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The joint inhibitory effects of phenol, copper (II), oxytetracycline (OTC) and sulfide on Anammox activity

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HIGHLIGHTS

- The combination of two or three factors had varying effects on the Anammox activity.
- The joint toxicity of OTC and copper (II) on the Anammox activity was antagonistic.
- The toxicity of the combinations of OTC and S^{2-} or of phenol and S^{2-} was synergistic.
- The joint toxicity of phenol and copper (II) was dependent on the level of phenol.
- The activity inhibition can be ranked in the order: NO_2^-–N > copper (II) > OTC.

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ABSTRACT

A batch test was employed to analyze the joint toxicity of copper (II) and oxytetracycline (OTC), OTC and sulfide, phenol and sulfide (S^{2-}), phenol and copper (II), and OTC, copper (II) and substrate on an Anammox mixed culture. The joint toxicity of OTC and copper (II) on the Anammox mixed culture was antagonistic, whereas the interaction between OTC and S^{2-} and between phenol and S^{2-} was generally synergistic. The joint toxicity of phenol and copper (II) was dependent on the level of phenol: the joint toxicity was antagonistic at a high phenol level of 300 mg L^{-1}, whereas the joint toxicity was synergistic at a low phenol level of 75 mg L^{-1}. The joint toxic effect of OTC, copper (II) and NO_2^-–N on the Anammox activity can be ranked in the following order: NO_2^-–N > copper (II) > OTC.

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1. Introduction

As an innovative and promising process for biological nitrogen removal, the anaerobic ammonium oxidation (Anammox) process has enormous potential for the treatment of nitrogenous pollution in wastewater with a low level of organic carbon (Strous et al., 1999a; Jaroszynski et al., 2012; Jin et al., 2012a,b). Under anaerobic conditions, the Anammox bacteria, which are the dominant species in the Anammox system, oxidize ammonium to produce nitrogen gas using nitrite as the electron acceptor (Strous et al., 1999a). Although some full-scale Anammox processes have been established successively (van der Star et al., 2007; Gao and Tao, 2011), there are still many inhibitory factors for nitrogen-containing wastewater that hinder the widespread application of the Anammox process (Gao and Tao, 2011; Jin et al., 2012b), which need to be further studied.

The complexity of real wastewater provides challenges for the removal of nitrogen from the wastewater through the Anammox process. Phenol, copper (II), oxytetracycline (OTC) and sulfide (S^{2-}) are four pollutants that are commonly found in wastewater (Beristain-Cardoso et al., 2009, 2011; Álvarez et al., 2010). Nitrogen-rich wastewater often contains two or more of these substances, such as piggery wastewater, which contains OTC, copper (II) and S^{2-}; wastewater from the production of OTC, which is rich in OTC and S^{2-}; wastewater from coke ovens, which contains phenol and S^{2-}; and some types of petrochemical wastewaters that contain phenol and copper (II). In addition, under anaerobic conditions, SO_4^{2-} can be reduced to sulfide or H_2S (Dapena-Mora et al., 2007; Chen et al., 2008). Therefore, it is necessary to determine the combined effects of these inhibitors on the mixed culture to obtain information on the applicability of the Anammox process. Because of the toxic effects of substrates (ammonium and nitrite), many researchers have focused on the substrate inhibition on the Anammox systems and the improvement of the Anammox performance (Jin et al., 2012b).

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