Nitrogen removal via nitrite from thermally hydrolysed and digested reject water

E. Statiris*, C. Noutsopoulos, D. Mamais, N. Petalas, S. Malamis
*School of Civil Engineeting, National Technical University of Athens
5 Iroon Polytechniou St, Zografou Campus, 15780, Athens Greece
*Statiris Evangelos: vagstatiris@gmail.com

Abstract: A pilot-scale SBR was applied in order to treat reject water produced after dewatering of hydrolyzed and digested sludge. The system operated by implementing the nitritation/denitritation process achieving 88.6±6.2% and 71.0±19% NH_4-N and TN removal respectively during the period with the higher nitrogen loading rate. During the examined period the SBR biomass was used in ex-situ tests in order to investigate the FNA inhibition on ammonia oxidation rates. These tests unveiled 50% inhibition at pH 7, 7.5 and 8 for FNA concentrations equal to 0.05, 0.04 and 0.035 mg HNO_2 L^{-1} respectively. Similar experiments in a non-acclimated biomass showed that significantly lower concentrations equal to 0.04, 0.017 and 0.010 mg HNO_2 L^{-1} can decrease the AUR for 50%.

Keywords: Reject water; Nitritation; FNA

Introduction

The nitritation/denitritation process seems to fit for the treatment of sludge reject water and other wastewater effluents as it offers 25% less oxygen demand and a significant reduction of external carbon source requirements during denitritation (Ge et al., 2015). During the nitritation process, the accumulation of nitrite can lead to significant concentrations of free nitrous acid (FNA) which can cause severe inhibition in nitrification processes (Anthonisen et al., 1976). This work aims to investigate the efficiency of a pilot-scale SBR unit applied to treat sludge reject water via the nitritation/denitritation process. The effect of FNA concentration on ammonia oxidation rates (AUR) was also investigated. Moreover, the inhibition caused by FNA on the SBR biomass was compared with the corresponding inhibition on a typical biomass taken from Psyttalia WWTP.

Material and Methods

A 9 m^3 pilot-scale SBR was operated for the treatment of reject water produced after dewatering of thermally hydrolyzed and digested sludge by using the short-cut nitrification/denitrification process (SCND). The SBR system operated for about 180 d before the three examined periods which lasted about 310 days, implementing stable short-cut nitrification/denitrification.

The batch assays were conducted to the SBR biomass in order to examine the inhibition of FNA on ammonia oxidation rates of an acclimated (in significant FNA concentrations) biomass. The AUR tests were also conducted to a typical nitrifying (non-acclimated to FNA) biomass of the Psyttalia WWTP.

Results and Conclusions

The SBR operated for approximately 310 days under stable conditions treating the reject water of a WWTP which was produced after the dewatering of thermally hydrolyzed and digested sludge. Table 1 presents an overview of the SBR performance during a period of stable nitritation process with the NOB bacteria suppressed. Nitrates were only occasionally observed and at very low concentrations.

Table 1: Pilot plant operating conditions, kinetics and effluent values

Parameter	1st period (183-258 d)	2nd period (258-400 d)	3rd period (400-491 d)
MLVSS (mg L^{-1})	5287±1038	5689±509	3890±1280
NLR_TKN (kg N m^{-3} d^{-1})	0.36±0.09	0.51±0.08	0.32±0.13
NH_4-$N_{effluent}$ (mg L^{-1})	97.5±43.3	150±74	31±25
NO_2-$N_{effluent}$ (mg L^{-1})	211±201	280±132	55±25
AUR (mgNO_2-N/g VSS^{-1} h^{-1})	4.2±0.6	7.6±0.7	7.5±2.2
NUR (mgNO_2-N/g VSS^{-1} h^{-1})	9.4±5.5	8.3±0.4	11.7±1.9
TN removal (%)	73.4±11.2	71±19	92.2±10.8
NH_4-N removal (%)	91.3±4.3	88.6±6.2	98±1.9

The higher NLR in terms of TKN was equal to 0.51±0.08 $kgNm^{-3}d^{-1}$ during the 2nd period while the SBR achieved 88.6±6.2% NH_4-N removal via nitrite and 71.0±19% TN removal respectively. As shown in Figure 1, the FNA inhibition on AUR was investigated for 3 different pH values.

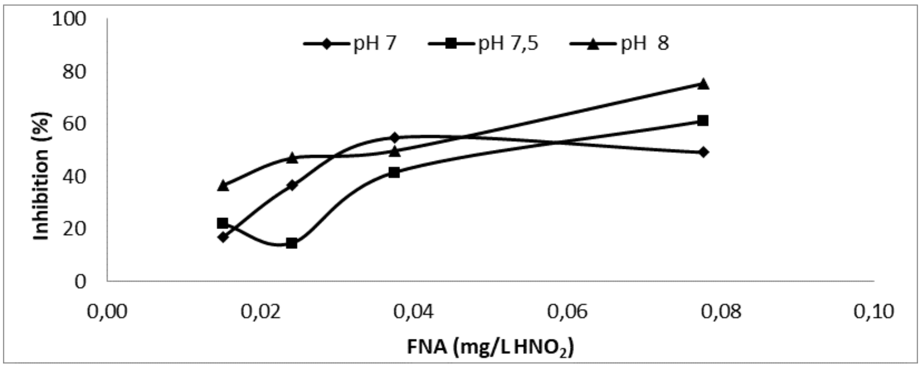

Figure 1: Investigation of FNA inhibition on ammonia oxidation rates of an acclimated biomass

Using increasing concentrations of FNA the higher inhibition was calculated at pH=8 (75.8% for 0.08 mg L^{-1} FNA) while at the same FNA concentration and pH 7 the inhibition was 55%. This reveals that nitrite is also an inhibitory factor for ammonia oxidation. For the SBR biomass, the 50% of the AUR inhibition emerged at concentrations of FNA equal to 0.05, 0.04 and 0.035 mg HNO_2 L^{-1} for pH of 7, 7.5 and 8 respectively. The 50% inhibition of the ammonia oxidation rates on the non-acclimated biomass were measured at lower FNA concentrations, equal to 0.04, 0.017 and 0.010 mg HNO_2 L^{-1} respectively at the same pH. As expected, the acclimated biomass showed a better tolerance against FNA compared to the non-acclimated biomass.

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