Study on the Purification of TN in Different Concentration Waters by Artificial Floating Bed

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Abstract. The artificial floating bed reduces the nitrogen, phosphorus and organic pollutants in the water by the absorption of the roots of the plants, thereby purifying the biological control of water quality. In this paper, by using four different concentrations of contaminated water samples, the static test of Ipomoea aquatica was carried out on a floating bed. The growth characteristics and main water quality indexes of the plants were measured at intervals of 10 days. The experimental period was 60 days, and the amaranth was quantitatively analyzed. The purification law of TN in water samples with different concentrations was analyzed, and the dynamic changes of nutrients in different tested water samples were analyzed, and the purification equation was constructed. The results showed that the floating bed cultivation of leek can absorb, adsorb and degrade the nitrogen in the water sample, carry out metabolic activities, and synthesize the substances needed by itself, which is closely related to the growth, and the TN concentration and the growth time of the plant are significantly negative.

1. Introduction

China is rich in lake resources, with natural lakes accounting for about 9.10×10⁶hm², accounting for about 0.95% of the land area [1]. However, with the rapid development of economy and the strong intervention of human activities, the lake resources in China have been seriously damaged, the functions of stable and orderly evolution of the lake ecosystem have been continuously lost, the lake environment has been deteriorating, eutrophication is prominent, and the main pollution indexes of the lake are total nitrogen and total phosphorus. The eutrophication of lakes has become one of the top environmental problems that the government and people are concerned about.

In order to control the pollution of lake water resources, governments at all levels have taken various measures to control. At present, the treatment methods adopted by China for lake pollution generally have the characteristics of large investment, long cycle and ineffective effect. Therefore, while using traditional methods to control lake pollution, it is imperative to explore new methods and models of biological management using modern new technologies.

Since 1991, our country has been using artificial floating bed technology in large reservoirs, lakes, rivers, canals and other water, successfully planted 46 families and 130 species of terrestrial plants,
accumulated more than 10 hectares, including large quarterly rice yield per hectare in more than 8.5 t, up to 10.07 t, canna, sunshade grass flowers such as better group than in cultivated land and landscape effect [3]. In 1998, Liu Shuyuan et al. used vermiculite, which was soilless, to grow water celery, water spinach and multi-flowering ryegrass [4-5]. Ma Lishan et al. used Vetiver zizanioids. to purify the eutrophic water bodies of Qinhua River, Jinchuan River and Xuanwu Lake in Nanjing respectively, with a biomass of 7.50×10^6 kg/hm²·a, and theoretically the amount of nitrogen and phosphorus could be respectively 1125~1325 kg/hm²·a and 450~600 kg/hm²·a. Studies by Gersgerg R M, Harbert R and Perfier et al. showed that the main removal pathway of ammonia nitrogen was nitrification and denitrification rather than plant absorption [6-8].

Although artificial floating bed technology has been widely studied and applied in many water environment treatment projects and experiments, the difference in the purification effect of the same plant in different concentrations of polluted water bodies and the adaptability of plants to polluted water bodies; The optimal nutrient level for growth and survival in the tested water samples; the problems of the dynamic changes of pollutants in the tested plant growth period have to be resolved. In this study, the purification law of TN in different tested water samples of amaranth was quantitatively analyzed, and the dynamic changes of nutrients in different tested water samples were analyzed. The effect of water body and the removal mechanism of pollution factors, as well as the dynamic changes of pollutants in the tested plant growth period are of great significance.

2. Materials and methods

2.1. Experimental Materials

The experimental plant Ipomoea aquatica was Jiangxi <Huayu> big leaf water spinach, which was taken from the experimental site of the Oil Crop Research Institute of the Chinese Academy of Agricultural Sciences. All the plants were from soil culture seedlings. Before the start of the experiment, the amount of cultivated plants required for the experiment was calculated. The tested plants were washed with soil and planted on the polluted water body for domestication two weeks in advance, so that the plants to be tested were adapted to water growth and survival. Observe the growth of the tested plants at any time, and replant in time to ensure the amount of plants in the pot experiment. In the pot experiment, the plants that have been cultured for two weeks should be washed with tap water, then the roots are washed with distilled water, and then transplanted to a customized floating bed carrier to start the pot experiment.

2.2. Test sample

In the 15 test buckets, the same volume (20L) of different concentrations of the tested water samples were injected, and all the tested water samples were prepared by diluting the water from Shahu Lake, and the dilution multiples were respectively Shahu raw water (undiluted), diluted 5 times, diluted 7 times, diluted 9 times, prepared 3 parallel test buckets for each dilution concentration, and numbered 1~3. Record the dilution factor and water addition amount in each barrel, and mark the liquid level line with oily pen on the barrel wall to facilitate subsequent water supply.

The test plants which have been domesticated and washed with distilled water are inserted into the small holes of the floating bed carrier (EPS) as shown in Fig. 1, and 5 plants are planted on each carrier, and the plant 1#~5# is marked with the oily pen on the carrier. Weigh the carrier plate with a balance together with the weight of the plants planted on the carrier plate and record. Simultaneously record temperature, humidity and weather conditions in the experimental environment.

2.3. Analysis

The water quality index analysis methods used in this study are carried out according to the method in the “Water and Wastewater Monitoring and Analysis Method” (Fourth Edition) prepared by the State Environmental Protection Administration.
2.4. **Statistical analysis**

One-way ANOVA and least significant difference (LSD) analysis were performed on the experimental data using Excel and SPSS software, and t-test was performed on the mean analysis of the samples to analyze the water quality indicators of the tested plants and the control group. Whether there is a significant difference between the test results (indicated by a different letter). According to the experimental analysis results, linear or non-linear regression analysis was used to obtain the relevant purification linear relationship and the treatment model of plant pollution factors in different concentrations of tested water samples.

3. **Results and analysis**

3.1. **Plant biomass changes**

The amaranth was weighed together with the carrier plate for each sampling before and after the test, and the average growth rate (g/g·d) was calculated by the growth of the plants during the test. The change in amaranth biomass is shown in Figure 1. The biomass growth rate of amaranth in the tested water samples of four different concentrations (9 times, 7 times, 5 times, raw water) was 129.92%, 131.79%, 139.28%, and 216.41%, respectively. The average growth rates were 0.022 g/g·d, 0.022 g/g·d, 0.023 g/g·d, and 0.036 g/g·d, respectively, and the average rate was 0.026 g/g·d. It indicated that the increase rate of amaranth biomass was positively correlated with the concentration of tested water samples. The higher the nutrient salt concentration, the faster the plant absorption and utilization rate, and the higher the biomass growth rate.

![Figure 1](image1.png)

**Figure 1.** Removal rate of TN from experimental samples

Notes: ––: Ipomoea aquatica. ––SK: (a): Removal rate of TN from raw water; (b): TN Removal rate of water diluted by 7 times; (c): Removal rate of water diluted by 5 times; (d): Removal rate of water diluted by 9 times.

3.2. **Analysis of total nitrogen removal rate**

It can be seen from Figure 1(a), that the leek has a certain removal effect on the TN in the raw water. From the time point of view, in the first 10 days, the plants had significant removal of TN. The TN in
the leek test bucket decreased from the initial 15.371 mg/L to 5.192 mg/L, and the removal rate was 66.2%. During the subsequent test period, the TN content in the test bucket of amaranth showed a slow decrease and fluctuation. At the end of the 60th day, the concentration of TN was 1.681 mg/L, and the removal rate was 89.1% during the whole test period. Because of the self-purification effect of the raw water blank control, the self-purification degradation rate of TN was 40%, and the purification effect of the blank water sample itself was deducted. The net removal rate of the raw water TN was 59.1%.

It can be seen from Figure 1(b) that the TN removal effect of amaranth on 5 times water sample, during the whole 60d test period, the TN in the test water sample was removed to a large extent, and the TN was decreased from 3.570 mg/L. The removal rate was 82.1% to 0.641 mg/L, and the self-cleaning TN removal rate of the 5 times test water sample was 21.2%. Therefore, the net removal rate of amaranth cultivation was 60.9%. Overall, during the entire trial period, amaranth cultivation showed a significant removal phase for TN, followed by a slow removal process, possibly due to lack of nutrients in the later stages, affecting plant uptake of nitrogen and due to utilization.

As shown in Figure 1(c), compared with the removal rate of TN in 7-fold water samples, the plants showed rapid growth within 10 days from the start of the experiment, so the nitrogen in the water samples was strongly absorbed and utilized. There was a significant decrease in TN content in the water sample. During the test period, the water sample of the leek was reduced from 2.590 mg/L to 0.732 mg/L, and the removal rate was 71.7%, while the self-purification rate of the 7-fold water sample was 28.4%. The net removal rate of the plants was 43.3%.

As shown in Figure 1(d), compared with the removal rate of TN in 9-fold water samples, the amaranth showed a rapid growth within 10 days from the start of the experiment, so it strongly absorbed and utilized nitrogen in the water samples. The TN content of the test water sample showed a significant decrease, and the inflection point appeared. During the subsequent test, it showed a slow decrease, which may be due to the lack of nutrients in the water sample, which affected the absorption and utilization of TN by plants. In the whole experiment, the TN of the leek test bucket decreased from 1.710 mg/L to 0.433 mg/L, and the removal rate was 74.7%, 66.4% and 54.1%, while the self-cleaning rate of the 9-fold water sample was 30.7%. The removal rate was 44.0%.

According to the removal mechanism of nitrogen in plants, comparing the purification trend of total nitrogen in different concentrations of water samples, it was found that in the first 10 days of the experiment, the plant was able to quickly and quickly because the TN was at a higher concentration in the test bucket. Growing and growing thick roots, the growth process of plants exacerbates the absorption and utilization of nitrogen and the growth of plant root microorganisms, so there is a significant decrease in TN in the first 10 days, due to the respiration of plants and the nitrification of nitrifying bacteria. The rapid consumption of dissolved oxygen in the water, that is, a significant decrease in dissolved oxygen, accompanied by a sharp decrease in dissolved oxygen, caused an inflection point at 10 days. After 10 days, due to the lack of nutrients in the water samples, the growth of plants slowed down and the lack of dissolved oxygen. In the subsequent experiments, TN showed a slow fluctuation process.

The results showed that the amaranth had better removal effect on TN in different water samples, and the amaranth had higher absorption efficiency to TN. According to the calculation, the removal rate and net removal rate of TN were negatively correlated with the nutrient concentration of the test water sample, that is, the lower the concentration, the higher the removal rate, indicating that the removal effect of the plant at low concentration is better than the high concentration.

4. Conclusion

4.1. Growth of floating plant

In the whole static test, each tested plant can grow normally in different concentrations of tested water samples, and new plants are separated, and the roots of the plants grow faster and alternate with each other to form a dense whole. At the beginning of the experiment, the nutrient salt in the water sample
was sufficient, the plant could grow faster and faster, and the plant growth was inhibited by the lack of nutrient salt and the decrease of DO content in the later stage. For example, the amaranth was 34.97 cm at the beginning of the experiment, and increased to 47.31 cm after 10 days, with a growth rate of 35.3%. At the end of the experiment, the plant height was 51.29 cm and the growth rate was 8.4%.

4.2. Dynamic changes of nutrients in different concentrations of water samples
The water quality of the test water samples was monitored and analyzed every 10 days. The results showed that the TN concentration in the test water samples was closely related to the growth of floating plants. Plants can absorb, adsorb, and degrade nitrogen, phosphorus, and organic matter in water samples, carry out metabolic activities, and synthesize the substances they need. At the beginning of the experiment, TN decreased rapidly with the rapid growth of plants. In the later stage, the nutrient salt and DO of the tested water samples slowed down the metabolism of the plants, and the removal of TN and the slow decrease of pH and DO in the plants.

4.3. Purification equation of floating bed cultivated plants
The floating bed cultivated plants had strong removal ability to TN in the test water samples. There was a significant negative correlation between the TN concentration in the water samples and the growth time of the plants. The TN concentration in the water samples was attenuated in the form of a cubic curve or an inverse curve.

4.4. Purification effect and regularity of nutrient salt on floating bed cultivated plants
The comparison of the net removal rate of water samples with different nutrient concentrations by plants (shown in Figure 1.) shows that the amaranth has the best purification effect on TN in medium concentration water samples (5 times diluted with raw water).

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