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Effect of temperature on AOB activity of a partial nitritation SBR treating landfill leachate with extremely high nitrogen concentration

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HIGHLIGHTS

- ▶ Successful partial nitritation at 25 and 35 °C treating leachate at 6 g $N\text{-}NH_4^+ L^{-1}$.
- ▶ A kinetic model was applied to study the influence of FA and FNA inhibition on AOB.
- ▶ FNA was the main source of AOB inhibition at 25 °C.
- ▶ At 35 °C, AOB inhibition was due to the combined action of FA and FNA.
- ▶ Two AOB phylotypes were found during stable state at 25 and 35 °C.

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ABSTRACT

This study investigates the effects of temperature on ammonia oxidizing bacteria activity in a partial nitritation (PN) sequencing batch reactor. Stable PN was achieved in a 250 L SBR with a minimum operating volume of 111 L treating mature landfill leachate containing an ammonium concentration of around 6000 mg $N\text{-}NH_4^+ L^{-1}$ at both 25 and 35 °C. A suitable influent to feed an anammox reactor was achieved in both cases. A kinetic model was applied to study the influence of free ammonia (FA), the free nitrous acid (FNA) inhibition, and the inorganic carbon (IC) limitation. NH_4^+ and NO_2^- concentrations were similar at 25 and 35 °C experiments (about 2500 mg $N\text{-}NH_4^+ L^{-1}$ and 3500 mg $N\text{-}NO_2^- L^{-1}$), FA and FNA concentrations differed due to the strong temperature dependence. FNA was the main source of inhibition at 25 °C, while at 35 °C combined FA and FNA inhibition occurred. DGGE results demonstrated that PN-SBR sludge was enriched on the same AOB phylotypes in both experiments.

1. Introduction

Urban landfill leachate characteristics vary greatly depending on factors such as seasonal weather variation, waste type and composition, and landfill age, among others. The biological treatment of landfill leachate mainly focuses on organic matter and ammonium removal, and is mostly carried out through conventional autotrophic nitrification–heterotrophic denitrification. However, when treating mature landfill leachates characterized by low C/N ratio, high aeration and an external carbon source are required, entailing high operational costs.

The anaerobic ammonium oxidation (anammox) process is a more sustainable alternative for the treatment of wastewaters containing high nitrogen loads and low biodegradable organic matter (Van Dongen et al., 2001). As a result, the feasibility of this process for landfill leachate treatment has previously been studied at low and high ammonium concentration (Ganigué et al., 2009; Ruscalleda et al., 2008; Siegrist et al., 1998). The anammox process requires a previous partial nitritation (PN) in order to produce a $NO_2^-:NH_4^+$ molar ratio of 1.32 (Strous et al., 1999). PN systems aim to out-compete nitrite oxidizing bacteria (NOB) to achieve nitrite accumulation by ammonia oxidizing bacteria (AOB) and with the startup as a key period to inhibit and/or washout NOB.

Several controlling factors can be applied to out-compete NOB and ensure nitrite accumulation, such as short sludge retention time (SRT), pH, dissolved oxygen (DO), free ammonia (FA) or free nitrous acid (FNA) inhibition or temperature (Ahn et al., 2011, Liang and Lu, 2007, Van Dongen et al., 2001). Focusing on temperature, PN reactors are usually operated between 30 and 35 °C, because at these values AOB have higher growth rates than NOB (Hellinga et al., 1998). However, temperature also affects the chemical equilibria of ammonium-free ammonia (FA) and nitrite-free nitrous acid (FNA), which can play a critical role in partial nitritation. High FA and FNA concentrations affected by temperature

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