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Effect of ammonia oxidizing bacteria (AOB) kinetics on bioaugmentation

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HIGHLIGHTS

- ▶ Bioaugmentation with ammonium oxidizing bacteria was tested at bench scale.
- ▶ Nitritation was improved in the seeded reactors.
- ▶ The effectiveness of seeding varied with SRT and substrate concentrations.
- ▶ Conventional activated sludge models overestimated the effect of bioaugmentation.
- ▶ The affinity for ammonia of seeded AOB affected bioaugmentation efficiency.

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ABSTRACT

Bioaugmentation with ammonium oxidizing bacteria (AOB) was tested for 620 d. A seeding reactor (R1), two seeded reactors (R2 at 21 °C; R3 at 15 °C) and an unseeded-control reactor (R4 at 21 °C) were operated in parallel (2.4 < SRT < 4 d). The effect of seeding on nitritation efficiency was found to be dependent on solids retention time (SRT), influent ammonia concentration to the seeded reactors and the temperature difference between the seeding and seeded reactors.

Mathematical modeling and batch tests were used to characterize the AOB selected in R1 and the effect of the seeding on AOB kinetics in R2 and R3. The AOB kinetics of R2 and R3 reflected the kinetics of R1 but differed from those in R4. This behavior affected the efficiency of bioaugmentation to varying degrees in the reactors and required a specific approach to represent the experimental results through mathematical modeling.

1. Introduction

Achieving nitrification by means of bioaugmentation involves the enrichment of the recycled activated sludge (RAS) stream with nitrifiers from an outside source. When compared to the conventional approach used in activated sludge biological nutrient removal (BNR) systems to achieve stable and reliable nitrification, bioaugmentation with nitrifier seed from a supplemental source allows the main stream BNR process to operate at a reduced solids retention time (SRT) and reduce the size of the aerobic reactor (Krhutkova et al., 2006). As such, bioaugmentation provides an opportunity for designers to take advantage of the lower SRT and reduce the size of the aerobic reactors required to achieve nitrification in the main process stream. Bioaugmentation can also be used to provide a higher degree of robustness (Parker and Wanner, 2007) to the overall nitrification process, as well as a method for rapid recovery should some transient event negatively impact the nitrification process (Yusof et al., 2010).

Bioaugmentation with nitrifiers has been proven effective in reducing the SRT necessary to meet nitrification in cold temperatures (Head and Oleszkiewicz, 2004; Berends et al., 2005; Krhutkova et al., 2006; Wanner et al., 2009). Seeding with nitrifiers was shown to be effective through bench, pilot and full-scale tests in reducing the start-up time and improving the stability of the nitrification process (Bartrolí et al., 2011; Guo et al., 2010a). Abbreviated start-up times, and correspondingly fast recovery after a partial washout, can reduce the risk of losing nitrification when operating at a low SRT (Satoh et al., 2003). An additional benefit of reducing the SRT is the improvement in the quality of sludge sent to further biological processing such as anaerobic digestion.

An accurate quantification of the beneficial effects of bioaugmentation is still elusive and some phenomena assessments need to be included in the overall evaluation. In some cases bioaugmentation was successfully modeled using conventional IWA activated sludge models (Salem et al., 2002, 2003). However, some phenomena are

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