NITROGEN REMOVAL USING ATTACHED IMMOBILIZED ANAMMOX SLUDGE ON PVA GEL BEADS

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INTRODUCTION

Ammonium-rich wastewaters are produced normally from the food processing, agricultural industries. Therefore, nitrogen pollution has become the attractive problem of scientists in recently.

The current method of removal of ammonium in wastewater treatment plants consists of a combination of aerobic nitrification catalyzed by autotrophic nitrifiers and anoxic denitrification catalyzed by heterotrophic denitrifiers. In the nitrification process, ammonium is oxidized to nitrate via nitrite, and nitrate is reduced with organic carbon via nitrite to N_2 in denitrification process. This combination was considered as the only economical way to remove ammonium from wastewater.

However, more economical considerations using shortcuts in the nitrification-denitrification process, i.e., Anaerobic Ammonium Oxidation (Anammox), was attracted much attentions.

When the Anammox process is combined with the nitritation step, the remaining ammonium and the converted nitrite from nitritation will be oxidized to yield nitrogen gas under anoxic conditions with nitrite as the electron acceptor. This autotrophic process allows over 50% saving of the oxygen and no organic carbon supplementation for denitrification. In addition, the biomass yield is very low for Anammox bacteria, so that little sludge is produced in Anammox process. The stoichiometry of the Anammox reaction was determined as follows:

$$NH_4^+ + 1.32\ NO_2^- + 0.066\ HCO_3^- + 0.13H^+ \rightarrow 1.02\ N_2 + 0.26\ NO_3^- + 0.066\ CH_2O_{0.5}N_{0.15} + 2.03\ H_2O$$

In this research, PVA gel beads was selected as biomass carriers for Anammox sludge and applied for fluidized bed reactor.

The objectives of this research were to evaluate the ammonium removal capabilities of Anammox sludge in fluidized bed reactor using PVA gel beads.

MATERIALS AND METHODS

Fluidized bed reactor set-up

This research is implemented in fluidized bed reactor (3.712 L) with carrier material is PVA gel beads. Diameter of PVA gel beads is 3.5 - 4 mm (specific gravity 1.03). Recirculated pump is installed with flowrate of 7 L/min to maintain the fluidized bed condition. Recirculated water is supplied at the bottom of reactor as shown in Figure 1. The surface net was installed at the cone area to avoid PVA gel beads come to recirculated port. Temperature is maintained at 35°C.

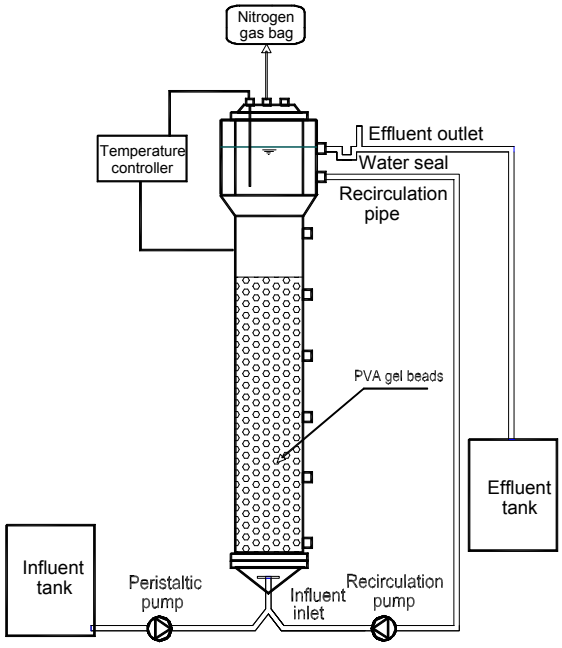

Figure 1. Flowchart of fluidized bed reactor

Origin of biomass

The biomass used for inoculation with anaerobic ammonia oxidizing bacteria originates from an Anammox fixed-bed reactor using PVA gel beads. The reactor is contained 0.8 L PVA gel beads for biomass attachment which is included 0.7 L of cultivated PVA and 0.1 L of new PVA.

Synthetic wastewater

Table 1. Composition of synthetic wastewater

Composition	Concentration (mg/L)	Micro nutrients**:	
$(NH_4)_2SO_4$ (mgN/L)	Variable (25-250)	$CuSO_4 .5H_2O$ (mg/L)	0.25
$NaNO_2$ (mgN/L)	Variable (25-250)	$ZnSO_4 .7H_2O$ (mg/L)	0.43
$KHCO_3$ (mg/L)	125	$CoCl_2.6H_2O$ (mg/L)	0.24
KH_2PO_4 (mgN/L)	54	$MnCl_2.4H_2O$ (mg/L)	0.99
$FeSO_4.7H_2O$ (mgN/L)	9	$Na_2MoO4_4.2H_2O$ (mg/L)	0.22
EDTA (mgN/L)	5	$NiCl_2.6H_2O$ (mg/L)	0.19
A.S. nutrients*	20mL/L	Na_2SeO_4 (mg/L)	0.11
Micro nutrients**	1mL/L	H_3BO_3 (mg/L)	0.014
A.S. nutrients*:			
NaCl (mg/L)	50	$CaCl_2$ (mg/L)	70
KCl (mg/L)	70	$MgSO_4$ (mg/L)	50

Analytical method

Table 2. The analytical methods of measured parameters in for fluidized bed reactor

Measured parameters	Method
NH_4-N	*o*-phenylphenol method
NO_2-N	Colorimetric
NO_3-N	Colorimetric (UV Screening methods)
Alkalinity	Titrimetric method
pH	Mettler Toledo-320 pH meter

RESULTS AND DISCUSSION

Figures 2 and 3 show the main results of nitrogen removal using attached immobilized anammox sludge on PVA gel beads during 190 days of operation. The first stage persisted 50 days with HRT was 24hrs. Influent concentrations of NH_4^+ and NO_2^- were increased to 150 mg N/L, each, as shown in Figure 2. At the end of this stage, effluent concentrations of NH_4^+ and NO_2^- were 22.8 mg N/L and 4.8 mg N/l, respectively. Total nitrogen removal efficiency was 76.7%. Total nitrogen removal rate (T-N RR) was increased up to 0.28 kg N/m^3/day (Fig. 3). With these results, HRT was decreased to 20 hrs in the second stage. Influent concentration of NH_4^+ and NO_2^- were increased coincidentally to 175 mg N/L.

At day 76, effluent concentrations of NH_4^+ and NO_2^- were high with 72 and 39.1 mg N/L, respectively (Fig. 2). Total nitrogen removal efficiency was decreased to 60.5%. T-N RR was declined to 0.171 kg N/m^3.day (Fig. 3). At beginning of the second stage (from day 50 to 76), it is due to anammox bacteria may not been adapted immediately with higher influent concentration of NH_4^+ and NO_2^- and lower HRT than the first stage. Therefore, influent NH_4^+ and NO_2^- concentrations were reduced (Fig. 2).

Some PVA gel beads floated at surface net because nitrogen gas trapment inside PVA gel bead. Consequently, at day 108, these PVA gel beads were removed out of reactor and cleared of surface net. Reactor was restarted with lower influent concentration of NH_4^+ and NO_2^- of 150 mg N/L and then 125 mg N/L (Fig. 2). However, at day 120, effluent concentrations of NH_4^+ was also high of 57.9 mg N/L and NO_2^- was 35.5 mg N/L. Total nitrogen removal efficiency was too low with 41.1%. T-N RR was only 0.119 kg N/m^3.day as shown in Fig. 3.

Subsequently, at day 190, influent concentration of NH_4^+ and NO_2^- were reached up to approximately 250 mg N/L of each. Effluent NH_4^+ and NO_2^- concentrations were reduced to 26.4 mg N/L and 4.4 mg N/L, respectively（Fig. 2）. Total nitrogen removal efficiency reached to 86.3%. And T-N RR was raised up gradually to 0.506 kg N/m^3.day at day 190.

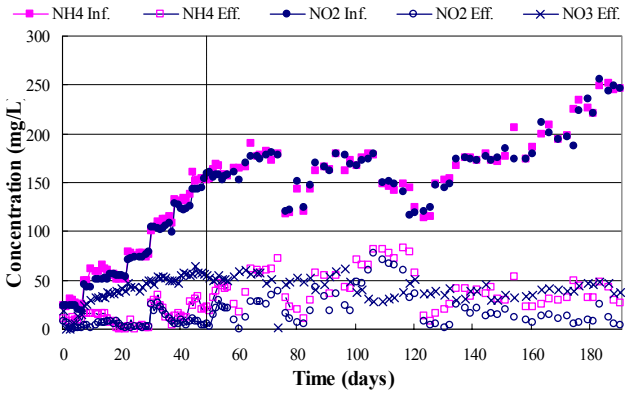

Figure 2. Time courses of influent and effluent concentrations of nitrogenous compounds during 190 days of operation. (Broken line divides the first 24hrs HRT stage and the second 20hrs HRT stage)

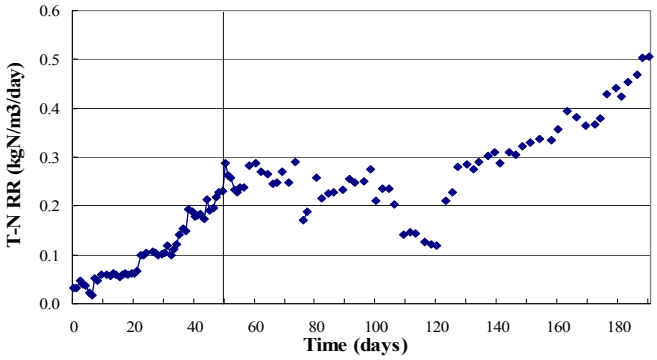

Figure 3. Time courses of T-N removal rate during 190 days of operation. (Broken line divides the first 24hrs HRT stage and the second 20hrs HRT stage)

CONCLUSIONS

During continuous operation of fluidized bead Anammox reactor, it was occurred some problems which interrupt the operation of reactor. After more than 6 months of operation, the T-N RR reached to 0.506 kg N/m^3.day. Careful operation was required for this fluidized bed reactor using PVA gel beads. This research is now continuing for getting better results. The final target of our research is to reach T-N RR more than 2 kg N/m^3/day.