Successful year-round mainstream partial nitritation anammox: Assessment of effluent quality, performance and N2O emissions

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For two decades now, partial nitritation anammox (PNA) systems were suggested to more efficiently remove nitrogen (N) from mainstream municipal wastewater. Yet to date, only a few pilot-scale systems and even fewer full-scale implementations of this technology have been described. Process instability continues to restrict the broad application of PNA. Especially problematic are insufficient anammox biomass retention, the growth of undesired aerobic nitrite-oxidizers, and nitrous oxide (N2O) emissions. In this study, a two-stage mainstream pilot-scale PNA system, consisting of three reactors (carbon pretreatment, nitritation, anammox - 8 m3 each), was operated over a year, treating municipal wastewater. The aim was to test whether both, robust autotrophic N removal and high effluent quality, can be achieved throughout the year. A second aim was to better understand rate limiting processes, potentially affecting the overall performance of PNA systems. In this pilot study, excellent effluent quality, in terms of inorganic nitrogen, was accomplished (average effluent concentrations: 0.4 mgNH4- N/L, 0.1 mgNO2-N/L, 0.9 mgNO3-N/L) even at wastewater temperatures previously considered problematic (as low as 8 æC). N removal was limited by nitritation rates (84 ś 43 mgNH4-N/L/d), while surplus anammox activity was observed at all times (178 ś 43 mgN/L/d). Throughout the study, nitrite-oxidation was maintained at a low level (<2.5% of ammonium consumption rate). Unfortunately, high N2O emissions from the nitritation stage (1.2% of total nitrogen in the influent) were observed, and, based on natural isotope abundance measurements, could be attributed to heterotrophic denitrification. In situ batch experiments were conducted to identify the role of dissolved oxygen (DO) and organic substrate availability in N2O emission-mitigation. The addition of organic substrate, to promote complete denitrification, was not successful in decreasing N2O emission, but increasing the DO from 0.3 to 2.9 mgO2/L decreased N2O emissions by a factor of 3.4.
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