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N_2O emission in a partial nitrification system: Dynamic emission characteristics and the ammonium-oxidizing bacteria community

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HIGHLIGHTS

- On average, (0.80 ± 0.19, n = 7)% of the incoming nitrogen load was emitted as N_2O.
- The dynamics of the N_2O emission characteristics were elucidated.
- The evolution of the AOB community in partial nitrification was investigated.
- The dominant AOB causing the N_2O emission were *Nitrosomonas* sp.

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ABSTRACT

This study attempts to elucidate the dynamics of nitrous oxide (N_2O) emission and investigate the evolution of the ammonium-oxidizing bacteria (AOB) community in a partial nitrification system producing an influent suitable for the anammox process. Based on long-term monitoring, (0.80 ± 0.19, n = 7)% of the incoming nitrogen load was emitted as N_2O. During the partial nitrification process, the N_2O emission rate reached a maximum at the beginning of the aerobic period and stabilized at a low level after an initial peak. Moreover, the quantity of N_2O emission increased quickly at the beginning of the cycle operation and then production slowed after 30 min. According to polymerase chain reaction (PCR) and denaturing gradient gel electrophoresis (DGGE) analysis, the dominant AOB causing the N_2O emission from the partial nitrification system were *Nitrosomonas* sp. Both *Nitrosomonas* sp. Nm33 and *Nitrosomonas* sp. Nm58 were enriched at high ammonia concentrations.

1. Introduction

Nitrous oxide (N_2O), which not only contributes to the greenhouse effect, but also destroys the ozone layer, is the third most efficient greenhouse gas after carbon dioxide (CO_2) and methane (CH_4) (Ravishankara et al., 2009). A small amount of accumulation of N_2O may cause destructive effects for centuries due to its long estimated half-life (approximately 120 years). Its high increase rate (currently 0.25–0.30% per year) has attracted great attention on research on all sources and sinks of this gas.

Two-thirds of the overall N_2O is emitted by microbial processes (USEPA, 2009). The biological nitrogen removal (BNR) process in wastewater treatment occupies an extremely important position among the microbial processes of N_2O emission. In the BNR process, microorganisms are utilized to convert inorganic nitrogen compounds into dinitrogen gas through different biochemical reactions. N_2O can be an intermediate or end product in the metabolism of both nitrification and denitrification processes. Over the past decade, controlling the emission of N_2O has become an important part of the biological wastewater treatment process. N_2O emissions are extremely variable and depend on many operational parameters such as dissolved oxygen (DO) and nitrite concentrations in both the nitrification and denitrification stages and carbon availability (low chemical oxygen demand (COD)/N ratio) in the denitrification stage. A recent review by Kampschreur et al. (2009) showed that there are large variations in the N_2O emissions from full-scale wastewater treatment plants (WWTPs) (0–14.6% of the nitrogen load) and lab-scale WWTPs (0–95% of the nitrogen load).

The conventional BNR process cannot treat wastewaters with high-strength ammonium loadings cost-effectively (Van Hulle et al., 2010). Innovative autotrophic BNR technologies based on

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