

NITROGEN REMOVAL BY DEAMMONIFICATION PROCESS USING EGSB REACTOR

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SUMMARY: Brazilian swine production has developed an important role in the global market. In this way, with the increase Confined Animal Feeding Operations (CAFOs) processes, high volume wastewater with high pollution potential has been generated. To minimize the environmental impacts, biological treatment of wastewater is an alternative to minimize risks. There are numerous biotechnologies able to mitigate the pollution potential of swine wastewater. However, some aspects must be considered to choice the best alternative as, costs, process reliability, operational complexity and required environmental impact reduction. In this context, new processes for nitrogen removal must be developed, as deammonification processes such as partial nitrification/anammox. These processes are highly efficient and there is no need external carbon source supplementation. However, there need further studies to understand microbial complexity, so that the biotechnology can be transfer to farmers with safety and reliability. The purpose of this study is to investigate the feasibility of applying the deammonification process at ambient temperatures with a high nitrogen loading rate (NLR).

Keywords: Deammonification, nitrogen removal, partial nitrification/anammox.

INTRODUCTION

The last decades, the animal production has changed from subsistence to an industrial model, decreasing production costs but increasing to her higher potential environmental impact (KUNZ, 2009).

In this way, with the increase of Confined Animal Feeding Operations (CAFOs) processes, high volume wastewater with high pollution potential and high concentration of nutrients (N and P). To minimize the activity environmental impacts, biological treatment of wastewater is an alternative to minimize the environmental risks (KUNZ *et al.*, 2007).

Recently, several novel and cost-effective biological nitrogen elimination processes have been developed, including partial nitrification, anaerobic ammonium oxidation (Anammox), and its combined system deammonification process (single stage or two stage). The single reactor configuration offers the potentiality of cost reduction in wastewaters treatment (AHN, 2006; VANOTTI, *et al.* 2013).

The deammonification process has a good applicability for nitrogen removal in wastewater of animal production and agroindustry. For successful establishment of deammonification process, it is important to pay attention in the influence of management conditions such as the temperature, dissolved oxygen concentration, inhibitory substances and reactor configuration.

However in an EGSB reactor (expanded granular sludge bed) the granular sludge bed is expanded and the hydraulic mixing is intensified in order to improve the wastewater and biomass contact (KATO, 2003).

The purpose of this study is to investigate the applicability the deammonification process at ambient temperatures with a high nitrogen loading rate (NLR).

MATERIAL AND METHODS

This study was conducted using an EGSB bioreactor lab-scale (1L). The bioreactor was inoculated containing nitrifying bacteria/anammox bacteria.

The reactor was fed with a synthetic wastewater consisting of 266-437 mgNH₄-N L⁻¹. The composition of synthetic wastewater was as follows: K₂HPO₄ (100 mg L⁻¹), NaHCO₃ (2911 mg L⁻¹), Na₂CO₃ (391 mg L⁻¹) MgSO₄ (60 mg L⁻¹), FeSO₄ (80 mg L⁻¹), CaCl₂ (80 mg L⁻¹), trace element solution 0.1 mL/L (Magrí, *et al.* 2012).

Nitrogen Removal Rate (NRR) of the reactor was monitored for 40 days. Nitrogen loading rate (NLR) was maintained between 0.9 and 1.5 kg-N m⁻³ d⁻¹. Hydraulic Retention Time (HRT) was fixed at 7.0 h. Operating an ambient temperature was 25°C ±1 and intermittent aeration in cycle of 30 minutes, (15 min anoxic phase/15 min aerobic phase) controlled by a Programmable Logic Controller (PLC) system.

The pH and DO values were determined using a pH meter (Hanna, pH 21) and a DO meter (YSI 55), respectively. Airflow (Q_{air}) was controlled (20 -30 mL/min) using flowmeter (Gilmont, GF-9260).

Samples were collected from the reactor influent and effluent. NH₄-N analyses were performed by potentiometric method. NO₂-N and NO₃-N concentrations were determined by a colorimetric method. Samples in the influent were determined according to standard methods (APHA, 2012).

RESULTS AND DISCUSSION

The reactor performance was monitored for 40 days, during which the influent concentrations and airflow varied, as shown in Table 1.

From day 0 to day 16 (phase I), during which the airflow was 20 mL/min, the NLR was maintained at 0.9 ± 0.02 kgN.m⁻³.d⁻¹ with removal efficiency of nitrogen of 31% ± 4.

After day 17 (phase II), an optimal operation strategy for enhancing the nitrogen removal, the airflow was gradually increased from 20 to 30 mL/min. After only 3 days, a stable and satisfactory reactor performance was achieved under these conditions, with removal efficiency of nitrogen for 45% ± 5.

After 23 days of operation (phase III), the NLR increased by 0.9 to 1.2 ± 0.04 kgN.m⁻³.d⁻¹ by enhancing the influent substrate concentration (Table 1) with removal efficiency of nitrogen of 45% ± 5.

In phase IV, the NLR was 1.42 ± 0.09 kgN.m⁻³.d⁻¹ by enhancing the influent substrate concentration (414 ± 23 mgNH₄-N L⁻¹). It was also observed decreased removal efficiency of nitrogen to 40% ± 2. However, the NRL did not affect the process stability, that can be confirmed by reaction stoichiometric coefficients (Fig. 1) (SLIEKERS, 2002).

The Table 2 compares data from the literature and this study, showing that nitrogen can be successfully removed by deammonification processes reactor is an optimal strategy compared to reactors UASB and Up-flow.

In this study, the EGSB reactor was operated in a way that enabled it to adapt to the progressively Nitrogen loading rate due to a high activity of microorganisms with anammox activity and nitrifying bacteria.

CONCLUSIONS

The EGSB reactor is an optimal strategy for NRR compared to reactors UASB and Up-flow. The high NRL studied did not affect the process stability that can be confirmed by reaction stoichiometric coefficients.

The results of this study demonstrated that deammonification process using EGSB reactor was an effective and stably system for high NLR are reliable at ambient temperatures.



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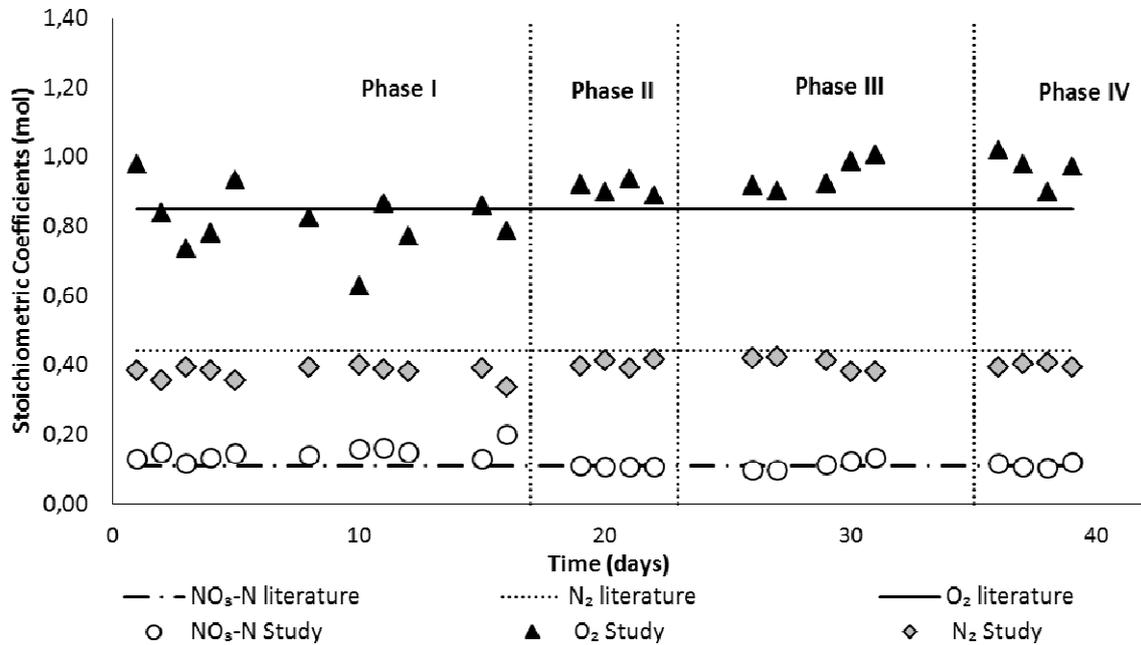


Figure 1. Monitoring of the stoichiometric coefficients

Table 1. Deammonification reactor operating strategy.

Items	Unit	Phase I	Phase II	Phase III	Phase IV
Time	days	1-139	140-145	146-159	160-163
Influent TN	mg L ⁻¹	270 ± 4	270 ± 4	342 ± 11	414 ± 23
N-removal	%	31 ± 4	45 ± 5	45 ± 5	40 ± 2
Airflow (Q _{air})	mL/min	20	30	30	30

Table 2 Different configurations of reactors and rates of nitrogen removal

Process type	Ractor	Substrate	Nitrogen Loading Rate (NLR) (Kg-N m ⁻³ L ⁻¹)	N-removal (%)	Reference
Deammonification	UASB	Synthetic	0.02-0.03	30-50	Ahn (2006)
	Up-flow	Synthetic	0.55	58	Prá (2013)
	EGSB	Synthetic	0.90-1.50	30-52	This Study