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Short Communication

Applied Phytoremediation by Maintaining Succession and Ecological Management Between Pistoia stratiotes and Eichhornia crassipes for River Water Quality Improvement in Taiwan

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- Ecological management

Abstract

Taiwan is a subtropical island, surrounded by the Taiwan Strait and Pacific Ocean; therefore, its bio-geographic isolation offers ecological advantages. However, historical factors, led to the invasion of water cabbage (*Pistoia stratioyes*) and water hyacinth (*Eichhornia crassipes*) to nearly all of the low altitude land waters on the island. These two kinds of plants expand widely very fast and have no predators on the island. The water pollution problems provide them with sufficient nutrients, leading to the deterioration of the ecological environment and blocking the river ways. After decades of pollutions, it is now hard and costly to solve the problem by normal river-cleaning techniques. From the point of view of succession, water hyacinth competitiveness is stronger than that of water cabbage; if put them into the same waters with fair competition, the water hyacinth will always be the ultimate survivor. Taking SDS as an indicator, the removal rate reached the optimal 94.1% in the stable stage. Since it is not easy to change the current human activities, such as discharging high volumes of sewage and livestock wastewater into river bodies, utilizing the competition and succession between these two species, and with regular clear management methods, we can maintain keeping their relationship during the primary succession stage, which will then improve the water quality to a certain degree.

ABBREVIATIONS

BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; SDS: Sodium Dodecyl Sulfate

INTRODUCTION

During the Japanese colonial period in Taiwan (1895-1945), in order to meet the needs of Japanese garden designs, tropical water cabbage and water hyacinth plants were introduced to Taiwan. After several decades, these two plant types are already currently distributed in Taiwan's wetlands, ponds, lakes, reservoirs and rivers [1]. Due to Taiwan's failure to complete an effective sewerage system, domestic sewage and planting mountain hillside crops make all kinds of nitrogen, phosphorus and other nutrients which reach the reservoirs, lakes and rivers, providing favourable growth conditions for aquatic algae and plants. Therefore, water cabbage and water hyacinth have become the dominant plants in many waters, and occupying most of the water, causing silting, interrupting the normal circulation channel of the dissolved oxygen in the water, and affecting the survival of the other aquatic organisms. With heavy rain, the negative impact on the rivers' drainage function is difficult to estimate. In June of 1995, Typhoon Deanna hit, and Erlin Township of Changhua County water did not retreat; it was later confirmed by the Water Resources Agency of the Ministry of Economic Affairs, that water hyacinths had blocked the drainage holes [2].

Water cabbage has high adaptability to the environment, and also strong asexual reproduction ability. Spring and summer are the seasons of major proliferation and growth, with autumn and winter as a phase of decline, with the vast majority of plants gradually turning yellow, withering, and dying. It is interesting to note that the decomposition rate of the water cabbage plant is very fast after death; in a short period of time it will decompose into bottom sediment.

Water hyacinth, however, is a kind of widely distributed floating macrophyte and belongs to the perennial plants, and is obviously affected by seasonal temperature change. During the winter, growth almost stops, and population size remains unchanged; however, when spring comes, growth begins to restore and peaks in the summer. In general, priority is given to asexual reproduction; when conditions are right, these plants can double in two weeks [3,4].

Since the government agencies will clean up river aquatic plants every 3-6 months, causing the floating plants in the river growth to return to zero, water cabbage will resume its faster growth, with water hyacinth growing a little slower in comparison. After about one and a half months of growth, as shown in Figure 1(a), because the water hyacinth plant is higher than water cabbage, in the process of competition of sunshine, the water cabbage will gradually be surrounded by water hyacinth. About three months later, as shown in Figure 1(b), the water hyacinth will have completely replaced the water cabbage, and taken up all the space in a river. In other words, in the environment where the water hyacinth and water cabbage coexist, because of the competition for environmental resources, the water hyacinth will be the final winner, and the river ecological structure will change accordingly [5,6].

ECOLOGICAL MANAGEMENT METHOD

According to the research, water cabbage has a low absorption rate of ammonia nitrogen, nitrate nitrogen, total nitrogen, phosphate and total phosphorus: 70%, 68%, 53%, 71% and 58%, respectively, while the BOD and COD removal rate is 38% and 27%. As for water hyacinth, its BOD and COD removal rate is 16% and 27%, with relatively high concentration of ammonia nitrogen, phosphate it has one of the best removal rates: 33% and 32%, respectively [6,7]. Therefore, water cabbage's nutrient absorption capacity is rapid in polluted waters, which affects the growth of the water hyacinth. As learned from on-site observation, it took about one and a half month's for the growth of the water hyacinth to occupy the area very close to the water cabbage. The water hyacinth then had the opportunity to quickly capture the water surface space. If not cleaned regularly, water hyacinth will eventually lead to serious water quality deterioration, and possibly block waterways in heavy rain, causing flooding.

Figure 1 (a) and (b): The aquatic plants of an irrigation channel (23°41'25.5"N 120°31'29.6"E) were cleared after one month (a) and four months (b), showing the growth situation of the water cabbage and water hyacinth.

If SDS is used as the water quality indicator for domestic sewage, the coordinates (23°41'25.5"N 120°31'29.6"E) signified the control point, and took the downstream 100 meters as the comparison point; samples were taken at 10 centimetres below the surface of the water in the afternoon. The analysis was conducted according to the methylene blue colorimetric method (NIEA W525.52A: EPA, Taiwan) for samples [8]. The results showed that the removal rates of SDS were 12.3%, 64.7%, and 94.1% after the zero stage, the primary growth stage (after 2 months) and the stable stage (after 5 months), respectively. The ultraviolet microorganisms, temperature, microbes and aquatic plants in the environment may contribute to the removal of SDS [9,10], while the contribution of aquatic plants is most obvious [11].

Due to the growth characteristic of the water hyacinth, in the absence of dramatic changes of the stable waters, and with adequate nutrient supply, it will be the final winner among floating plants. At present, in many rivers, livestock wastewater and sewage have become major sources of water pollution; therefore, the water cabbage and the water hyacinth are difficult to eradicate. How to evaluate the comparison of water reuse potential with total water use in the present situation, the competitive characteristics of both kinds of plants for water quality phytoremediation, and how the polluted water can be reused are important issues [12,13]. Based on years of empirical results, that there are many advantages of bioremediation over conventional methods able to identify [14].

CONCLUSION AND RECOMMENDATIONS

Water cabbage and water hyacinth have invaded the waters around Taiwan, with a variety of negative effects on the ecological environment. But in general, especially in the irrigation channels, without good removal mechanisms, the water hyacinth will eventually become the most dominant aquatic plants. In the sewage systems in underdeveloped areas, with the nutrient removal rate of the water cabbage and water hyacinth for effective water quality phytoremediation, maintenance for pollutants removal about every six months in the primary stages of succession will be a great help. This is a kind of low cost strategy for consideration.

As for cleared out plants, due to the high moisture content and possible heavy metals or toxic compounds, after crushing and exposure, these raw materials can make an effective biofuel, which can then be developed in biogas production enterprises.

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