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Research on the Purification Effect of Aquatic Plants on Polluted Water

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ABSTRACT

Aquatic plants are an effective ecological restoration method for water purification. This article reviews the importance and role of plants in water purification, and explores their research progress in the purification mechanisms of pollutants such as nitrogen and phosphorus, their impact on water ecosystems, and their applications in water pollution prevention and control. The importance and future research directions of aquatic plants in water pollution control were analyzed based on their adaptability and biodiversity. Research has found that aquatic plants have significant purification effects and a wide range of applications in water purification. Future research can continue to delve into the purification mechanisms and ecological effects of aquatic plants, in order to promote the advancement of water technology. The importance of aquatic plants in water purification cannot be ignored and is expected to become an important means of future water environment restoration.

KEYWORDS

Aquatic plants; Polluted water bodies; Purify.

1. INTRODUCTION

With the rapid development of industry and society, the large-scale discharge of sewage has led to severe eutrophication of many lakes and reservoirs in China, and serious damage to the ecological environment. Among many measures for treating eutrophic water bodies, utilizing aquatic plants to absorb nutrients and taking them away through harvesting plants is a simple, efficient, and low-cost method. Aquatic plants can provide nutrients by absorbing elements such as nitrogen and phosphorus through their rich roots, and become a component of their own cells through lignification. The joint planting of multiple aquatic plants to form artificial wetlands is an important way to treat wastewater.

Research has found that there are significant differences in the removal efficiency of N and P by different wetland plants, and the purification efficiency of various pollutants by different plants is also different. Plant growth has a certain seasonal periodicity, with the aboveground and underground

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parts mutually promoting and constraining each other, and having different growth centers at different stages. That is, the focus of plant growth will change with the growth cycle of the plant. Therefore, in order to achieve better purification effects on polluted water bodies, further research is needed on the growth characteristics of different wetland plants and their impact on polluted water bodies. Therefore, this article aims to provide practical and feasible remediation techniques for water environment remediation by studying the purification effects of different aquatic plants on polluted water bodies.

2. TYPES OF AQUATIC PLANTS AND THEIR IMPORTANCE IN WATER PURIFICATION

2.1. Types of aquatic plants

Aquatic plants refer to plants that grow in water or moist soil, including herbaceous and woody plants. China has numerous water systems and abundant aquatic plant resources, with over 300 species of higher aquatic plants alone. The leaves of aquatic plants are soft and transparent, and some form into filaments, such as goldfish algae. Filamentous leaves can greatly increase the contact area with water, allowing the leaves to receive the maximum amount of light that is rarely available in water, absorb the very little dissolved carbon dioxide in water, and ensure the progress of photosynthesis. According to the lifestyle of aquatic plants, they are generally divided into the following categories: emergent plants, floating plants, submerged and floating plants, and wet plants. The restoration and reconstruction of aquatic plants play an important role in the steady-state transformation of freshwater ecosystems (from turbid water to clear water) and are the main measures for aquatic ecological restoration.

2.2. The importance of aquatic plants in water purification

Using plants grown in water to absorb pollutants and improve the aquatic environment is a common method for ecological restoration of water eutrophication. Many aquatic plants can still survive in polluted water environments and can play a role in adsorption and sedimentation, gradually reducing pollutants in the water [1]. Research has shown that aquatic plants have a competitive advantage over plankton in the same water environment, which can effectively prevent the large-scale reproduction of plankton. At the same time, during the growth process of aquatic plants, they can continuously absorb and absorb nutrients that cause water pollution, seize nutrients for algae growth, effectively reduce the proliferation of algae, and remove pollutants, achieving purification effects [2].

3. THE ROLE OF AQUATIC PLANTS IN WATER RESTORATION

3.1. Allelopathy

In the study of plant allelopathy, the study of plant allelopathy in terrestrial ecosystems was conducted earlier. Allelopathy and the competition of plants for light, water, nutrients, and space together constitute the interactions between plants and other organisms. The allelopathic effects of terrestrial plants have highlighted their enormous application value in guiding the sustainable development of agriculture and forestry. Compared to terrestrial ecosystems, the complexity of aquatic ecosystems results in a relatively lagging research on the allelopathic effects of aquatic plants. In fact, the number of species in aquatic ecosystems is much larger than that in terrestrial ecosystems. In addition to various aquatic plants, they also include aquatic organisms such as bacteria, fungi, algae, aquatic animals, and corals (marine). There are various relationships between them, especially the allelopathic effects of aquatic plants. Aquatic plants have different lifestyles and growth forms (some live below the water surface, while others live above the water surface), resulting in fierce competition in terms of lighting, nutrition, and living space. Allelopathy, as an effective competitive strategy, is widely present among aquatic plants. The allelopathic effects of aquatic plants include allelopathic effects between aquatic plants, allelopathic effects of aquatic plants on aquatic animals, and allelopathic effects of aquatic plants on phytoplankton. These interrelationships play a crucial role in the composition and distribution of aquatic communities in aquatic ecosystems. Among them, research on the allelopathic effects of aquatic plants on phytoplankton has attracted much attention as the degree of eutrophication in water bodies intensifies.

The research shows [3] that allelopathy generally exists in water bodies, and aquatic crops such as Alternanthera philoxeroides, Man Jianghong, and watercress can restrain Chlamydomonas reinhardtii. The inhibitory effect of higher aquatic plants on algae is reflected on the one hand in the competition for mineral nutrients with algae, and on the other hand in the release of allelopathic substances from aquatic plants to the environment to inhibit algae growth. Among them, allelopathy is a more important mechanism for higher plants to inhibit algae compared to competition. Allelopathy refers to the beneficial and harmful effects that plants have on the growth and development of neighboring plants (including microorganisms and themselves) by releasing specific secondary substances into the environment.

3.2. Absorption of nutrients such as N and P

Aquatic plants play an important role in the bioremediation of eutrophic lakes. Firstly, aquatic plants can absorb excessive nutrients such as nitrogen, phosphorus, etc. in water bodies to reduce the degree of eutrophication in lakes. These nutrients are one of the main causes of eutrophication in lakes, and excessive nutrients can lead to excessive proliferation of algae, formation of algal blooms, and deterioration of water quality. By absorbing these nutrients, aquatic plants can effectively improve water quality, reduce the growth of algae in the water, and thus slow down the process of eutrophication in lakes. The removal of nitrogen and phosphorus is mainly an in-situ ecological governance technology that involves the joint action of aquatic plants and rhizosphere microorganisms, which absorb, accumulate, or degrade pollutants in water through the metabolic activity of rhizosphere microorganisms.

Numerous studies have shown that different aquatic plants have different abilities to purify wastewater, but the removal pathways for nitrogen, phosphorus, and potassium mainly include plant absorption, precipitation, adsorption, and microbial fixation. Cai Peiying et al. [5] found that seven aquatic plants have good removal effects on NH3-N in real wastewater. The order of NH3-N removal rates by water hyacinth, long leaved Polygonum, and banana from high to low is: water hyacinth>short leaved Polygonum>banana>windmill>hollow lotus>duckweed>long leaved Polygonum>control. Except for Polygonum multiflorum, all seven aquatic plants have a removal rate of over 95% for NH3-N in domestic wastewater, and the plant system has an ideal removal effect.

Emerging plants have good removal ability for nitrogen and phosphorus, and have a good enrichment effect on heavy metal ions. They are salt tolerant and have good sewage purification effects. The representative plant reed is one of the preferred plants for aquatic plant ponds. Floating plants such as water hyacinth and duckweed have good removal effects on pollutants such as COD, BOD, NH3-N, TN, and TP in purifying petrochemical wastewater and domestic sewage. Especially, the absorption capacity of water hyacinth for toxins is even higher than that of reeds. Water hyacinth and duckweed can be selected as species for ecological restoration. The goldfish algae and foxtail algae in submerged plants have excellent purification and remediation capabilities, and can achieve good removal effects on organic matter, heavy metals, nitrogen, phosphorus, and other pollutants.

3.3. Absorption of Sediments

Aquatic plants can reduce the wind speed on the surface of soil or water, which helps with suspended solid precipitation; The well-developed root systems of some large aquatic plants provide them with a larger water contact area, which promotes the adsorption and sedimentation of insoluble colloids in the water. In addition, aquatic plants can also provide habitats for microorganisms and other organisms, which is beneficial for the health of aquatic ecosystems. Aquatic plants can reduce the wind speed on the surface of soil or water, which helps with suspended solid precipitation; The well-developed root systems of some large aquatic plants provide them with a larger water contact area, which promotes the adsorption and sedimentation of insoluble colloids in the water. In addition, aquatic plants can also provide habitats for microorganisms and other organisms, which is beneficial for the health of aquatic ecosystems.

Research has shown that wetland plants have different purification effects on water bodies with different sediment contents. With the increase of sediment content, their purification effects are correspondingly significant. Under the condition that the growth of wetland plants is not significantly inhibited, wetland plants show better purification effects on water bodies with higher sediment content. Under low sediment content conditions, the algae with the best purification effect is the goldfish algae, with a relative purification percentage of 12.08%. When the suspended sediment content in the influent is 21.76, 37.04, and 44.20 mg/L, the wetland plants with the best purification effect are the black algae, water chestnut, calamus, and windmill grass, with purification relative percentages of 28.23%, 38.94%, 43.50%, and 58.16%, respectively [6].

3.4. Oxygenation effect

The principle of oxygen production by aquatic plants is that they use photosynthesis to decompose carbon dioxide in water into oxygen and hydrogen. Oxygen is released into the air, and hydrogen is used to synthesize sugars, thus completing the process of oxygen production. During the process of oxygen production, aquatic plants require light as a source of energy, and the higher the intensity of light, the stronger the plant's photosynthesis and the more oxygen it produces. Aquatic plants can also release oxygen through photosynthesis, increase the dissolved oxygen content in water, help enhance the activity of water microorganisms, and further promote the biodegradation process of pollutants. This "green" purification method is more environmentally friendly and sustainable compared to traditional physical and chemical treatment methods.

Li Min et al. studied the synergistic purification effect of macroalgae and microecological agents on eutrophic water in aquaculture ponds. The results showed that the synergistic effect of aquatic plants and microecological agents on water quality purification was significantly better than that of the aquatic plant control group; The removal effects of different concentrations of microecological agents and aquatic plants on total nitrogen (TN), total phosphorus (TP), chemical oxygen demand (COD), ammonium nitrogen (NH4+- N), and nitrite nitrogen (NO2-- N) in water vary; The synergistic effect of microecological agents and large algae can significantly reduce the concentrations of TP, NH4+-N, and NO2-- N in eutrophic water, and control the increase of TN and COD concentrations. Research has shown that the aquatic plant microbial enhanced system is a good purification system for eutrophic aquaculture water. When the coverage rate of aquatic plants is 20%, the appropriate concentration of microecological agents added to the water is 3 × 104mL-1 [7].

4. RESEARCH ON AQUATIC PLANT RESTORATION TECHNOLOGY

4.1. Selection of aquatic plants

When selecting aquatic plants for repairing polluted water bodies, it is necessary to conduct a thorough analysis of water quality and select plants with certain purification capabilities for different water bodies. Adhere to adapting measures to local conditions and give priority to native plants growing in polluted water bodies. This can not only treat polluted water bodies but also maintain a stable natural ecosystem, avoid introducing foreign species, and reduce the uncontrollable factors that may arise from species invasion. In the long run, plants with strong adaptability, stress resistance, operability, easy cultivation, management, maintenance, and post-treatment should be selected.

4.2. Aquatic plant configuration

Aquatic plants are a key ecological group in water bodies, and submerged plants such as foxtail algae, giant catfish algae, and goldfish algae can inhibit the proliferation of algae. In planting, it is possible to choose to cooperate with them to improve water quality. Planting some oxygen producing varieties in water bodies with good water quality to improve dissolved oxygen conditions and form a stable and benign ecosystem. At present, most studies focus on selecting a single plant, but pollutants in water are influenced by many factors such as the environment. Therefore, it is necessary to study and consider using other remediation methods to avoid residual plant bodies becoming new sources of pollution, and further research is needed to find more pollution control plants [8].

5. CONCLUSION

Aquatic plant remediation technology has the advantages of low cost, low energy consumption, and low environmental disturbance, but also has the disadvantages of slow effectiveness and long cycle. Therefore, it is necessary to adopt a combination of multiple methods based on the current situation of the repaired water environment, while ensuring good economic benefits and high beautification value of the water environment, to achieve the restoration of water ecosystem structure and function, as well as biodiversity. Simultaneously considering the use and management of aquatic plants, as well as the rational allocation of species, fully leveraging the synergistic effects between aquatic plants to achieve the goal of aquatic ecological restoration.

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