



Effect of electron donors on anammox coupling with nitrate reduction for removing nitrogen from nitrate and ammonium



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HIGHLIGHTS

- ▶ Anammox coupled with NO₃⁻ reduction was stimulated by addition of swine wastewater, acetate, hydrogen and iron.
- ▶ No inhibitory effect on anammox in a medium with NO₂⁻/NH₄⁺ was induced by these electron donors, except for iron.
- ▶ Swine wastewater carried an exponential increase in denitrification under high concentrations.
- ▶ Hydrogen did not carry an increase in denitrification even when its addition was increased.

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ABSTRACT

Anammox coupling with nitrate reduction under various electron donors was studied using sludge acclimatized to have anammox and denitrification activities. Due to a deficiency in electron donors for NO₃⁻ reduction, anammox activity in an inorganic medium containing NO₃⁻ and NH₄⁺ was lower than that in NO₂⁻ and NH₄⁺. Anammox could use NO₂⁻ competitively against denitrifiers under a very limited NO₂⁻ concentration, and additions of swine wastewater or acetate stimulated anammox activity in an inorganic medium containing NO₃⁻ and NH₄⁺ with no inhibition effects. However, a high concentration of swine wastewater caused an exponential increase in denitrification activity. The addition of hydrogen and iron stimulated anammox activity in an inorganic medium containing NO₃⁻ and NH₄⁺, but iron showed an inhibitory effect on anammox in a medium containing NO₂⁻ and NH₄⁺. Hydrogen was shown to be advantageous since it did not increase denitrification even when its addition was increased.

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1. Introduction

Biological nitrogen removal has been conventionally achieved by nitrification followed by denitrification. However, some kinds of wastewater characterized by a low BOD/N (Biological Oxygen Demand/Nitrogen) ratio (e.g. livestock wastewaters) make it difficult to remove nitrogen using such a removal process because they have an insufficient supply of electron donors for denitrification (Boursier et al., 2005; Waki et al., 2010a). In recent years, anaerobic ammonium oxidation (anammox), which oxidizes NH₄⁺ to N₂ using NO₂⁻ as an electron acceptor under anoxic conditions, has been introduced (Mulder et al., 1995; Strous et al., 1997). Since it can remove nitrogen without an additional electron donor for denitrifica-

tion, the process is expected to be applicable for removing nitrogen from low BOD/N ratio wastewater.

Most anammox treatment studies were carried out using an inorganic medium containing NO₂⁻ and NH₄⁺, which is most suitable for producing an anammox reaction. Actual wastewater was purified to remove BOD, followed by partial nitrification to contain NO₂⁻ and NH₄⁺, and was then used for anammox treatment (Tokutomi et al., 2011; van der Star et al., 2007). Process manipulation methods with dissolved oxygen concentration, inorganic carbon concentration, temperature, inhibitors, and heat shock of sludge, have been proposed for attaining partial nitrification (i.e., maintaining dominance of the aerobic ammonium oxidizer and suppressing the nitrite oxidizer) (Isaka et al., 2008; Peng and Zhu, 2006; Tokutomi et al., 2010). However, such manipulations require an advanced and extensive process. Without a manipulation for partial nitrification, wastewater treated by an aerobic process is inclined to contain NO₃⁻. For example, swine wastewater treated by an activated sludge treatment frequently contains NO₃⁻, as well as residual NH₄⁺ and BOD (Waki et al., 2010a). Therefore, a nitrogen

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