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Multidimensional investigation of the damaging effects and inhibitory mechanism of oxytetracycline on aerobic denitrification bacteria

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Excessive nitrogen nutrition can seriously damage aquatic ecosystem and threaten water safety of public [1]. As a novel microbial denitrification technology, aerobic denitrification (AD) offers multiple advantages, including rapid reaction, stable pH, and space-saving [2]. However, AD is limited by the accumulation of NO_2^--N or the release of N_2O due to adverse factors [3]. Antibiotics are typical new pollutants, because of broad-spectrum antimicrobial properties, inevitably have impact on metabolic process of microorganisms. Oxytetracycline is a typical tetracycline antibiotic, and often detected in sewage treatment system. However, studies on the effect of OTC on nitrogen removal by AD bacteria have primarily focused on removal efficiency, metabolites, and antibiotic degradation, with limited research exploring mechanisms of antibiotic effects on AD metabolism based on microorganisms itselves [4,5]. In this study, the effect of OTC was comprehensively explored from multiple perspectives, the main results are as follows . From the perspective of bacterial performance, OTC had a significant effect on growth and denitrification efficiency of AD bacteria and showed a dose-dependent manner, which caused serious damage to cell morphological structure (Figure1). The LDH release further confirmed that cell membrane was damaged. From the perspective of electron behavior, OTC decreased electron-producing capacity, reduced the activity of electron transport system, inhibited electron consumption of NAR and NIR to varying degrees, thus increased the risk of nitrite accumulation. From the perspective of intracellular environment, OTC broke redox balance and antioxidant mechanism of bacteria, the related carbon and nitrogen cycle functional genes were significantly downregulated, which affected amino acid, organic acid and nucleotide metabolic of bacteria (Figure2). The above results provide important information for evaluating potential risks of antibiotics on the application of AD technology, and provide key background and theoretical support for stabilizing the process.

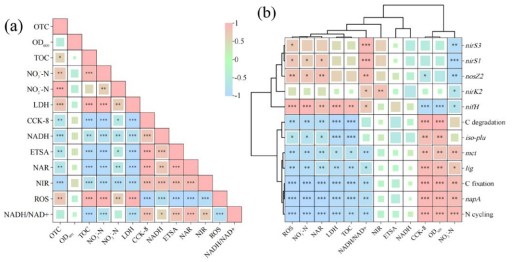


Figure1 Correlation analysis between OTC and performance indicators (a), main performance indicators and expression of functional genes (b).

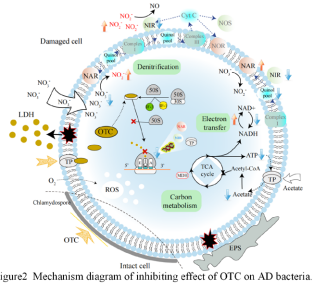


Figure2 Mechanism diagram of inhibiting effect of OTC on AD bacteria. (TP in the figure represents transfer protein.)

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