Effects of step-feed on granulation processes and nitrogen removal performances of partial nitrifying granules

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HIGHLIGHTS

- PNG was successfully cultivated under step-feed mode.
- Step-feed delayed the granulation processes of PNG.
- PNG cultivated in both reactors with or without step-feed had similar properties.
- Step-feed enhanced denitrification and TN removal, as well as ammonia oxidation.

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ABSTRACT

Two anoxic/oxic sequencing batch reactors (A/O SBRs) were operated to investigate the effects of step-feed on granulation processes and performances of partial nitrifying granules (PNG). R1 was operated in a traditional single-feed mode, while a two-step-feed strategy was used in R2. Results showed that R1 had a faster granulation process and better performance in maintaining partial nitrification compared with R2, indicating that the step-feed mode had a negative effect of on formation of PNG. However, after full granulation, PNG in both reactors had similar properties in terms of suspended solids (MLSS), sludge volume index (SVI) and granule size. Moreover, mature granules in R2 had a higher nitrite accumulation rate than that in R1. Step-feed strategy was also observed to enhance denitrification and TN removal, as well as ammonia oxidation. It can be concluded that step-feed was unfavorable for cultivating PNG, but it significantly improved the nitrogen removal performance of PNG.

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1. Introduction

Partial nitrifying activated sludge (PNAS) processes have attracted the most attention in recent years, owing to their advantages with respect to conventional nitrate pathway: reduce the energy consumption for aeration and organic carbon requirement for denitrification (Peng and Zhu, 2006; Ruiz et al., 2003). Several factors have been identified to selectively inhibit or washout nitrite oxidizing bacteria (NOB) over ammonia oxidizing bacteria (AOB), mainly including dissolved oxygen (DO), temperature, sludge retention time (SRT), free ammonia (FA) and free nitrous acid (FNA) (Peng and Zhu, 2006; Ruiz et al., 2003). DO is one of the main factors inhibiting NOB, but long-term operation at low DO would result in low nitritation rate, sludge bulking or the increasing N₂O production (Chuang et al., 2007; Zeng et al., 2009). In addition, the capacity of partial nitrification is limited due to lower biomass concentration in activated sludge (AS) systems without effective biomass retention (Jubany et al., 2009; Mosquera-Corral et al., 2005b).

Granules based systems have been proposed as a suitable alternative to obtain stable and robust partial nitrification (Gao et al., 2011; Lopez-Palau et al., 2011; Vázquez-Padín et al., 2010). Partial nitrifying granules (PNG) present high cell density and much faster settling velocities than AS, thus ensuring higher biomass concentration and specific activities and consequent higher maximum load (Bartroli et al., 2010; Gao et al., 2011; Lopez-Palau et al., 2011). Moreover, DO diffusion limitation within granules allow operating reactors reaching stable partial nitrification without strict DO and temperature controls (Shi et al., 2011; Vázquez-Padín et al., 2010).

Granules also have special layered microbial structure with more denitrifying bacteria existed inside the granules, giving them a great potential for better denitrification (Mosquera-Corral et al., 2005a; Tay et al., 2002). However, during PNG processes, denitrifi-