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Partial nitrification and nitrous oxide emission in an intermittently aerated sequencing batch biofilm reactor

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HIGHLIGHTS

- On average, (1.50 ± 0.22, $n = 5$)% of the incoming nitrogen load was emitted as N_2O.
- The dynamics of the N_2O emission characteristics were elucidated.
- The dominant AOB causing the N_2O emission were *Nitrosospira*.

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ABSTRACT

This study attempts to start up partial nitrification in a sequencing batch biofilm reactor (SBBR) producing an influent suitable for the anammox process and investigate the emission of nitrous oxide (N_2O). After 31 days of operation, partial nitrification was achieved at (35 ± 1) °C under intermittently aerated. Based on long-term monitoring, about (1.50 ± 0.22, $n = 5$)% of the incoming nitrogen, loaded to the partial nitrification system, was emitted as N_2O. The dynamic behavior of N_2O emission (quantity (y) varying with time (x)) in the partial nitrification process can be fit to a line where $y = 0.0375x + 0.4806$, $R^2 = 0.9949$. Furthermore, the molecular ecology using polymerase chain reaction (PCR) and denaturing gradient gel electrophoresis (DGGE) techniques was studied, *Arcobacter* and *Nitrospira* were washed out during to the controlled aeration and high temperature. *Acidobacteria*, *Cytophagales* and *Hyphomicrobiaceae* were enriched after long term operation of the partial nitrification. *Nitrosospira* was the dominant AOB causing nitrous oxide emission via a nitrifier denitrification pathway.

1. Introduction

Wastewaters containing abundant nitrogen may cause eutrophication in the receiving water bodies if the nitrogen not be removed before the water released into aquatic environment. Conventional nitrogen biological removal (BNR) which is used for treating low nitrogen concentrations wastewaters is performed through autotrophic nitrification in aerobic conditions and heterotrophic denitrification in anoxic conditions [1]. Aeration is needed for the aerobic nitrification process and organic carbon source that often in the form of methanol is required for denitrification. The conventional BNR process cannot treat wastewaters with high-strength ammonium loadings cost-effectively.

Innovative autotrophic BNR technologies based on the anaerobic ammonia oxidation (anammox) process have been developed and have higher nitrogen removal efficiency and lower energy consumption [2–4]. Partial nitrification, the pretreatment step for the anammox process, can produce a suitable influent composed by about 1:1 ammonium to nitrite molar ratio, which is of significant importance for the success of the subsequent anammox process [5].

In the BNR process, microorganisms are utilized to convert inorganic nitrogen compounds into dinitrogen gas through different biochemical reactions [6]. Nitrous oxide (N_2O) can be an intermediate or end product in the metabolism of both nitrification and denitrification processes [7]. N_2O is an important greenhouse gas, about 300 times more effective than carbon dioxide (CO_2). A small amount of accumulation of N_2O may cause destructive effects for centuries due to its long estimated half-life (approximately 120 years) [8]. Wastewater treatment processes occupies an extremely important position among the microbial processes of N_2O emission. N_2O emissions from wastewater treatment processes gradually increased across the time series [9]. Over the past decade, controlling the emission of N_2O has become an important part of the biological wastewater treatment process.

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