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Unexpected malformations in  
*Xenopus tropicalis*



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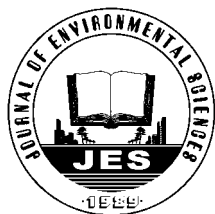
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## N<sub>2</sub>O emission from nitrogen removal via nitrite in oxic-anoxic granular sludge sequencing batch reactor

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### ABSTRACT

Bionitrification is considered to be a potential source of nitrous oxide (N<sub>2</sub>O) emissions, which are produced as a by-product during the nitrogen removal process. To investigate the production of N<sub>2</sub>O during the process of nitrogen removal via nitrite, a granular sludge was studied using a lab-scale sequence batch reactor operated with real-time control. The total production of N<sub>2</sub>O generated during the nitrification and denitrification processes were 1.724 mg/L and 0.125 mg/L, respectively, demonstrating that N<sub>2</sub>O is produced during both processes, with the nitrification phase generating larger amount. In addition, due to the N<sub>2</sub>O-N mass/oxidized ammonia mass ratio, it can be concluded that nitrite accumulation has a positive influence on N<sub>2</sub>O emissions. Results obtained from PCR-DGGE analysis demonstrate that a specific *Nitrosomonas* microorganism is related to N<sub>2</sub>O emission.

## Introduction

Nitrous oxide (N<sub>2</sub>O) is one of the most potent greenhouse gases, with an efficient absorption of infrared radiation, and an atmospheric lifetime of approximately 120 years. The global warming equimolar concentration of N<sub>2</sub>O is 310 times that of carbon dioxide, and 23 times methane (IPCC, 2001). It has been demonstrated that N<sub>2</sub>O is produced during the nitrogen removal processes. Consequently, wastewater treatment plants are considered to be a potential N<sub>2</sub>O source (Okabe et al., 2011; Wunderlin et al., 2012). Therefore, it is necessary to reduce and control N<sub>2</sub>O emissions from wastewater treatment plants.

It has been demonstrated that nitrogen removal is performed by different groups of microorganisms, including ammonium-oxidizing bacteria (AOB), nitrite-oxidizing bacteria (NOB) and denitrifying microbial communities.

Fluorescence *in situ* hybridization (FISH) and PCR-denaturing gradient gel electrophoresis (PCR-DGGE) analysis demonstrated that AOB are the dominant nitrifying bacteria (Yang et al., 2009; Colliver and Stephenson, 2000), with *Nitrosomonas europaea* and *Alcaligenes faecalis* being the typical microorganisms associated with N<sub>2</sub>O emission during the nitrogen removal process (Otte et al., 1996; Poth and Focht, 1985; Jiang and Bakken, 1999). Nitrifier denitrification, where nitrite is reduced to N<sub>2</sub>O or N<sub>2</sub>, was reported to be an important source of N<sub>2</sub>O production (Bock et al., 1995).

Aerobic granulation process is becoming a promising technology in wastewater treatment. But previous studies focused on N<sub>2</sub>O production usually associated with flocculent sludge, there is little research investigating N<sub>2</sub>O production associated with granular sludge, especially in the oxic-anoxic operating environments of sequencing batch reactors (SBRs). Therefore, this study aimed to assess the N<sub>2</sub>O production caused by nitrogen removal in relation to well-cultivated granular sludge. This was

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achieved using a real-time control system, which enabled the identification of the relationship between  $N_2O$  emission and the ability to optimize microbial communities population using a real-time control system. The findings are useful in providing a theoretical basis for practical application in the future.

## 1 Materials and methods

### 1.1 Reactor setup and operation

The SBR with the working volume of 3.2 L was operated at  $31 \pm 0.5^\circ\text{C}$ . The side face of the reactor was twisted with heating wire, and covered with asbestos cloth to maintain the water temperature in the reactor. Probes for monitoring dissolved oxygen (DO), pH and temperature, were inserted into the reactor from the side face. The reactor was operated under real-time control conditions for 2 cycles per day. Each cycle of SBR consisted of five steps: feeding (1 min), aeration (180 min), anoxic (40 min), settling (30 min), decant (20 min).

### 1.2 Inoculation

The seeding sludge was a well-cultivated granular sludge with an high removal efficiency of nitrogen and chemical oxygen demand (COD) and enhanced nitrite accumulation at the end of each cycle. The mixed liquor suspended solids (MLSSs) were maintained at approximately 2800 to 3000 mg/L. Any excess granular sludge was disposed of at the end of the anoxic denitrification process to maintain a solid retention time (SRT) of approximately 25 days.

### 1.3 Synthetic feed

A volume of 2.6 L of synthetic wastewater was fed into the SBR at the beginning of each cycle. Each liter of influent contained:  $300 \pm 15$  mg COD;  $30 \pm 2$  mg  $\text{NH}_4^+\text{-N}$ ;  $4.0 \pm 0.5$  mg  $\text{PO}_4^{3-}\text{-P}$  and 1.0 mL nutrient solution. One liter of nutrient solution contained: 1.5 g  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ ; 0.15 g  $\text{H}_3\text{BO}_3$ ; 0.03 g  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ; 0.18 g KI; 10 g EDTA; 0.12 g  $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ ; 0.12 g  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ; and 0.15 g  $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ .  $\text{NaHCO}_3$  was added, with the pH maintained at 7.3–7.8.

### 1.4 Analytical methods

During the nitrogen removal process, DO and pH levels were monitored each minute and recorded by the inserted probes (WTW 340i, WTW Company, Germany) frequency. The concentrations of N-containing ions ( $\text{NH}_4^+\text{-N}$ ,  $\text{NO}_2^-\text{-N}$ , and  $\text{NO}_3^-\text{-N}$ ), and the COD and MLSS were measured according to standard methods (APHA, 2005).

The total amount of  $N_2O$  produced consists of the  $N_2O$  emitted from the system (the emission-gas  $N_2O$ ) and the amount dissolved in the solution (the dissolved  $N_2O$ ).

The  $N_2O$  samples emitted were collected from the SBR headspace at 1 hr intervals during the aerobic-phase, and 20 min intervals during the anoxic-phase using a gas-tight, 100  $\mu\text{L}$  syringe with a lock. These samples were then injected into a GC unit (Shimadzu 2010, Japan) for analysis. The GC unit was installed with an electron capture detector (ECD), and Porapak Q column ( $30 \text{ m} \times 0.53 \text{ mm} \times 20 \mu\text{m}$ ), using high purity nitrogen as the carrier gas. The temperatures of the injector, ECD and column were 150, 300 and  $70^\circ\text{C}$ , respectively. All samples were analyzed in triplicate. The dissolved  $N_2O$  samples were obtained simultaneously with the emitted samples during aerobic- and anoxic-phases from the mixed liquid in the SBR reactor. The dissolved  $N_2O$  was measured according to the headspace method, described by Shiskowski (2007).

The concentrations of  $N_2O$  emissions (from both the aerobic and anoxic phase) were determined according to Kimochi et al. (1998). The  $N_2O$  emission rate was calculated according to Liu et al. (2008).

The bacterial biomass sampled for PCR analysis was collected from the reactor set to oxic/anoxic operating mode. The primers used for the nested PCR included a reverse universal primer 518, supplied by Shanghai Songon Biology Engineering Technology and Services Co. Ltd. (China) and a bacteria specific forward primer. The forward primers used were the AOB specific primers (CTO189f and CTO654r), used to amplify bacterial 16S rDNA, and the GC-338 primer underlined below (primer 338 plus a GC clamp attached at its 5' end). The nucleotide sequences of the primers were as follows: CTO189f and CTO654r; primer GC-BSF; and primer 518. The genomic DNA extraction and PCR conditions used were according to the literature (Kowalchuk et al., 1998), with a slight deviation in the annealing temperature of the touch down PCR, which was set to  $55^\circ\text{C}$ .

## 2 Results and discussion

### 2.1 $N_2O$ production during nitrogen removal via nitrite

The experiment was conducted using a SBR in oxic-anoxic operating mode. In a typical cycle, the total production of  $N_2O$  reached 1.724 mg/L during oxic nitrification, with 0.125 mg/L of  $N_2O$  produced during anoxic denitrification, which is different with the results of flocculent sludge (Liu et al., 2008). They found that the  $N_2O$  production during nitrification was 1.85 mg/L, whereas during denitrification no  $N_2O$  was produced. But our results demonstrate that  $N_2O$  is produced during both the nitrification and denitrification processes, with the greatest amount generated during oxic nitrification process.

As shown in Fig. 1a, during the initial stage of the oxic-phase (the initial 15 min), the concentration of DO was observed to decrease rapidly and then rebound sharply.

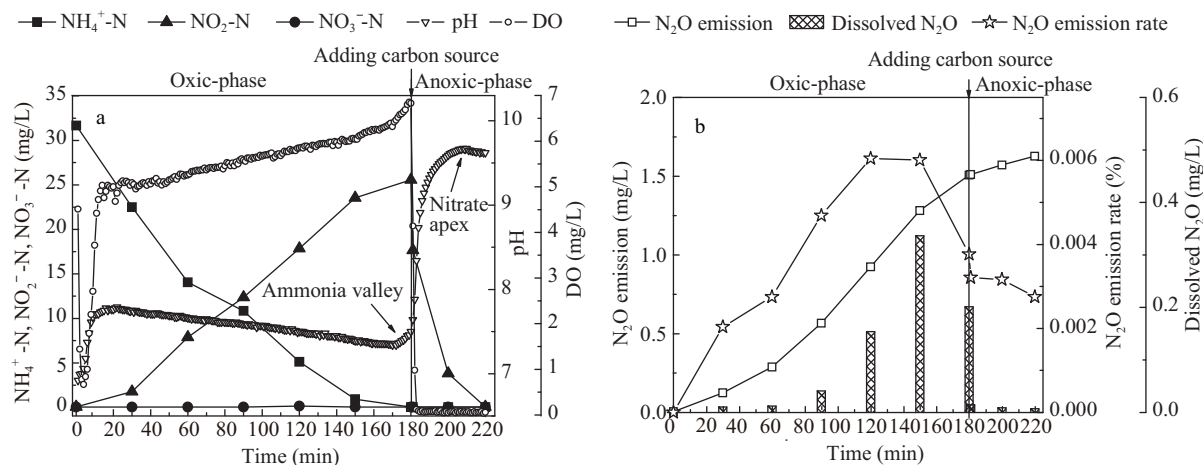


Fig. 1 Dynamic diversification of  $\text{NH}_4^+\text{-N}$ ,  $\text{NO}_2^-\text{-N}$ ,  $\text{NO}_3^-\text{-N}$ , pH and DO (a), and  $\text{N}_2\text{O}$  production and emission rate (b), in a typical cycle.

Meanwhile pH increased steadily. These observations are associated with the  $\text{NH}_4^+\text{-N}$  being used to synthesize the new cell tissue and cell respiration of the heterotrophic bacteria, which are multiplying during this phase (Liu et al., 2008). Subsequently, the system entered an oxic nitrification phase. During nitrification,  $\text{NH}_4^+\text{-N}$  was almost completely oxidized to  $\text{NO}_2^-\text{-N}$ . Little  $\text{NO}_3^-\text{-N}$  was detected. Following 172 min of oxic-phase treatment, the typical bending-point, ammonia valley occurred, which indicates the end of nitrification, as shown on the pH curve. Upon maintaining aeration for a further 8 min, a sudden rise in pH was observed. Complete conversion of  $\text{NH}_4^+\text{-N}$  into  $\text{NO}_2^-\text{-N}$  occurred the end of the oxic nitrification phase, along with the maximum concentration of nitrite. The nitrite accumulation rate ( $\text{NO}_2^-\text{-N}/(\text{NO}_x^-\text{-N})$ ) was higher than 98% at the end of oxic nitrification.

The total amount of  $\text{N}_2\text{O}\text{-N}$  produced during the oxic-phase reached 1.71 mg/L, with 5.41% of the oxidized ammonia mass converted into  $\text{N}_2\text{O}$ . Figure 1b illustrates the continuous increase in  $\text{N}_2\text{O}$  emissions, while the concentration of dissolved  $\text{N}_2\text{O}$  ascended rapidly and then descended during the last 30 min of the oxic nitrification phase. The loss of dissolved  $\text{N}_2\text{O}$  was mainly due to aeration stimulating the  $\text{N}_2\text{O}$  release rate, where upon complete oxidization of ammonia, a high concentration of dissolved  $\text{N}_2\text{O}$  was associated with the activated sludge, continuous aeration of the reactor then led to the atmospheric release of the  $\text{N}_2\text{O}$  dissolved in the system, and resulted in the decline of the dissolved  $\text{N}_2\text{O}$  concentration value.

Over the entire oxic nitrification process, the concentration of nitrite increased rapidly, along with  $\text{N}_2\text{O}$  emission. As shown in Fig. 2, the generated  $\text{N}_2\text{O}\text{-N}/\text{oxidized ammonia mass}$  ratio and  $\text{NO}_2^-\text{-N}$  displayed similar trends during the oxic phase, reflecting a correlation between the concentration of nitrite in the system and  $\text{N}_2\text{O}$  emissions, whereby high nitrite accumulation led to increases in  $\text{N}_2\text{O}$  emission to some extent (Kampschreur et al., 2009; Alinsafi et al., 2008; Shiskowski, 2007; Itokawa et al.,

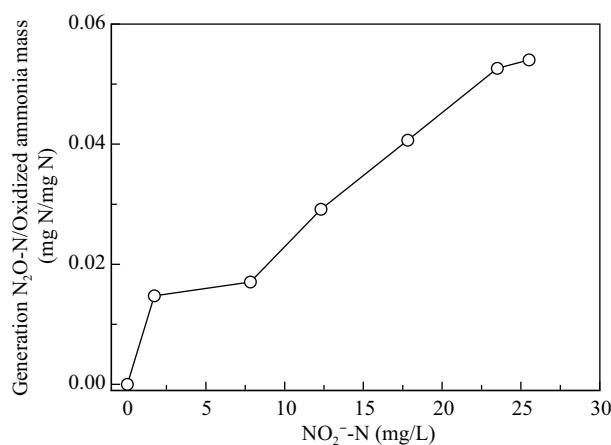
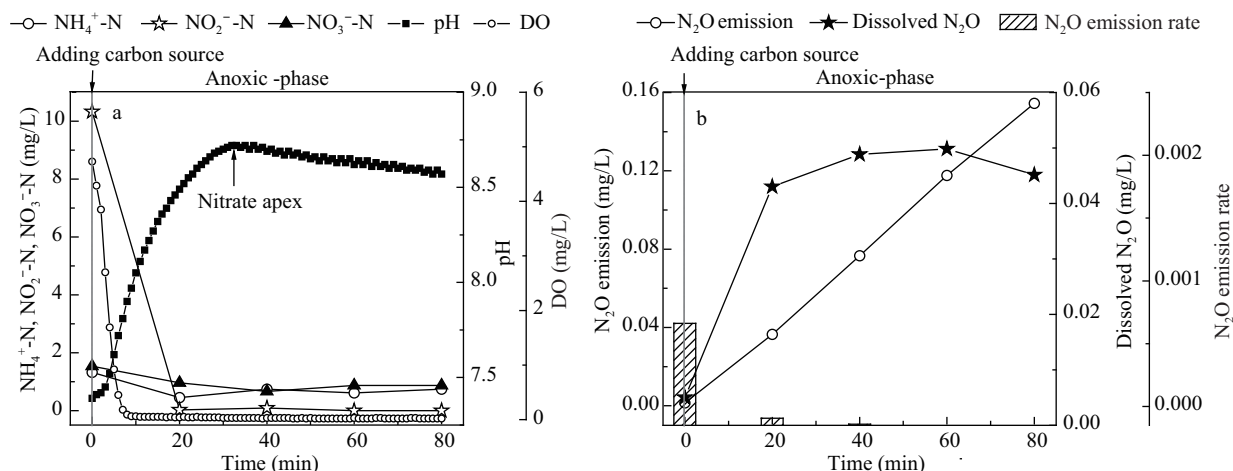


Fig. 2 Relationship between generated  $\text{N}_2\text{O}\text{-N}/\text{oxidized ammonia mass}$  and  $\text{NO}_2^-\text{-N}$  during the oxic phase.

2001).

After aeration stopped sodium acetate was added to the system to provide an external carbon source within the system. The presence of an external carbon source is vital for the removal of nitrite during the anoxic denitrification process. During the first minute, despite the lack of aeration, the concentration of DO was maintained at 3 mg/L. In the presence of a sufficient carbon source, the dissolved  $\text{N}_2\text{O}$  underwent rapid reduction to  $\text{N}_2$  by heterotrophic organisms, which is demonstrated in the reduced emissions of  $\text{N}_2\text{O}$  from the water. As denitrification progressed,  $\text{N}_2\text{O}$  emissions increased. Some researchers think that the behavior of the  $\text{N}_2\text{O}$  emissions may be associated with the high nitrite concentrations accumulated during the oxic phase, and the accumulation of  $\text{N}_2\text{O}$  during denitrification (Alinsafi et al., 2008; von Schulthess et al., 1995). Furthermore, the electronic competition between the enzymes associated with denitrification, namely nitrate reductase, nitrite reductase, nitric oxide reductase and nitrous oxide



**Fig. 3** Dynamic diversification of NH<sub>4</sub><sup>+</sup>-N, NO<sub>2</sub><sup>-</sup>-N, NO<sub>3</sub><sup>-</sup>-N, pH and DO (a), and N<sub>2</sub>O production and emission rates, associated with the extended denitrification time (b).

reductase, may explain the increased N<sub>2</sub>O production occurring under anoxic conditions. If the reduction and synthesis of nitrous oxide reductase was enhanced, it may correspond to a reduction in N<sub>2</sub>O emissions (Otte et al., 1996).

## 2.2 Effect of real-time control on N<sub>2</sub>O emission

The application of the real-time control theory (Wang et al., 2004) can be utilized for the typical ammonia valley and nitrate apex bending-points (Fig. 1a), which characterize the end of nitrification (ammonia valley on the pH curve), or the end of denitrification (nitrate apex on the pH curve).

The application of real-time control may be employed by stopping aeration upon the complete oxidation of ammonia to nitrite, thereby preventing the excessive aeration that contributes to the release of dissolved N<sub>2</sub>O into the atmosphere. This real-time control strategy would enable the amount of N<sub>2</sub>O produced during the aerobic nitrification phase stage to be effectively controlled.

Figure 3 shows the dynamic diversification of the liquid and gas samples in response to an extended denitrification period. During this cycle, the nitrite accumulation rate was reached at 87.10% at the end of nitrification. Upon the addition of an external carbon source the system then entered the anoxic denitrification phase. During the denitrification process, nitrite was reduced continuously, with the nitrogen concentrations in the water samples reduced to a minimum in the first 40 minutes, and remaining static for the final 40 minutes. The end of denitrification, which was observed at the 32nd minute when the “nitrate apex” appeared, was determined from measurements of pH and DO that were captured by the probes. As the denitrification reaction progressed, N<sub>2</sub>O emission increased gradually. The emission rate of N<sub>2</sub>O could be divided into three phases: a rising period, a smooth period and a decline period.

The emissions of N<sub>2</sub>O can be limited by the application of the real-time control strategy by stopping denitrification at approximately 40 minutes, when N<sub>2</sub>O emissions are at a minimum. For the experimental data pertaining to the aerobic granular sludge, the N<sub>2</sub>O emissions resulting from an extended denitrification period is 2.01 times greater than when real-time control is applied. Therefore, the application of a real-time control strategy can significantly reduce the N<sub>2</sub>O emission associated with denitrification.

## 2.3 Microbial community analysis

The unique layered structure of the aerobic granular sludge provides a suitable living environment for a variety of nitrogen-related bacteria that are utilized in the wastewater treatment.

The microbial community composition for the granular sludge used in this study is relatively simple. We found that there were microorganisms *Betaproteobacteria*, *Nitrosomonas* and *Zoogloea* sp. in granular sludge. *Betaproteobacteria* microorganisms play an important role during anaerobic digestion and mainly exist in the anaerobic digestion sludge (Rivière et al., 2007). *Nitrosomonas* is a bacterium that undergoes self-nitrification (Poth et al., 1985). Compared with the other bacteria, *Nitrosomonas* is associated with the greatest release of N<sub>2</sub>O emission during nitrification, especially under low DO and high nitrogen conditions (Inamori et al., 1997). *Zoogloea* sp. secretes a large number of adhesive materials, such as EPS, which form the bacteria micelle, and are the major components of activated sludge. As the micelles of the bacteria were embedded in the resin, they could not easily be swallowed by the protozoa, but easy to settling.

Three types of micro-organisms were present in the granular sludge system during the oxic/anoxic operating mode. Among these micro-organisms, the *Nitrosomonas* bacterium was associated with N<sub>2</sub>O emission.

### 3 Conclusions

The findings of the study demonstrate that when utilizing aerobic granular sludge, the emission of N<sub>2</sub>O occurs during both the nitrification and denitrification processes, however nitrification was the main source of N<sub>2</sub>O emission. Furthermore, the application of a real-time control strategy can be employed to control the end point of nitrification and denitrification, in order to save energy, and to reduce N<sub>2</sub>O emission during nitrogen removal. During the oxic phase, nitrite accumulation was found to have a positive influence on N<sub>2</sub>O emissions. PCR-DGGE analysis demonstrate *Nitrosomonas* was largely responsible for the emission of N<sub>2</sub>O.

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### REFERENCES

- Alinsafi, A., Adouani, N., Beline, F., Lendormi, T., Limousy, L., Sire, O., 2008. Nitrite effect on nitrous oxide emission from denitrifying activated sludge. *Process Biochem.* 43, 683–689.
- APHA, AWWA, WEF, 2005. *Standard Methods for the Examination of Water and Wastewater*, 21st ed. American Public Health Association/American Water Works Association/Water Environment Federation, Washington, DC, USA.
- Bock, E., Schmidt, I., Stüven, R., Zart, D., 1995. Nitrogen loss caused by denitrifying *Nitrosomonas* cells using ammonium or hydrogen as electron donors and nitrite as electron acceptor. *Arch. Microbiol.* 163(1), 16–20.
- Colliver, B. B., Stephenson, T., 2000. Production of nitrogen oxide and dinitrogen oxide by autotrophic nitrifiers. *Biotechnol. Adv.* 18(3), 219–232.
- Inamori, Y., Wu, X. L., Mizuochi, M., 1997. N<sub>2</sub>O producing capability of *Nitrosomonas europaea*, *Nitrobacter winogradskyi* and *Alcaligenes faecalis*. *Water Sci. Technol.* 36(10), 65–72.
- IPCC, 2001. *Climate Change 2001: the Scientific Basis*. Cambridge University Press, Cambridge.
- Itokawa, H., Hanaki, K., Matsuo, T., 2001. Nitrous oxide production in high-loading biological nitrogen removal process under low COD/N ratio condition. *Water Res.* 35(3), 657–664.
- Jiang, Q. Q., Bakken, L. R., 1999. Nitrous oxide production and methane oxidation by different ammonia-oxidizing bacteria. *Appl. Environ. Microbiol.* 65(6), 2679–2684.
- Kampschreur, M. J., Temmink, H., Kleerebezem, R., Jetten, M. S. M., van Loosdrecht, M. C. M., 2009. Nitrous oxide emission during wastewater treatment. *Water Res.* 43, 4093–4103.
- Kimochi, Y., Inamori, Y., Mizuochi, M., Xu, K. Q., Matsumura, M., 1998. Nitrogen removal and N<sub>2</sub>O emission in a full-scale domestic wastewater treatment plant with intermittent aeration. *J. Ferment. Bioeng.* 86(2), 202–206.
- Kowalchuk, G. A., Bodelier, P. L. E., Heilig, G. H. J., Stephen, J. R., Laanbroek, H. J., 1998. Community analysis of ammonia-oxidising bacteria, in relation to oxygen availability in soils and root-oxygenated sediments, using PCR, DGGE and oligonucleotide probe hybridisation. *FEMS Microbiol. Ecol.* 24(4), 339–350.
- Liu, X. H., Peng, Y., Wu, C. Y., Akio, T., Peng, Y. Z., 2008. Nitrous oxide production during nitrogen removal from domestic wastewater in lab-scale sequencing batch reactor. *J. Environ. Sci.*, 20(6), 641–645.
- Okabe, S., Oshiki, M., Takahashi, Y., Satoh, H., 2011. N<sub>2</sub>O emission from a partial nitrification-anammox process and identification of a key biological process of N<sub>2</sub>O emission from anammox granules. *Water Res.* 45(19), 6461–6470.
- Otte, S., Grobden, N. G., Robertson, L. A., Jetten, M. S., Kuenen, J. G., 1996. Nitrous oxide production by *Alcaligenes faecalis* under transient and dynamic aerobic and anaerobic conditions. *Appl. Environ. Microbiol.* 62(7), 2421–2426.
- Poth, M., Focht, D. D., 1985. <sup>15</sup>N kinetic analysis of N<sub>2</sub>O production by *Nitrosomonas europaea*: An examination of nitrifier denitrification. *Appl. Environ. Microbiol.* 49(5), 1134–1141.
- Rivière, D., Desvignes, V., Pelletier, E., Chaussonnerie, S., Guermazi, S., Weissenbach, J. et al., 2007. Nitrous oxide—a powerful greenhouse gas with a wastewater treatment connection. *Water Environ. Federat.* 1279–1290.
- Schulthess, R. V., Kuhni, M., Gujer, W., 1995. Release of nitric and nitrous oxides from denitrifying activated sludge. *Water Res.* 29(1), 215–226.
- Wang, S. Y., Gao, D. W., Peng, Y. Z., Wang, P., Yang, Q., 2004. Nitrification-denitrification via nitrite for nitrogen removal from high nitrogen soybean wastewater with on-line fuzzy control. *Water Sci. Technol.* 49(5-6), 121–127.
- Wunderlin, P., Mohn, J., Joss, A., Emmenegger, L., Siegrist, H., 2012. Mechanisms of N<sub>2</sub>O production in biological wastewater treatment under nitrifying and denitrifying conditions. *Water Res.* 46(4), 1027–1037.
- Yang, Q., Liu, X. H., Peng, C. Y., Wang, S. Y., Sun, H. W., Peng, Y. Z., 2009. N<sub>2</sub>O Production during nitrogen removal via nitrite from domestic wastewater: main sources and control method. *Environ. Sci. Technol.* 43(24), 9400–9406.





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