Anammox application to low strength ammonium containing wastewater

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1. Introduction

Commonly, anammox process was operated and had high nitrogen removal efficiency at temperature of 30-40^{0}C, and many researchers focus on obtaining good nitrogen removal efficiency with high influent concentration and low flow rate. In this study, one fixed-bed anammox reactor using nonwovens as biomass carrier was operated at room temperature (20±20^{0}C in winter) with lower influent concentration and higher flow rate for 400 days. The reactor running was successful and stable in start-up and all operation periods.

2. Materials and methods

2.1 Experiment set-up

The reactor used in this experiment is shown in Figure 1. The influent was supplied to the reactor by up-flow mode. The reactor was heated outside the reactor to about 20^{0}C in winter and kept room temperature in summer. The reactor set was kept away from light all the time. The reactor was made of glass and the size is φ 95mm x 423mm, with the available volume of 2.8L.

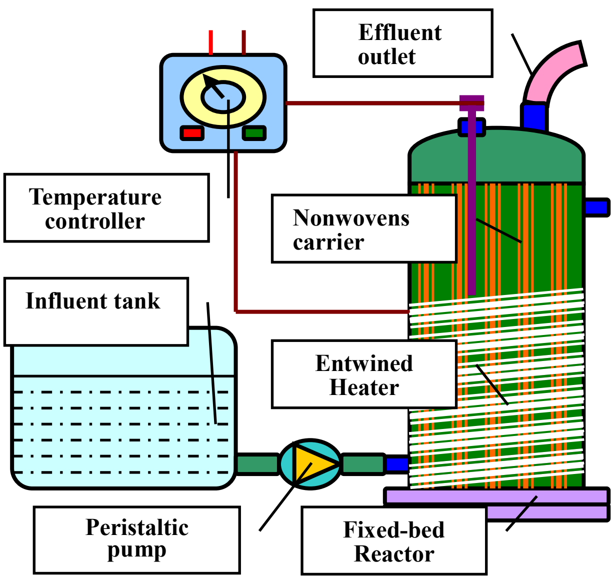


Figure 1. Schematic diagram of experiment

2.2 Seed sludge

The seed sludge was anammox bacteria obtained from another anammox reactor cultivating in my laboratory 1.4g-VSS.

2.3 Biomass carrier materials

The nonwovens was outspread evenly by 8 strips like a column inside of reactor. Each strip size is 2×10×395mm, split every strip to get double surface area, therefore, the total superficial area is 126,400mm^2.

The purpose to this splitting is (1) to get more surface superficial area of this carrier where more biofilm could attached on it, (2) and to get thinner biofilm with higher bacteria activity, so that more substrates and nutrient could diffuse evenly and easily to anammox biofilm.

2.4 Start up

(1) Separate the granular sludge, (2) crush and grind the granular sludge into smaller particles, (3) and make the nonwovens carrier suck the latex of smaller particles, therefore, seed sludge can distribute to the surface of nonwovens carrier very evenly. Then put the nonwovens into reactor. Finally, pump influent into reactor quickly until water is full of the reactor.

2.5 Synthetic influent

Influent wastewater was prepared by adding ammonium and nitrite in the forms of $(NH_4)_2SO_4$ and $NaNO_2$, with other nutrients and buffer according to the composition given in Table 1.

Table 1 Composition of synthetic wastewater

Composition	Concentration
$(NH_4)_2SO_4$	70±5 (mg N/L)
$NaNO_2$	70±5 (mg N/L)
EDTA	5 (mg/L)
$FeSO_4.7H_2O$	9 (mg/L)
$KHCO_3$	125.1 (mg/L)
KH_2PO_4	54.4 (mg/L)

2.6 Increasing of T-N loading rate

Total nitrogen loading rate was increased stepwise from 0.1 to 1.2kgN/m^3.d as shown in Figure 3. After loading rate of 1.2 kgN/m^3.d, T-N loading rate was increased by 0.2±0.05 kgN/m^3.d Fluent nitrite concentration were always kept below 20mgN/L.

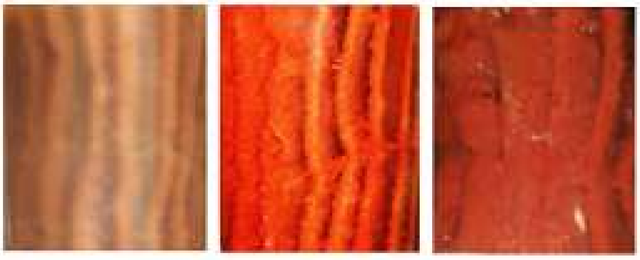
2.7 Analytical methods

Ammonium concentrations were measured by the phenate method using ortho-phenylphenol as a substitute for liquid phenol. Nitrite, nitrate and other parameters are measured according to Standard Methods. DO of influent synthetic wastewater was measured by using a DO meter (D-55, Horiba).

3. Results and Discussion

3.1 Observation of the attached biomass

The changes in anammox bioflim shape and color at different periods were shown in Fig. 2. The biofilm developed in thicker and the color of anammox biofilm changed deep red color gradually.



a. after 2 months　b. after 6 months　c. after 12 months

Figure 2. Biofilm changes in different periods

3.2 Nitrogen removal performances for Reactor

T-N removal performances were shown in Figure 3. At the starting periods up to 50 days, influent T-N concentration was kept to the low level of 50 to 70mgN/L. From day 51 to 300 days, influent T-N concentration was kekept at 150mgN/L and t-N loading rates were increased stepwise by increasing influent flow rate. After continuous operation of 300days, T-N loading rate reached to 3.2 kg-TN/m^3/d. Owing to the long term operation and the massive growth of anammox sludge on the nonwoven biomass carrier, clogging and channeling phenomena were occurred, so that 6.5g-VSS of anammox sludge was withdrawn from the reactor on day 340.

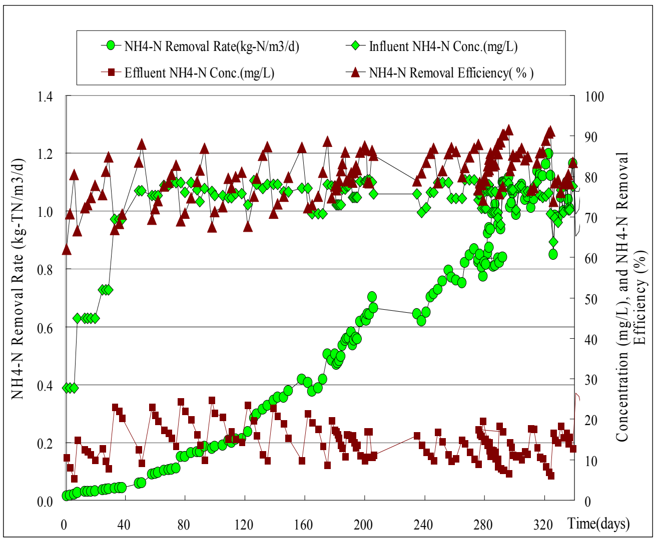


Figure 3 Changes in TN and NO_2-N

Figure 4 shows the daily changes in influent and effluent NH_4-N concentrations, NH4-N removal rates and NH4-N removal efficiencies. Nh4-N removal efficiency were ranged from 70 to 85% and effluent NH4-N concentration were below 30 mg/L.

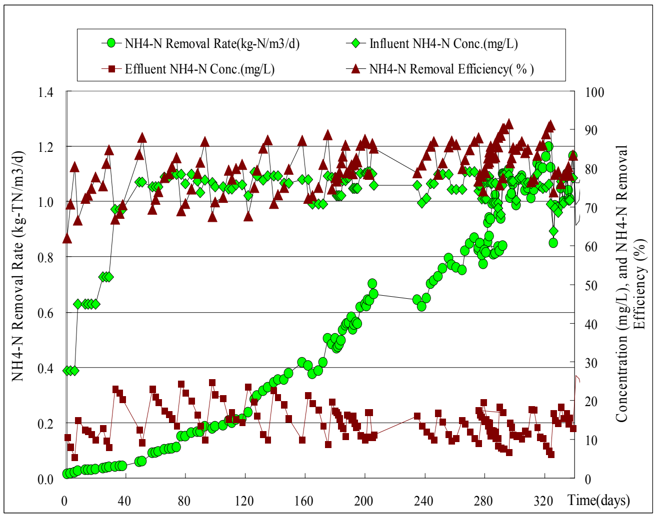


Figure 4 NH_4-N daily changes

Figure 5 shows the daily changes in influent and effluent NO_2-N concentrations, NO_2-N removal rates and efficiencies. NO_2-N removal efficiencies were ranged from 80 to 95% and effluent NO_2-N concentration were kept below 30mgN/L. Hence, this anammox reactor was operated under NO_2-N limited concentration.

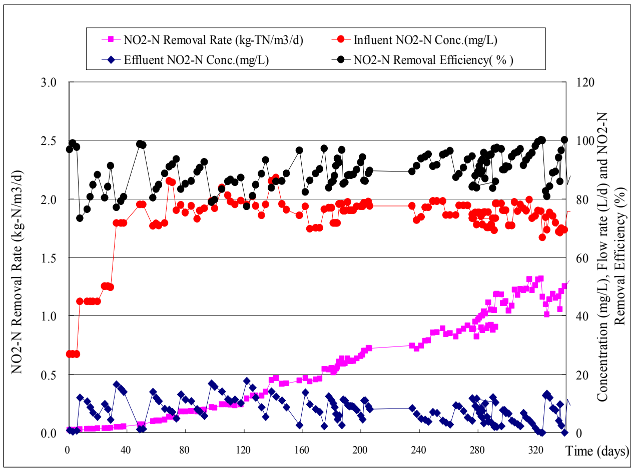


Figure 5 NO_2-N daily changes

4 Conclusion

We have succeeded the establishment of anammox reactor using low strength influent substrate of 150 mgN/L under low temperature of 20-25^{0}C. This study on anammox process at low temperature would be signification in practical industrial application.

Reference

1) Takao Fujii, Kenji Furukawa, Characterization of the microbial community in an anaerobic ammonium-oxidizing biofilm cultured on a nonwoven biomass carrier. Journal of Bioscience and Bioengineering, Volume 94, Issue 5, 2002, Pages 412-418.