Intermittent aeration and HRT control towards single-stage nitrogen removal using Partial Nitritation-Anammox in a Membrane Aerated Biofilm Reactor

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Highlights:

• SNAP process in a MABR presents as a cost-effective, eco-friendly alternative to traditional nitrification/denitrification systems.

• Main advantages include lower energy use, smaller footprint, independence from external carbon source, and reduced GEE emissions [1]

• The SNAP-MABR process can be applied to treat effluent of UASB reactors in decentralized systems.

Keywords: Intermittent aeration; MABR; SNAP

INTRODUCTION

Efficient inhibition of Nitrite Oxidizing Bacteria (NOB) stands as a significant challenge for successful application of simultaneous Partial Nitritation and Anammox (PNA) in municipal wastewater treatment facilities. While PNA has been successfully applied as a sidestream treatment process, mainstream application is still a challenge, due to relatively low N content present in municipal wastewater. In this context, the Membrane Aerated Biofilm Reactor (MABR) emerges as a promising alternative for implementing single-stage nitrogen removal using Partial Nitritation-Anammox (SNAP) in wastewater with low nitrogen levels. Nonetheless, effective NOB inhibition remains an obstacle, as highlighted by previous studies [2] [4]. In response to these challenges, the current research aims to assess the impact of intermittent aeration and HRT control on both NOB inhibition potential and deammonification efficiency of a MABR treating low-strength nitrogen synthetic wastewater.

METHODOLOGY

The reactor consisted of an upflow lab-scale MABR made of acrylic (2,9 L of working volume), continuously fed with synthetic inorganic wastewater adapted from [3]. Oxygen was supplied by an air compressor at 2 L air.min^{-1}. The lumen pressure within the aerated membrane was set at 70 kPa through a counter-pressure system, providing a constant oxygen transfer rate (OTR). A recirculation system was adopted to enhance mixing at the inlet (r = 1,0). The reactor's temperature was maintained at 30 °C through an electric heating jacket controlled by a digital thermostat. Monitored parameters included dissolved oxygen, temperature of the reactor's bulk liquid, pH, alkalinity, ammoniacal nitrogen, nitrite, and nitrate concentrations in both the influent and effluent streams. The reactor was inoculated with aerobic sludge from a Moving-Bed Biofilm Reactor (MBBR) of a municipal WWTP. The operational setting is presented on **Table 1**.

Table 1. MABR operation conditions

Stage	On/off aeration periods (min)	HRT (h)	Influent composition		Nitrogen loading rates	
			N-NH_4^+ (mg N.L^{-1})	Alcalinity (mg $CaCO_3$.L^{-1})	NSLR [(2)] (g N.m^{-2}.d^{-1})	NVLR [(3)] (g N.m^{-3}.d^{-1})
I	[(1)]	24	100	600	2,0	100
II-1	20 / 40	24	100	600	2,0	100
II-2	20 / 40	24	50	400	1,0	50
II-3	10 / 50	24	50	400	1,0	50
III-1	10 / 50	18	50	400	1,3	67
III-2	10 / 50	12	50	400	2,0	100

(1) Continuous aeration; (2) Nitrogen surface loading rate; (3) Nitrogen volumetric loading rate

Operation stages were set with the objective of evaluating the impact of different aeration strategies and HRT on the deammonification efficiency and on NOB inhibition.

RESULTS AND CONCLUSIONS

The results presented in **Figure 1** show that intermittent aeration acted as an important inhibition factor of NOB activity, as demonstrated in stage by a great increase in the Nitrogen Removal Efficiency (NRE) from 29% to 51%, from the end of stage I to stage II-1.

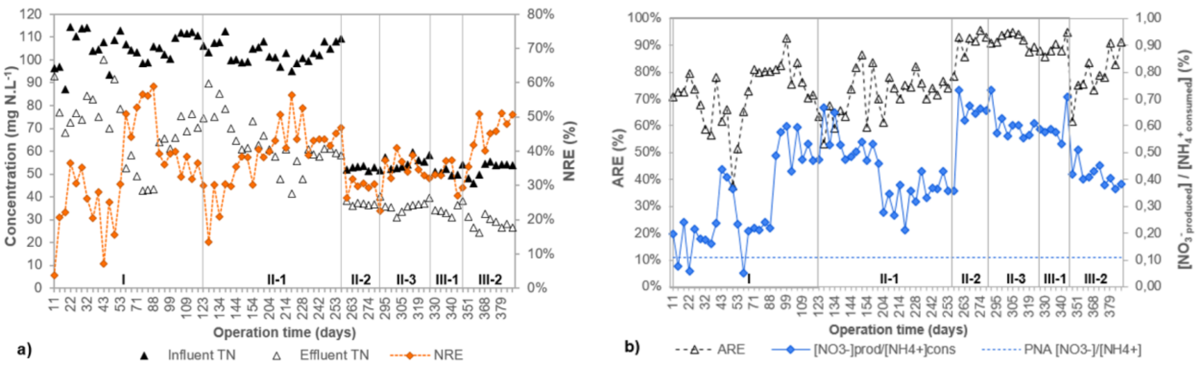

Figure 1. Monitoring results of (a) influent/effluent total nitrogen and nitrogen removal efficiency (NRE) and (b) ammonia removal efficiency (ARE) and [N-NO_3^-]$_{produced}$/[N-NH_4^+]$_{consumed}$ ratio

Furthermore, HRT reduction also had a positive effect on intensifying NOB inhibition and enhancing anammox activity when the N-NH_4^+ inlet was reduced from 100 to 50 mg N.L^{-1}, as evidenced by the decreasing $N\text{-}NO_3^-{}_{produced}/N\text{-}NH_4^+{}_{consumed}$ ratio and the increasing NRE from stages II-2 to III-2, followed by HRT reduction from 18 h to 12 h. During this period, the ratio $N\text{-}NO_3^-{}_{produced}/N\text{-}NH4^+{}_{consumed}$ decreased by 66% (0,78 to 0,34) as a response to HRT reduction, moving towards the stoichiometric value of 0,11 for NPA [5]. Both intermittent aeration and HRT control contributed to hindering NOB growth, which reflected improvements in NRE without significantly compromising Ammonia Removal Efficiencies (ARE).

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