The Study of Aerobic Membrane Bioreactor used to Process Low Carbon and Nitrogen Ratio Sewage

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Abstract. In sewage treatment, the sewage whose carbon and nitrogen(C/N) ratios is less than 8 is de-fined as low C/N ratio sewage. This study contrasts the treatment effects under different C/N ratios in aero-bic membrane bioreactor. The experiment is performed in the following conditions: Temperature is from 7 to 30℃; pH is from 6.4 to 7.9; CODcr is from 114.8 to 400.0mg/L; TN is from 28.9 to 50.9mg/L; NH4+-N is from 16.8 to 29.8mg/L. The range of outlet CODcr and NH4+-N are from 8.78 to 20.78mg/L and 3.1 to 7.0mg/L respectively, and the range removal rates of them are from 82.98 to 97.49% and 67.3 to 86.9% re-spectively. Both two indexes achieve A level of dicharge standard in "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918—2002). But the TN in outlet cannot reach this standard.

1 Introduction

In Chinese village and city, A phenomenon that sewage presents low C/N ratio becomes more and more general[1~3], so there are lots of technology that are used in this kind of water treatment. Some scholar think that biological removal of nitrogen is happening in the case of 7.1 C/N ratio[4]. And the sewage whose C/N is less than 8 or BOD5/TN is less thatn 5 is defined as low C/N ratio sewage[5~6]. The advantages of membrane bio-Reactor are good outlet water quanlity, small floor space and convenient management.

2 Material and Method

2.1 *Raw water and agent*

The test raw water is derived from sanitary sewage in East China Jiaotong University. This test needs to add carbon and nitrogen source by dosing pump and water distribution bucket to adjust inlet C/N which reach 4, 6, 7, 8 respectively. And the water quantiy shows as the Table 1 And the Table 2 presents the basic parameter of the agent.

Table 1. Test raw water

Item	Range
Temperature（℃）	7.0~30.0
pH	6.4~7.9
COD_{cr}（mg/L）	114.8~400.0
TN（mg/L）	28.9 ~50.9
NH_4^+-N（mg/L）	16.8 ~29.8

Table 2. The basic parameter of the agent

Name	standard
Edible glucose	Quanlity level：premium grade place of origin：Bin Zhou city, Shan Dong province；Manufacturers：Xi Wang pharmacy limited company
Industrial ammonium chloride	Usefulness level：industrial grade； Principal component：ammonium chloride Content：99（%）；Particle size：300 (mesh)；Manufacturers：ShuangHuan Group Co.Ltd

2.2 *Test process and apparatus*

2.2.1 *Test process*

The raw water is derived from sanitary sewage in East China Jiaotong University. The water enters the regulating reservoir after filtrating by grating, promoted by sinking pump into distribution reservoir where is added carbon and nitrogen source to adjust C/N. And the sewage is lifted by deliver pump into aerobic membrane bioreactor. After disposing by bioreactor, the yielding water is discharged by suction Pump. And the Figure 1 shows the process flow diagram of experiment. Figure 2 and Firgure 3 present the grid and regulating reservoir.

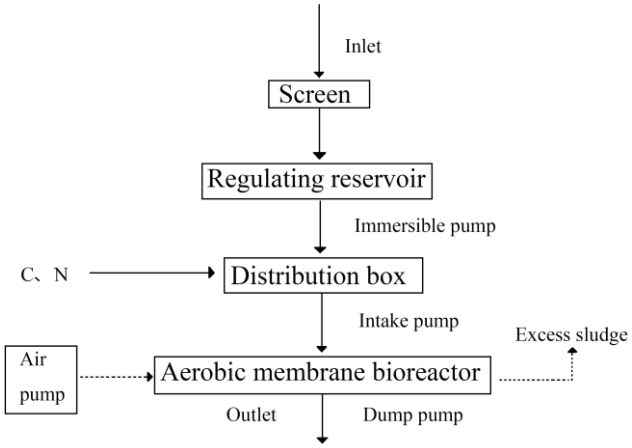

Figure 1. Process Flow Diagram of Experiment

Figure 2. Grid

Figure 3. Regulating reservoir

2.2.2 *Testing apparatus*

The Figure 4 present the product picture and structural map odaerobic membrane bioreactor.

The length , width and height of membrane bioreactor are 860mm, 300mm and 800mm respectively, and the available depth is 690mm while the effective volume is 178L. And the bioreactor is formed by anoxic zone(52.78L), aerobic zone(52.78L) and filter membrane zone(72.44L).

The sewage is lifted from regulatingreservoir into circular bucket distribution and square distribution reservoir where the test raw water is deployed. And then the raw water is promoted by pump into aerobic membrane bioreactor. The water inlet is installed in the bottom of bioreactor which is a way into anoxic zone for raw water. And in this zone, after mixing by stirrer, the water enter aerobic zone. There are lots of microporous aeration in the aerobic zone, which can aerate to active sludge intermixture by air pump. And there is a level control meter to control the deliver pump in the aerobic zone. In the filter membrane zone, there are hollow fiber membrane, aerating by perforated pipe sparger set in the bottom, and the treating water is pumped by the suction pump.

Figure 4. Aerobic Membrane Bioreactor

All the deliver pump, suction pump and stirrer are controlled by electric control cabinet. And the reactor not only uses the level control meter to control the reactor volume, but also makes use of overflow pipe and siphon in the anoxic zone so as to prevent the spill-over in the reactor when the pumps are in trouble. The air for aeration in the bioreator is supported by air pump, and its strength is controlled by air flow meter. The transmembrane pressure is showed by air pump in the suction pipe. And the water meter shows the treating water flow.

The Table 3 shows the basic information of matching device.

Table 3. The basic information of matching device

Item	Type	Performance Parameter	Manufacturer
Sinking pump	QDX3-14-0.37 Sinking pump	Rated flow: 3m^3/h Rated head: 14m Rated power: 0.37Kw Rated voltage: 220V Rated current: 3.5A Rated frequency:50Hz Rotate speed:3000r/min	Shang Hai Bo Yu Pump Limited Company
The sewage delivery pipe	Plastic hose	dn20，L≈20m	
Distribution bucket	Plastic	650mm×880mm Effective volume:250L	
Distribution reservoir	Rigid plastic	50mm×500mm×420mm Effective volume:150L	
Inlet water pump	MP-15RN magnetic drive pump	Rated flow: 8m^3/h Rated head: 1.5m Rated power: 10w Rated voltage: 220V Rated current: 100mA Rated frequency:50Hz Rotate speed:2600r/min	Shang Hai New West Mountain Limited Company
Vacuum meter	Shang Hai Manufacture01090005	Range:-0.1~0Mpa	Shang Hai Hua Rong Instrument and Meter Plant
Air pump	LP-60	Air flow:90L/min Pressure:0.039Mpa The maximum water depth:3.5m Distribution number: 14 Power:50W Voltage:220V Frequency:50Hz	Shen Zhen Xing Ri Sheng Limited Company
Outlet water meter	LZB-10 Glass rotameter	Range:6~60L/h	Yu Yao Wen Tai Instrument and Meter Limited Company
Air flow meter	LZB-6 Glass rotameter	Range:0.04~0.4m^3/h,0.06~0.6m^3/h	Yu Yao Wen Tai Instrument and Meter Limited Company

2.3 Testing methods

The preparatory work includes inoculated sludg, sludge acclimatization and launching aerobic membrane bioreactor. When the bioreactor runs stably, the inlet carbon nitrogen ratio(COD/TN) can be controlled under four kinds working conditions, 4, 6, 7 and 8. Every condition runs after a period of time to stabilize activated sludge in the bioreactor. Water sample is taken every other day, and the period of every working condition is fourteen days. And during this period, the COD_{cr}, TN, NH_4^+-N and pH can be measured.

3 **Results And Analysis**

3.1 *The removal efficiency of organics*

The Figure 5 shows the removal efficiency of organics.
From this figure, it can be known that the inlet concentration range of CODcr is from 114.8 mg/L to 400.0 mg/L while the outlet is from 8.78mg/L to 20.78 mg/L. And the removal rate range is from 82.98% to

97.49%. The outlet average concentration is 17.8mg/L, and the average removal rate is 91.5%. All of these indexes achieve A level of dicharge standard in "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918—2002).

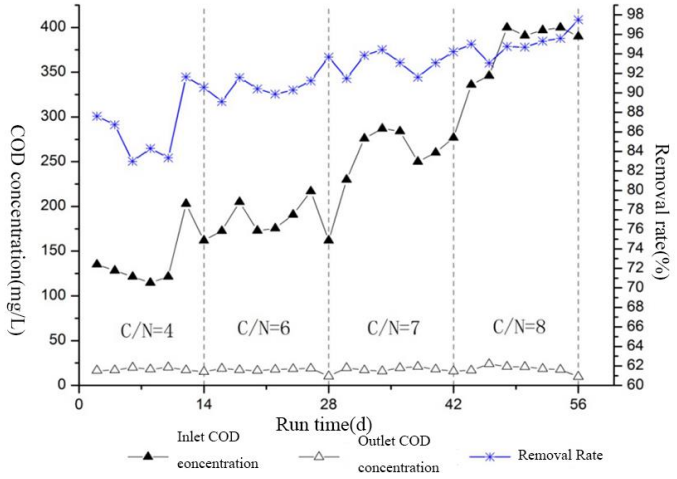

Figure. 5 the the removal efficiency of CODcr

3.2 *The removal efficiency of total nitrogen*

The Figure 6 shows the removal efficiency of total nitrogen.

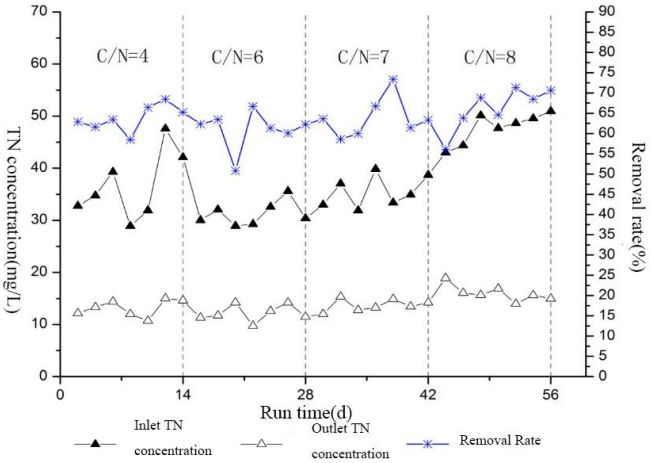

Figure. 6 Removal efficiency of TN

As from the Fig. 4, during the operation of the aerobic membrane bioreactor, the inlet concentration range of TN is from 28.9 mg/L to 50.9mg/L while the outlet is from 9.7mg/L to 18.9mg/L. And the removal rate range is from 50.8% to 73.3%. The outlet average concentration is 13.8mg/L, and the average removal rate is 63.7%. It can be known that the aerobic membrane bioreactor is not pretty suitable for TN removal which is highly rely on carbon source in raw water. Part of these indexes achieve A level of dicharge standard in "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918—2002).

3.3 *The removal efficiency of ammonia nitrogen*

The Figure 7 shows the removal efficiency of ammonia nitrogen.

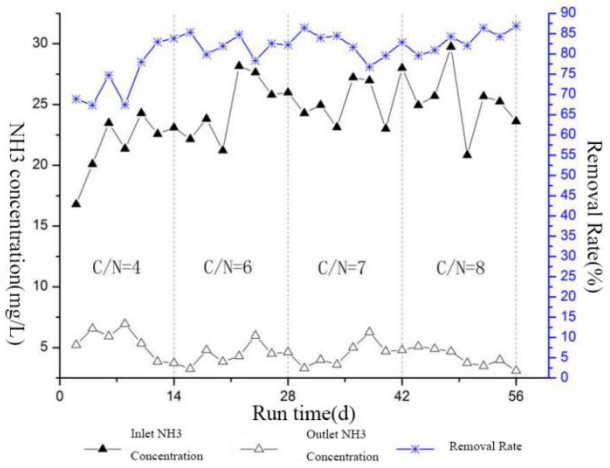

Figure.7 The removal efficiency of NH_4^+-N

As from the Fig. 5，during the whole operation，the inlet concentration range of $NH4^+$-N is from 16.8 mg/L to 29.8 mg/L while the outlet is from 3.7mg/L to 7.0 mg/L. And the removal rate range is from 67.3% to 86.9%. The outlet average concentration is 4.6mg/L, and the average removal rate is 80.6%. All of these indexes achieve A level of dicharge standard in "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918—2002).

4 Conclusion

The experiment is performed in the following conditions: the temperature is from 7 to 30℃; pH is from 6.4 to 7.9; CODcr is from 114.8 to 400.0mg/L; TN is from 28.9 to 50.9mg/L; NH4+-N is from 16.8 to 29.8mg/L. The range of outlet CODcr and NH4+-N are from 8.78 to 20.78mg/L and 3.1 to 7.0mg/L respectively, and the range removal rates of them are from 82.98 to 97.49% and 67.3 to 86.9% respectively. Both two indexes achieve A level of dicharge standard in "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918—2002). But the TN in outlet cannot reach this standard.

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References

[1] Zijie Z. & Rongchen L. 2000. Sewerage，Wasterwater Engineering Vol 2. China: Architecture & Building Press.

[2] Carrera J & Vicent T & Lafuente J. 2004. Effect of influent COD/N ratio on biological nitrogen removal (BNR) from high-strength ammonium industrial wastewater. Process Biochemistry. 12: 2035-2041.

[3] Hongmei L. 2010. Study on treatment of low C/N sewage using by UCT technology. Jilin University.

[4] Jieyun C. & Zhi Z & Yong L.etc.. 2010. Comprehensive Regulation technology for enhancing nitrogen removal from low-carbon wastewater in reversed A^2/O process. China Water&Wastewater. 19: 32-36.

[5] Yadong L. & Dong L. & Huiping Z. etc.. Treatment of low C/N(P) domestic sewage using terminal intermittent aeration A^2/O technique. Journal of Harbin institute of technology. 02: 79-86.

[6] Xiaoyan C. 2010. Study on nitrogen removal of low carbon-nitrogen ratio domestic sewage with waste activated sludge as supplement. Chongqing University.