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Eutrophication of Water Body Based on Ecological Simulation Technology

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Abstract: At present, the treatment efficiency of ecological floating bed is not high, the number of floating bed plants is not large, the impact of external conditions on the treatment effect is not clear, and the mechanism of treatment is not deep enough, which limits the full application value of ecological floating bed technology. In order to explore more efficient floating bed plants and find out the influence of various external factors on the treatment effect of floating bed, the ecological floating bed technology can better serve the treatment of eutrophic water bodies. In this paper, the state floating bed is used as the carrier, and the purification effect of eutrophic water body is studied by two groups of experiments using the rarely used ecological floating bed technology to treat polluted water body. All the plants survived and grew well in the process of the experiment, which has certain economic and practical value. The removal rates of DP, TN and TOC were 95.0%, 96.97% and 92.53% respectively.

1. Introduction

Water is the material basis for the survival of the earth's organisms, and is closely related to people's production and life. However, in recent years, with the rapid development of social economy and the acceleration of urbanization, frequent human activities and changeable natural climate make the pollution of water environment in China exceed its environmental capacity for a long time. A large number of untreated or substandard industrial wastewater, domestic sewage, fertilizers, pesticides and other harmful substances are discharged into rivers and lakes, exceeding the self-purification and decomposition capacity of water bodies, resulting in serious problems such as eutrophication of water bodies, degradation of ecological functions, and decline of water volume [1].

The root cause of water eutrophication is the excessive input of nitrogen, phosphorus and other nutrients in the water body, which makes the water quality become "fertilizer", provides a large amount of nutrients for aquatic organisms, makes them reproduce in large numbers, and finally

leads to "water bloom". There are many ways for nutrients such as nitrogen and phosphorus to enter the water body. According to their sources, they can be divided into point source pollution and non-point source pollution. [2-3] In the natural state, some water bodies transition from eutrophication to eutrophication mainly due to water evaporation, natural precipitation, river entrained impact materials, aquatic biological debris, etc. nutrients gradually accumulate, but this process is quite long [4]. When the water body is disturbed, there are two ways to cut off the point pollution source and control the non-point pollution under the premise of appropriate temperature, pH and other conditions. Improve the drainage system to prevent various industrial wastewater and domestic sewage from entering the water body. The external pollution source can be filtered and treated by wetland treatment; The control of surface source pollution has a large amount of work and high cost. The commonly used methods include pre reservoir interception, artificial wetland and natural wetland [5-6]. The second is to treat the polluted water body, including the absorption of nutrients, the utilization of various ions, the precipitation of heavy metal ions and the reduction of algae in the water body [7]. In recent decades, the rapid economic development and rapid population expansion have affected the natural landscape, weakened the self-regulation ability of the water ecosystem, and disrupted people's normal production and life [8]. Therefore, many scholars and research institutions at home and abroad have conducted long-term research and Exploration on how to find a solution to the pollution of water landscape, restore the natural attributes of water bodies, rebuild the healthy water ecology, make the development and utilization of water resources sustainable, control the eutrophication trend of lakes, rivers, reservoirs and other water bodies, and how to improve the eutrophication pollution of urban water bodies. A kind of ecological technology, ecological floating bed technology, has been paid attention to by scientific researchers and government workers and has been widely adopted [9]. In the early 20th century, floating beds were used as spawning grounds and habitats for fish; The concept of floating bed was first proposed by American ecologists in the 1950s; In the 1980s, German scholars designed a truly ecological floating bed for water purification; German American botanists published papers summarizing the six characteristics of ecological floating beds; China introduced ecological floating bed technology in the 1990s [10-11].

According to the current situation of eutrophication of surface water, this paper compares the corresponding treatment technologies and concludes the superiority of ecological floating bed technology. In view of the low technical efficiency of the ecological floating bed, the few species of floating bed plants, the unclear influence of various auxiliary processes on the treatment effect, and the lack of in-depth research on the correlation of water quality indicators and the relationship between communities, the self-designed ecological floating bed, combined with investigation and reference data, is used to try to use a variety of new plants as floating bed plants to detect various water quality indicators, plankton and microbial community structure, A new method of treating eutrophic water body with floating bed and plants was put forward. Four kinds of ornamental plants were used as floating bed plants to compare the experimental results.

2. Overview of Relevant Concepts

2.1 Hazards of water eutrophication

Eutrophication of the water body will promote the rapid growth of some autotrophic organisms in the water body, especially the rapid increase in the number of cyanobacteria, which will reduce the transparency, make it difficult for sunlight to pass through the water body, hinder the normal

photosynthesis of oxygen producing organisms in the water, and reduce the concentration of dissolved oxygen. Due to the insufficient dissolved oxygen concentration in the water, the water body is black and smelly. The organic matter accumulated at the bottom of the water will decompose under anaerobic conditions to produce harmful gases such as H2S and CH4, which will pollute the surrounding gas. With the change of water quality and the reduction of living space of organisms, some aquatic organisms have obviously decreased or even disappeared, which has seriously damaged the ecological environment and food chain in the water body, thus leading to the reduction of biological quantity and biodiversity, and destroying the ecological balance of the whole water body. The eutrophic water body contains more ammonia nitrogen, which will be converted into nitrite under certain conditions. If people and animals ingest too much nitrite and nitrate for a long time, they will be poisoned and cause disease. In addition, the hepatotoxin and neurotoxin in cyanobacteria will harm the human body due to the accumulation effect of the food chain. Water eutrophication has a serious impact on water supply security in many areas of China. For example, the outbreak of red tide in Taihu Lake caused the crisis of drinking water supply in Wuxi City, the outbreak of water bloom in Songzi River, and the villagers in Bailizhou Town, Zhijiang City, Hubei Province had difficulty in drinking water. Eutrophication of water body not only seriously affects people's utilization of water resources, but also causes great economic losses and hard social and economic development. It has a great impact on the tourism economy, water plant income, aquaculture, etc. for example, the red tide broke out in the Seto Inland Sea of Japan, which destroyed the local fishery and caused an economic loss of 7.1 billion yen; The red tide broke out in Taihu Lake, resulting in the shutdown of Wuxi water plant, with an economic loss of 160 million yuan. According to statistics, the economic loss caused by environmental pollution in China is as high as 30% of GDP, which is equivalent to several trillion yuan of loss every year.

2.2 Ecological floating bed technology

Ecological floating bed, also known as artificial floating bed, biological floating bed, ecological floating bed, plant filter bed, soilless cultivation floating bed, etc., is a device that plants higher aquatic plants or terrestrial water loving plants after adaptive cultivation on the carrier, forms an efficient artificial ecosystem through absorption, adsorption and integration of plants and microorganisms, inhibits the growth of algae in the water body, and creates a water landscape [12].

The application of ecological floating bed technology to treat polluted water has the following characteristics [13-14]:

(1) The water body is repaired in situ and placed directly on the water surface without occupying land, which is convenient for landscape design;

(2) There are many floating bed plants with good purification effect, providing habitat and beautifying the water landscape;

(3) The floating body has various shapes and is easy to be manufactured and transported. It is not limited by the water level and will not deposit the river;

(4) Wide range of carrier materials, low cost, no pollution, anti-oxidation and corrosion resistance, no environmental risk;

(5) Convenient management and maintenance, only regular cleaning is required to reduce human resources and reduce operating costs;

(6) The site is widely used and has educational functions. It not only beautifies the environment, but also has economic value.

2.3Physical function of ecological floating bed

The physical effects of ecological floating bed system on sewage treatment mainly include adsorption, volatilization, interception and sedimentation.

Ammonia nitrogen in polluted water will volatilize at higher pH. If the pH value of the water treated by the ecological floating bed is high, some ammonia nitrogen will escape from the sewage in gaseous form. In the ecological floating bed, phosphate can cooperate with some Ca2 +, Mg2 + and other cations in the sewage to form precipitation. These solid substances will directly precipitate to the bottom of the water, or adhere to the ecological floating bed, or be intercepted and removed by plant roots. In order to avoid clogging, the floating bed structure should be reasonably designed [15].

2.4 Plant absorption

Floating bed plants are the main body of ecological floating beds, which need to absorb and utilize a large amount of organic matter, nitrogen and phosphorus, as well as various trace elements and ions. The excessive pollutants in the sewage can be used as the nutrient elements of plants, and the treatment effect is better. The specific absorption modes of different substances by plants are as follows: plants directly absorb some soluble small molecular organic substances for their growth and reproduction [16]. Plants absorb ammonia nitrogen in sewage, synthesize amino acids and other substances required by cells through photosynthesis, and convert ammonia nitrogen into organic nitrogen [17-18].

2.5 relevant formulas

The mass concentration of ammonia nitrogen in water is calculated according to the formula:

$$\rho_N = (A_s - A_b - a)/(b*V) \quad (1)$$

Where: ρ N -- mass concentration of ammonia nitrogen in water sample (in n), mg / L;
As -- absorbance of water sample;
AB -- absorbance of blank test;
A - intercept of calibration curve;
B - slope of calibration curve;
V - sample volume, ml.
The absorbance is calculated according to the formula:

$$A_J = A_{220} - 2A_{275} \quad (2)$$

Where: a220 -- absorbance measured at 220nm wavelength;
A275 -- absorbance measured at 275nm wavelength.
Nitrite nitrogen is calculated as follows:

$$YXSY（\mathrm{N}，\ \mathrm{mg/L}）= m/V \quad (3)$$

Where: m -- the corrected absorbance measured by the water sample, and the corresponding nitrite nitrogen content found from the standard curve, μ g;

V - volume of water sample, ml.

The total phosphorus content is expressed in C (mg / L) and calculated according to the following formula:

$$C = m/V \quad (4)$$

Where: m -- phosphorus content measured by the sample, μg;
V -- volume of sample for measurement, ml.
The calculation formula of Pearson correlation coefficient is:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 (y_i - \bar{y})^2}} \quad (5)$$

Where, n is the number of samples; Xi and Yi are variable values of two quantities respectively.

3. Ecological Floating Bed Design and Experimental Method

3.1 Improvement of floating bed

Changing the material of the traditional floating bed to PVC can solve the problem of secondary pollution caused by the complicated structure of the traditional floating bed and the decay caused by the use of wood, bamboo and other materials; The floating bed is designed with a fixed way of rings and elastic ropes for plants, which solves the problem of space limitation caused by normal growth and growth of plants over time; Increase the treatment area of the floating bed to the water body, so that the water quality will not be more difficult to treat due to the reoxygenation with the air

3.2 Experimental methods

The test site is located on the balcony of the ground floor in the school on the sunny side. In addition to meeting the lighting and ventilation conditions required for plant growth, it can also prevent rain water from falling into the water tank and causing changes in the concentration of various pollutants. The left water tank is provided with a foam plate floating bed, and the right water tank is provided with an improved floating bed. In order to facilitate comparison and sampling, two large white uncovered water tanks are placed side by side on the balcony, and the same volume (120L) of eutrophic water with the same concentration of each pollutant is injected into the water tank.

4. Analysis of Experimental Results

4.1Comparison of purification effect of ammonia nitrogen

It can be seen from Fig. 1 that by using the traditional floating bed technology and the improved floating window technology, there is not much difference in the purification effect of ammonia nitrogen. In the first 20 days, the concentration of ammonia nitrogen in the two groups of experiments decreased from about 8.6mg/l to about 0.5mg/l, and the removal rate of ammonia nitrogen reached more than 90%, and the removal rate has been maintained in the following time, However, the improved floating bed in the early stage will not block the reoxygenation activity of air to the water body, so the bacteria in the water body can digest more ammonia nitrogen into nitrite, so the effect of the improved floating bed must be better than the traditional floating bed to some extent.

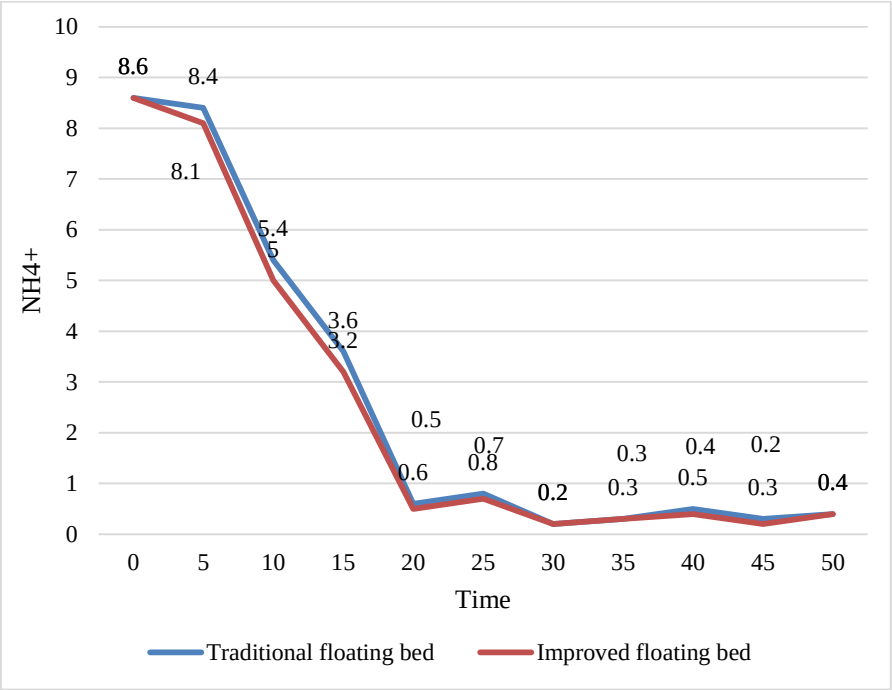

Figure 1. Removal effect of different floating beds on ammonia nitrogen

4.2 Changes of nitrite and nitrate nitrogen

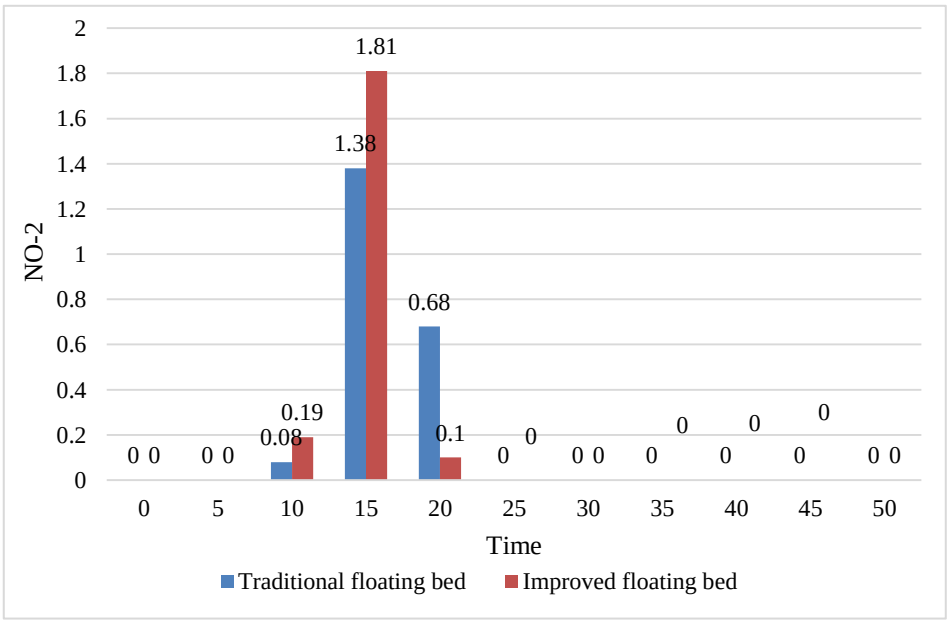

Figure 2. Change of nitrite nitrogen in two water tanks

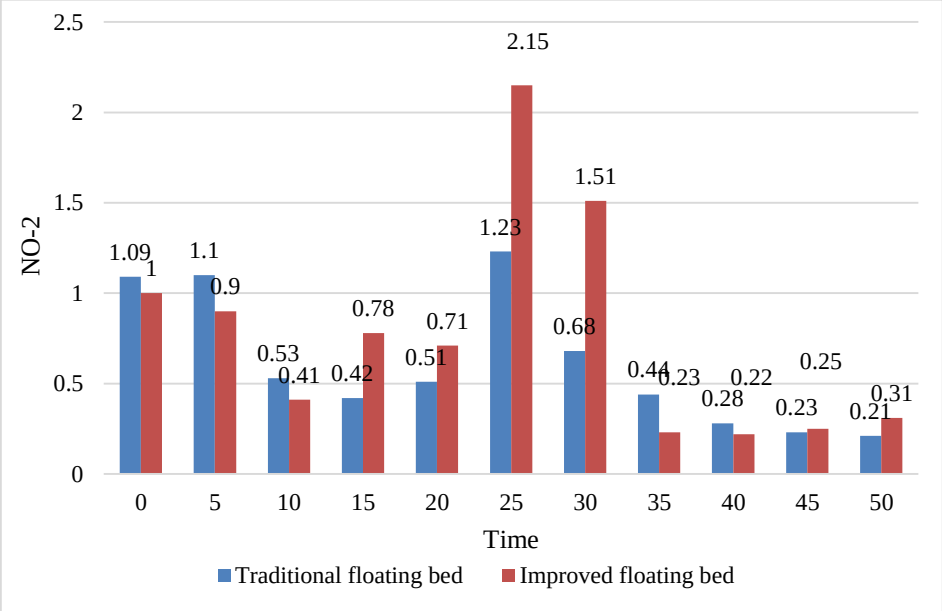

Figure 3. Change of nitrate nitrogen in two water tanks

From FIG. 2, FIG. 3 can see that the concentration of nitrite and nitrate nitrogen in the improved floating bed are higher than that of the traditional floating bed in a certain period of time, so it is well shown that the nitrite conversion is better than the traditional floating bed.

4.3Comparison of the purification effect on the total phosphorus

Table 1.Removal effect of different floating beds on total phosphorus

Time	Traditional floating bed	Improved floating bed
0	1.10	1.10
5	0.38	0.36
10	0.36	0.33
15	0.37	0.34
20	0.31	0.28
25	0.39	0.31
30	0.61	0.51
35	0.44	0.38
40	0.28	0.21
45	0.21	0.19
50	0.29	0.23

As can be seen from Table 1, with the experiment, to the fifth day, the concentration of phosphorus from 1.1 mg/L to 3.6 mg/L and 3.3 mg/L, the two floating bed phosphorus treatment effect reached more than 60%, but the improved floating bed effect is slightly better, in the late evolution, improve the floating bed of phosphorus degradation is higher than the traditional floating bed, reached more than 90%, to meet the demand of phosphorus removal.

4.4Comparison of the purification effect on the TOC

Table 2.Removal effect of TOC by different floating beds

Time	Traditional floating bed	Improved floating bed
0	23.3	23.3
5	19.3	13.9
10	15.8	12.3
15	7.2	6.2
20	12.1	4.2
25	8.9	7.1
30	8.3	5.8
35	13.1	11.5
40	8.1	8.1
45	12.6	9.8
50	8.6	8.2

As shown in Table 2, in the treatment of TOC, the lowest TOC concentration was 7.2 mg/L and the fastest degradation rate was 69%, while the lowest TOC concentration was 4.2 mg/L and the fastest degradation rate was 81%.

5. Conclusions

This paper summarizes the concept of eutrophication, by designing a modified floating bed for comparative experimental analysis, experimental results show that through biotechnology can solve the problem of water eutrophication, and the improved floating bed described in this paper, in the removal effect of nitrite, phosphorus and TOC, the effect is better than the traditional floating bed, can be well applied to the future water purification work, has a good practical prospect.

References

[1] Rozemeijer J, Noordhuis R, Ouwerkerk K, et al. Climate variability effects on eutrophication of groundwater, lakes, rivers, and coastal waters in the Netherlands. Science of The Total Environment, 2021, 771(4):145-166. https://doi.org/10.1016/j.scitotenv.2021.145366

[2] Chen N, Feng C P, Zhang Z Y, et al. Preparation and characterization of lanthanum loaded granular ceramic for phosphorus adsorption from aqueous solution. Journal of the Taiwan Institute of Chemical Engineers, 2017, 43 (5): 783- 789. https://doi.org/10.1016/j.jtice.2012.04.003

[3] Chintala R, Mollinedo J, Schumacher T E, et al. Nitrate sorption and desorption in biochars from fast pyrolysis. Microporous and Mesoporous Materials, 2017, 179: 250-257.

[4] Polomki R F, Taylor M D, Bielenberg D G, et al. Nitrogen and phosphorus remediation by three floating aquatic macrophytes in greenhouse-based laboratory-scale subsurface constructed wetlands. Water, Air & Pollution, 2019, 197(1-4): 223-232. https://doi.org/10.1007/s11270-008-9805-x

[5] Bohman B. Transboundary Law for Social-Ecological Resilience? A Study on Eutrophication in the Baltic Sea Area. 2017,3(1):4-6.

[6] Barante B, Nascimento N O, Silva T, et al. Cyanobacteria dynamics and phytoplankton species richness as a measure of waterbody recovery: Response to phosphorus removal treatment in a

tropical eutrophic reservoir. Ecological Indicators, 2020, 117(3):106-107.

[7] Toma P D, Tokar A, Toropoc M S. Modelling and Simulation Eutrophication of Water Rivers. Revista de Chimie, 2019(8):9-13. https://doi.org/10.37358/RC.19.8.7455

[8] Zhidkova A Y, Podberesnij V V, Kononova O A, et al. Information-measuring system for the eutrophication estimation of the water body. Journal of Physics: Conference Series, 2020, 1515(2):22-23 (5pp).

[9] LA Bravo-Inclá, A-Fabela M, Vez N C. long-term eutrophication diagnosis of a high altitude body of water, zimapán reservoir, mexico. 2019,5(2):5-8.

[10] Minakova E A, Shlychkov A P, Kondratyev S A. Eutrophication Potential of the System: "Catchment Area - Water Body" as a Measure of Sustainable Development of the Aquatic Ecosystem. IOP Conference Series Earth and Environmental Science, 2021, 666(5):050-052.

[11] Khoren A, Natella M, Payne R B, et al. Eutrophication leads to the formation of a sulfide-rich deep-water layer in Lake Sevan, Armenia. Isotopes in environmental and health studies, 2021, 57(5):535-552.

[12] Jones A, Labaj A, Campbell J, et al. Zooplankton assemblage and body size responses to severe lake eutrophication from agricultural activities near mink farms in Nova Scotia, Canada. Journal of Plankton Research, 2022(3):3. https://doi.org/10.1093/plankt/fbac022

[13] skhai A A, Ageikov V Y, Semchukov A N. Ecohydrological mechanism of phytoplankton distribution in the water body. IOP Conference Series: Earth and Environmental Science, 2021, 866(1):12-40 (5pp).

[14] Chakrabarti S. Eutrophication - A Global Aquatic Environmental Problem: A Review. Research and Reviews, 2018(2),53(5):1-1.

[15] Samarawicrama L, Sanjeevani K S, Sammani D, et al. Assessment of water eutrophication in selected locations of the Diyawanna Oya using visual assessment method. 2017,31(2):13-14.

[16] Vasileios P, Sotiris O. Anthropogenic eutrophication affects the body size of Cymodocea nodosa in the North Aegean Sea: A long-term, scale-based approach. Marine Pollution Bulletin, 2017, 134(SEP.):38-48.

[17] Lker D, Bayrhan R, Burak S. Assessment and Comparison of Commonly Used Eutrophication Indexes. Turkish Journal of Water Science and Management, 2020, 4(1):4-30. https://doi.org/10.31807/tjwsm.583530

[18] Biswas M, Mandal D, Sonar R, et al. Motijheel Lake-Victim of Cultural Eutrophication. 2018,31(3):81-82.