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Modeling the fate and effect of benzalkonium chlorides in a continuous-flow biological nitrogen removal system treating poultry processing wastewater

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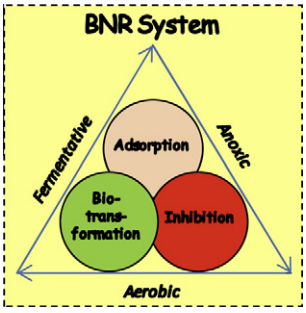
HIGHLIGHTS

- The fate and effect of BAC in a continuous-flow BNR system were simulated.
- The model considered BAC adsorption, inhibition, and resistance/biotransformation.
- BAC adsorption determines the level of its inhibitory effect.
- BAC biotransformation determines the extent of exposure of microbial communities.
- BAC inhibition is reduced/eliminated by microbial acclimation and enrichment.

GRAPHICAL ABSTRACT



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ABSTRACT

The fate and effect of the antimicrobial compounds benzalkonium chlorides (BACs) on the biological nitrogen removal (BNR) processes for a continuous-flow, three-stage laboratory-scale BNR system were modeled. Three kinetic sub-models, corresponding to each reactor, were developed and then combined in a comprehensive ASM1-based model. Kinetic parameters for the three sub-models were evaluated using experimental data obtained from independent batch assays. The biodegradation of BACs was modeled with a mixed-substrate Monod equation. The inhibitory effect of BACs on the utilization of degradable COD and denitrification was modeled as competitive inhibition, whereas non-competitive inhibition was used to model the effect of BACs on nitrification and inhibition coefficients were evaluated. The model simulated well the long-term performance of the BNR system treating a poultry processing wastewater with and without BACs. Enhanced BAC degradation by heterotrophs and increased resistance of nitrifiers to BACs, reflecting acclimation/enrichment over time, is a salient feature of the model.

1. Introduction

Sanitation practices in poultry and meat processing facilities generate wastewater which is combined with other wastewater streams and typically treated in biological nitrogen removal (BNR) systems comprised of a combination of fermentation, nitrification and denitrification processes. Quaternary ammonium compounds (QACs) are common antimicrobial compounds used extensively in industrial sanitizer formulations (Cross and Singer, 1994; Kummerer et al., 2002; Tezel and Pavlostathis, 2012). Among all classes of QACs, benzalkonium chloride homologs (BACs) of different alkyl chain lengths, mainly C_{12}, C_{14}, and C_{16}, are common in commercial sanitizer formulations (Sutterlin et al., 2008). The poor selectivity and target specificity of BACs could negatively impact

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