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NOB activity suppression in the anammox based process ELAN® applied to the water line of a WWTP

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Abstract: The ELAN® process is an anammox based process based on granular biomass operated in aerobic conditions in a single sequencing batch reactor (SBR) reactor. The operation of this ELAN® process was evaluated at laboratory scale. The reactor was operated at low ammonia concentrations of 50 mg N/L and relatively low temperature of 15 ºC in order to simulate the conditions of the water line of a municipal WWTP. Nitrogen removal efficiency of around 80% was achieved during the first operational period of around 40 days. At this point it progressively decreased due to the appearance of the nitrite oxidizing bacteria (NOB) activity, which was found to be mainly present in the flocculent biomass. In order to wash out the NOB, the settling velocity imposed during the settling period was increased from 0.13 to 0.36 m/h, which allowed increasing the nitrogen removal efficiency from 20% to 60%.

Keywords: Anammox; mainstream; nitrite oxidizing bacteria, nitrogen removal, temperature.

Introduction

The application of the Anammox based process for the nitrogen removal in a WWTP involves the reduction of the aeration costs and diminishes the sludge production (Volcke *et al.*, 2010). These processes have been successfully applied to treat the reject water from sludge anaerobic digesters that normally accounts for 20% of the total nitrogen in a WWTP. Nowadays it is increasing the interest in the development of these processes to substitute the traditional activated sludge ones were nitrogen is removed via nitrification-denitrification. This new approach would comprise two steps, first a organic matter valorization (e.g., anaerobic digestion) and a subsequent anammox based process to remove nitrogen. For the anammox based process to be applied to the mainstream line of a WWTP two unfavorable factors have to be overcome: the low ammonia concentration and the low temperatures of municipal wastewater. The present work is focused on the study, at laboratory and pilot scale, of the feasibility of the ELAN® process applied to the main stream of a WWTP.

Material and Methods

A laboratory scale sequencing batch reactor (SBR) with a useful volume of 4 L was operated in cycles of three hours. It was operated at 15 ºC, fed with supernatant collected from an anaerobic sludge digester placed in a municipal WWTP diluted to simulate an urban wastewater. The average ammonia inlet concentration was of 50 mg NH_4^+-N/L. The reactor was inoculated with 9 g VSS/L of granular biomass from an ELAN® pilot plant treating the supernatant of an anaerobic sludge digester. The applied nitrogen loading rate (NLR) was of 0.10 g NH_4^+-N/L·d and the hydraulic retention time (HRT) of 0.5 days. Batch respirometry experiments were performed to evaluate NOB activity.

Results and Conclusions

The lab scale SBR was operated along 220 days in three different stages. Stage I lasted 40 days and corresponded to the start-up and acclimation of the process to treat the low ammonia concentration and operate at low temperature. The dissolved oxygen concentration was maintained around 0.1 mg O_2/L to achieve a nitrogen removal efficiency of 80% (Figure 1.1).

This initial efficiency progressively decreased along Stage II (days 40 – 170) due to the activity of the nitrite oxidizing bacteria (NOB). At this point the increase of the nitrite oxidation rate (NOR) (Figure 1.1) and the accumulation of nitrate inside the reactor until values around 30 mg NO_3^--N/L were observed. NOB were present in the inoculum in a low proportion (2 – 3%), but with a negligible activity at macroscopic scale. During the reactor operation the structure of the granular biomass was progressively damaged and the detachment of biomass from the granule surface occurred. Granules inoculated in the reactor had a density of 66 g VSS/$L_{granule}$, and after 170 days of operation, the density dropped to 23 g VSS/$L_{granule}$. In addition, the color and opacity of the granules diminished, especially after day 100, and finally a flocculent fraction of biomass and granules fragments were observed in the reactor. The presence of this kind of biomass provoked an increase of the surface for oxygen liquid-solid transfer and promoted the access of NOB to the substrates which proliferate in relevant amount consuming nitrite to produce nitrate.

Biomass activity assays were performed to determine the abundance of NOB in the granular biomass or in the flocculent one. NOB activity of 0.020 g N/g VSS·d was measured in the granular biomass and of 0.118 g N/g VSS·d in the flocculent one. In Stage III (days 171-240) the imposed settling velocity in the SBR cycle was increased from 0.13 to 0.36 m/h to remove the NOB which are mainly present in the flocculent biomass. This action favored the recovery of the nitrogen removal efficiency (from values of 20% to 60%).

An ELAN® reactor at pilot plant scale treating primary settled wastewater is being operated in a municipal WWTP in order to further evaluate this process.

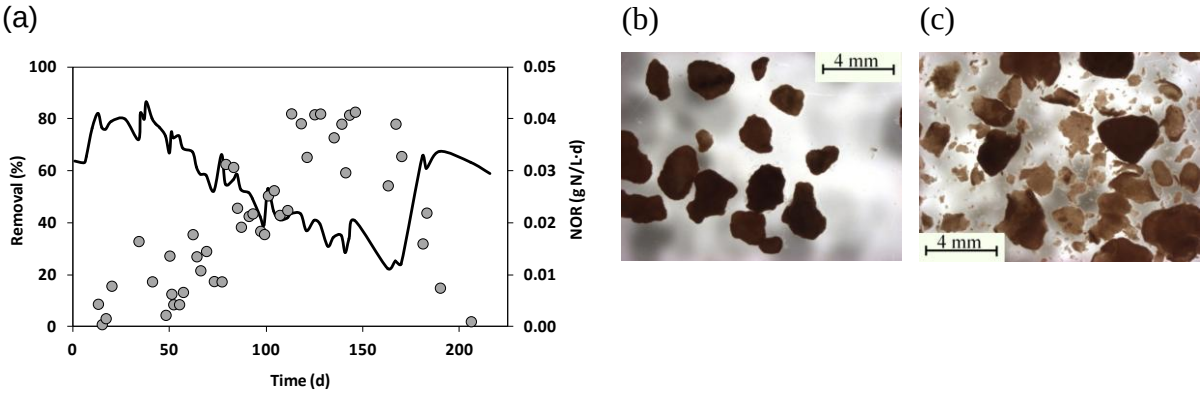

Figure 1.1 Profile of nitrogen removal percentage (—) and nitrite oxidizing rate (NOR) (●) in the lab scale SBR(a). And images of the granules (zoom: 6.5x). (b) Inoculum and (c) on day 120.

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References

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