PARTIAL NITRITATION OF LANDFILL LEACHATE USING ACRYL RESIN FIBER AS AN ATTACHING MATERIAL

Pham Khac Lieu – Student member – Graduate School of Science and Technology, Kumamoto University
Hiroyuki Tokitoh– Student member – Graduate School of Science and Technology, Kumamoto University
Kenji Furukawa – Member – Department of Architecture and Civil Engineering, Kumamoto University

1. INTRODUCTION

In recent years, the development of ANAMMOX process has opened up a new pathway for nitrogen removal from wastewater[1]. Partial nitrification, i.e. conversion of a half of ammonium into nitrite, is required as a preceding step for ANAMMOX application. Combination of partial nitritation and ANAMMOX was studied and applied to treat ammonia-rich wastewaters, such as sludge digester liquor[2,3]. Landfill leachate was suggested as a potential object to combined partial nitritation-ANAMMOX treatment.

As a separate process, partial nitritation far has been increasingly concerned, especially for high ammonia influents. Some studies on partial nitritation had been done with suspended growth reactors[4,5]or biofilm reactor[6,7]. In general, partial nitritation could be achieved when nitrite oxidizers are selectively inhibited versus ammonium oxidizers by carrying out the process at high temperature (over 28°C), low dissolved oxygen (0.5~1.5 mg/L) and pH 7.2~8.0. However, almost previous studies were carried out on influents without organic contents, without or low concentration of inorganic ions (Ca^{2+}, Mg^{2+}, Fe^{2+}, Cl^-, SO_4^{2-} etc.) which are far from landfill leachate characteristics.

Acryl resin fiber has been used as attaching material for nitrification of groundwater at the Environmental Sanitary Engineering Laboratory of Kumamoto University[8].

As the first step of research on nitrogen removal from landfill leachate by combined nitritation-Anammox process, the partial nitritation of synthetic leachate was studied in lab-scale reactor using acryl resin fiber as attaching material. This paper presents some first results of the study.

2. MATERIALS AND METHODS

2.1. Reactor system

The nitritation reactor system was controllable in influent flow, air flow, pH and temperature. The system's scheme is shown in Figure 1.

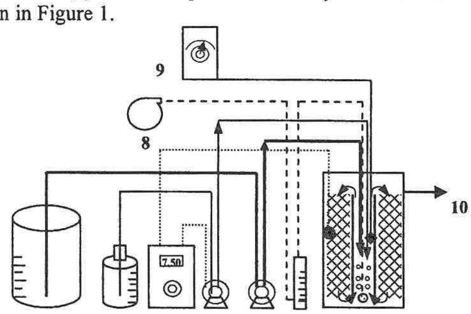

Figure 1. Scheme of nitritation reactor system
(1) Influent tank (2) $NaHCO_3$ solution (3) pH controller (4) Bicarbonate pump (5) Influent pump (6) Air-flow meter (7) Reactor (8) Air pump (9) Heater (10) Effluent

The reactor is made from acryl resin, with a total volume of 5.0 L and an effective volume of 4.65 L. The attaching material is acryl resin fiber, being prepared in form of a net (see Figure 2). Two pieces of net were used and each of them has the size of 28 cm x 40 cm and the weight of 27 g.

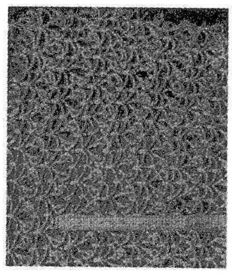

Figure 2. Photo of acryl fiber material

2.2 Influent composition

The influent in this study was a synthetic leachate simulating mature or anaerobically pre-treated leachates[9,10]. The desired composition of the influent is in Table 1. During start-up phase, the simple influents containing only components 1~4 at lower concentrations were applied.

Table 1. Composition of influent (unit: mg/L)

Component	Concentration
1. NH_4Cl	916
2. KH_2PO_4	43.4
3. $NaHCO_3$	420
4. $KHCO_3$	500
5. $C_8H_5O_4K$ (*)	37.5
6. $FeSO_4.7H_2O$	16
7. $Na_2.EDTA$	16
8. $CaCl_2.2H_2O$	235.2
9. $MgSO_4.7H_2O$	328

(*) Potassium hydrogen phthalate

All chemicals were made available as stock solutions and the influents were prepared by appropriately diluting with tap water. Alkalinity, pH, NH_4-N, NO_2-N and NO_3-N were monitored daily for influent and effluent. Analytical methods for parameters were followed the Standard Methods[11], except ammonium that was analysed by OPP method[12] . pH was measured with pH meter (TOLEDO 320). Nitrogen compounds were determined spectrophotometrically using U-2010 Spectrophotometer (HITACHI).

2.3. Design of experiment (DOE) methodology

To evaluate effects of operational conditions on partial nitritation process, the methodology from DOE was applied. Temperature (T), pH and air flowrate (AirQ) were factors, and ammonium conversion rate, effluent NO_2-N/NH_4-N ratio and effluent NO_3-N percentage were responses for DOE. The experimental matrix for screening DOE which is in random order and includes 11 runs is presented in Table 2. Each run was designed in a period of 4~5 days or 16~20 HRTs.

Table 2. Experimental design matrix

Run #	1	2	3	4	5	6	7	8	9	10	11
T, °C	32.5	30	35	30	32.5	35	35	30	32.5	35	30
pH	7.5	7.8	7.8	7.2	7.5	7.8	7.2	7.8	7.5	7.2	7.2
AirQ, L/min	0.3	0.1	0.1	0.5	0.3	0.5	0.5	0.5	0.3	0.1	0.1

3. RESULTS AND DISCUSSION

3.1. Reactor start up

The reactor was seeded with activated sludge which has been stably cultured in the laboratory. The original MLSS and VSS were 2.9 g/L and 2.6 g/L, respectively. Total amount of seeding was 14 g based on MLSS The influent was introduced at starting flowrate of 0.2 L/h (HRT $\approx$ 24 h), with a simple composition including 76.34 mg/L NH_4Cl, 88.0 mg/L KH_2PO_4 and mixed solution of 63 mg/L $NaHCO_3$+75 mg/L $KHCO_3$. Then the volumetric loading rate (VLR) was gradually increased by both increases in concentration and in flowrate. The start-up profile of is shown in Figure 3.

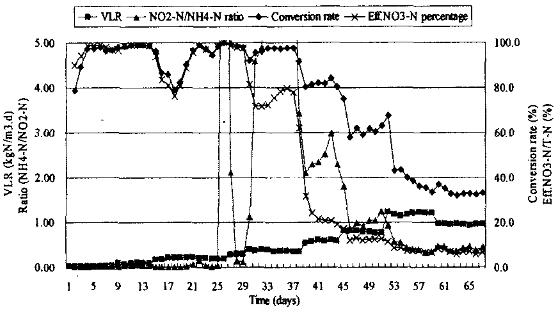

Figure 3. VLR, NH_4 conversion rate, effluent NO_2-N/NH_4-N ratio and effluent NO_3-N percentage profile during start-up phase

When the VLR reached around 0.8 kgN/m^3.d, the reactor was quite stable at ammonium conversion rate of around 60%. Influent flowrate of 0.78 L/h was selected corresponding to HRT of 6 h. An accident increase in VLR (by increasing ammonium concentration from 200 mg/L to 300 mg/L) was tried in 8 days. However, it showed a continuously decrease in conversion rate. Then, the ammonium concentration of 240 mg/L was chosen to get a VLR around 1 kgN/m^3.d. This VLR, in fact, gave stable operation of reactor more than 10 days (40 times of HRT).

3.2. Effects of operational conditions on responses

After starting-up, the reactor was put into experimental plan (see table 2) to investigate the effects of operational conditions on responses. So far, eight of eleven runs were completed, because in the run # 9, it was appeared a operational problem with the reactor (see next section). The results are shown in Figure 4.

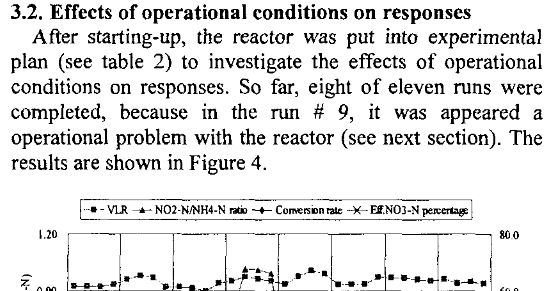

Figure 4. VLR, NH_4 conversion rate, effluent NO_2-N/NH_4-N ratio and effluent NO_3-N percentage profile during DOE phase

From the first eight runs, it can be seen that all three factors had effects on responses. The most significant effect was of air flowrate while pH and temperature seemed to have minor effects. This is due to pH (7.2~7.8) and temperature (30~35°C) are already within the best ranges for partial nitritation (as mentioned in part 1). The run #4 resulted in an effluent most suitable for ANAMMOX process with average conversion rate of 53.0%, effluent NO_2-N/NH_4-N ratio of 0.99 and effluent NO_3-N of 10.1%. If considering last three data of this run (the first data had high standard deviations from the means), the average responses would be 54.1%, 1.01 and 10.5%, respectively.

However, there are more 3 runs required for statistical treatment in order to adequately evaluate the effects.

3.3. Stability of the process

After run #8, a problem appeared with the reactor. When the reactor was put on the run #9, responses did not well repeat those obtained in the run #1. The accumulation of detached biomass on reactor bottom and appearance of slimy filamentous heterotrophs on reactor walls were observed. These phenomena led to the reduction in nitrifiers' activity due to circulation prevention and competition in attaching space of heterotrophs. The reason here might be due to fast growth of heterotrophic bacteria under conditions of short HRT and presence of organic carbon. High concentration of bivalent metal ions (Ca^{2+}, Mg^{2+} and Fe^{2+}) and alkalinity in influent also enhanced the bioflocs formation. The reactor was put into recovery phase, in which the non-organic, non-bivalent metal and low ammonium concentration influent was introduced. The experiment is still going on.

4. CONCLUSION

Partial nitritation of leachate can be achieved with a fixed film reactor using acryl resin fiber as attaching material. The short HRT (6h) is an advantage of the process. At temperature of 30°C, pH 7.2 and air flowrate of 0.5 L/min (or air-to-nitrogen load of 160 L-air/g-N), the effluent can be suitable for next ANAMMOX process. Further studies are going on to get the stability of the system as well as the better effluent.

REFERENCES

1. I. Schmidt et al. (2003). *FEMS Microbiology Reviews* **27**, 481-492.
2. .van Dongen et al. (2001). *Water Science & Technology* **44 (1)**, 153-160.
3. C. Fux et al. (2002). *Journal of Biotechnology* **99**, 295-306.
4. W. Bae et al. (2002). *Biodegradation* **12**, 359-366.
5. G. Ruiz et al. (2003). *Water Research* **37**, 1371–1377.
6. J.M.Garrido et al. (1997). *Biotechnology and Bioengineering* **53**, 168-178.
7. H.J.Yun and D.J.Kim (2003). *J.Chem.Technol.Biotechnol.* **78**, 377-383.
8. K. Furukawa et al. (2003). *Proceeding of 4th Seminar of Core University Program.* JSPS (Japan) and NCST (Vietnam).
9. T.H.Hoilijoki et al. (2000). *Water Research* **34 (5)**, 1435-1446.
10. R.H.Kettunen et al. (1996). *Bioresource Technology* **58**, 31-40.
11. APHA, AWWA, WPCF (1995). Standard method for the examination of water and wastewater. 19th edition, USA.
12. J.Kanda (1995). *Water Research* **29 (12)**, 2646-2750