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Phytoremediation: A Novel review on the Efficacy of Aquatic Plants in the Wastewater Treatment

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Abstract

Wastewater causes significant environmental harm. Researchers have created a variety of approaches to address this issue.In this study, phytoremediation technology was used to remove pollutants from wastewater so that it could be used for other purposes. This technology is one of the most promising because it is inexpensive, ecologically benign, and effective at removing pollutants.Using a methodical mapping approach, the aquatic plant is treated for domestic, commercial, and municipal wastewater as part of the phytoremediation process.Additionally, a comparative descriptive approach was used for the studied variables in the exclusions where it has been found thatEichhornia Crassipes is an aquatic weed that detached NO2- and NO3- up to 93% of industrial wastewater, High CNP-content wastewater was treated using canna lilies. The removal of BOD3 (biological oxygen demand) and COD (chemical oxygen demand) ranged from 69.8 to 96.4% and 63.6 to 99.1%, respectively.In 21 days, Azolla filiculoides eliminated from municipal wastewater BOD (63%), PO43 (84%), SO42- (83%), Cl (76%), NO3- (76%), COD (79%), and EC (49%).

Keywords: Phytoremediation, Wastewater treatment, artificial wetland, Canna Lily, Azolla Filiculoides, Eichhornia Crassipes

1. Introduction

Water, without a doubt one of the most valuable natural resources on the planet, covers approximately 70% of the planet. In contrast, even though the earth contains an enormous amount of water, only 0.4% is available for consumption, the oceans and seas' 97% of the water is salty however the remaining 2.6% is apprehended in glaciers, polar ice caps, or underground.[1]

The global environment is being threatened by wastewater pollution. The problem of water pollution is getting worse. As industrialization and civilization advance, more wastewater is produced at a faster rate, endangering the ecosystem. Rapid population growth is a significant cause of this issue. As a result, the pollution level in the water bodies is constantly rising. There are negative effects on aquatic life due to the amount of waste present in water bodies. [2][3] In recent years, numerous studies have been conducted to examine aquatic life and prevent contamination of water bodies. [4] By removing both the organic content and major nutrients like nitrogen and phosphorus from wastewater, the adverse effects

of pollution from wastewater can be reduced. Water resource scarcity can be reduced and the environment can be protected most effectively by recycling and reusing wastewater. Several conventional treatment technologies for wastewater treatment have been developed. These systems, on the other hand, have larger working areas and higher maintenance costs. [5]

The artificial technology of constructed wetlands aids in the treatment of wastewater. This system contains aquatic plants in a narrow pond. The method consisting natural physical, microbial, biological, and chemical procedures for the treatment of wastewater. The distinct benefit these treatment technologies have over conventional systems is their basic construction, which requires less technical expertise to operate and maintain. [6] Eichhornia crassipes, Canna lily, and Azolla fliculoides plants were implemented in a constructed wetland for wastewater treatment. The plant has a distinctive ability to treat wastewater by engrossing nutrients and other substances from water and therefore pollution levels are toned down. Using aquatic plants, this phytoremediation method lowers the levels of organic and inorganic pollutants in industrial wastewater effluent. The Plant is useful in removing various contaminants, including metals, explosives, pesticides, and oil. [7][8][9]

In the past few decades, scientists have studied and found numerous uses for plants' capacity to remove pollutants from the environment. The most representative studies on the use of plants in wastewater treatment are discussed in this paper.

2. Wastewater

2.1. Domestic Wastewater: Residential and business wastewater must be disposed of appropriately because it contains physiological wastes produced as a result of human activities. The ability of aquatic plants to purge pollutants from residential wastewater is adequate. The treatment by water hyacinth (Eichhornia crassipes) is the most common. [10][11]

2.2. Industrial wastewater: It is industrial wastewater, which is a byproduct of productive processes including mining, farming, energy production, agro-industrial production, textile production, etc. Phytoremediation is one of the most reasonable methods for the treatment of industrial wastewater [12]. Aquatic plants can be used for the effective treatment of paper mill waste. Various contaminants, such as TKN, Mg^{2+}, PO_4^{-3}, K^+, Ca^{2+}, and Na^+ amounts in paper mill effluent, are related to micronutrients in lower contents but generate toxicity when present in larger concentrations. The growth of aquatic plants is caused by the abundance of nutrients in the pulp and paper mill. It dramatically reduces the amount of nitrogen, which is referred to as hyper-nutrient buildup.[13]

2.3. Municipal wastewater: These are home and commercial wastewaters that may be combined with stormwater runoff or with commercial wastewater that has already undergone treatment to be admitted to combined sewerage systems. Therefore, according to the source of the wastewater supply, water pollutants are categorized as either physical, chemical, or organic. These pollutants slow down biological degradation and the transmission of diseases by reducing oxygen levels. Each country, therefore, ensures that wastewater is treated to the highest standard possible. [14][15]

3. Aquatic phytoremediation plants

3.1. Water hyacinth (Eichhornia crassipes): Aquatic vascular plants called water hyacinths have rounded, upright, bright green leaves and lavender flowers that resemble orchids. It has an excellent capacity for reproduction and grows quickly. The ability of the plant to use solar energy, the nutrient content of the water, cultural practices, and environmental conditions all play a role in water hyacinth growth. This aquatic plant can handle pH values between 4 and 10; however neutral water is ideal for its growth. The use of water hyacinths for the treatment of many types of wastewater is demonstrated. [16]

Figure 1: Water hyacinth (Eichhornia crassipes) [17]

3.2. Canna Lily: The canna plant's faster growth rate and notably increased biomass production are major characteristics, which are directly associated with a nutrient application and tolerance to water strain and chemical fluctuations, production it's a suitable candidate for phytoremediation. Another study also reported a very high dry biomass accumulation by Canna lily is a potential plant for wastewater treatment. To determine the impact of various pollutants, if any, on the plant, it is also important to research how wastewater affects the growth characteristics of Canna. Therefore, the existing study originated to examine the potential of Canna lily in nutrient removal from domestic wastewater under subtropical circumstances.[18][19]

Figure 2: Canna lily [20]

3.3. Azolla Filiculoides: Lamarck created the genus Azolla in the year 1783. It has several benefits, but the one that makes it stand out as a "super-plant" is its capacity to grow in the shortest amount of time.[21] Azolla filiculoides can be used as a biofertilizer in rice agriculture. Azolla, an aquatic fern with a rapid rate of growth and productivity, will enhance the quality of treated urban wastewater. it performs to be very promising because its phosphorus deduction efficiencies (40-65 %) and heavy metal biosorption using alive Azolla (phytoremediation) as a biosorbent material are mutually comparatively new technologies for metal removal.[22]

Figure 3: Azolla Filiculoides [23]

4. Artificial wetlands

Artificial wetlands are created to store biosolids and water in a variety of settings and utilize a natural process to help remove pollutants including heavy metals, organic matter, and nitrogen load, among others. Comparing artificial wetlands to natural wetlands, various pollutants can be reduced. [24][25]
According to the hydraulic comportment, they are classified as follows:

4.1. **Surface flows Wetlands:** In these types of wetlands, aquatic plants include both emergent and submerged species. Its depth of water is 0.75 meters, however, it is 1.20 meters in the locations where water mirrors. [26]

4.2. **Subsurface Flow Wetlands:** It is specially built in the shape of a riverbed or canal and is intended specifically for the treatment of some types of wastewater or in its last stage of treatment.[25][26]

4.3. **Vertical Subsurface Flow Wetlands:** These systems involve the passage of wastewater through the substrate, which is often graveled, where it comes into contact with microorganisms that colonize the surface of both the substrate and the roots of plants.[25][26]

5. Advantages of wastewater phytoremediation

- It is low-cost Sustainable technology.
- It is effective for ex situ or in situ treatment of a variety of pollutants.
- It causes less environmental damage and fewer disturbances in the area.

6. Conclusions

Wastewater treatment with aquatic plants such as Canna lily, water hyacinth (Eichhornia crassipes), and Azolla Filiculoides is found to be potentially effective in the present study. It is a phytoremediation strategy and requires low treatment costs. Whether a discharge emanates from an industrial, home, or municipal source, its effectiveness in removing pollutants is unaffected. The findings of this study demonstrated that aquatic plants can phytoremediation wastewater to remove a variety of pollutants and nutrients, including Ec, pH, TDS, COD, BOD, DO, NO3-, PO4-3, Cl-, and SO42-. It was discovered that plants are best situated if their surroundings are adjusted to their living conditions in a horizontal or vertical flow, which would encourage the plant to expand quickly in preparation for the most noticeable removal such as Eichhornia crassipes, an aquatic weed that has an effective abstraction of nitrites and nitrates up to 93% for industrial wastewater and Azolla filiculoides which removed EC (49%), SO_4^{2-} (83%), NO3- (76%), Cl (76%), PO_4^{3-} (84%), COD (79%), BOD (63%) for municipal wastewater. This technology is accessible, efficient, environmentally friendly, and expanding quickly.

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