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Application of *Eichhornia crassipes* on the purification of contaminated water

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Abstract. The explosive growth of water hyacinth had been a serious threat to the biodiversity of local ecosystems and the production, life and health of residents. It has become a malignantly invasive alien species in many countries and regions of the world. In this paper, biological characteristics and distribution, application in water pollution control, and application risk and control strategy in water pollution control of water hyacinth were summarized and elaborated.

1. Biological characteristics and distribution

Water hyacinth (*Eichhornia crassipes* Soml., abbreviated as *EC*) is native to South America and belongs to the genus *Eichhornia* in family *Liliflorae*, which is a kind of perennial floating aquatic plant. *EC* can be sexually and asexually propagated, but mainly asexual reproduction by stolons, and extend and spread rapidly. *EC* is mainly distributed in rivers and lakes in tropical, subtropical and some temperate regions, and can rapidly multiply and flourish in water bodies by means of clonal growth. The explosive growth of *EC* could be a serious threat to the biodiversity of local ecosystems and the production, life and health of residents. It has become a malignantly invasive alien species in many countries and regions of the world [1, 2]. In the 1930s, *EC* was introduced into China as a feed for livestock and poultry, and then began to promote planting. It has now spread to most provinces and cities in China, such as Kunming, Jiangsu, Zhejiang, Shanghai, Fujian, Hunan, Hubei, Sichuan, and southern Henan [3].

2. Application in water pollution control

Water pollution and eutrophication are global water environmental problems, characterized by rapid development, high damage and difficult management. The remediation technology for water pollution control based on aquatic plants has become one of the most effective ways in management and restoration of eutrophic waters due to its advantages of good treatment effect, low investment and operating cost, easy management and good landscape effect. In recent years, as one of the earliest and most in-depth studies, and widely used in practical ecological restoration projects, *EC* has been widely used in the pollution control and water ecological restoration, for instance, the treatment of petrochemical wastewater, domestic sewage, eutrophic rivers and lakes, landfill leachate, etc.



2.1. Removal of nitrogen and phosphorus in the eutrophic water

Aquatic plants can directly remove N and P from eutrophic water by their own tissue absorption, which plays an important role in the purification of polluted water. *EC* possesses obvious absorption, accumulation and decomposition effects on pollutants in eutrophic water, such as N and P based its developed roots, rapid growth and reproduction, and strong stain resistance. Wan *et al.* (2004) showed that *EC* has strong absorption capacity for TN and TP in water with the removal rates of 83.09% and 80.30%, respectively, compared with other aquatic plants [4]. It is shown that the ratio of nitrogen to phosphorus in the aerial part and the underground part of *EC* was more than 1, and the aboveground tissue had higher accumulation of nitrogen and phosphorus [5]. The study showed that after five months treatment of urban heavy polluted river by *EC* restoration, the transparency of the river water increased from 40 cm to 120 cm, the COD, TSS, TN and NH₃-N decreased by 70.4%, 39.6%, 49.7% and 21.8%, respectively [6]. It was possessed a good treatment effect on eutrophic water by *EC* purification system and the absorption capacity of N and P from eutrophic water reached 43.06~71.16 g·m⁻² and 8.68~16.63 g·m⁻², respectively [7].

In summary, *EC* has strong absorption capacity for pollutants in water bodies due to the developed root system and is much easily collected and removed from water body. In the low temperature season, particularly in winter, the growth of *EC* has been being in the dormant state, but still has the capacity of nutrient absorption with obvious effect. The *EC* cultivation can improve the original productivity and the purification ability of the water body and increase transparency through inhibiting algae growth and support the restoration of the aquatic ecosystem.

2.2. Removal of organic pesticides and heavy metals from contaminated water

Organic pesticides and heavy metals in water bodies are characterized by chemical stability, difficulty in biodegradation, easy enrichment in organisms, and easy to damage the ecological environment. Compared with traditional repair techniques, phytoremediation can reduce the toxicity degree of pollutants by the way of transferring, degrading or maintaining. *EC* has the characteristics of fast growth, strong environmental adaptability, enrichment for various nutrients and heavy metal elements from water, and can effectively reduce inorganic and organic pollutants in eutrophic water or sewage. *EC* also has certain research and application in the treatment of petrochemical wastewater.

For the treatment of heavy metal-contaminated water bodies, the previous physical and chemical method are not only expensive but also less effective, while the use of aquatic plants to treatment heavy metal-contaminated water bodies is an inexpensive and effective method [8]. Studies have shown that *EC* after exposed to 5 mg/L of Cu²⁺ solution for 14 days can accumulate 314 mg/kg DW Cu and the photosynthetic system has not been significantly damaged when the exposure concentration of Cu²⁺ being less than 1 mg/L [9]. Tan *et al.* (2009) showed that *EC* has a good purifying effect on Pb²⁺ solution with the removal rate of 99% by 300g *EC* [10]. In addition, the contribution of the roots of *EC* on heavy metal accumulation is much larger than that of the stems and leaves, with several tens to hundred times accumulation quantity of heavy metal than that of the stems and leaves [11]. Therefore, *EC* has great potential for phytoremediation of heavy metal-contaminated water bodies.

2.3. Inhibition the growth of algae in eutrophic water

The eutrophication and the frequent occurrence of algal blooms have become a very common water environmental problem and using aquatic plants to control algae pollution based on the allelopathy has broad application prospects, and a lot of research has been carried out. Chen *et al.* (2005) first discovered that the powder of *EC* root and its extracts had significant inhibitory effect on the growth of *Alexandrium tamarense*; It is showed that the roots of *EC* could release allelochemicals such as hydroxybenzene and destroy the structure of the algae cells through free radical reaction to achieve the effect of algae suppression [12]. It is found that five allelochemicals in the root exudates of *EC* significantly inhibited the growth of single and mixed *Microcystis aeruginosa* and *Scenedesmus obliquus* [13]. To study the allelopathy of *EC* on algae and develop a kind of effective, specific and biodegradable algicide has a good application prospect in the treatment of cyanobacteria blooms.

3. Application risk and control strategy in water pollution control

Although the use of *EC* to control polluted water has many advantages and been applied and promoted within certain range, there are some management problems and risks. Because of *EC* growing rapidly in polluted water bodies, if the growth range and area cannot be effectively controlled, some side effects may occur. Furthermore, a slight oversight in management will lead to ecological disasters, destroying ecosystem structure and reducing ecosystem service functions, resulting in huge economic loss. Therefore, in the actual project of applying water hyacinth to repair polluted water bodies, it must be properly controlled and managed.

3.1. Mechanical control

Through regularly salvage and collection by mechanical or manual means, more biomass of *ES* had been removed from the water body to achieve the purpose of improving the purification of water quality. However, the effect of mechanical control depends on the efficiency of salvage equipment and the sufficiency of manpower and financial resources and it is more effective when the coverage area is small. Due to the high cost of salvage and subsequent treatment, it is difficult to achieve large-scale effective salvage and control of *EC*.

3.2. Chemical control

Chemical control is characterized by rapid, convenient and easy to spread and apply in large areas. However, the use of chemical reagents may be harmful to the environment and may enter the body of humans and animals through the food chain. Therefore, in most cases, it is not appropriate to adopt or use chemical method for water hyacinth control.

3.3. Biological control

This method has the advantages of long-lasting control effect, environmental safety, low cost of prevention and control, but slow effect. It has been found that *Neochetina eichhorniae* has a good control effect on *EC*, but the biological control may lead to new biological invasion [14]. In addition, it is necessary to adopt scientific and reasonable methods for *EC* resource utilization to compensate for the high cost of salvaging and protect ecological environment from secondary pollution.

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