Heterotrophic denitrifiers growing on soluble microbial products contribute to nitrous oxide production in anammox biofilm: Model evaluation

In this work, a model framework was constructed to assess and predict nitrous oxide (N\textsubscript{2}O) production, substrate and microbe interactions in an anammox biofilm bioreactor. The anammox kinetics were extended by including kinetics of autotrophic soluble microbial products (SMP) formation, which consisted of utilization-associated products (UAP) and biomass-associated products (BAP). Heterotrophic bacteria growing on UAP, BAP and decay released substance (SS) were modelled to perform four-step sequential reductions from nitrate to dinitrogen gas. N\textsubscript{2}O was modelled as an intermediate of heterotrophic denitrification via three pathways with UAP, BAP and SS as the electron donors. The developed model framework was evaluated using long-term operational data from an anammox biofilm reactor and satisfactorily reproduced effluent nitrogen and SMP as well as N\textsubscript{2}O emission factors under different operational conditions. The modeling results revealed that N\textsubscript{2}O was mainly produced with UAP as the electron donor while BAP and SS play minor roles. Heterotrophic denitrifiers growing on UAP would significantly contribute to N\textsubscript{2}O emission from anammox biofilm reactor even though heterotrophs only account for a relatively small fraction of active biomass in the anammox biofilm. Comprehensive simulations were conducted to investigate the effects of N loading rate and biofilm thickness, which indicated that maintaining a low N loading rate and a thick biofilm thickness were essential for high total nitrogen removal efficiency and low N\textsubscript{2}O emission.

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