

Developing Granular Sludge and Maintaining High Nitrite Accumulation for Anammox to Treat Municipal Wastewater High-efficiently in a Flexible Two-stage Process

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Abstract : Nowadays, conventional nitrogen removal process (nitrification and denitrification) was adopted in most wastewater treatment plants, but many problems have occurred, such as: high aeration energy consumption, extra carbon sources dosage and high sludge treatment costs. The emergence of anammox has brought about the great revolution to the nitrogen removal technology, and only the ammonia and nitrite were required to remove nitrogen autotrophically, no demand for aeration and sludge treatment. However, there existed many challenges in anammox applications: difficulty of biomass retention, insufficiency of nitrite substrate, damage from complex organic etc. Much effort was put into the research in overcoming the above challenges, and the payment was rewarded. It was also imperative to establish an innovative process that can settle the above problems synchronously, after all any obstacle above mentioned can cause the collapse of anammox system. Therefore, in this study, a two-stage process was established that the sequencing batch reactor (SBR) and upflow anaerobic sludge blanket (UASB) were used in the pre-stage and post-stage, respectively. The domestic wastewater entered into the SBR first and went through anaerobic/aerobic/anoxic (An/O/A) mode, and the draining at the aerobic end of SBR was mixed with domestic wastewater, the mixture then entering to the UASB. In the long term, organic and nitrogen removal performance was evaluated. All along the operation, most COD was removed in pre-stage (COD removal efficiency > 64.1%), including some macromolecular organic matter, like: tryptophan, tyrosinase and fulvic acid, which could weaken the damage of organic matter to anammox. And the An/O/A operating mode of SBR was beneficial to the achievement and maintenance of partial nitrification (PN). Hence, sufficient and steady nitrite supply was another favorable condition to anammox enhancement. Besides, the flexible mixing ratio helped to gain a substrate ratio appropriate to anammox (1.32-1.46), which further enhance the anammox. Further, the UASB was used and gas recirculation strategy was adopted in the post-stage, aiming to achieve granulation by the selection pressure. As expected, the granules formed rapidly during 38 days, which increased from 153.3 to 354.3 μm . Based on bioactivity and gene measurement, the anammox metabolism and abundance level rose evidently, by 2.35 mgN/gVss \cdot h and 5.3 $\times 10^9$. The anammox bacteria mainly distributed in the large granules (>1000 μm), while the biomass in the flocs (<200 μm) and microgranules (200-500 μm) barely displayed anammox bioactivity. Enhanced anammox promoted the advanced autotrophic nitrogen removal, which increased from 71.9% to 93.4%, even when the temperature was only 12.9 $^{\circ}\text{C}$. Therefore, it was feasible to enhance anammox in the multiple favorable conditions created, and the strategy extended the application of anammox to the full-scale mainstream, enhanced the understanding of anammox in the aspects of culturing conditions.

Keywords : anammox, granules, nitrite accumulation, nitrogen removal efficiency

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