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Review article

COMPREHENSIVE REVIEW ON PHYTOREMEDIATION OF INDUSTRIAL EFFLUENTS

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ABSTRACT

Now a days, most of the industrial bodies outlet numerous quantity of effluents that directly harms the environment by increasing pollution and reducing the availability of pure water. For controlling certain environmental aspects, government bodies have taken several steps to control the effluent outlet from industry by applying the technique named as phytoremediation that receives attention as most cost effective treatment and also act as eco-friendly that uses natural sources such as plants, algae to decrease contaminants from sediments, soil and wastewater. It also plays a major role in removing heavy metals from wastewater using various parts of plants like flower, root and shoot system, this method is commonly known as Rhizofiltration. Different parts of plants has the ability to remove 60% of toxic metals when gets contacted with effluents. Aquatic plants like algae are also infused in effluent treatment using capsulation methods. Rather than this some conventional treatment methods are also used such as ion exchange, adsorption, reverse osmosis, electrochemical treatment, chemical precipitation, etc. This paper mainly overviews the water pollution problems and describe how plants play a major role in phytoremediation by focusing on the plans that are utilised for controlling the effluent outlet from industrial bodies.

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Keywords: phytoremediation, aquatic plants, wastewater, heavy metals.

AIMS AND BACKGROUND

The amount of wastewater in India has increased significantly, causing various types of damage to water bodies, which are also considered a threat to animals, plants and other organisms. Due to this sewage, the groundwater level becomes toxic due to its abundant presence. With the rapid development of industrialisation in the 20th century, the field of science and technology will witness a vigorous development. In the past four years, Indian industry has developed rapidly. According to CPCB (1975), only 59% of the 8432 large and medium-sized enterprises in the country have adequate measures (fully and functioning sewage treatment plants (ETP)) in place to treat sewage before discharge[1]. Small businesses in the country also produce a lot of sewage, but it is still often overlooked because of the pollution. India produces 6.351 billion cubic meters of wastewater every year. Since traditional wastewater collection and treatment systems are energy-intensive processes and incur huge wastewater costs, only 23% of wastewater are mainly treated at the primary level before disposal and disposal[2]. The remaining 77% of untreated wastewater are discharged into surface water and land. Sewage treatment plants are expensive for low-cost companies and require 15–20% of the industry's annual costs. Air, water and land are the three basic conveniences. But water is more important to living things. Generally speaking, the choice of phytoremediation plants depends on the application field[3]. A large number of studies have investigated the possibility of using different types of *Sargassum* biomass (non-living brown algae) as effective bio sorbents for heavy metals such as Cd and Cu. In addition, *Sargasso* is a non-biological biomass, which can effectively capture uranium. *Salvinia* is used to treat heavy metals, dairy products and sewage from tanneries, rubber, pulp and paper, pesticides and fertilisers. Responsible for combining the phosphoryl and dicarboxylic acid groups of terrestrial plants, we have studied the rhizosphere filtration of uranium (U) by terrestrial plants, and found that some sunflower species have a high affinity for uranium and can concentrate it from the water in the roots. Uranyl ion is present in *Datura innoxia* cells. *Azola pinnata* removes some heavy metals such as iron and copper from contaminated water. Hardy plants such as wormwood or watercress have been successfully used to improve wastewater treatment.

Sustainable management of unpolluted water and aquatic ecosystems requires cheap and environmentally friendly restoration methods. Recent studies have shown that aquatic plants have the potential to remove organic and inorganic pollutants. It uses the potential of plant roots to absorb nutrients from wastewater. Plant species selected for phytoremediation have the ability to accumulate certain or broad-spectrum contaminants. Light restoration technology is more effective and economical than traditional treatment methods. Taking into account, the efficacy of *Salvinia Molesta* and *Pistia* plants in wastewater treatment, further research should be encouraged in the future[4,5].

PLANTS AS PHYTOREMEDIATION FOR EFFLUENT TREATMENT

Aquatic plants are essential in biological wastewater treatment systems because they are used for phytoremediation using root filtration, plant extraction, plant ovulation, plant degradation, or plant transformation[6]. The destruction of pollutants depends on exposure time, pollutant concentration, environmental factors (pH, temperature) and plant characteristics (species, root formation, etc.)[6]. However, it should be noted that various types of aquatic plants have been used in the process of wastewater phytoremediation and have achieved remarkable success[7]. Several scientists have studied the mechanism by which aquatic plants absorb nutrients from the sewage system. The ability of aquatic plants to absorb nutrients is used to counteract the eutrophication of lakes, ponds and wetlands. Nitrogen is one of the main causes of eutrophication and is considered to be the limiting factor for the primary growth of most freshwater ecosystems. Although in many aquatic ecosystems, large amounts of phosphorus usually cause cyanobacteria to multiply, causing environmental imbalances and a series of environmental problems. Therefore, choosing the right species of aquatic plants can significantly improve the effect of removing excess nutrients. For example, submerged plants have a high absorption capacity for phosphorus (P) and play an important role in the restoration of freshwater ecosystems[8]. However, the extent to which submerged plants retain different levels of phosphorus content in their tissues and the influencing factors remain unclear. For example, after evaluating various articles in the context of this research, we found that some researchers are willing to explicitly mention plants used for wastewater phytoremediation and their effectiveness, and some of them work on multiple floors. Plant Dick et al.[9] concluded that *Pistia* and *Eichornia crassipes* have great potential to remove nutrients from eutrophic waters, thereby improving water quality. It also showed that aquatic orchids, plagues and foxtail orchids can effectively remove nutrients from water, which has been confirmed by static and dynamic experiments.

Some experiments show that among the various advanced nutrient removal methods, the microalgae-based process is the most preferred, demonstrating the outstanding advantages of simultaneous removal of nitrogen and phosphorus, no chemical treatment, O_2 generation, CO_2 storage, and reduction of metal pollution. Authors concluded that plants of the family Zygophyllaceae, Gramineae, Hamamelidaceae, Halogenaceae and Typhaeae have high absorption capacity for heavy metals. It is pointed that the usefulness of *S. platensis* for fish water treatment and its usefulness as an agricultural fertiliser as well as *L. stolonifera* is generally regarded as an efficient plant regulator when treating wastewater containing toxic heavy metals such as lead, cadmium, and chromium. Goncalves et al.[6,10–13] concluded that bacterial microalgae consortia are often more profitable than consortia consisting solely of photosynthetic microorganisms because they are used as an alternative to secondary and tertiary wastewater treatment, while microalgal consortia is only used for wastewater treatment (as an alternative to tertiary treatment).

The mechanism of removing heavy metals includes precipitation, flocculation, absorption and exchange of cations and anions, complexation, precipitation, oxidation/reduction, microbial activity and absorption. Microalgae directly remove heavy metals from contaminated water through two main mechanisms; the first may be low-concentration metabolic-dependent absorption in cells, and the second is biosorption, which may be an inactive adsorption process. Phytoremediation is defined as the process of using plants, fungi or algae to absorb heavy metals to purify soil and water systems. Since aquatic plants can absorb metals and toxic elements from the environment or reduce their harm, people have recently paid much attention to the use of aquatic plants, especially microalgae and macroalgae[14]. Algae has many characteristics that make it an ideal candidate for the selective removal and concentration of heavy metals, including high resistance to heavy metals, autotrophic and heterotrophic growth ability, high surface area to volume ratio, phototaxis, and phytochelatin expression and potential. Genetic engineering experiments can also be related to the high concentration of pectin in the cell membrane. This can make plants have strong resistance to heavy metals, thereby increasing the extraction rate of plants. Two kinds of algae, *Thalassiosira weissflogii* and *Thalassiosira pseudonana*, have a higher affinity for glutathione substrates or metal ions due to the superior activity of phytochelatin synthase, so they produce large amounts of phytochelatin and check its ability to accumulate heavy metals such as zinc, lead, and copper. Compared with other more expensive and non-ecological methods, microalgae and microalgae's enrichment of heavy metals provide advantages for phytoremediation[15]. Through the use of genetic engineering and to create transgenic species can increase the possibility of heavy metal accumulation in algae, these species overexpress the plant chelator and metallothionein complexed with heavy metals and transferred to the vacuole to maximise plant accumulation and aquatic ecosystem. In this study, we found that some researchers are willing to specifically mention plants used for wastewater phytoremediation and their effectiveness, and some of them work on multiple floors. They concluded that the gills of *Pistia* and *Eichornia* have great potential to remove nutrients from eutrophic waters, thereby improving water. It also showed that aquatic orchids, sage and foxtail orchids can effectively remove nutrients in water, which has been confirmed by static and dynamic experiments[16]. The conclusion is that the plants of the Gramineae, Maidanaceae, Carobaceae, Typhaeae, and Salicaceae have relatively high absorption capacity for heavy metals. It shows that among the various advanced nutrient removal methods, the microalgae-based method is the most preferred, demonstrating the outstanding advantages of simultaneous removal of N and P, no chemical treatment, O_2 formation, CO_2 storage, and metal reduction. The plants of Gramineae, Zygophyllaceae, Hamamelidaceae, Typhaeae and Halofanaceae have high absorption capacity for heavy metals[17]. The benefits of *S. platensis* in fish water treatment and its use as a fertiliser for agriculture in Alabama. The stolons are also generally regarded as an efficient phytoremediation agent when treating wastewater containing toxic heavy metals such as lead, cadmium, and chromium. Microalgae flora is generally more beneficial than a flora composed entirely of photosynthetic microorganisms because they are used as a substitute for the secondary and tertiary wastewater treatment stages, while the microalgal flora can only be used for wastewater treatment (as a tertiary purification Phase alternative). Phytoremediation attempts were made to use the aquatic macroalgae *C. vulgaris* to treat textile wastewater. The results of this study indicate that *C. vulgaris* has a phytoremediation potential to reduce the toxicity of textile wastewater. *C. vulgaris* effectively reduces BOD, COD, pH, EC and TDS in 1050% concentrated textile wastewater[18].

AQUATIC HERBS AS POTENTIAL PHYTOREMEDIATION TOOL

The phytoremediation ability of two floating plants were observed in *Pistia stratiotes* and *Eichhornia crassipes* that use atomic absorption spectrophotometry to remove heavy metals in wastewater. The layered body manages to eliminate some heavy metals, and has the highest affinity for lead and copper, which are 70.7 and 70.7%, respectively. Cu, As, Al and Pb are 82.8, 78.6, 74, 73 and 73% respectively. Authors concluded that aquatic plants may be better candidates for extracting plants from industrial wastewater because of their cost-effectiveness. For each observation, the treated water from the replica was stored in a clean, dry glass bottle and immediately shipped to the laboratory for characterisation. Parameters such as pH, temperature, total dissolved solids and conductivity. The pH meter with glass electrode simultaneously uses the conductivity meter to measure the temperature, total dissolved solids and conductivity, and steel runoff before and after treatment. Ecosystem balance and ecological restoration occur naturally and help maintain the sustainability of the ecosystem. Biodiversity plays an important role in biogeochemical cycles and ecosystem balance. The human activities of developing and misusing technology lead to the development of natural resources and disturb the balance of the ecosystem. The aquatic ecosystem contains various organic and inorganic components, including heavy metals, leading to their bioaccumulation and bio enhancement. This can be solved by protecting natural resources (including biodiversity) and using their bioremediation potential. This article is a conceptual overview of studies evaluating the effectiveness of floating macrophytes in heavy metal bioremediation. Regularly assessing the system literature can effectively use aquatic plants to purify water and reduce pollution, so as to balance the ecosystem[17].

ADVANTAGES OF MARINE PLANTS

The availability and growth rate of marine plant is too fast that can tolerate the effectiveness of heavy metals by restricting the accumulation of absorption to the leaves by upholding the toxic compounds. The difference in recovery rates between AQ wetland

and HM can be explained from several aspects, including wetland type, heavy metal pollution and wetland plant type[18].

CONCLUSIONS

The heavy metals that are persistent pollutants in the environment must be completely removed before they can be completely reduced. The use of phytoremediation seems to be a less destructive, economical and environmentally friendly clean technology. Like other hyperaccumulators, aquatic plants play a very important role in recovering heavy metals from contaminated sites. Using aquatic plants in bioaccumulation (living plant biomass) and biosorption (plant biomass) can be successfully used to eradicate heavy metals. The benefits of using aquatic plants to remove pollutants are huge, because the technology can not only remove pollutants, but is also inexpensive and visually attractive, which is conducive to the sustainability of 's entire ecosystem.

Genetic engineering has increased the storage capacity and tolerance of plants, and has shown extraordinary benefits in improving the efficiency of phytoremediation. For plants, a wide range of steps have been evaluated at the molecular level, which is conducive to the genetic protection of by the transgenic method. Transgenic plants show high tolerance and ability to absorb metals, so the genetic engineering has been successful in terrestrial plants, but the genetic engineering to increase the absorption of heavy metals by aquatic plants is still in the early stage[17].

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