volume generation, monitoring of pH
3.	Flotation	Useful for removing small size or low-density particles from polluted water. This behavior is very useful for pulp and paper industrial effluents, Selective process and require less retention period. Efficient in primary removal of metal and metal compounds	Selectivity depend on type of pH, Initial energy and capital cost are high,

S. No.	Treatment methods	Pros	Cons
4.	Biological methods	No costly chemical requires, require only microorganism, Microorganism play a major role in biodegradation of complex organic pollutant, Process is simple, economical and attractive Single or mixed culture of organism can be used to degrade pollutants, Effective in removal of ammonia, dark color, iron, complex compounds and organic matter, BOD and COD also reduces	Optimum growth medium and their favorable conditions needed like optimum temperature, pH etc. Survivability and maintenance of microorganisms require, Slow process due to involvement of live microorganism, Difficulties in non-biodegradable dye degradation, Require good knowledge of microbial enzyme kinetics for this process
5.	Adsorption/filtration	Technically simple and fast method, Availability of wide range of commercial products, Excellent ability to separate a wide range of pollutants, Effective in reduction of BOD and COD demands, Addition of coagulation can enhance efficiency of this method for removal of suspended solids and color, Turbidity, fluoride and suspended solids removal possible through this method	Non-selective and costly method Type of material play a major role in performance Saturation and clogging of reactors are common in this method, Replacement of adsorbing material is not cost-effective process.
6.	Ion exchange	Relatively inexpensive and efficient for metal removal, with suitable resins we can separate different types of metals and pollutants, Well-established and tested technique, Easy to use, control and maintain, In combination with other technique like precipitation and filtration efficiency can be enhance, Batch and continuous operations possible, High reusability, rapid and efficient process, Recovery of valuable metals possible.	Initial cost is high due to selection of different types of resin for different pollutants, High Regeneration time and maintenance cost, Rapid saturation and clogging problem of reactors, Performance depend on pH, Fouling smell is common problem due to pollutant and require some physicochemical pretreatment process, In presence of strong oxidative materials matrix can easily degrade
7.	Electrochemical	Efficient and rapid technology as compare to traditional coagulation, Drinking water treatment possible, Recovery of valuable metals (silver, platinum, copper, gold) are possible through this technique, controlling pH is not compulsory, Increases biodegradable nature of pollutants, pH control is not necessary; Economically feasible and very effective in removing different types of pollutants like oil, suspended and dissolved solids and metals, dyes etc.	High investment requires due to involvement of electrodes, High maintenance and choking problem of porous electrodes, Pos-treatment require, in case of high deposition of metals on electrodes, Generation of flocs, Generated sludge adds additional cost to treatment
8.	Membrane filtration	Well-known separation and mechanisms, No chemicals required, Removal of toxic compounds like phenols, cyanide, zinc etc. Availability of wide range of commercial membrane products, Simple, rapid and efficient, even at high concentrations. Low solid waste generation. Eliminates all types of dyes, salts, microorganisms, suspended solids and dissolved inorganic matter. Produces a high-quality-treated effluent	High energy, maintenance, operation and Investment cost Requirements, Variable design of membrane filtration systems, Choking and fouling problem of membrane filter is common, Selection of membrane is depending on the specific application
9.	Ultrasonication	Easy maintenance, Methane yield increases in case of pretreatment of sludge, Low cost pretreatment method	High cost and energy requirement, Selection of ultrasonication frequency is depend on the type of application, Unsuitable for lignocellulosic biomass

Table 1: Pros and cons of wastewater treatment methods

Conventional Treatment Methods

Conventional methods like precipitation, crystallization, coagulation, flocculation, agglomeration, filtration, flotation, adsorption, ion exchange, biological, electrochemical, membrane methods are disused here.

Precipitation: Removal of metallic cations, anions such as fluoride, cyanide, and phosphate, organic molecules like phenols and aromatic amines and detergents/oily emulsions were reported through precipitation or crystallization methods. The techniques require low capital cost and simple in operation (D. Biver and A. Degols, 1983). A role of pH for precipitation of lignin from the solution was mentioned by De los Santos Ramos *et al.* in the year 2009 [18]. Removal of calcium fluoride, nickel, detergents and oily emulsions were also reported through this technique. Impurities suspended solid particle size distribution and pH had major role in crystallization kinetics and the phase transformation in wastewater treatment process.

Removal of phenols/aromatic amines through phenol oxidase/horseradish peroxidase enzymes, phosphate through chlorinating agent/ polycarboxylic acid/phosphonates, heavy metals (copper, chromium and lead), addition of alum/sodium aluminate and toxic compound like Cyanide were based on precipitation technique. Pros and cons of this method were mentioned by Crini, and Lichtfouse in the year 2019 [19].

Coagulation/Flocculation/ Agglomeration: Coagulation, most popular physico-chemical method for the treatment of industrial wastewater was mentioned by Carvalho *et al.* in the year 2013. This removed finely divided non-settleable solid particles, especially colloids, by aggregation into larger particles through the destabilization of the electric double layer. As per Sarkar *et al.*, floatation occurred due to disruption of particulate matter of wastewater by addition of chemical coagulant [20]. Application of this coagulation method for the treatment of textile wastewater was reported by Lin and Lin in the year 1993 [21].

Application of this technique for dairy industry for reducing COD demand was also reported by Dyrset, Lystad, & Levine [22]. Application of coagulation technique with $FeSO_4$ and H_2O_2 compounds, for the removal of fat (upto 80%) from dairy wastewater was reported by Vlyssides *et al.* in the year 2012 [23]. Justina *et al.*, described the role of natural coagulant like tannin for the treatment of dairy wastewater effluent [24]. Recently, ferric chloride, anionic organic polymeric dispersant, polymeric aluminium ferric sulphate and cationic polyacrylamide coagulants were also reported for effective removal of turbidity (98%), COD (87%) and suspended solids (99.5%) from wastewater effluent [25].

Filtration: Filtration can be done through conventional cheese cloth or through commercially available different size of filters. This technique can be more effective in combination with precipitation or coagulation technique because after formation of precipitants, filtration process becomes easier. Example, addition of magnesium oxide powder in wastewater effluent for the effective removal of heavy metals. Recently, scientists achieved high phosphorus, iron and manganese removal from wastewater effluent through combination of both filtration and precipitation techniques.

Flotation: When acid or base is mixed with wastewater effluent than scum formation incident takes place and that process known as flotation. Chemical flotation method take place in presence of chemical agent and accelerates the floatation process [26]. Chemical oxygen demand (COD) reduction upto 20% through application of efficient ozone flotation system was also reported [27]. According to Miranda *et al*, instead of single chemical system, hybrid chemicals system would be more useful for the removal of silica or organic matter from the wastewater effluents. [28]. Due to technological advancement, now online monitoring of flocculation technique through computer mode is also possible [29]. Paper industries had been using this approach for optimization of dissolved air floatation systems [30].

Adsorption: Physical process for removal of pollutant from water effluents is also possible because of large surface area and high affinity for the pollutant. As compare to soils, sediments and other organic matter, activated carbon had higher adsorption capacity and capable for removing 54 to 97.4% organic pollutants. The effectiveness of activated carbon for removal of organic materials in paper industry water effluent had been reported in the literature [31]. Combination of modified clay and activated carbon for cleaning of real textile effluents through adsorption method [32] and application of biofilm for adsorption and biodegradation of water pollutant [33] were also reported in the literature. As per author Bellebia et al, electrocoagulation just after adsorption process was also more effective approach for the removal of wastewater pollutants [34].

Ion exchange: Ion exchange is also very effective technique in removal of turbidity or high molecular weight organic pollutant from wastewater effluent through application of various cations or anions. Application of suitable anion exchangers for removing higher molecular weight organics from pollutant water is known as ion exchange technique. Application of both ion exchange resins and activated carbon were effective for the treatment of paper industry effluent [31]. Combination of microfiltration & electrodialysis with ion exchange technique was also reported for removal of 95% salt and 90% lignin from paper pulp industry effluent [35]. Biosorption of uranyl ions through pelletized Rhizopus species in a packed bed reactor was also investigated.

Biological method: Environmentally and cost-effective method based on microorganism and plant species (hydrophytes) is suitable for both wetland and dairy wastewater effluent treatment. Anerobic method was more effective as compare to aerobic biological treatment method [36]. Biological methods were adopted for the treatment of dairy waste effluent [37], pond system (*Chlorella* spp.) and industrial wastewater (Duckweed) [38]. Degradation of recalcitrant compound (in real textile effluents) through biological method was also reported [39]. Currently, cost effective and environment friendly biological methods were used by different countries like Italy, Canadá, Ireland and Argentina [40].

Electrochemical method: Electrochemical method is one of the fast and reliable method for the treatment of wastewater. In this method, electromotive force (emf) generated between two electrodes is responsible for travelling of pollutant ions according to their charge towards respective electrodes. Advantage of this method over coagulation was no use of chemicals [41]. Electrocoagulation method used to treat wastewater through suitable combination of aluminum/iron electrode [42]. Combination of electrocoagulation with adsorption on granular activated carbon was more effective as compare to individual method for the removal of oxygen demand from paper mill wastewaters [34]. Application of UV light in presence of TiO_2 promised for the effective removal of dark color of the textile dye effluent [43]. Chatzisymeon *et al* reported the use of titanium–tantalum–platinum–iridium anode for the treatment of real textile effluent [44]. Removal of metal ions, oily content, suspended solids and colour from different types of wastewater effluent were also reported through this method [34].

Membrane method: Removal of 66% COD and 30% color through homogenization decantation and membrane method was reported Buscio in the year 2015 [45]. A polyamide hollow-filter membrane and a composite spiral-wound filter membrane were used by scientist for the treatment of coal-liquefaction wastewaters. According to Brik *et al.*, 87% color removal from mixed textile effluent possible by application of membrane-based bioreactor technology [46].

Ultrasonication method: Recently, ultrasonication method, based on ultrasound waves frequency is also emerged one of useful technique for microbial decontamination and for the removal of pollutant from wastewater effluent (Figure 3). Although, ultrasound frequencies range vary between 20 kHz to 10MHz, but most useful frequency range lie between 20 kHz and 350 kHz. This frequency transforms low-energy or low-density sound waves into high-energy or high-density collapsing bubbles and produced transient acoustic cavitation [47]. Ultrasound cavitation effect can breakdown down the large complexes or particle size into smaller particle size which further accelerate the process of separation of toxic chemicals or pollutants from wastewater effluent [48]. Studies of ultrasonic extraction for heavy metal determinations was carried out for industrial and environmental cleaning applications [49]. Frequencies above 50 kHz are commonly used for cleaning and removal of small particles from wastewater effluents.

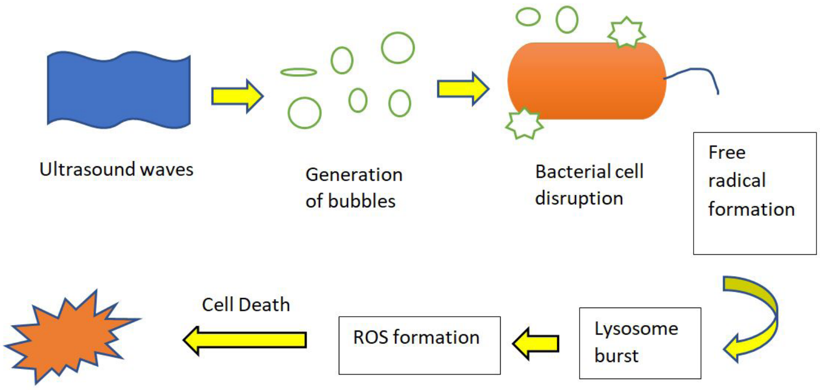

Figure 3: Schematic representation of microorganism killing through Ultrasound waves

Advanced nanotechnological approaches for wastewater treatment

Due to large surface to volume ratio, nanomaterials application for wastewater treatment is feasible and efficient method. Removal of organic matter, salt reduction, and killing of microorganisms, reduction in COD and decolorization of the polluted water was achieved through application of advanced nanotechnological approach technique.

Silver nanoparticles: Sine ancient time silver was well known for antimicrobial agent and now a day its nano form is also come into picture for killing various pathogenic organisms in effective manner [50]. High toxic nature of the nanoparticles had wide applications against various microorganisms like bacteria, fungi and viruses [51]. Adhere to cell membrane and increase the permeability of cell, damage to cellular DNA and generate free radicals were some of popular mechanism for killing microbes through silver nanoparticles in wastewater [52]. Silver nanoparticles embedded filters were cost effective and efficient in wastewater treatment. Silver nano embedded porous concrete pebbles were able to remove maximum microbial load within 4 minutes contact time [53]. Recently, application of cement-silver nanocomposite concrete pebbles were used for the treatment of contaminated water and achieved 99% removal of microbial load as shown in Figure 4 [54].

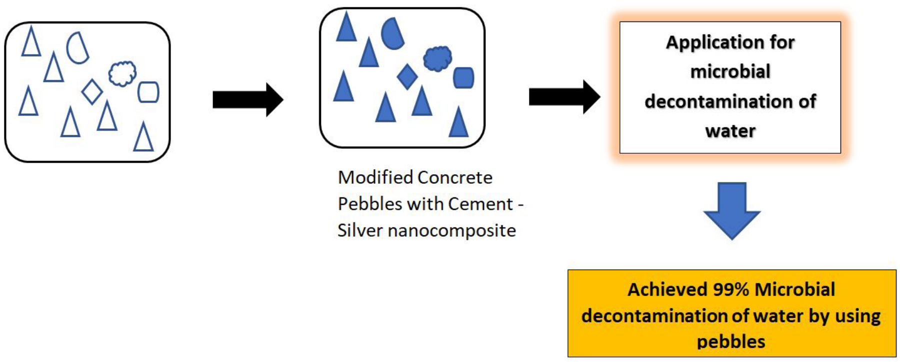

Figure 4: Schematic diagram of application of modified concrete pebbles for water decontamination

Carbon nanotubes (CNT): A role of carbon nanotube was recognized in the field of wastewater treatment due to its unique features like large surface area, fast kinetics, adsorption capability of wide range contaminants and good selectivity for pollutant through functionalization techniques. When graphene sheet rolled into cylindrical form with 1nm diameter was known as SWCNT [55]. Multiple layers of concentric cylinders with a spacing of about 0.34nm between the adjacent layers were known as MWCNT. Application of both types' nanotubes were in trend for removal of dichlorobenzene, ethyl benzene, dyes and divalent ions (Zn^{2+}, Pb^{2+}, Cu^{2+}, and Cd^{2+}) from polluted water [56]. Composite of CNT and iron oxide was good choice for the removal of chromium with advantage of easily separating out from water via an applied external magnetic field. Composite of carbon nanotube nanomaterial and powdered orange peel-based strips was also used for the removal of textile dye from contaminated water at pH 10 as shown in Figure 5. This system offered an economical, user-friendly, efficient and reusable adsorption treatment for the removal of dyes from wastewater [57].

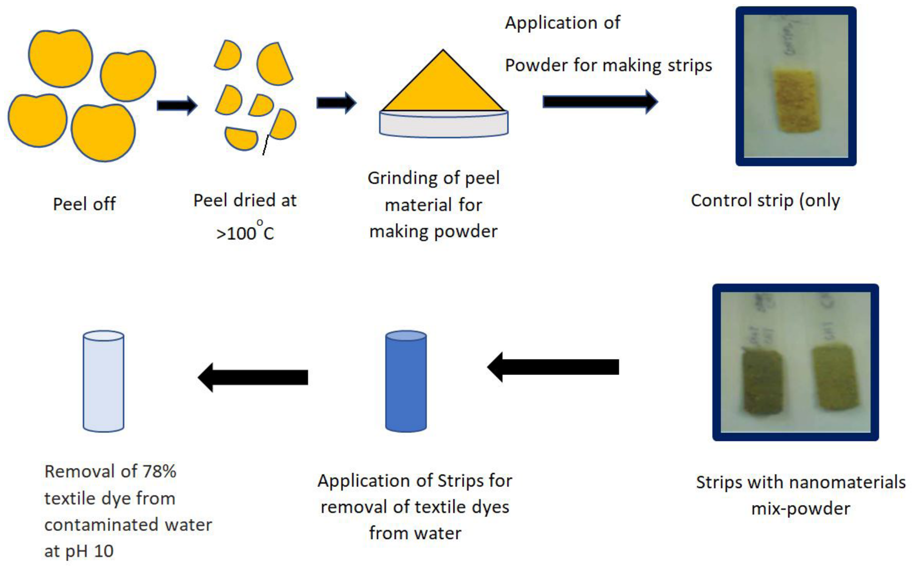

Figure 5: Preparation of orange peel powder strips and their application for the removal of textile dye from water (Schematic presentation)

Nanocellulose (NC): Cellulosic material is well known for their absorbing properties and which further enhance through nano-composite preparations. A composite of silver nanoparticle and nanocellulose were used for removal of dyes, heavy metals and microbes [58]. In this system, they achieved removal of 99.48% Pb (II), 98.30% Cr (III) and 99% microbial load (Figure 6). Polyaniline-impregnated nanocellulose (PANI-NC) composites was also reported for the treatment of wastewater (Figure 7). Recently, carboxymethyl nanocellulose stabilized nano zero-valent iron was also efficient for the 100% removal of Cr (VI) [59,60].

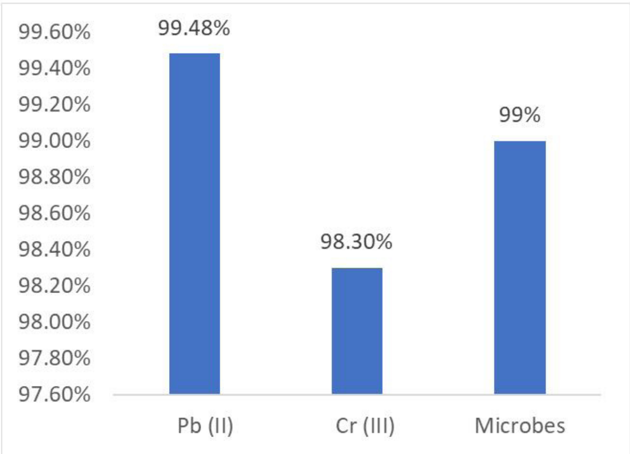

Figure 6: Removal of Heavy metals (Pb and Cr and Microbes from water with Nano-cellulase (NC) based system

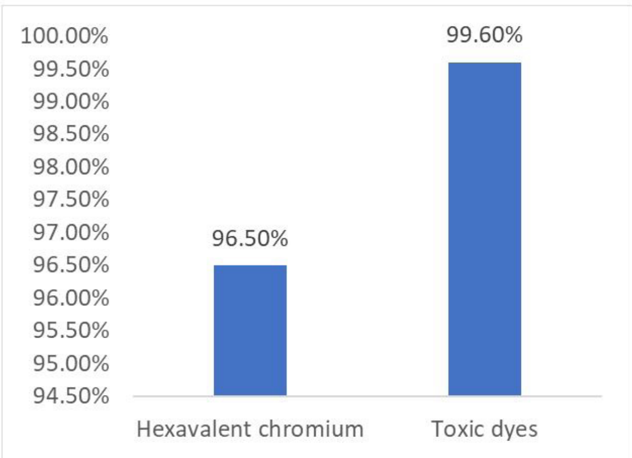

Figure 7: Removal of Hexavalent chromium and Toxic dye from water with polyniline-impregnated Nanocellulose (PANI-NC)

Iron and Iron Oxides Nanoparticles: Extremely small size, strong reducing power, good adsorption properties and large surface area of nano zerovalent iron nanoparticles were some of them charterstics character which make them suitable choice for the removal of contaminants from polluted water. Wang *et al.* found $Fe(OH)_3$ as a suitable and effective agent for the removal of Cr (VI) [61]. Application of iron nanoparticle for the removal of phenols, metalloids, phosphates, radio elements [62], organic compounds, heavy metals [63] organic dyes and halogenated nitro compounds [64] had been also reported in the literature.

Iron oxide nanoparticles were available in different forms like Fe_3O_4, α-Fe_2O_3 and γ-Fe_2O_4. Due to high stability, cheap and effective adsorbent nature their application for removal of heavy metal from waste water is very well known [65].

Zinc and ZnO Nanoparticles: Reduction rate of zinc was higher as compare to iron nanoparticles which was result into high degradation rate of water pollutant like for CCl_4 and octa-chloro-dibenzo-p-dioxin (OCDD). OCDD, well known toxic water pollutant is efficiently degraded into lower chlorinated congeners through the zero valent zinc nanoparticles in favorable condition [66]. In favorable conditions, CCl_4 water pollutant degradation rate is high in presence of nano zero valent zinc nanoparticles as compare to nano zerovalent iron.

Zinc oxide nanoparticles showed strong oxidation, environment-friendly nature and good photocatalytic properties as compare to TiO_2 nanoparticle and this made them suitable choice for wastewater treatment [67]. ZnO nanoparticles had a capability to adsorb broader spectrum of solar radiations as compare to other semiconducting metal oxide [68].

TiO_2 Nanoparticles: TiO_2 nanoparticles have high photocatalytic activity (in presence of UV light), good economic value and high photo-chemical-biological stability [69,70]. The photocatalytic properties of TiO_2 nanoparticles were very useful for killing wide range of microorganism in contaminated water [71]. Due to poor selectivity, application of TiO_2 for removal of large kind of water pollutants were in trend like for arsenic, cyanide, chlorinated organic compounds, polycyclic aromatic hydrocarbons, phenols and heavy metals [72-74].

Nanocomposites: A role of nanocomposites had been increased from last few years for the removal of various water contaminant like metal ions, textile dyes, herbicides and pesticides [75]. Membrane fouling minimized or stopped by additions of nanomaterials-based nanocomposites [76,77]. It means, we could incorporate or add properties like antimicrobial, photocatalytic, and catalytic into membrane through application of specific type of nanoparticles-based nanocomposite material for the wastewater treatment purposes [78].

Quantum Dots: Recently, application of quantum dots for detection and removal of micro size pollutant from waste water emerged as economical, fast, reliable and efficient method [79]. These bind to target pollutant in the contaminated water and emit fluorescence in a ratio of equal to amount of the target pollutant [80]. Finding and quantification of tetra bromo bisphenol pollutant and para-nitrophenol pollutant from contaminated water were done with the help of Mn-doped ZnS quantum dots [81] and graphene quantum dots respectively [82]. In foreseeable future, applications of quantum dots will definitely increase for environmental pollution problems and this will revolutionize the world economy [83-85].

Conclusions and future prospects

As country's economic growth increased, load on natural resources is also increased and consequence of this, water, air and soil pollutions problems come into light. Conditions became worst in those countries where proper infrastructure and waste management practices were not available. Mostly industries like textile, dairy, beverages, tannery, pesticides, pharmaceutical, agricultural etc. are situated on water coastal region or in dense population areas. Result of this water, air, soil pollution problem generates, and human suffered from different types of chronic disease (dermatitis, nasal septum perforation, failure of respiratory system, lung and nasal cancer etc.) which ultimately obstruct the development of nation. To overcome from aforesaid problems, we require knowing accurate source of pollution and accordingly selection of proper wastewater treatment method. Efficiency of the methods can be further enhancing through directional innovative research and implementation of government strategies and policies.

Currently, we had various physical, chemical and biological methods for the treatment of wastewater, but selection of the appropriate method is totally depend on the requirement of set of conditions for the pollutant treatment. Every pollutant treatment require different set of conditions and this further limit the expansion of water treatment process in poor countries because it add extra cost to final company's product. Recovery of precious materials, water, and energy can compensate the cost of wastewater treatment. Currently, nanotechnological approaches is also into trend for reducing the cost and increasing the efficiency of wastewater treatment which have already discussed in detail in the current article. For future studies, we must do optimization study of currently available wastewater treatment methods and further doing continuously deep research and innovations for the discovery of new economical, low tech and user-friendly methods.

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