Study on the Efficiency Treatment of Polluted Water by Biofilm Process Filled with Bamboo Filler

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Abstract

The biofilm process has the advantages of strong load impact resistance, low power consumption, easy operation and management, and good treatment effect. The key factor of the biofilm method is the biofilm carrier filler. The performance of the filler will directly affect the operation and treatment effect of the reactor. Aiming at the severely polluted rivers, this paper proposes to use bamboo materials with extensive raw materials, cheap processing, green and pollution-free materials to make biofilm reactor fillers, and conduct laboratory-scale research on them. The results show that, compared with the suspended filler, the bamboo filler has a faster filming speed and a rich microbial population structure on the film, which is beneficial to the removal of pollutants in the water. In addition, the bamboo filler has a degradable carbon source, which helps to further improve the reactor. The denitrification efficiency. The research results will provide technical support for the practical application of bamboo fillers in biofilm reactors and the in-situ remediation of polluted river water quality in my country.

Keywords: Bamboo filler, biofilm, wastewater.

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1 Introduction

With the improvement of rural living standards and the development of agricultural economy, large amounts of pollutants produced by agricultural production, living and industrial enterprises have been discharged, and the water environment of rural rivers and lakes has continued to deteriorate, endangering the drinking water safety of the masses [1, 2]. Rehabilitation of polluted river ecology through ecological-biotechnology is currently a common measure, but because the growth of aquatic plants is related to the season, and dead plant residues will re-release the nitrogen, phosphorus and other organic matter originally absorbed and fixed in the body into the water body, causing the water body Repeated pollution [3, 4]. Therefore, it is of great significance to seek efficient, safe, and easy-to-follow pollution river water quality purification technologies for the restoration of degraded river ecosystems.

Biofilm process is one of the important methods of water treatment, because its excellent performance is the first choice in water treatment engineering. The filler is the place where microorganisms grow and the carrier of the biofilm [5]. The performance of the filler directly affects the efficiency and economic rationality of the biofilm, which is the key to the biofilm technology [6, 7]. Therefore, the research and development of fillers are very active. Due to the low concentration of pollutants and the imbalance of nutrients in low-polluted water bodies, biological treatment or restoration is difficult to form biofilms [8]. Therefore, finding a suitable carrier for the biological treatment or restoration of polluted water bodies is a difficult problem that needs to be solved. This is of practical significance to the purification and treatment of polluted river water quality.

In this study, pure natural bamboo filler was introduced into the experiment, and the removal effect of bamboo silk biofilm carrier and suspended filler biofilm carrier in the removal of COD and nitrogen pollutants was studied in a comparative study, and the biological phase was characterized. The method analyzes its mechanism of action from the micro level, and seeks their respective advantages and disadvantages. Provide references for the selection and optimization of biofilm carriers.

2 Materials and Methods

2.1 Wastewater

The wastewater is configured according to the water quality of Xianfeng River, and the artificially simulated wastewater water quality index is shown in Table 1.

Table 1 Simulated sewage water quality indicators

Element	COD/(mg·L^{-1})	TN/(mg·L^{-1})	NH_4^+-N/(mg·L^{-1})	TP/(mg·L^{-1})
Range	172–256	22.32–25.72	15.87–17.25	1.72–1.86

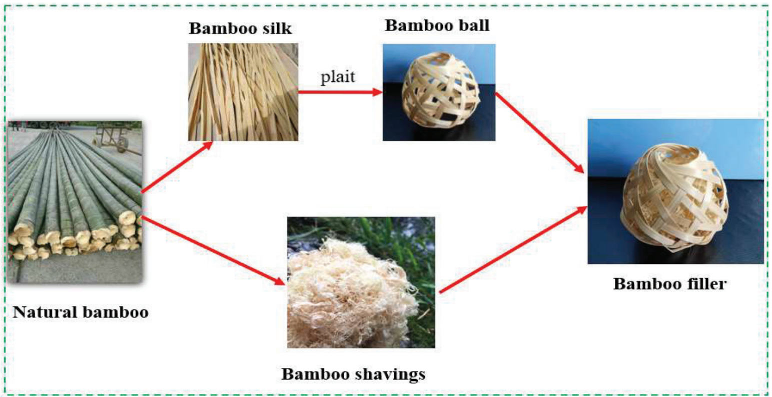

Figure 1 The production of bamboo filler.

2.2 Bamboo Filler

The raw material of the bamboo ball filler biological carrier is moso bamboo. After processing, bamboo strips with a width of 4 mm and a thickness of 0.4 mm are woven into a bamboo ball with a diameter of about 5 cm, and then the waste bamboo shavings are filled into the bamboo ball. The shape of bamboo ball packing is spherical, the porosity is 89.1%, the specific surface area is 582.5 m^2/m^3, the bulk density is 0.78 g/L, and the number of piles is 2,740. The suspended filler is artificially synthesized, with a spherical shape (5 cm in diameter), a porosity of 57.7%, a specific surface area of 184 m^2/m^3, a bulk density of 0.63 g/L, and a number of piles of 2740.

Before the experiment, the homemade bamboo filler was soaked in acetone solution for 2 to 3 days, and the acetone solution was changed once a day. The soaked bamboo silk was washed with tap water, and then dried for later use. Untreated bamboo silk will release a certain amount of nitrogen-containing bamboo juice during the test. Soaking in acetone can reduce the influence of bamboo juice on the test.

2.3 Test Device

The bioreactor used in the experiment is made of acrylic glass, the reactor is a rectangular parallelepiped (150 mm*80 mm*300 mm), the effective reaction

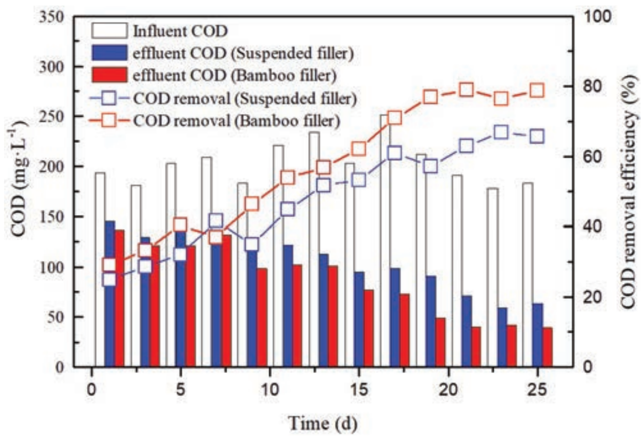

Figure 2 COD concentration of effluent from biofilm reactors with different fillers.

volume is 3 L, and the air is provided by a small blower. The filling rate of the bamboo packing and the suspended filler packing in the reactor are both 42%. The simulated sewage flows into the bioreactor by gravity flow from the high-level water tank, and the wastewater slowly flows upward from the bottom of the reactor, and the flow rate is artificially controlled by a valve.

2.4 Method

When the reactor is started up, the method of inoculation and film hanging is adopted, and the continuous flow water inlet device is used at room temperature. The operating temperature is gradually increased from 20.4°C to 25.6°C. Take in and out water samples at 9:00 every day, and determine the water quality within 2 hours. The water quality determination method adopts the national standard method, in which COD adopts the potassium dichromate method, and NH_4^+-N, NO_3^--N, NO_2^--N and TN all adopt ultraviolet spectrophotometry.

3 Results and Discussion

3.1 COD Removal Effect

Figure 2 shows the change of COD concentration in the effluent of the bamboo-filled biofilm reactor and the suspended filler biofilm reactor with time.

It can be seen from Figure 2 that the influent COD is 172.3∼256.8 mg/L, the effluent COD of the bamboo-filled biofilm reactor is 39.4∼136.7 mg/L, the removal rate is 29.1%∼79.2%, and the average removal rate is 56.9%; The effluent COD of the suspended filler packing bioreactor is 59.4∼145.2 mg/L, the removal rate is 24.9%∼66.8%, and the average removal rate is 48.1%. The bamboo silk packing reactor has significantly better COD purification effect than the suspended filler. The analysis believes that because the bamboo ball is filled with a large amount of bamboo shavings, the specific surface area of the bamboo filler is increased, and there are many strip grooves on the surface, so its surface is rough, and as a natural carrier, the bamboo filler is biologically compatible. With good performance, the density and number of microorganisms on the biofilm will be significantly better than the suspended filler. In addition, during the test, it was found that during the biological purification process of bamboo filler, the thickness of the biofilm on the surface of the bamboo filler was significantly better than that on the suspended filler due to its easy degradability, which resulted in a more abundant microbial population structure in the microbial film on the bamboo filler [9, 10]. Through the mutual cooperation between microorganisms, it is conducive to strengthen water purification and repair.

3.2 Removal Effect of Nitrogen Pollutants

It can be seen from Figure 3 that the influent NH_4^+-N is 15.9∼17.3 mg/L, the effluent NH_4^+-N of the bamboo-filled bioreactor is 4.9∼12.1 mg/L,

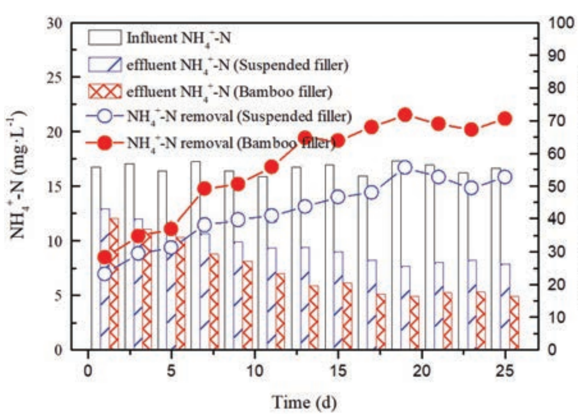

Figure 3 The concentration of NH_4^+-N in the effluent of biofilm reactors with different fillers.

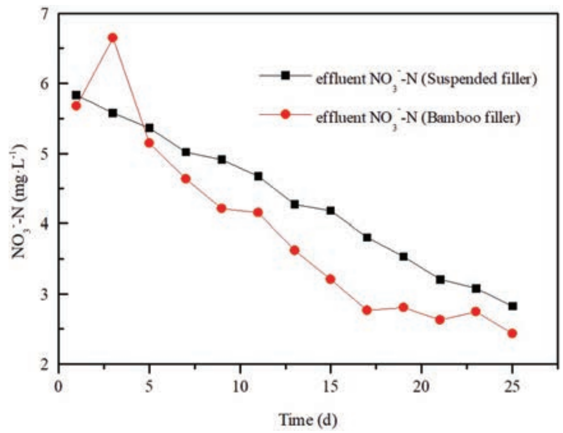

Figure 4 NO_3^--N concentration of effluent from biofilm reactors with different fillers.

the removal rate is 28.3%∼70.5%, and the average removal The rate is 56.2%; the effluent NH_4^+-N of the suspended filler packing bioreactor is 7.7∼12.9 mg/L, the removal rate is 23.1%∼55.6%, and the average removal rate is 42.4%. It can be clearly seen from the data that the removal rate of NH_4^+-N in the water by the bamboo silk filler bioreactor is significantly higher than that of the suspended filler bioreactor. This may be because the bamboo silk has good biocompatibility and nitrifying bacteria is easier Adsorb it up and form its own dominant flora [11].

It can be seen from Figure 4 that the NO_3^--N concentration in the bamboo-filled bioreactor decreases faster than the suspended filler-filled bioreactor. After 15 days of operation, the NO_3^--N removal rate of the bamboo-filled bioreactor reaches 73.1%. The NO_3^--N removal rate of the suspended filler packing bioreactor is 59.5%. It can be seen that the bamboo packing has a better denitrification effect. Three days before the start of the experiment, the nitrate concentration in the bamboo-filled bioreactor increased, and rose to 6.65 mg/L on the 3rd day, while no similar situation occurred in the suspended filler-filled bioreactor. The increase in nitrate concentration in the bamboo filler biofilm reactor may be caused by the release of nitrogen substances in the bamboo filler into the water [12]. The nitrate concentration in the bamboo-filled biofilm reactor began to gradually decrease after the 3rd day. During the experiment, it was also found that a large number of bubbles were adsorbed on the bamboo packing in the bamboo packing biofilm reactor, while the suspended filler packing in the suspended filler packing biofilm reactor had fewer bubbles. Analysis suggests that due

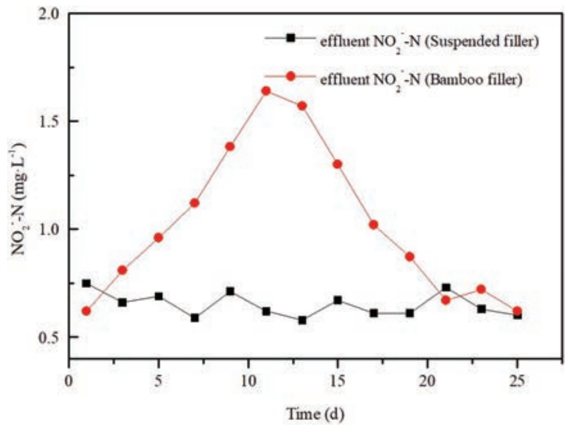

Figure 5 $NO_2{}^-$-N concentration of effluent from biofilm reactors with different fillers.

to the larger specific surface area of the bamboo filler, microorganisms are more likely to adhere to the surface of the filler [13]. Therefore, the bamboo-filled biofilm reactor can provide more denitrification growth space, which is beneficial to the conversion of nitrate in the reactor.

It can be seen from Figure 5 that during the test, the $NO_2{}^-$-N concentration in the bamboo-filled biofilm reactor was between 0.62 and 1.64 mg/L, while the $NO_2{}^-$-N concentration in the suspended filler-filled biofilm reactor was always lower than 0.8 mg/L. The bamboo-filled biofilm reactor experienced nitrite accumulation in 1–18 days, and the maximum nitrite nitrogen in the effluent reached 1.64 mg/L. This may be due to the nitrous acid in the denitrification system in a low-carbon source environment. Salt is prone to accumulation. However, with the operation of the reactor, the concentration of nitrite nitrogen in the effluent of the bamboo-filled biofilm reactor slowly dropped to 0.62 mg/L. The phenomenon of nitrite nitrogen enrichment in the reactor at the beginning of the analysis test may be caused by the limited release rate of the carbon source of the bamboo filler. There are covalent bonds within the bamboo silk cellulose molecules, and there are intermolecular forces between the molecules. The intermolecular forces of cellulose are less than the covalent bond energy within the molecules. Under the action of cellulose decomposing bacteria, the intermolecular forces of cellulose are destroyed first, making The cellulose molecules on the surface of bamboo silk are decomposed into long-chain cellulose or organic cellulose flakes, and denitrifying bacteria cannot effectively use these macromolecular cellulose materials, and the macromolecular chain-like cellulose flakes become smaller soluble molecules. It takes a longer time and goes through a more complex biochemical process. Therefore, at the beginning of the experiment, the amount of soluble carbon source organic matter available in the reactor is relatively small. Because nitrate reductase can preferentially catalyze the decomposition of carbon source, the macromolecular fiber The conversion of nitrate-nitrogen occurs in the nitrite, and it is difficult for nitrite reductase to catalyze the available carbon source of larger molecules [14]. Part of the nitrate in the silk test device is converted into nitrite, causing the accumulation of nitrite. In the later stage of the experiment, the carbon source in the bamboo filler continuously and stably released a large amount of organic matter, the content of the available carbon source in the reactor was greatly increased, and the nitrite reductase catalyzed the decomposition of the available carbon source, which made the nitrite nitrogen in the bamboo silk test device. It is converted into nitrogen and discharged to achieve the removal effect of biological denitrification. It is speculated that this is the reason for the slow decrease of the concentration of nitrite nitrogen in the effluent water of the reactor in the later stage of the test.

It can be seen from Figure 6 that the TN of the influent water is 22.32∼25.71 mg/L, the TN of the effluent of the bamboo-filled biofilm reactor is 7.9∼18.6 mg/L, the removal rate is 15.2%∼67.1%, and the average removal rate is 47.9%; And the effluent TN 11.3∼19.5 mg/L of the suspended filler-filled biofilm reactor has a removal rate of 16.7%∼53.2%, and an average removal rate of 38.1%. It shows that NH_4^+-N in the bamboo silk packing reactor can be directly converted to N_2 under aerobic conditions, while the

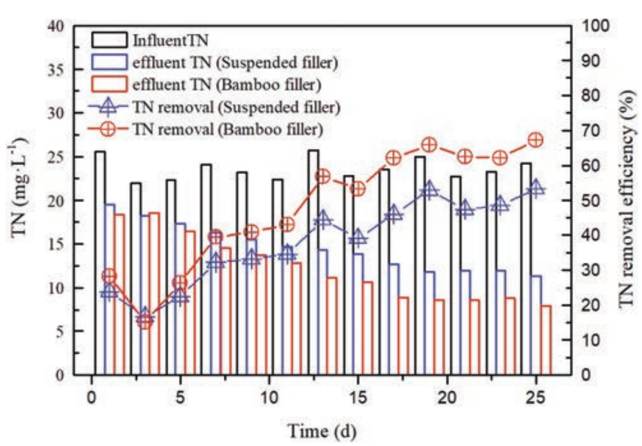

Figure 6 TN concentration of effluent from biofilm reactors with different fillers.

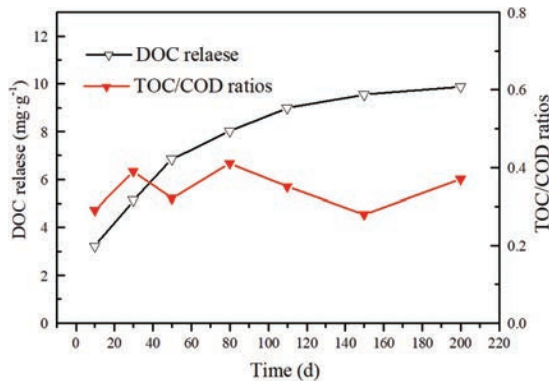

Figure 7 Analysis of DOC and TOC/COD released by bamboo filler.

$NH_4{}^+$-N in the suspended filler biofilm reactor is mainly concentrated in the $NO_3{}^-$-N section. The above reaction mechanism is attributed to the complex membrane structure on the surface of the bamboo silk filler and the biodegradability of the bamboo silk filler. However, the suspended filler does not have this more complicated membrane structure. The thickness of the bamboo silk filler biofilm is compared with that of the hollow plastic ball. The biofilm is thick, there is a large anaerobic zone, the denitrification process is obvious, and the nitrogen pollutants in the water can be removed from the water.

DOC usually refers to the organic matter available to microorganisms. The released DOC can be used as a potential carbon source for microorganisms and is an important factor in enhancing denitrification. It can be seen from the figure that the cumulative release of DOC from bamboo filler is 9.8 mg/g. The analysis believes that bamboo silk can continuously release carbon and the rate is relatively stable when used as a solid organic carbon source, and that the release of organic matter from bamboo silk is relatively high, which is conducive to the progress of denitrification [15].

COD refers to the amount of oxidizer required for substances that are easily oxidized by strong oxidizers. TOC is the total organic carbon content in the water body. Theoretically, when the reducing substances are carbon-containing organic substances, 1 g COD $= 0.38$ gTOC ($mC/mO_2 = 12/32 = 0.38$), and the corresponding TOC/COD ratio is 0.38. In this experiment, the average TOC/COD of bamboo filler was 0.34, and the ratio was close to 0.38. This shows that the organic matter released by the bamboo filler has good solubility and degradability. Some researchers measured the COD release of rice straw within 30 days to be 178 mg/g, and found that the COD release of polyvinyl alcohol sodium alginate (PVA-SA), corn cobs, and peanut shells within 6 days was 100.86–134.10 mg/g, indicating that the content of organic matter released by various materials has a certain relationship with the type of biomass and the release time [16]. In addition, compared with suspended filler packing, bamboo packing has the advantages of sufficient carbon source in the reactor, fast nitrate removal rate, and high nitrate removal rate.

4 Conclusion

(1) Studies have shown that compared with suspended filler packing, the bamboo packing bioreactor has a higher specific surface area and biocompatibility. Microbes are easier to adhere to the surface of the bamboo packing, and the microbial population structure is more abundant. The mutual cooperation is conducive to the removal of COD in water.
(2) Under the same test conditions, the nitrate removal rate in the bamboo-filled biofilm reactor was faster, and the nitrate nitrogen removal rate of the bamboo-filled test device reached 73.1%. The nitrogen removal rate is 59.5%. It can be seen that the bamboo-filled biofilm reactor has a better denitrification effect. Experiments show that bamboo filler natural polymer materials as denitrification carbon source engineering application feasibility is relatively high.
(3) Bamboo silk filler has the characteristics of extremely short film hanging time, low cost, can be made by yourself, easy to use, little or no mud production, convenient subsequent processing of bamboo silk filler without secondary pollution, and low oxygen consumption. Small footprint and stable operation.

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