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A Review On Advancement In Waste Water Treatment

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Abstract:

Each and every individual has a fundamental right to clean and safe water. Despite the fact that water covers three-quarters of the Earth's surface, only 3% of it is fresh. 2.5 percent of the world's fresh water is trapped in glaciers, polar ice caps, the atmosphere, and heavily polluted soil; or it rests too deep beneath the earth's surface to be removed at a reasonable cost. Fresh water is only available in 0.5 percent of the Earth's surface. Currently, millions of people in many parts of the world lack access to sufficient water to meet their basic needs. Furthermore, rising population, increased industries, urbanization, and intensive agricultural practices have polluted the water as well as generated a lot of effluent. Because it includes dangerous diseases, this poisonous water has killed millions of people. Traditional wastewater treatment procedures have a number of drawbacks, including the usage of chemicals, the generation of disinfection by products, time consumption, and cost. Various revolutionary approaches, such as nanotechnology, microalgae, and the Floating Treatment Wetland system (FTWs), are effective, eco-friendly, natural, energy-saving, and cost-effective wastewater treatment methods. The combination of wastewater treatment and energy production to provide reclaimed water and sustainable electricity is a very promising strategy for dealing with the energy crisis and fresh water constraint. This hazardous water has killed millions of people since it contains harmful diseases. The use of chemicals, the formation of disinfection by products, time consumption, and expense are all disadvantages of traditional wastewater treatment techniques. Various novel technologies to wastewater treatment, such as nanotechnology and the Floating Treatment Wetland system (FTWs), are effective, eco-friendly, natural, energy-efficient, and cost-effective. Combining wastewater treatment with energy production to produce reclaimed water and long-term electricity is a viable solution for addressing the energy problem and fresh water scarcity.

Keywords: wastewater treatment; nanotechnology, industrialization, urbanization, Floating Treatment Wetland system, eco-friendly, reclaimed, sustainable pathogens.

Introduction:

Earth is known as a blue planet because water covers around 70% of the planet's surface. Saline water accounts for 97.5 percent of total water, with fresh water accounting for the remaining 2.5 percent. Water that is both clean and safe is a necessary component of a successful society and economy [1]. Water quality has been steadily deteriorating as a result of rising population, expanding industrialization, urbanization, and widespread agricultural operations, which is a severe problem [2–4]. Around 1.2 billion people do not have access to safe drinking water, 2.6 billion people do not have access to basic sanitation facilities, and children die as a result of unsafe and dirty water[5,6]. Every year, nearly 1.8 million children die from diarrhoea, which is caused by drinking contaminated water[5,7]. Nanotechnology is defined as the manipulation of matter at the molecular and atomic levels to produce a new structure, device, or system with improved electrical, optical, magnetic, conductive, and mechanical properties [8–12].

Nanotechnology is being investigated as a potential wastewater treatment solution.

Because of their unique qualities, such as their small size, vast surface area, and simplicity of functionalization, nanostructures are efficient catalysts and redox active media for wastewater purification. Heavy metals, organic and inorganic solvents, colour, biological toxins, and pathogens have all been demonstrated to be efficient in removing pollutants from wastewater using nanomaterials. This review study compares and contrasts the two.

Conventional Wastewater Treatment

Following are the steps involved in Conventional Wastewater Treatment:

Preliminary treatment, which eliminates large and/or heavy material, is the first step in waste water treatment. Screening and grit removal are the two stages of preliminary treatment. Using screens, the screening process removes big floating material such as wood, paper, and plastics. Following screening, grit removal is carried out, which mostly eliminates inorganic particles such as gravel, sand, and other heavy particulate matter (e.g., bone fragments, coffee grounds, and corn kernels) that settle in grit channels [14].

Around 40% of biological oxygen demand (BOD), 80–90% of suspended particles, and around 55% of faecal coliforms are removed during first treatment [18].

The biological process is the secondary treatment, and it consists of two basic aerobic processes: suspended growth and fixed film processes. The most common suspended growth system is activated sludge, which can be in the form of an oxidation ditch or a sequential batch reactor, among other things. Anaerobic bacteria transform the organic content in the wastewater into biogas, which comprises huge amounts of methane gas and carbon dioxide, in the anaerobic treatment. Water is treated anaerobically to eliminate highly organic concentrated trash. [13]. The number of stages required to treat wastewater is determined by the amount of contaminants [17].

Because of their intrinsic metabolic activity, actively developing microorganisms (single cell), mainly bacteria and protozoa, are employed to oxidize organic materials from wastewater [19]. The nitrification and luxury cell uptake processes remove certain micronutrients including nitrogen and phosphorous, as well as organic pollutants, from sewage. Through the process of eutrophication, these micronutrients are frequently used by algae and fungus for their growth, resulting in a fall in the oxygen content of the water body to which the treated water is released [20]. Yamashita and Ryoko discovered that anoxic bioreactors with various combinations of wood and iron, as well as trickling filters made of ceramics, were beneficial in one investigation. It aided in the removal of nitrogen and phosphorus through the nitrification process.

During the operational time, which was found to last over 1200 days [21], the bioreactor packed with aspen wood and iron performed better than the bioreactor packed with cedar chips and iron.

Tertiary treatment removes residual organic, inorganic materials, and bacteria from the effluent of secondary treatment using chemicals such as chlorine, chlorine dioxide, sodium hypochlorite, and chloramines, as well as UV (ultraviolet) or ozone radiation [18,20]. It is important to note that the above-mentioned stages or processes of wastewater treatment are costly to construct and frequently fail due to a lack of maintenance. As a result, advanced methods such as nanotechnology and other low-cost, low-maintenance, and highly efficient technology such as nanotechnology and other advanced methods are being developed.(Fig 1)

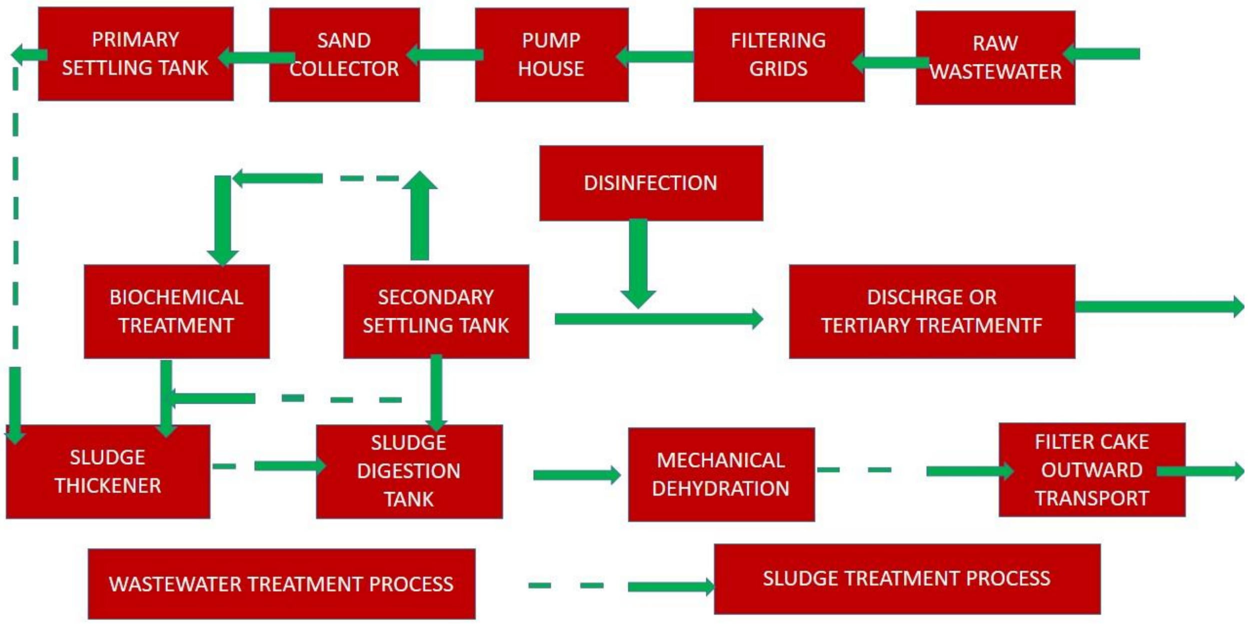

Fig 1: Flow chart of wastewater treatment by conventional method

Role of Nanotechnology in Wastewater Management

Polymeric nanoparticles (NPs), metal NPs, carbon-based nanomaterials, zeolite, self-assembled monolayer on mesoporous supports (SAMMS), biopolymers, and others have all been described as nanomaterials that could be employed in wastewater treatment [22]. Adsorption and biosorption, nanofiltration, photocatalysis, disinfection and pathogenic control, sensing and monitoring, and other nanotechnology-based wastewater treatment methods are used.

Adsorption and biosorption are the first two types of adsorption.

Adsorption is a surface phenomena in which particles adhere to the material's top layer. Under specified conditions, the substance that is deposited on the surface of another material is called absorbate, and the surface of the substance on which absorbate absorbs is called absorbent [23–25]. Biosorption is a physicochemical process in which microbial cells absorb a material.

Yang et al. looked into the biosorption of chromium (Cr) (VI) in synthetic wastewater. They discovered that Cr(VI) biosorption was pH dependent, and that the maximum Cr(VI) biosorption capacity of algal-bacterial aerobic granular sludge at pH 2 was 51.0 mg g1 (VI).

Algal-bacterial aerobic granular sludge has the highest granular stability when compared to ordinary bacterial aerobic granular sludge[30]. Similarly, Ding et al. demonstrated Rapid Th(IV) work on alginate-immobilized Aspergillus niger microsphere(AAM) biosorbent in less than 100 minutes[31]. At pH 6 and 40 degrees Celsius, AAM outperformed other biosorbents.

Nanomaterials made of Carbon

Carbon science has been explored for many years in numerous disciplines of science and technology.

Carbon nanostructures are found in a variety of low-dimensional allotropes, including activated charcoal, carbon nanotubes (CNTs), the C60 family of buckyballs, graphite, and graphene [32]. Carbon nanostructures are commonly utilised as nanoadsorbents for wastewater treatment because of their global availability, low cost, excellent chemical and thermal stability, large active surface areas, high adsorption capabilities, and environmentally favourable nature [33]. Because of its large surface area and high body, activated charcoal has been the most widely utilised adsorbent for many years.

Although their usage is limited because to their high cost, various allotropes of carbon and functionalized carbon are being investigated as nano adsorbents [34]. CNTs are massive, cylindrical carbon nanotubes.

CNTs are widely used in the wastewater treatment industry [36–38]. Tunable surface chemistry, which allows surface changes with a chemical inert nature, hollow structure, high specific surface area, lightweight mass density, high body, and robust interaction with pollutants, have given these CNTs outstanding performance as adsorbents [39]. All of these characteristics make them ideal for wastewater treatment [40]. Significant amounts of metals and ions in water pose a major threat to the environment and human health.

Yadav and Srivastava examined the surface absorption and activity of Mn^{7+} ions by CNTs and found that CNTs efficiently absorb Mn^{7+}, with UV-Visible spectrophotometric measurement revealing that CNTs reduced the concentration of Mn^{7+} from 150 ppm to 3 ppm.

As a source of Mn^{7+} ions, they used laboratory grade $KMnO_4$ [41]. Because of their low sensitivity and low cost, several forms of carbon waste nano adsorbents are used as an adsorbent for both waste treatment and disposal [42-45].

Nanoadsorbents made of metals

Heavy metals, ions, and dyes are removed from wastewater using nanometals and their oxides such as Fe_3O_4 [47], TiO_2 [48], MnO_2 [49], MgO[50], ZnO [51], and CdO [52].

When it comes to heavy metal and radioactive metal removal, nanometal oxides are comparable to activated carbon. The complexation of dissolved metals with the oxygen in metal oxides governs the sorption process [54,55]. Calcium (Ca^{2+}) and copper (Cu^{2+}) are among the ions and metals found in waste water from oil refineries. He et al. used magnetization and carboxylation of GO to create reusable nanoadsorbents based on Fe_3O_4/GO-COOH to remove such metals and ions. At 60 minutes, the nanoadsorbents removed 78.4 percent of Ca^{2+} and 51 percent of Cu^{2+}, respectively. After five adsorption–desorption cycles, the nanoadsorbent maintained high recovery rates (82.1 percent for Ca^{2+} and 91.8 percent for Cu^{2+}) and removal percentages (72.3 percent for Ca^{2+} and 49.33 percent for Cu^{2+}) [56]. For the adsorption of anionic dyes such as methyl orange, Jethave and colleagues created a nanoadsorbent made of zinc-aluminium oxide NPs doped with lead (LD/Zn-AlO/NPs) (MO). After 30 minutes, the MO removal efficiency of LD/Zn-AlO/NPs was 99.60 percent. Thermodynamic parameters revealed that adsorption is spontaneous and exothermic. In a single component system, LD/Zn-AlO/NPs showed a maximum adsorption capability of 200 mg/g for MO [57].

Nanoadsorbents made of Polymers

Compound nano composites have been the subject of much research for the development of environmental properties and wastewater treatment during the last many years. It has a large surface area for rapid remotion, increased processability, exceptional stability, cost effectiveness, and selectivity to remove a wide range of contaminants from wastewater [58,59]. Polysaccharides, such as Cs cyclodextrin, nano-magnetic polymers, valency organic polymers, and animate thing chemical compound[60,61] are cost-effective and often utilised chemical compound adsorbents. Nanocellulosics, which are generated from cellulose, have the advantages of being nontoxic, widely available, and excellent adsorbents with a simple surface modification, making them suitable for effluent rectification[62]. Preparation of lignin-derived nanoparticles has recently been introduced, and they show undeniably exceptional potential for wastewater treatment. They've been discovered to be effective at degrading colours by chemical action.

Zeolites

Zeolites are three-dimensional, crystalline microporous materials with well-defined structures made of aluminium, silicon, and oxygen in their regular framework, as well as cavities and channels within which cations, water, or tiny molecules may live [64–66]. Because of their low productivity rate, selectivity, and compatibility with the natural environment, zeolites are found naturally as silicate minerals and operate as adsorbents [67-70]. Zeolites have been employed in wastewater treatment in various studies [72,73]. Zhaoet al. created cubic NaA zeolite, a microporous crystalline aluminosilicate zeolite made up of Na_2O and Al_2O_3. Nanotubular structures extract it from natural minerals as a supply material for adsorption of ammonium ions (NH_4^+) from wastewaters. The produced NaA zeolite had a maximum adsorption capacity for NH_4 ions of 44.3 mg/g.

Nanofilters

Water filtration is the process of removing or reducing the concentration of particulate matter, such as suspended particles and microorganisms, as well as potentially harmful biological and chemical contaminants, from contaminated water in order to produce safe and clean water for drinking, pharmaceutical, and medical purposes [74]. Membrane technology has got a lot of attention in recent years, and the nanofiltration (NF) membrane is the most important innovation in membrane technology. NF membranes have a relative molecular mass cut-off (MWCO) for dead particles inside the metric linear unit, as the name implies [75]. NF membranes are a relatively new technology that is the most widely employed for the treatment of drinking water and waste products [76]. With a pressure between 5–20 bars and a pore size between 0.5 and 2.0 nm, NF is a pressure-driven membrane process that falls between ultrafiltration (UF) and reverse osmosis (RO), characterised by a high rejection of power or higher-valent ions, an occasional rejection of monovalent ions, high flux and low energy consumption compared to RO, and a high rejection compared to UF [77-81]. It's a relatively new development in membrane technology, and it can be either aqueous or non-aqueous. Because of its unique filtration process and the availability of a variety of membranes, NF is one of the most important and commonly used techniques in the field of waste matter treatment. NF can filter out almost all organic and inorganic pollutants, as well as a large number of hazardous microorganisms, from wastewater [82-84]. NF membranes are incredibly adaptable, cost-effective, and simple to get. Chemical compounds and ceramic membranes are the two most commonly used types of NF membranes. Due to their low chemical resistance and high fouling rate, the chemical compounds have a short lifespan [85].

Ceramic membranes, on the other hand, have better mechanical, chemical, and thermal stability [86].

Photocatalysis

"Photocatalysis" is made up of two Greek words. "Photo" refers to light, and "catalysis" refers to any material that affects the rate of a chemical reaction without actually being a part of it. As a result, photocatalysis can be characterised as a catalyst-driven and accelerated light-induced reaction [87]. In other terms, photocatalysis is a chemical reaction induced by a solid material (photocatalyst) that absorbs light (photons). fig 2(a)

Photocatalysis is an Advanced Oxidation Process (AOP) that uses Fenton's reagent, hydrogen peroxide (H_2O_2), UV light, ozone (O_3), or a catalyst to produce extremely intense chemical oxidants in situ. The hydroxyl radicals (•OH) produced are powerful enough to oxidise even the most resistant organic molecules [89,90].Fig 2(b)

AOPs are commonly used to remove CECs from wastewater effluent. Because of its ability to interrupt down a wide range of organic materials, estrogens, dyes, organic acids, pesticides, fossil oil, microbes (including viruses and chlorine resistant organisms), and some inorganic molecules like nitrous oxides, photocatalysis has been extensively studied by the scientific community for wastewater treatment [91,92]. When combined with filtration or precipitation, it may also be used to remove metals (i.e. mercury) present in wastewater.

Nanomaterials respond differently than heavy materials due to their mechanical, chemical, electrical, magnetic, and optical properties, as well as quantum effects, and so operate as photocatalysts, which have recently piqued researchers' interest [93-95].

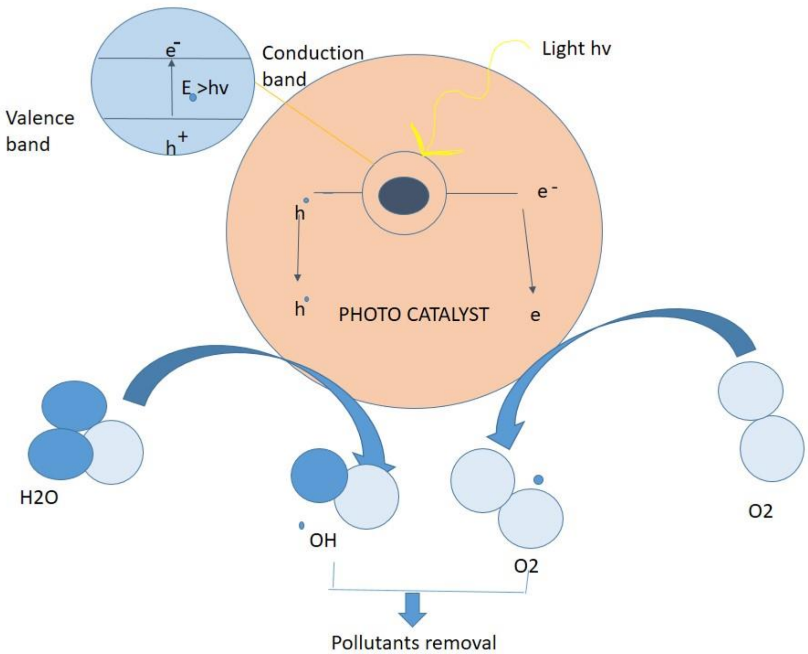

Fig 2 (a) : Photocatalyst that absorbs light(photon) and induces a chemical reaction

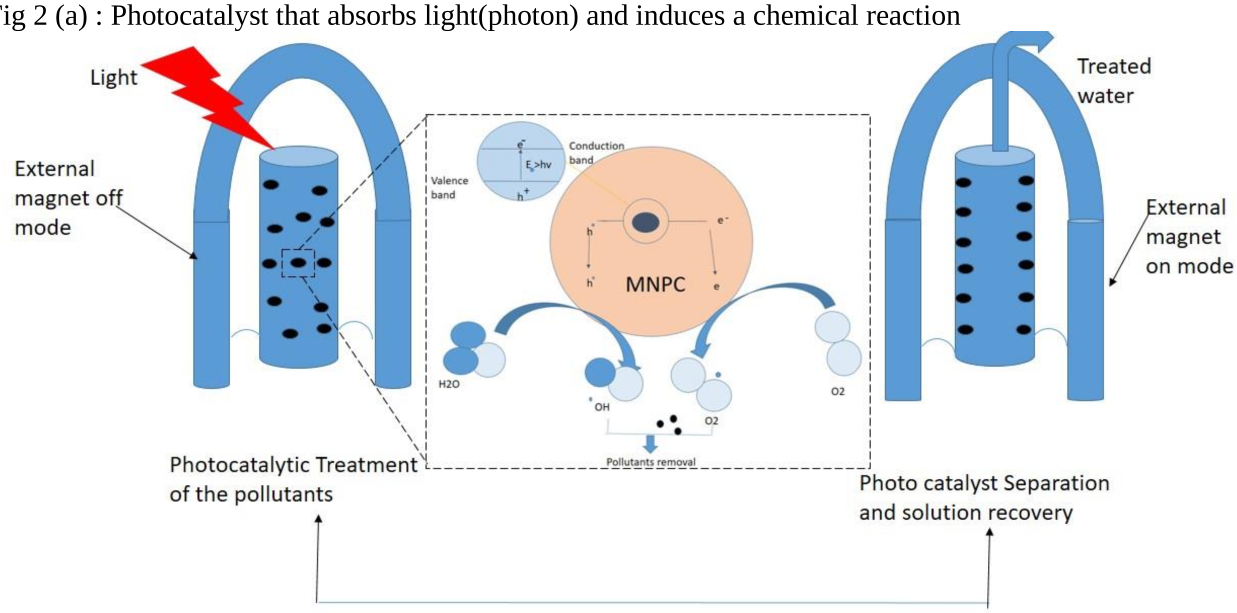

Fig 2 (b) : Pollutants removal by Photocatalysts

Pathological control and Disinfection

Disinfection is the process of physically or chemically reducing the bacteria population on the fabric's surface or bulk to an acceptable level [96]. Free chlorine, hypochlorite, chlorinedioxide, chloramines, ozone, reverse osmosis, and peracetic acid are some of the traditional disinfection procedures used for wastewater treatment [97–99]. However, because of their high energy consumption, the need for expensive equipment, and a wide range of DBPs, these techniques are limited in their application [100,101]. As a result, there is a pressing need to create effective, long-lasting, low-cost, low-effort, time-saving disinfection solutions [102]. Nanomaterials have superior functionality for pathogen inactivation in water, such as huge surface areas and specialised reactivity, which are unable to obtain using traditional approaches [103]. These nanomaterials' inactivation mechanisms include surface-based electrostatic contact and photochemical reactions, which result in the production of reactive oxygen species (ROS), cell wall breakdown, and targeted delivery of disinfection chemicals [104–107]. (Figure 5). Inhibition of infections in water is simple due to the high surface characteristics and reactivity of these nanoparticles [18]. For wastewater disinfection, nanomaterials based on Ag, CuO, ZnO, TiO2, polymeric NPs, and CNTs have been explored [109–114].

Monitoring and Sensing

Several living and non-living things (e.g., disease-causing microorganisms, municipal/industrial waste, sewage discharge, animal excrement, and heavy metals) have contaminated the environment [115]. Monitoring water quality on large and small scales can be difficult due to extremely low pollutant concentrations, as well as the complexity and diversity of wastewater matrices [116]. Fast and efficient techniques must be developed to address these difficulties. In recent years, scientists have been more interested in improving nanomaterial-based sensors for monitoring water quality. Nanosensors can be defined as devices/materials sensitive to changes in surrounding stimuli, such as heat, chemical and mechanical stress, changes in volume, concentration, and temperature, due to their wonderful properties, such as proficient recognition of trace contaminants and fast analysis[8,117,118].

Nanosensors are devices or materials that are sensitive to changes in the environment, such as heat, chemical and mechanical stress, volume, concentration, gravitational and magnetic forces, and electrical forces, and are used to transmit physical, chemical, or biological information about the behaviour and characteristics of NPs from the nanoscale to the macroscopic level [119,120]. A recognising component (nanometals, nanotubes, nanowires, NPs, and so on) is coupled to a transducer (voltammetric, amperometric, conductometric, spectrophotometric, and so on) and a display for real-time monitoring in nanosensors [121].

Methicillin-resistant S. aureus (MRSA) is a tainted antibiotic-resistant bacteria whose mecA, an MRSA ARG, has been discovered to be the source of antibiotic resistance.

Characteristics and operating parameter

Plant coverage and vegetation

Floating Treatment wetlands (FTWs) are wetlands that are essentially identical to natural wetlands, with the exception of an artificial floating raft that encourages the growth of macrophytes (Tanner et al., 2011). FTW is a wastewater reclamation system that combines hydroponic planting technology with ecological engineering to provide a long-term, low-cost productivity, long-lasting, easy-to-maintain, and cost-effective solution (Rehman et al., 2019). The term "floating emergent macrophytes treatment wetland" was first proposed by Fonder and Headley in 2010 to describe this system, but because the title was too long, it was later abbreviated to "floating treatment wetland" by Headley and Tanner in 2012. Following that, nicknames such as "built floating wetlands," "floating treatment wetlands," and "artificial floating Islands" were employed. (Van Duzer 2004);(Van De Moortel et al., 2010);(Billore et al., 2009);(Headley & Tanner, 2012);(Li et al., 2010);(Van De Moortel et al., 2010 (2019, Rehman et al.)

Characteristics and operating parameters

The type of wastewater, climate, species growth, root type and growth in terms of length and surface area, aerenchymatous nature of roots, tolerance to high pollutant levels, and ability to efficiently grow hydroponically are all factors that go into selecting plant species for the FTW system (Headley & Tanner, 2012)(Rehman et al., 2019). (Colares et al., 2020).

The following are the essential criteria to consider when choosing a plant species for a floating treatment wetland system:

1.It should preferably be native and non-invasive species. 2. It should have a habit of being both terrestrial and perennial, 3. It should be able to establish a dense and submerged root network. 4. Should have aerenchymatous roots and rhizomes to increase oxygen transport and buoyant potential, Wang et al., 2014); Tanner et al., 2011); Z. Chen, Cuervo, et al., 2016); Colares et al., 2020); Wang et al., . 5.Capable of responding to tough hydroponic conditions without displaying toxicity signs, 6. It should be able to absorb a lot of nutrients. The most commonly employed macrophytes in FTW systems are from the families Cyperaceae (Carexfasicularis, Cyperusarticulatus, C. papyrus, Schoenoplectus validus, Scirpuscalifornicus, S. lacustris), Poaceae (Paspalumpennisetum, Phragmites australis, Vetiveriazizanioides), and Typhaceae (Paspalumpenn (eg. Typhasp., T. dominguensis, T. latifolia,). Both terrestrial and halophytic plant species have the potential to be used in FTWs, according to studies. Aquatic plants, on the other hand, performed admirably and have a place in wastewater treatment, depending on plant species availability and treatment system type. Terrestrial plant species have the ability to create a vast network of habitats.

The root biofilm network in FTWs should be built so that it has the most contact with dirty water and does not touch the pond's bottom. The buoyancy, durability, functionality, size, weight, environmental sensitivity, depth of water being treated, anchoring, flexibility, and cost are all important factors to consider while developing an FTW (Headley & Tanner, 2012), (Z. Chen, Cuervo, et al., 2016). (Shahid et al., 2019). In many trials, a floatable raft made of various buoyant materials such as PVC pipes, bamboos, polyurethanes, and polyester sheets was employed. The cost, durability, strength, endurance, and ability to survive changes in environmental conditions are all determined by the materials used in FTW's construction (Colares et al., 2020).

Plants having aerenchymatous abilities, such as macrophytes, are favoured because they allow the raft to float more efficiently as the shoot length increases. The most typically employed plants have been halophytes and emergent aquatic macrophytes. The design engineering factors are also influenced by the treatment's purpose and the wastewater to be treated. When treating wastewater with a high percentage of fine particles, larger FTWs with a lower depth are preferred because they establish a dense root system that acts as a filter for fine particulate matter, whereas when treating wastewater with coarse suspended solid particles, FTWs should have a free zone with a loosely structured root network that lets water to easily flow through it, increasing coagulation of larger particles as well as pollution degradation, because the best free water zone acts as a laminar flow (Headley & Tanner, 2012). (Rehman et al., 2019). However, the amount of macrophyte cover and the density of plants on a floating raft are both essential aspects. Because by the conclusion of the growing season, 80 percent of the mat area will be covered by vegetation, the suggested surface coverage should be less than 50 percent of the mat surface (Colares et al., 2020).

Pollution removal mechanisms

Various physico-chemical and biological techniques are used to recycle wastewater in FTWs. Contaminants settling and binding in the sediment pool, uptake of nutrients (nitrogen and phosphorus) and heavy metal ions by plants, release of root exudates and extracellular enzymes from plant roots, development of microorganisms biofilm on the root surface, and enhancement of anaerobic conditions in the water column beneath the floating mat are all important processes involved in contaminant removal in FTWs.

Removal of suspended and dissolved solids

The conductivity and salinity of water are measured using total dissolved solids (TDS). Total suspended solids (TSS) displays nitrates, phosphates, carbonates, and bicarbonates of K, Na, Mg, and Ca salts, as well as organic materials and other particles. TSS are primarily removed from FTWs through physical settling, plant absorption, and filtering (Wei et al., 2020). (E. Borne et al., n.d.). According to studies, adding FTWs to water reduces TDS and TSS by a large amount (Prajapati et al., 2017)(Nichols et al., 2016). (Tanner, 1996). In the trapping, filtration, and sedimentation of suspended particles and contaminants, the plant root network is critical (Tanner et al., 2011)

FTWS's Indian status for wastewater reclamation

In 2009, Billore et colleagues used an experimental mesocosm along the river Kshipra to study Phragmitesaustralis. The results revealed TS removal of 55–60%, NH4-N removal of 45–55%, NO3-N removal of 33–45%, TKN removal of 45–50%, and BOD removal of 40–50%.

The introduction of the world's largest floating island with 3500 saplings for the resuscitation of Hyderabad's Neknampur lake by the NGO Dhruvansh has significantly improved the water quality by absorbing a high level of nitrogen and phosphorus in the lake (the Hindu, Feb 03, 2018). The FTWs were erected near the wastewater entrance point with three different cleaning layers: a floating aquatic weed layer, a Typha layer, and a Phragmites layer In 2009, Billore et colleagues used an experimental mesocosm along the river Kshipra to study Phragmitesaustralis. The results revealed TS removal of 55–60%, NH4-N removal of 45–55%, NO3-N removal of 33–45%, TKN removal of 45–50%, and BOD removal of 40–50%. (Billore et al., 2009).

After passing through these layers, polluted water is sufficiently cleaned for fish and other aquatic species to survive. In December 2019, the Dhruvansh NGO was recognised for its efforts to save and revitalise Neknampur Lake (The Hindu, 20 December 2019). The Delhi government used FTW in 2018 to manage water pollution in the Delhi Rajkori lake, and it was given the term floating purification Iceland (Times of India, December 28, 2018).

Tall plants should be avoided because they can cause FTWs to sail, drift, or sink in high wind currents.

Deciduous plants with a lot of aboveground biomass loss should be avoided since they leak contaminants into the water column even more.

Plants with a dense, fibrous root system should be chosen since they have a wide surface area for biofilm production.

Plants that can withstand high levels of pollution and anaerobic environments should be selected.

Before installation, all aquatic weeds should be eliminated, and the pond and FTW should be monitored on a regular basis to prevent their proliferation. Weed pulling should be done on a regular basis starting with FTW.

Initially, netting or plastic grids should be used to protect saplings from bird or insect eating.

NPs settle more slowly than larger particles, but their huge surface area allows them to adsorb more silt and soil particles, and their high insolubility in water (CNTs and fullerenes) allows them to be easily removed using water columns.

Photochemical transformations can be aided by light, and oxidation reduction is sometimes preferred.

Because there is a demand for clean and safe water, and because traditional methods for decontamination and purification of water generally entail chemicals and are energy and operationally intensive, engineering knowledge and infrastructure are required.

Conclusion

Nanotechnology and FTWs are two innovative waste water treatment approaches. Nanomaterials utilised in nanotechnology approach have unique qualities such high surface–to–volume ratios, high sensitivity, reactivity, high adsorption capacity, and ease of usage. However, because of their small size, nanotechnology can be transported into the bodies of humans and other aquatic animals, potentially causing toxicity. FTWs are a low-cost method of wastewater reclamation. It is an excellent example of wastewater treatment using eco-engineering technology. Durability, strength of a floating raft, its capacity to offer space for growing plant roots, and its ability to tolerate variable water currents are all important factors to consider while installing FTWs.

Both of these strategies, however, are very promising for wastewater management and have a bright future ahead of them, but they will require a serious and determined effort by the scientific community and government organisations.

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