Improvement of Taihu water quality by the technology of immobilized nitrogen cycle bacteria

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Abstract Experimental studies were carried out on the purification of eutrophic Taihu Lake water by dynamic experiment using immobilized nitrogen cycle bacteria (INCB). The results showed that the eutrophic water of Taihu Lake can be purified effectively as it passes through the experimental reactor into which some immobilized nitrogen cycle bacteria were put. The removal efficiencies for Total N (TN), NH_4^+-N with immobilized nitrogen cycle bacteria were 72.4% and 85.6%, respectively. It was found that the immobilized nitrogen cycle bacteria also have purificatory effect on eutrophic water of Taihu Lake at winter temperature (7°C), and that the removalm efficiencies for Total N (TN), NH_4^+-N were 55.6%, and 58.9%, respectively. The removal efficiencies for TN and NH_4^+-N depend on the time the water stays in the experimental reactor.

Keywords Radiation polymerization, Immobilized nitrogen cycle bacteria, Dynamic experiment, Taihu Lake water in winter

CLC numbers X172, X524 A

1 INTRODUCTION

Taihu Lake is one of the five famous largest freshwater lakes in China, with an area of 2338 km^2 and a depth of 2–4 m. With the social and economic development during the last decades, the Taihu Lake has been polluted and become more eutrophic, which have influence on the social and economic sustainable development around its areas. To control the Lake eutrophication, dredging, diluting,[1] restoring hydrophyte, and taking biomanipulation[2] and other means have been applied to control and harness these problems. As a new technology, the physico-ecological engineering (PEEN) using physical and biological methods to remedy and rehabilitate a healthy ecological system from the phytoplankton-dominated state in eutrophic lakes can improve local lake water quality obviously.[3] It is found that bacteria and mutualism of bacteria with hydrophyte have important effect for purifying water. However, the remedial system of hydrophyte is not strong enough resisting the environmental hazards. Accordingly, making a carrier with

Supported by European Union [Contract No. CI1*-CT93-0094 (DG 12 HSMU)], also by the social development project of Jiangsu Province, China (No.BS99021)
Manuscript received date: 2001-12-20

suitable pore structure can provide refuge effect for bacteria and developing the technology of immobilized nitrogen cycle bacteria (INCB)[4] by physical and microbial methods for remedying and rehabilitating the healthy aqua-ecosystem in eutrophic lakes has very important theoretic and practical meaning. The key issues of INCB are microbial-based with aids of physical means. There are three major techniques of INCB, e.g., making carriers for immobilized nitrogen cycle bacteria, cultivating special nitrogen cycle bacteria with high efficiency for nitrification-denitrification, and improving water quality from laboratory to local water with INCB. By using INCB bacteria releasing techniques in PEEN, four groups of nitrogen cycle bacteria, including ammonifying, nitrobacteria, nitrosobacteria and denitrifying bacteria have increased remarkably in the water; oxidation-deoxidization of nitrogen have consolidated; nitrogen have been removed more effectively from the water and local lake water quality have improved obviously. The similar study has not been found about the improvement of lake water quality, and this paper supply major biological aspect with INCB toward this goal. Therefore the INCB technique provided a new, important, and more effective approach for improving water quality, controlling eutrophication and resisting the environmental hazards.

2 METHODS

2.1 Organisum

Four group of nitrogen cycle Bacteria were obtained from Taihu Lake, including ammonifying, nitrobacteria, nitrosobacteria and denitrifying bacteria. The basic medium used for the agar slants and the synthetic liquid medium used for the growth of the four groups of bacteria was the same as reported previously.[5,6] After 2 months of cultivation, the four kinds of nitrogen cycle bacteria were harvested by centrifuge at 4000 r/min for 10 mins. The wet nitrogen cycle bacteria were obtained and further prepared for immobilization.

2.2 Preparation of porous carriers

In order to grow different sorts of bacteria, various kinds of hydrophilic and hydrophobic glass-forming monomers, 2-Hydroxyethyl acrylate (HEA), 2-Hydroxyethyl methylacrylate(HEMA) and polyethylene glycol dimethacrylate (nG) -14G, 9G, 4G, 2G were used in this work and mixed with distilled water to different concentration. The mixtures were irradiated at -78°C with γ-rays from ^{60}Co source for 10 h with a dose rate of 1 kGy/h. The resultant polymer carriers were prepared in small pieces, approximately 5–10 mm in diameter and shaken with excess amount of water for 3 days in order to be fully swollen. The swollen carriers were sterilized by autoclave at 120°C for 40 mins. The sterilized carriers were immersed into the nutrient medium for 2 days to be filled with the nutrient medium.

2.3 Preparation of immobilized nitrogen cycle bacteria (INCB)

The swollen carriers were added to the mixture of precultured nitrogen cycle bacteria and the nutrient medium. The composition of the nutrient medium used in this work was the same as said previously.[6] After aerobic and anaerobic incubation for 72 h, the

polymer carrier of immobilized nitrogen cycle bacteria allowed to cultivate in incubator at 28 ± 1 ℃ under gentle rotary shaking. After being cultivated, the immobilized nitrogen cycle bacteria (*INCB*) were prepared.

2.4 Experimental system

This experiment was performed in the device designed by our research group, the reactor (working volume 91L) with its control and monitoring systems. The eutrophic Taihu Lake water was continuously pumped at a constant rate during all the runs. The temperature of the reactor depended on the room temperatures from 14°C to 7°C. The DO was monitored via the JPB-607 model DO monitor device and the pH in the reactor was monitored via the PHS-3C pH device.

2.5 Analytical methods

Total N, nitrate, nitrite and ammonium nitrogen were analyzed according to standard methods of China.[7]

3 RESULTS AND DISCUSSION

3.1 The purification efficiency of immobilized nitrogen cycle bacteria for Taihu Lake water with dynamic experiment

After the eutrophic Taihu Lake water passed the reactor, the Total N and NH_4^+-N of the water were decreased gradually. It was found that the Total N and $NH4^+$-N decreased 29.1% and 27.8% respectively on the 5 th day and decreased 54.2% and 74.1% respectively on the 10 th day. After 10 d experiments, the removal efficiencies of Total N and NH_4^+-N tend to stabilize and reached 72.4% and 85.6% respectively. The results showed that at the beginning the removal efficiencies of INCB system for Total N and NH_4^+-N were relatively lower due to immobilization, however after 10 d experiment continuously, the removal efficiencies of INCB for Total N and $NH4^+$-N keep steady. The F examine showed that eutrophic Taihu Lake water purified with immobilized nitrogen cycle bacteria (INCB) and that with no INCB treatment had remarkable difference ($p < 0.01$). Therefore, the INCB could remove nitrogen from the water and purify eutrophic Taihu Lake water efficaciously (Fig.1).

3.2 Removal efficiencies for Total N and $NH4^+$-N of eutrophic Taihu Lake water with INCB in different temperatures

During the experimental period, the water temperature changed with the weather from 14°C to 7°C. The result showed that the removal efficiencies for Total N and NH_4^+-N of eutrophic Taihu Lake water using INCB decreased as temperature decreased. When the water temperature descended from 14°C to 7°C, the removal efficiencies for Total N and NH_4^+-N with INCB decreased slowly from 72.4% and 85.6% to 55.6% and 58.9% respectively as shown in Fig.2. After 30 d experiments, the removal efficiencies of Total N and NH_4^+-N have slightly decreased due to temperature decrease shown in Fig.1. This showed that although the change of temperature had some effect on the removal efficien-

cies for Total N and NH_4^+-N because of the activity of INCB system decreased slightly under the low temperature and caused removal efficiencies for Total N and NH_4^+-N decrease, the INCB has relative higher removal efficiencies for Total N and NH_4^+-N of eutrophic Taihu Lake water.

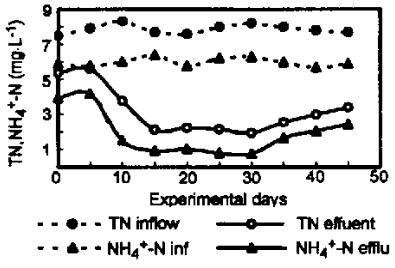

Fig.1 Changes of TN and NH_4^+-N during Dynamic experiment

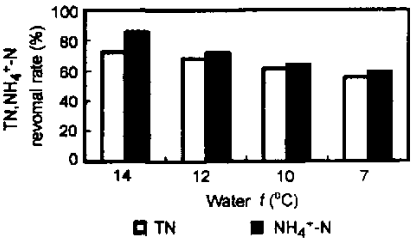

Fig.2 The effect of water temperatures on the removal efficiencies for TN and NH_4^+-N

4 CONCLUSION

Based on this investigation, INCB plays a significant role in purifying eutrophic Taihu Lake water, especially during autumn and winter. With the temperature dropping, most hydrophytes stop growing and some hydrophytes would die and become the source of pollution. As a new technology, the INCB using physical and biological methods to purify eutrophic Taihu Lake water can improve eutrophic Taihu Lake water quality obviously by using INCB and the "microecosytem" porous carrier, which provides the bacteria with favourable ecological environment. With this kind of porous carriers, nitrogen cycle bacteria can improve eutrophic Taihu Lake water through nitrification-denitrofication reaction which lead to purify the Taihu Lake water quality.

Acknowledgements

The authors thank Prof. QU Bei-shen for assistance in taking electron microphotographs of pore structure of carrier.

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