The Processing of Livestock Waste Through the Use of Activated Sludge - Treatment with Intermittent Aeration Process -

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ABSTRACT : To prevent surface and underground water pollution, wastewater treatment is essential. Four bench-scale activated sludge units (10 L operational volumes) were operated at 5, 10 and 20℃ for evaluation of treatment efficiencies with typical wastewater from swine housing. The units were set for a 24-hour cycle. As compared to the conventional process, high removal efficiencies for organic substances, nitrogen and phosphorus in swine wastewater were obtained simultaneously with an intermittent aeration process (IAP). The NOx-N produced during an aeration period was immediately reduced to nitrogen gas (e.g. N_2 or N_2O) in the subsequent non-aeration periods, and nitrification in aeration periods occurred smoothly. Under these conditions, phosphorus removal occurred with the release of phosphorus during the non-aeration periods followed by the excess uptake of phosphorus in the activated sludge during aeration periods. It was confirmed that the IAP had a better ability to remove pollutants under both low temperatures and high nitrogen loading conditions than the ordinary method did. In addition to that, the total emission of N_2O from IAP was reduced to approximately 1/50 of the conventional process for the same loading. By adopting an adequate aeration programme for individual swine wastewater treatment, this system will provide a promising means for nitrogen and phosphorus control without pH control or addition of methanol. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 5 : 698-701*)

Key Words : Waste Water, TN, Intermittent Aeration, Activated Sludge, IAP

INTRODUCTION

In Japan, the annual nitrogen amount contained in animal waste was nearly equal to the annual consumption of nitrogen on cropland where chemical fertilizer had been spread. To prevent surface and underground water pollution, wastewater treatment is essential. It was previously reported that the activated sludge process with intermittent aeration process (IAP) is effective for swine wastewater (Osada et al., 1991). High removal efficiencies for BOD, TOC, total nitrogen (TN) and total phosphorus (TP) were achieved with the IAP. In an attempt to evaluate the advantage of the IAP under low temperature conditions, this study deals with the IAP for swine wastewater, which is extremely rich in nitrogen. In addition to that, IAP is reported to be valuable for the regulation of emissions of nitrous oxide, which is a greenhouse effect gas (IPCC, 1995).

MATERIALS AND METHODS

Four bench-scale activated sludge units (10 L operational volumes) were operated at 5, 10 and 20℃. The units were set for a 24-hour cycle. Two types of aeration programmes were conducted. For the conventional one, a continuous aeration for 21 hours was adopted (ordinary method), while for the intermittent aeration, aeration was done at one-hour intervals. The aeration periods started just after daily charging (0 time in figure 1).

After the end of the aeration periods, the sludge in the mixed liquor was allowed to settle for two hours, and then the supernatant was discharged. A mixture of swine feces and urine was used as influent wastewaters. The contents are as follows: 1,670 mg/L BOD, 310~420 mg/L TN (standard nitrogen loading) or 584~658 mg/L TN (High nitrogen loading). The similar operational conditions of each run are as follows: 3.3 days of hydraulic retention time (HRT); 20-25 days of sludge retention time (SRT); 7,000~9,000 mg/L of MLSS; 0.5 kg/m^3/d of BOD loading; 1.5 L/min/10 L aeration rate.

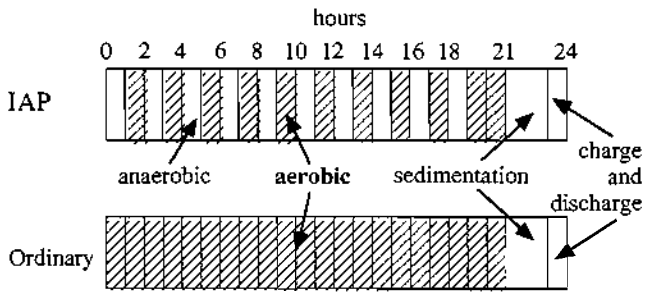

Figure 1. Time chart of experimental operation

Each unit was operated for a period longer than two SRTs (about 50 days) to obtain a steady-state

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Received Demcember 28, 1998; Accepted June 29, 1999

condition. Also, the performance of each unit was evaluated for an additional two SRTs. The water qualities of the influent and the effluent were analyzed two or three times a week for pH, TOC, TN, TP, NH_4-N, and NO_x-N, and weekly for BOD. All analyses made were in accordance with the procedures of APHA (1985). Exhaust gases were collected from each head space (3 L) of the units opened (aeration periods) or closed (non-aeration periods) for 15 minutes. N_2O and CH_4 were determined by gas chromatography by use of an electron capture detector (ECD) and a flame ionized detector (FID), respectively. Other harmful gases (NH_3, NO and NO_2) were monitored with indicator tubes. Total nitrogen of sludges was determined for nitrogen balance.

RESULTS AND DISCUSSION

Wastewater treatment efficiencies

Even at a temperatures of 20℃ and at standard nitrogen loading conditions, TN and TP removal efficiencies (55~75 and 30~50%, respectively) from the wastewater were not so high with the ordinary method. With IAP, high removal efficiencies for organic substances, nitrogen and phosphorus in swine wastewater were obtained simultaneously (table 1). Those removal efficiencies decreased with the increase in the nitrogen loading ratio to BOD (N/BOD) of the charged wastewater. In periods with low temperatures, most of the removal efficiency items decreased, except phosphorus.

Nitrogen and phosphorus removal from wastewater

Due to the accumulation of NO_x-N during continuous aeration in treatment of wastewater and the concomitant drop in pH, the nitrogen and phosphorus removal efficiencies were not so high with the ordinary process. In this process, denitrification occured just after charging for the major part of nitrogen removal from wastewater. With IAP, the NO_x-N produced during an aeration period was immediately reduced to nitrogen gas (e.g. N_2 or N_2O), in the subsequent non-aeration periods and nitrification in aeration periods occurred smoothly (figure 2). Under these conditions, phosphorus removal occurred with the release of phosphorus during the non-aeration periods followed by the excess uptake of phosphorus during aeration periods in the activated sludge. The removal efficiencies in question decreased with the increase in the nitrogen loading ratio to BOD (N/BOD) of the charged wastewater (table 1). The NO_x-N, which was built up during the aeration periods, was partly reduced to nitrogen gas at the following non-aeration periods. The NO_x-N disturbed the release of phosphorus during the non-aeration periods, as did the presence of molecular oxygen, and it diminished the uptake of phosphorus during the aeration periods. In periods with low temperature, most of the removal efficiency items decreased, except phosphorus. Biological activities of oxidation of organic materials, nitrification and denitrification were affected at low

Table 1. Removal efficiencies (%) of IAP under low temperatures and high nitrogen conditions

Items	Standard nitrogen loading T-N: 310-420 mg/L			High nitrogen loading T-N: 584-658 mg/L		
	20℃	10℃	5℃	20℃	10℃	5℃
BOD	99.7	99.4	97.3	99.6	94.7	97.5
TOC	97.2	94.7	91.6	95.6	92.1	85.7
SS	99.5	99.6	-	99.3	98.2	-
TN	93.4	88.4	48.2	86.3	69.3	32.5
TP	46.3	44.9	82.1	51.6	55.5	82.0

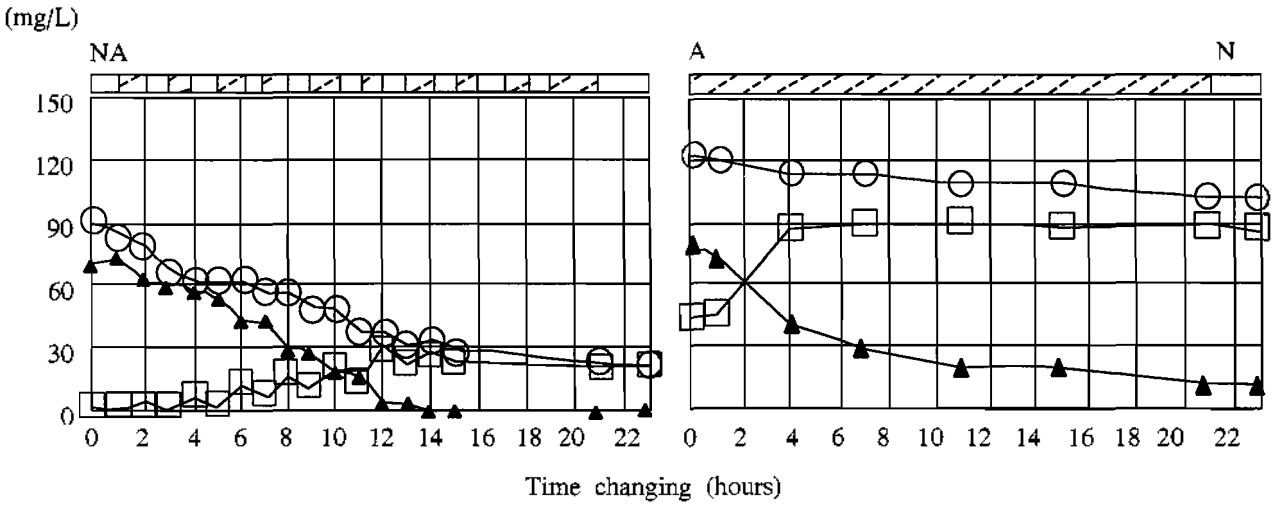

Figure 2. Changes of nitrogens (Total N (○), NH_4-N (▲) and NO_x-N (□)) during IAP and ordinary operations at 20℃ and Standard nitrogen loading condition

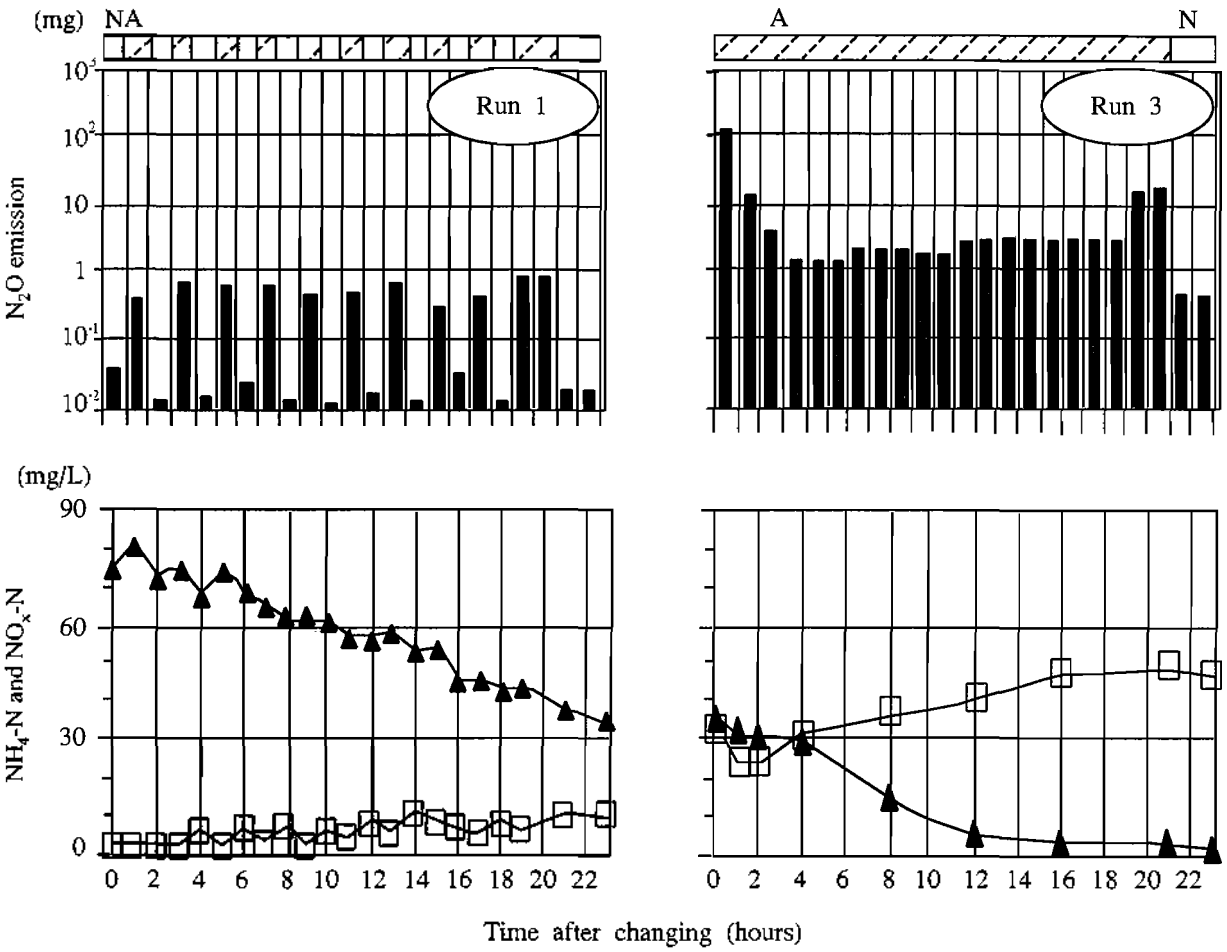

Figure 3. N_2O emission and dissolved nitrogen (NH_4-N (▲) and NOx-N (□)) changes in treated wastewater during an ordinary operation (Run 3) and IAP (Run 1); *A=aeration period, N=non-aeration period

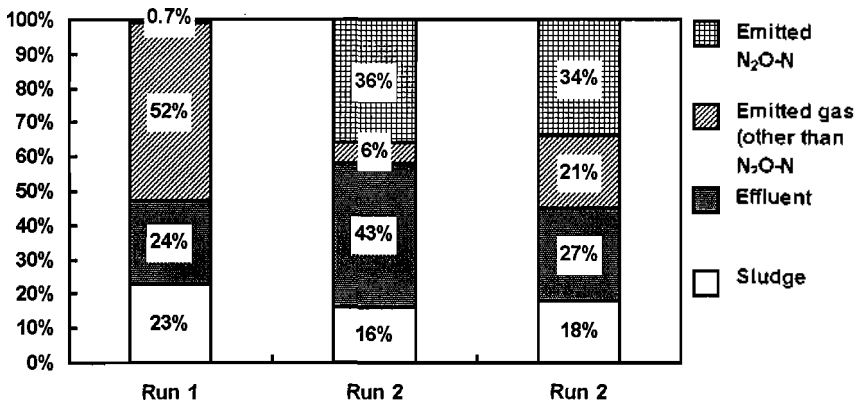

Figure 4. Nitrogen balance in each run

temperatures. It was confirmed that the IAP had a better ability to remove pollutants under low temperature conditions (table 1).

N_2O emission

Large differences in the removal rate of nitrogen between the intermittent aeration process (Run 1, figure 4) and the conventional process (Run 2, figure 4) were observed for the same nitrogen loading (303 mg/L). Profiles of nitrous oxide emission during Run 1 and Run 3 are compared in figure 3. They have almost the same nitrogen concentrations just after

charging. A large amount of N_2O was emitted during the initial stage of the aeration periods at low D.O. (0-0.5 mg O_2/L) in Run 3, which corresponded with NO_x-N decrease in the treated wastewater (figure 3). N_2O-N emission was stable at a relatively low level (15-18 ppmv) after the D.O. rose to 3.5 (2 hours after charging). These data suggest that the emitted N_2O mainly derived from a denitrification process. Zheng et al. (1994), however, has reported a high concentration of N_2O-N production during both the nitrification and the denitrification process at low D.O. (under 0.2 mg O_2/L) conditions.

During IAP (Run 1), N_2O emission mainly occurred during the aeration periods, and it was relatively low (15-19 ppmv, figure 1). The total emission of N_2O was reduced by approximately 1/50 of the conventional process for the same loading (Run 3, figure 4). Hanaki et al. (1992) pointed out that a low COD/NOx-N ratio enhanced the N_2O production. The incorporation of the intermittent low D.O. (non-aeration) periods in IAP might enhance denitrification and therefore avoid the accumulation of NOx-N. This seems to create a condition with a high ratio of organic substrate and NOx-N. The total emission of other harmful gases (NH_3, NO, NO_2 and CH_4) was negligible.

CONCLUSIONS

High removal efficiencies for organic subsatnces, nitrogen and phosphorus in swine wastewater were simultaneously performed by IAP. IAP also had a better ability to remove pollutants under low temperature conditions. In addition to that, the total emission of N_2O from IAP was reduced to approximately 1/50 of the conventional process for the same loading. By adopting an adequate aeration programme for individual swine wastewater treatment, this system will provide a promising means for nitrogen and phosphorus control without pH control or addition of methanol.

ACKNOWLEDGEMENTS

I wish to thank Mrs. Lene Nokkentved for proofreading my articles. Thank you to the staff for maintaining our experimental facilities. I gratefully acknowledge the helpful discussions with Dr. Kiyonori Haga, Mr. Kazutaka Kuroda and Dr. Michihiro Yonaga.

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