Development of a simultaneous partial nitrification, anaerobic ammonia oxidation and denitrification (SNAD) bench scale process for removal of ammonia from effluent of a fertilizer industry

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HIGHLIGHTS

- SNAD process was developed to treat ammonia laden effluent of fertilizer industry.
- Enriched biomass developed stably treated effluent with C/N ratio 0.066.
- 98.9% ammonia removal was achieved in a single reactor.
- Sequencing 16S rDNA showed presence of nitrifiers, denitrifiers & anammox bacteria.
- Quantitative analysis of bacteria revealed their spatial arrangement in reactor.

ABSTRACT

A simultaneous partial nitrification, anammox and denitrification (SNAD) process was developed for the treatment of ammonia laden effluent of a fertilizer industry. Autotrophic aerobic and anaerobic ammonia oxidizing biomass was enriched and their ammonia removal ability was confirmed in synthetic effluent system. Seed consortium developed from these was applied in the treatment of effluent in an oxygen limited bench scale SNAD type (1L) reactor run at ambient temperature (30°C). Around 98.9% ammonia removal was achieved with ammonia loading rate 0.35kgNH₄⁺-N/m³ day in the presence of 46.6 mg/L COD at 2.31 days hydraulic retention time. Qualitative and quantitative analysis of the biomass from upper and lower zone of the reactor revealed presence of autotrophic ammonia oxidizing bacteria (AOB), Planctomycetes and denitrifiers as the dominant bacteria carrying out anoxic oxidation of ammonia in the reactor. Physiological and molecular studies strongly indicate presence of anammox bacteria in the anoxic zone of the SNAD reactor.

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1. Introduction

Ammonia released in the effluent of agriculture based industries has become a prime concern with the increasing awareness of pollution in the water bodies leading to eutrophication and acidification of the aquatic systems. Conventional ammonia removal from wastewater accomplished through the combination of nitrification (aerobic) and denitrification (anaerobic) is expensive, energy and space requiring process generating high amount of sludge (Bagchi et al., 2012). Development of a novel cost-effective process for the treatment of high ammonia and low or no level of COD, therefore has been the need of the day.

New technologies developed over the time for efficient removal of ammonia from wastewaters include, SHARON (single reactor system for high activity ammonia removal over nitrite), SND (simultaneous nitrification denitrification), SNAP (Single stage nitrogen removal using anammox and partial nitritation), CANON (complete autotrophic nitrogen removal over nitrite), OLAND (oxy- gen limited autotrophic nitrification and denitrification), DEMON (DEamMONification), and BABE (Bio-Augmentation Batch Enhanced), as reviewed by Bagchi et al. (2012) involve partial nitrification (oxidation of ammonia to nitrite) followed by anoxic oxidation of the remaining ammonia by the anammox bacteria in the presence of nitrite as electron acceptor. These processes are operated in a single reactor unit with reduced aeration (1kWh/kgN) and external organic load requirements, saving 90% of the operation costs (Wang et al., 2010). Although significant nitrification is not expected at DO below 0.3 mg/L, treatment processes that promote simultaneous nitrification–denitrification can reach...