Nitrogen Removal Characteristics of Two Kinds of Water Quality by Bamboo Biological Membrane Reactor

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Abstract. The effect of nitrogen removal was investigated using a Bamboo filament bioreactor to treat wastewater with high organic load and low C/N ratio. Results showed that total nitrogen removal efficiency was 26.6~96.95%, effluent BOD/COD ratio was 0.07~0.74 when influent COD was 790~5000 mg/L, BOD 60.0~1100mg/L and the BOD/COD ratio was respectively 0.02~0.44. When COD was 130.0~278.0 mg/L, BOD was 42.5~96.7mg/L, NH4+-N was 16.2~98.1mg/L, TN was 28.7~103.8 mg/L, COD/TN was 1.6~4.7, TN removal rate was 29.4%~58.8%. This indicated that good TN removal efficiency can be achieved when using a Bamboo filament bioreactor to treat wastewater with high organic load and low C/N ratio; Nitrogen removal fluctuated was due to secretion of bamboo juice secreted from the cavity of filamentous bamboo. The distribution characteristics of the main bacteria was investigated to show that total number of bacteria at inlet and outlet were same roughly during the wastewater treatment, while bacteria, nitrifying bacteria were distributed in outlet, and Nitrifying bacteria accounted for 1.57% of total bacteria, while denitrifying bacteria evenly distributed in the reactor.

1. Introduction
Simultaneous nitrification denitrification is used to oxidize ammonia completely too gaseous nitrogen [1], so as to complete the elimination of the nitrogen pollutants in water. Nitrifying bacteria is a kind of flora with long generation cycle and decreased rate of growth which can improve the denitrification effect by membrane rejection or biological vectors [2]. At present,solid carbon source is a common option as denitrification carbon source supplement at both at home and abroad. That will fulfill a "supply-demand" carbon source in the denitrification process, one of the best effect is rich-solid organic natural cellulose substances [3-7].

Bamboo filament is an excellent biological carrier for the growth and reproduction of the various strains. Bamboo filament is mainly composed of cellulose, hemicellulose and lignin, which can used as a solid carbon source in biological denitrification [8, 9].Two typical kinds water are selected in the experiment: difficultly degraded effluents that contains high concentration of organic pollutants and low C/N ratio wastewater. The experiment is to study whether biological membranes with bamboo filament filler can guarantee the biological nitrification, simultaneous nitrification and denitrification can implement in two different cases.in order to seek a new biological carrier for biological carrier by own made bamboo filament biological reactor.
2. Materials and methods

2.1. Experiment set-up
Perspex Cylindrical reactors (45cm high, 10cm in diameter, Fig.1) with a working volume of 2.33L were used. A set baffle was set up to make the reactor to divide into two areas (the left and the right). This can prevent the emerge of a short flow and prolong the journey of the sewage in the reactor, improving the effect of mass transfer. The oxygen was supplied by microporous aeration fan (Model: sp-780).

Note: ①sewage tank ②peristaltic pump ③Isolation board ④fall region ⑤rise region ⑥sampling port

Fig.1 Schematic diagram of experimental set-up

2.2. Materials and methods
Bamboo filament packing was made up of Moso bamboo (about a year after harvest), being sawn into rectangular (20mm×1mm×1mm). Technical parameters are shown in Table 1. Bamboo filament was soaked in water for 7d and then disorganized spare piled into the reactor.

Table 1 The technical parameters of filamentous bamboo biocarrier

| Porosity | Water absorption | The specific surface area | Heaping number | Individual density |
|----------|------------------|---------------------------|----------------|--------------------|
| 80.5%    | 292%             | 214.8m²/m³                | 2.08××10⁶/m³  | 1.29g/L            |

2.3. Water quality
Raw water was from the septic tank effluent of Henan Institute of Urban Construction. Chinese Patent Medicine wastewater was added into raw water so as to simulate the high organic loading test water. CODcr was 790.0~5000.0mg/L, BOD was 60.0~1100.0mg/L, NH₄⁺-N was 18.2~76.8mg / L, NO₂-N <0.09mg / L, NO₃-N was 0.26~3.89mg/L, the COD/TN ratio was 25.5 to 283. Septic tank effluent was used to simulate low C/N ratio water. CODcr was 130.0 to 278.0mg/L, BOD was 42.5~96.7mg/L, NH₄⁺-N was 16.2 ~ 98.1mg/L, NO₂-N <0.42mg/L, NO₃-N was 0.01~0.30mg/L, the COD/TN ratio was 1.6~4.7. First case ensures a sufficient C/N, and by using only biodegradable and high concentrations of organic water pollution; while the second case C/N is low (3.8), using only a low organic load high nitrogen Water.

2.4. Test method
The reactor is started, cultured and domestication on July 12, 2011. With the continuous a little water from Septic tank effluent water, the process hang film. In the cultivation of the domestication process add a little industrial glucose in water to speed up the growth of hanging membrane and membrane mature. In July 28, the reactor from the bamboo filament on the packing biofilm was peeling. I observed that a large number of clock of worm and a small amount of rotifer and nematodes, it shows that cultivate acclimatization period is over. From July 29 to August 6, on condition that it does not
affect the treatment effect of the reactor, I slowly increase the load and the system inoculating culture to the reactor, and on August 6, I begin the test process. From August 6 to 26, add traditional Chinese medicine pharmaceutical wastewater into the effluent water of septic tank to rise the organic load water for denitrification test. August 28, I take the denitrification test just with the septic tank water at the low C/N water. Water quality analysis once in every 2d, using quantitative filter paper before the analysis, and then take a certain amount of filtrate for analyzing. Due to the test process bamboo filament corruption quickly, in order to maintain the bamboo filament quantities and effectively specific surface area, iadded amount of bamboo every day, according to the consumption of bamboo the day before.

2.5. Analysis methods and instruments
COD uses potassium dichromate titration method; The BOD applied BOD– 220A microbial method BOD quick tester, NH4+-N, NO2-N, NO3-N and TN uses standard methods[10] (VIS-7220 / Alpha-1101 spectrophotometer).

2.6. Flora analysis
In the import and export place of the reactor, take out quantitative (400 bars) bamboo filament packing which have more biological membrane. Add 10 grain sterilization glass bead in an aseptic operation conditions and clean taper bottle injection sterile water 100ml, shaked 20 minutes in 200~250 r/min cradle until the bamboo filament of biological membrane fully off and uniform distribution. Take its suspension 1 ml as analysis object, with the dilution plate method was used for determination of the total bacterial count, and conversion out 100 ml in the number of alcohols strains, and finally remove these bamboo filament packing specific surface area, i.e., for all types of bacteria concentration; With the must probable method (MPN) determination of nitrite bacteria, nitric acid bacteria and denitrifying bacteria, according to the number of three tube MPN method retrieval table calculation results.

Figure 2a displays that influent NH4+-N and effluent NH4+-N were 18.2 ~ 76.8 mg/L and 0 to 57.2 mg/L, its removal efficiency was 29.03% to 100 %, of which 6 and 26 August, the effluent concentration is greater than the influent concentration probably the bamboo filament after use, because of the cavity decay due to some amino acids, proteins and other substances released into water so that the effluent NH4+-N concentration increased. Figure 2b and Figure 2c shows the influent, effluent NO2-N, NO3-N concentration were very low, where the influent NO2-N concentration of 0.01 to 0.15, the effluent concentration of 0.01~0.06mg/L, while waterNO3-N concentration of 0.26 to 3.89, the effluent concentration of 0.21~1.99mg/L. This shows that the NH4+-N reduction is not converted into NO3–N, but is transformed into N2, no accumulation of NO3–N. Figure 2d shows the influent and effluent TN 22.6 to 80.4, respectively, 0.69 ~ 56.5mg/L, which is the removal rate of 26.6% to 97.0%.
Fig. 2 Total nitrogen concentration variation in influent and effluent under high organic load

The bamboo surface of the biofilm structure occurs the main causes of simultaneous nitrification and denitrification. With the proliferation of the biofilm, bamboo surface comes to form a the aerobic layer hypoxia layer and anaerobic layer micro-membrane structure; NH$_4^+$-N in the aerobic layer because O$_2$ is Sufficient to NO$_3$-N, the NO$_3$-N part by diffusion into the anoxic layer and anaerobic layer of denitrifying. Because bamboo is cellulose material, into the biofilm deep NO$_3$-N using bamboo fiber formed by decomposition of low molecular organic denitrifying. Bamboo filament surface biofilm formation is firm, not because the biological membrane deep microbial aging and loss. Because the bamboo cellulose constantly decomposition to provide degradable matrix for deep microorganisms for keeping a good biological activity. Nitrifying bacteria and denitrifying bacteria and other bacteria proliferation and the simultaneous removal of nitrogen pollutants.
From August 26, the test just using septic tank effluent water: COD 130.0 ~ 278.0 mg/L, BOD 42.5 ~ 96.7 mg/L, NH$_4^+$-N 16.2 ~ 98.1 mg/L, TN 28.0 ~ 105.1 mg/L, COD/TN of 1.6 to 4.6, belonging to the low C/N ratio of sewage.

Figure 3a shows the influent, effluent NH$_4^+$-N were 16.2 to 98.1 mg/L and 15.8 ~ 65.6 mg/L, its removal rate of 4.95% to 48.8%. Figures 3b and 3c show influent and effluent concentrations of NO$_2$-N were 0.01 to 0.38 mg/L, 0.01 ~ 0.30 mg/L, influent and effluent concentrations of NO$_3$-N were 0.01 ~ 0.30 mg/L, 0.07 to 0.54 mg/L. The system also does not appear accumulation of NO$_3$–N. It can be seen from Figure 3d, TN influent and effluent concentrations were 28.0 ~ 105.1 mg/L, 20.3 ~ 51.3 mg/L, removal rate from 29.4% to 58.8%. Therefore, in the C/N lower circumstances, bamboo filler can be broken down into the available carbon source to improve nitrogen removal system, but it may make bamboo filament decomposition rate is slower and blocked the system the nitrification process. And also in the C/N lower circumstances, prone to the accumulation of NO$_2$-N phenomenon.

3.3. Population distribution characteristics of various types of flora in the reactor in the high organic loads and low C/N under the two water conditions

Table 2 shows, under the condition of high concentration of refractory reactor imports, bottom and the total number of bacteria were 6.02 x 10$^{10}$, 4.73 x 10$^{10}$, 4.29 by gasoloid density was exceed 10$^{10}$ cfu/mL; Low C/N conditions bioreactor imports, bottom and the total number of bacteria were 8.89 x 10$^{10}$, 1.83 x 10$^{10}$, 9.01 by gasoloid density was exceed 10$^{9}$ cfu/mL. Bacteria quantity contrast found that inlet nitrifying bacteria is 49.48 times of the total, is at the bottom of the 15.08 times, visible nitrifying bacteria are mainly distributed in the bamboo filament reactor drop flow area; And inlet denitrifying bacteria is 1.59 times of the total, is 1.42 times of the bottom, the bottom is 1.12 times, visible
denitrifying bacteria along the path uniform distribution, presumably denitrifying process happened along the path.

At the same time, on August 27, 29, 31 for three consecutive days the biomass in the reactor at the entrances bamboo filler, the biofilm amount on the inlet filler were 9.87,20.12, 13.19g/m², its corresponding outlet filler biofilm amount respectively 5.02,6.93,3.95 g/m², corresponding at the entrances to the biofilm than value 1.97,2.90,3.34. This value with the import and export at the ratio of the total number of bacteria compared to (9.86) is much smaller, it may be because the entrance biofilms including a large number of bacteria from septic tanks, and a small amount of humus, at the outlet of the biofilm may mainly by a small amount bacteria, and a large number of bamboo putrefaction. So the reactor inlet and at the outlet of the biofilm little difference in the total, but the bacterial total was nearly an order of magnitude difference.

| Project                        | Flora concentration at the high concentration of refractory wastewater treatment | Flora concentration at the low C / N wastewater treatment |
|--------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------|
|                                | Import                      | Bottom                  | Export                   | Import                      | Bottom                  | Export                   |
| The total number of bacteria   | 6×10^10                     | 4.7×10^10              | 4.3×10^10               | 8.9×10^10                   | 1.8×10^10               | 9×10^9                   |
| The number of nitrifying bacteria |                              |                         |                          | 1.40×10^9                   | 9.5×10^7                | 2.9×10^7                |
| The number of denitrifying bacteria |                              |                         |                          | 1.60×10^7                   | 1.1×10^7                | 0.97×10^7               |

4. Discussion
Contact oxidation process by Bamboo filler can removal nitrogen pollutants in refractory the water with high concentration of organic pollutants and in low C/N wastewater. The biochemical (BOD/COD) in the effluent is higher than influent can illustrate that the bamboo filament biological reactor greatly upgrade and enhance carbon source in the quantity and quality.

The total number of bacteria and the nitrifying bacteria are rapidly diminishing in the direction of the flow along the direction of flow in the reactor. This is probably due to the high ammonia concentration and low organic matter in the entrance make the nitrifying bacteria become the dominant bacteria. Then the ammonia is degraded by the nitrifying bacteria in the bamboo filler packing area and the nitrifying bacteria diminished rapidly.

The number of denitrifying bacterias of the imports and exports did not change so much. This indicated that there numerous denitrifying bacterias in the imports of the reactor. They consume carbon source available in raw water to transfer nitrate and nitrite to gaseous nitrogen rapidly. Although the carbon source of raw water depletion, but the bamboo process of rotting deterioration, bamboo fiber decomposition of organic matter and continue to provide a carbon source for the denitrifying bacteria, thereby maintaining the efficient operation of the system, so that the whole system within the denitrifying bacteria to maintain our edge.

5. Conclusion
When influent COD was 790.0 to 5000.0 mg/L, BOD was 60.0~1100.0mg/L, BOD/COD ratio was 0.01 to 0.47, the system effluent COD was 62.9 ~ 864mg/L, BOD was 8.9~192.6mg/L, BOD/COD ratio was 0.07 to 0.74, at the same time into the effluent TN were 23.5 ~ 80.2, 0.72 ~ 73.8mg/L, the removal rate was 29.7% to 94.25%.

Raw water CODcr was 130.0~278.0mg/L, BOD was 42.5~96.7mg/L, TN was 28.7~103.8mg/L, COD/TN ratio was 1.2 to 4.5, the effluent TN maintained at 25.3 to 60.3mg/L.
In the case of low C/N ratio influent, the nitrifying bacteria concentration at the inlet of the reactor is high, reduce the concentration at the outlet for the dominant strain, denitrifying bacteria into the considerable number of the exit. Inlet biofilm greater than the outlet.

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