Aeration pulses as an energy-efficient way for obtaining partial nitritation/anammox in low-strength ammonia wastewater.

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Highlights:

- This work aims to investigate the influence of intermittent aeration to obtain PN/A in a low-strength ammonia synthetic wastewater.
- The concept of aeration pulses (aerated times lasting less than one minute) is introduced, and its impact is evaluated.
- The combination of aeration pulses and lower HRT provided a total nitrogen removal efficiency of 32 ± 16% with PN/A occurrence.

Keywords: nitrogen; intermittent aeration; A-B Process

INTRODUCTION

Removing nitrogen is an important objective of wastewater treatment plants (WWTP). Partial nitritation/anammox (PN/A) is a promising alternative for nitrogen treatment, once it achieves low nitrogen concentration effluents, combined with low energy consumption, low sludge production and not requiring exogenous carbon addition (Cao et al., 2017).

NP/A has great potential of applicability as further treatment for UASB reactors, as an A-B Process. In Latin America, UASB reactors are the third technology with more plants installed, being mainly applied to small facilities. It allows the anaerobic removal of up to 75% of the BOD from the effluent but with no nitrogen removal. Hence, A-B configuration optimizes the nutrient removal process and carbon capture (Chernicharo et al., 2015).

There are some challenges in treating the mainstream of WWTP by PN/A, though. In PN/A nitrite oxidizing bacteria (NOB) must be inhibited, but its co-occurrence with ammonium oxidizing bacteria (AOB) is common in the mainstream treatment. AOB have an advantage in competing for oxygen and recover more quickly than NOB from sporadic anoxic situations (Cao et al., 2017). Thus, intermittent aeration (IA) is a potential strategy for obtaining partial nitritation, as presented by Miao et al. (2022) and Miao et al. (2016).

Despite that, the understanding of IA influence over the complex bacterial activity and interactions in N-cycle is limited. Hence, this work aimed to study IA strategies to optimize the N removal efficiency and energy costs of PN/A process. It also explored a novel concept of aeration pulses (aerated times lasting less than one minute), not yet consistently reported.

METHODOLOGY

The study assessed the effect of different aerated times (A) and non-aerated times (NA) over PN/A in a 3,6 L bench scale reactor, presented in Figure 1.1, continuously fed with a controlled low strength (< 50 mg N.L-1) inorganic wastewater. Table 1.1 describes the experimental phases applied so far, after start-up and adaptation phases.

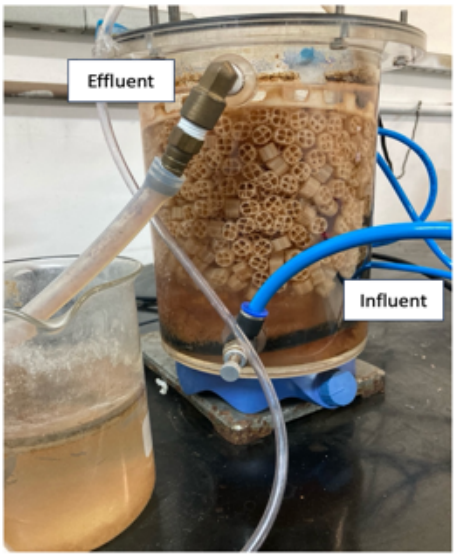

Figure 1.1 Experimental apparatus

Phase	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*
A/NA (minutes)	10/50	5/45	2.5/22.5	0.17/1.5	0.17/3	0.5/9	0.5/9	0.5/9
A:NA Ratio	1:5	1:9	1:9	1:9	1:18	1:18	1:18	1:18
HRT (hours)	12	12	12	12	12	12	10	8

Table 1.1 Aerated and non-aerated times applied in the operation experimental phases applied so far.

RESULTS AND CONCLUSIONS

Figure 1.2 presents some of the results obtained up to now. With 10 minutes aerated and 50 minutes non-aerated time it was possible to oxidized 100% of ammoniacal nitrogen and achieve 84 ± 17% total nitrification, with 15 ± 16% Total Nitrogen Removal (TNR). This result supports that IA can be applied to efficiently produce nitrate with substantial less energy consumption compared to continuous aeration.

A slight improvement of TNR was observed after the use of aeration pulses of 30 seconds aerated and 9 minutes non-aerated. A TNR of 32 ± 16%, the best result so far was obtained in the phase h, in which this aeration condition was associated to a HRT of 8 hours.

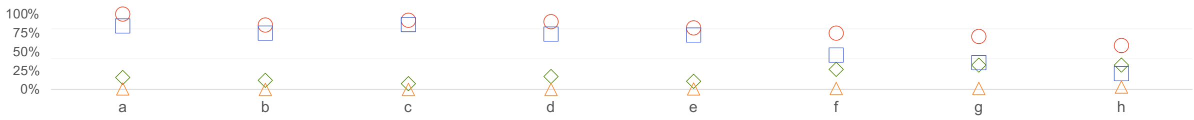

Figure 1.2 Total Nitrogen Removal Efficiency (◇); Ammonium Oxidation Efficiency (○); Total Nitrification Efficiency (□) and Nitrite Accumulating Efficiency (△)

The alkalinity consumption per ammonium oxidized ratio in phase h was 4.95 ± 77 mg $CaCO_3$ / mg NH_4^+-N oxidized, close to the stoichiometric value of the PN/A process (3.68 mg $CaCO_3$ per mg NH4+-N oxidized). Figure 1.3 (A) shows the alkalinity consumption per ammonium oxidized in each phase. The use of aeration pulses of 30 seconds aerated and 9 minutes non-aerated combined with lower HRT brought the alkalinity consumption per ammonium oxidized ratio closer to PN/A process stoichiometric value.

Figure 1.3 A: Alkalinity consumption per ammonium oxidized (··○··) and PN/A stoichiometric alkalinity consumption per ammonium oxidized (—). B: Nitrate production per ammonium oxidized (··△··) and PN/A stoichiometric nitrate production per ammonium oxidized (—)

Nitrate production per ammonium oxidized rate is another parameter that can indicate the occurrence of PN/A process. Figure 1.3 (B) shows the values obtained for this parameter in each phase. The application of aeration pulses of 30 seconds aerated and 9 minutes non aerated brought the nitrate production per ammonium oxidize rate closer to the PN/A stoichiometric value of 0.11 mg NO_3^--N per NH_4^+-N oxidized. For phase h it was obtained 0.41± 0.07 mg NO_3^--N per NH_4^+-N oxidized.

Changing the HRT from 10 hours to 8 hours, reduced 31% the nitrate production per ammonium oxidized rate, indicating an improvement in NOB inhibition. Still, the TNR and the alkalinity consumption per ammonium oxidized ratio varied less than 1%. This corroborates with the hypotheses that PN/A occurred in the reactor, but not yet in its fully potential.

Until this moment, the results showed that the combination of aeration pulses and lower HRT provided the highest TNR with PN/A occurrence. Others operational conditions are currently under investigation.

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