

START UP AND OPERATION OF AEROBIC REACTOR FOR SWINE EFFLUENT PARTIAL NITRIFICATION AND SIMULTANEOUS REMOVAL OF COD

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1 INTRODUCTION

Recently new technologies have been developed or adapted, mainly from industrial or domestic effluents, for the treatment of swine wastewater to remove organic matter and nutrients, for example nitrogen (Kunz *et al.*, 2005).

For nitrogen removal the most used process is nitrification/denitrification. *Nitrosomonas* (ammonia oxidation bacteria – AOB) are the main bacteria involved in the nitritation process responsible for the ammonia oxidation to nitrite, *Nitrobacter* (Nitrite oxidation bacteria – NOB), are the main bacteria acting on the oxidation of nitrite to nitrate (nitratation) (Henze *et al.*, 1997). The partial nitrification strategy is based on the accumulation of NO_2^- favoring the AOB and inhibiting the NOB (Wiesmann, 2007).

Because nitrite act as an intermediate both to nitrification and denitrification, a lot of studies have been performed studying the nitrogen biological removal via nitrite that can make the nitrification/denitrification process more economic, in addition to create the possibility to connect the partial nitritation process with anammox (Bernet e Béline, 2009). A great advantage of the anammox process is the possibility of direct oxidation of ammonia to gaseous nitrogen, using nitrite as a final acceptor of electrons, in a nitrite/ammonia theoretical ratio of 1.3 using inorganic carbon for cellular growing (Strous *et al.*, 1998; van de Graaf *et al.*, 1996).

The main objective of the present study was to start up an activated sludge laboratory scale biological aerobic reactor, fed with a swine effluent from an UASB reactor, to implement the partial nitritation process with simultaneous removal of COD.

2 MATERIALS AND METHODS

2.1 Experimental set-up

The experimental system (figure 1) was composed by a complete mix aerobic reactor (CMAR) assembled in acrylic, with 5 L volume and mechanical agitation (Fisaton-F713). The aeration apparatus was composed by an air pump (Big Air-320) and ceramic air diffusers. The secondary settled reactor was also assembled in acrylic with 1 L of useful volume.

The feeding medium was collected from a full scale UASB reactor (Kunz *et al.*, 2009), stored in a 6 L Erlenmeyer, homogenized with a magnetic stirrer (IKA-RH Basic 2) and pumped to the CMAR using a peristaltic pump (Milan-BP200) with a variable flow rate (between 1.58 mL/min and 3.6 mL/min) according to the desired organic loading rate (OLR). The sludge was recirculated four times per day at recirculation flow rate between 20% and 60% of influent flow rate using a peristaltic pump (Milan-BP200). The surplus sludge was discharged manually maintaining the sludge age at 20 days.

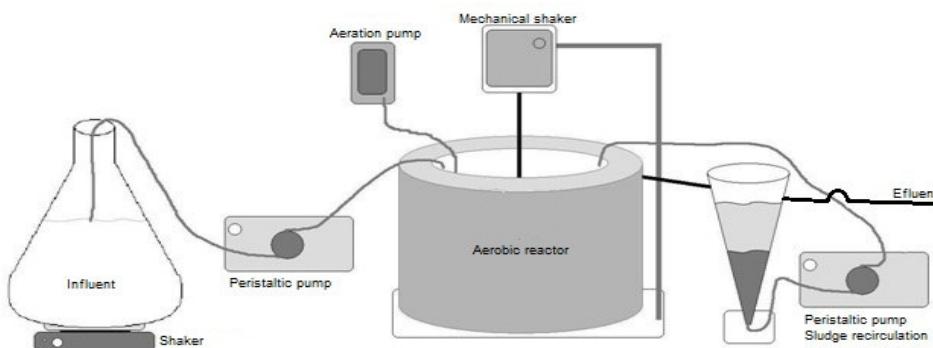


FIGURE 1 Scheme of the partial nitritation system used in the experiment.

2.2 Reactor start up and operation

The reactor was inoculated with a sludge from an activated sludge reactor fed with swine effluent (Kunz *et al.*, 2009), at 1.58 g L^{-1} of TSS. The CMAR was fed with a swine effluent collected from an UASB reactor located at Embrapa swine and poultry and diluted to reach the desired loading rate as shown in Table 1.

The system was operated in three different periods without oxygen restriction ($4.86 \text{ mgO}_2 \text{ L}^{-1} \pm 1.05$) at $35.0 \text{ }^\circ\text{C} \pm 0.75$ during 112 days. Alkalinity was supplemented adjusting the pH at 7.5 with NaOH 1 mol L^{-1} to firstly establish the nitrification process from day six until day 35, after this the alkalinity supplementation was suppressed.

TABLE 1 CMAR operating condition during start up and operation time.

Period (d)	HRT (h)	Feeding medium dilution factor	Average COD concentration (mg L^{-1})	Average ammonia concentration (mg L^{-1})	Average organic loading rate ($\text{g COD L}^{-1} \text{ d}^{-1}$)	Average ammonia loading rate ($\text{g NH}_3\text{-N L}^{-1} \text{ d}^{-1}$)
01-14	52	0.25	1023.7 ± 124.8	171.3 ± 44.7	0.36 ± 0.01	0.12 ± 0.04
15-69	36	0.66	1276.2 ± 336.4	428.5 ± 181.9	0.78 ± 0.12	0.21 ± 0.01
70-112	42	1	1841.6 ± 137.7	637.9 ± 91.3	0.92 ± 0.12	0.34 ± 0.01

Analysis of COD was performed using the dichromate colorimetric method (APHA, 1995). The pH determinations were performed using a pontenciometer (Tecnal- Tec/3MP). Dissolved oxygen was analyzed using a membrane probe (YSI 55 Handheld Dissolved Oxygen). Ammonia ($\text{NH}_3\text{-N}$) was analyzed pontentiometrically using a selective electrode method (APHA *et al.*, 1995). Nitrate (NO_3^- -N) and nitrite (NO_2^- -N) determination were based in a colorimetric method (APHA, 1995) using a flow injection analysis system (FIALab – 2500). Alkalinity was determined with potentiometric titration (APHA, 1995).

3 RESULTS AND DISCUSSION

3.1 Establishment of partial nitritation

Figure 2 presents the relative distribution of nitrogen forms ($\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$) in the CMAR effluent during the three phases of the experiment.

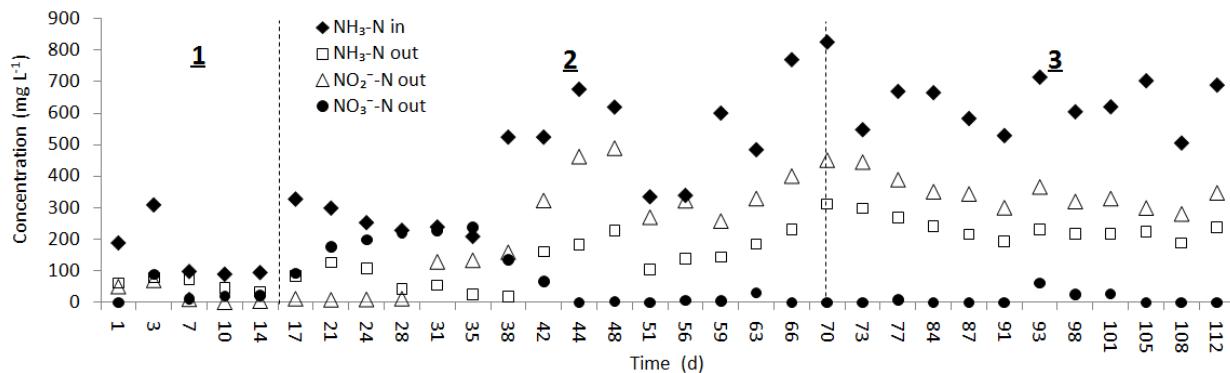


FIGURE 2 Nitrogen species concentration in the influent and effluent of the complete mix aerobic reactor.

During the first fourteen days of operation the ammonia loading rate (ALR) was kept in $0.12 \pm 0.04 \text{ g L}^{-1} \text{ d}^{-1}$, diluting the effluent at 25 % to facilitate the microorganisms adaptation and the reactor start up. In this first phase the pH decrease to 5.93 ± 0.40 , based on this fact alkalinity was supplemented and pH adjusted to 7.5 with NaOH 1 mol L^{-1} after the seventh day and then the nitrification process started.

After the fifteenth day the ALR was increased to $0.21 \pm 0.08 \text{ g L}^{-1} \text{ d}^{-1}$. At the beginning of the second phase the nitrification was completely established, after this the supplementation of alkalinity was cut with a consequent nitrite depletion. The reactor pH dropped to 6.45 ± 0.29 and the ratio $\text{NO}_2\text{-N}/\text{NH}_3\text{-N}$ reach to nearly 2, considering thus that after the forty-four day the partial nitritation was established.

Posteriorly began a stability period with pH at 6.45 ± 0.25 and nitritation efficiency of 62% until the day 69. After this the ALR was increased to 0.35 ± 0.07 by reducing the dilution factor and the partial nitritation became 56%, the pH 6.32 ± 0.22 and the ratio $\text{NO}_2\text{-N}/\text{NH}_3\text{-N}$ 1.5 as presented in figure 3. According to the anammox process stoichiometry, the molar ratio of nitrite for ammonia is 1.32 mol. Yamamoto et al (2006) observed that to achieve this molar ratio the process must have a ammonia conversion to nitrite nearly 57 %. In figure 3 it is possible to observe the experimental points and the dashed line (theoretical) of $\text{NO}_2\text{-N}$ in the effluent compared to the concentration of $\text{NH}_3\text{-N}$ in the influent of CMAR.

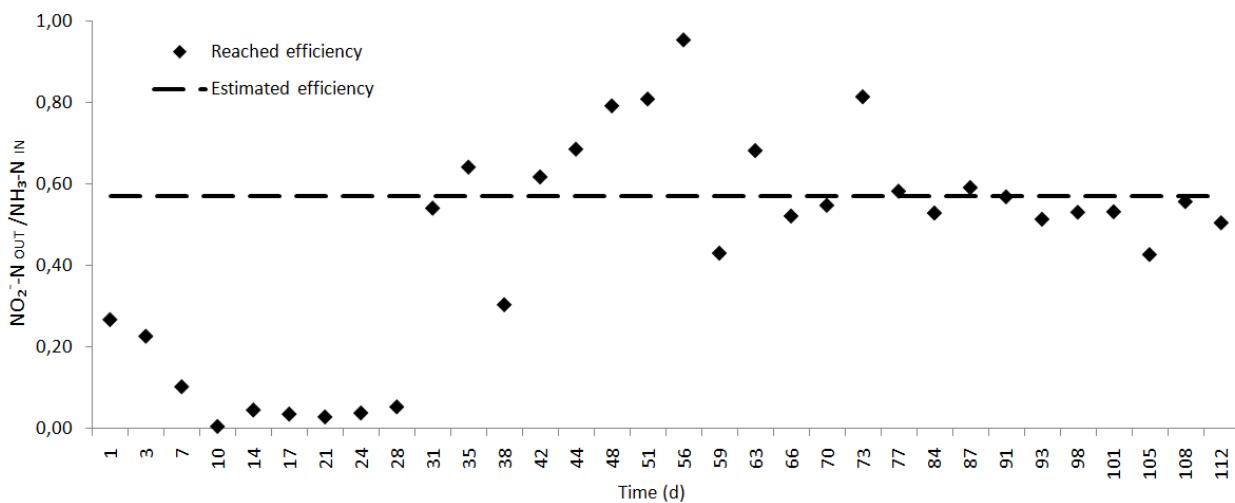


FIGURE 3 Oxidation efficiency of $\text{NH}_3\text{-N}$ to $\text{NO}_2\text{-N}$ during the experiment in the CMAR.

3.2 COD removal

The OLR progression took place in three periods, in the first one the OLR was $0.36 \pm 0.01 \text{ g L}^{-1} \text{ d}^{-1}$ and the average of COD removal efficiency was 84% (Figure 4). In the second period, where the partial nitritation was reached, the OLR was $0.78 \pm 0.12 \text{ g L}^{-1}$, the average of COD removal efficiency was 72%, that was 12 % lower than the first period. In the last period the OLR was $0.92 \pm 0.12 \text{ g L}^{-1} \text{ d}^{-1}$ with 82 % of efficiency. The decrease in the efficiency in the period number 2, probably is due to the HRT reduction from 52 to 36 hours, in the last period with HRT of 42 h the efficiency of reactor increased in 10 %, which was nearly that observed in the first period.

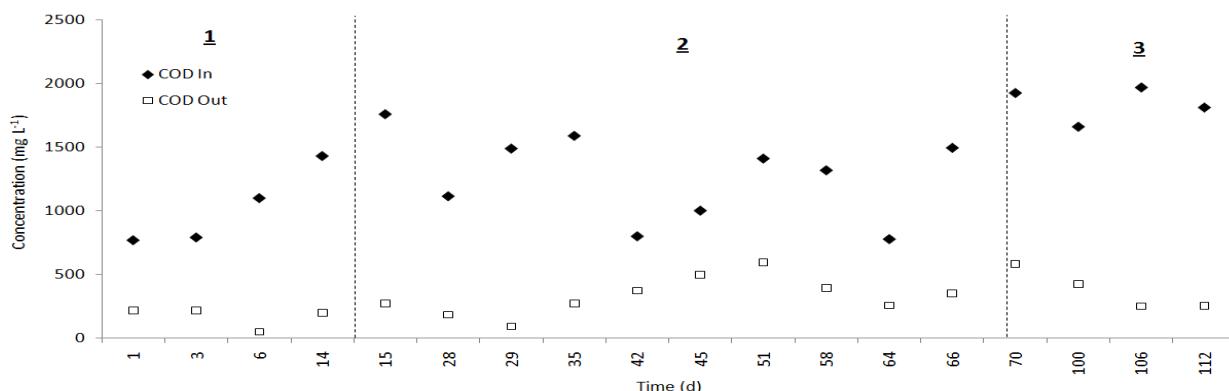


FIGURE 4 COD concentration in the influent and effluent of CMAR, where: 1, OLR 0.36 ± 0.01 ; 2, OLR 0.78 ± 0.12 ; 3, OLR 0.92 ± 0.12 .

4 CONCLUSIONS

The partial nitritation process with the simple experimental apparatus shown in this work can be an important tool for the pretreatment of swine effluents, especially if combined with the anammox process. It is possible to achieve COD removal levels higher than 80 % combined with the partial nitritation and reach nitrogen concentrations in the effluent matching the anammox input stoichiometry needed for a nitritation/anammox system. At the end of the experiment the partial nitritation efficiency was 51% and the COD removal 82% without alkalinity supplementation.

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