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Short Communication

# Long term effect of $MnO_2$ powder addition on nitrogen removal by anammox process

Sen Qiao [a,*], Zhen Bi [a], Jiti Zhou [a], Yingjun Cheng [b], Jie Zhang [c,*], Zafar Bhatti [d]

[a] Key Laboratory of Industrial Ecology and Environmental Engineering (Ministry of Education, China), School of Environmental Science and Technology, Dalian University of Technology, Dalian 116024, PR China
[b] Division of Resource Conservation and Environmental Protection, Dalian Municipal Development and Reform Commission, Dalian 116001, PR China
[c] State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin 150090, PR China
[d] Safe Drinking Water Branch, Ontario Ministry of the Environment, 2-St. Clair Ave. W, 19 Fl., Toronto, Canada ON M4V 1L5

## HIGHLIGHTS

- Nitrogen removal performance of anammox process increased with $MnO_2$ powder addition.
- The crude enzyme activity of anammox biomass with $MnO_2$ powder addition increased 78.2%.
- The T-Mn content of anammox biomass with $MnO_2$ powder increased 50-fold.
- The filament-like structure and larger particles in anammox cell of the reactor with $MnO_2$ powder were observed.

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## ABSTRACT

This study examined long-term effect of $MnO_2$ powder (average diameter of 4–7 μm) on nitrogen removal in anammox process. Two lab-scale up-flow anammox reactors were operated for 380 days, one with and one without $MnO_2$ powder addition. During the period when only substrate concentrations varied, the maximum nitrogen removal rate in the reactor with $MnO_2$ addition reached 920.9 g-N/m$^3$/d. This value was 2-folds higher than that (464.6 g-N/m$^3$/d) of the reactor without $MnO_2$ addition. The crude enzyme activities of the anammox biomass from the two reactors was measured as 0.531 ± 0.019 and 0.298 ± 0.007 μmol cytochrome *c* reduced/mg protein/min, respectively. Transmission electron microscopy observation demonstrated more undefined particles existing inside anammox bacterial cell in the reactor with $MnO_2$ powder addition. Furthermore, filament-like structures inside anammoxosome were observed, which formed a net-like structure with particles as the connecting nodes. The experiment results demonstrated that $MnO_2$ improved nitrogen removal performance of anammox process.



## 1. Introduction

Anaerobic ammonium oxidation (anammox) process is now recognized as a novel and important process in biological nitrogen removal, which can directly convert $NO_2^-$–N to $N_2$ gas with $NH_4^+$–N as the electron donor under anaerobic conditions (Strous et al., 1999). Compared with the conventional nitrification–denitrification processes, anammox process offers significant advantages such as no demand for oxygen and organic carbon, low sludge production and reduced $CO_2$ or $N_2O$ emissions (Schmid et al., 2003). The first full-scale anammox reactor (75 m$^3$) in the world was reported to treat anaerobic sludge digester liquor with average N removal rate of 750 kg-N/d (Van der Star et al., 2007). Recently, Tang et al. (2010) reported a very high nitrogen removal rate of 74.3–76.7 kg-N/m$^3$/d in a lab-scale anammox UASB reactor, in which the biomass concentration was as high as 42.0–57.7 g-VSS/L. These results suggested high potential of anammox process in biological nitrogen removal from wastewaters. However, extremely slowly growth rate of anammox bacteria with a doubling time of 11 days (Strous et al., 1999) causes the longer start-up period. Consequently, enhancing the bacterial activity of anammox bacteria or shortening the start-up period of anammox reactors is subject of great interest and challenge.

Recently, a number of exciting studies have also been published, which utilized external field energy such as magnetic field, electric field and low intensity ultrasound to increase the activity of anammox bacteria. For instance, Liu and Yang (2009) reported the maximum nitrogen removal rate of anammox biomassn increased by

* Corresponding authors. Tel./fax: +86 411 84706252 (S. Qiao), Tel./fax: 0451 86282031 (J. Zhang).
*E-mail addresses:* qscyj@mail.dlut.edu.cn (S. Qiao), 6282031@163.com (J. Zhang).

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