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Closed-loop control of ammonium concentration in nitritation: Convenient for reactor operation but also for modeling

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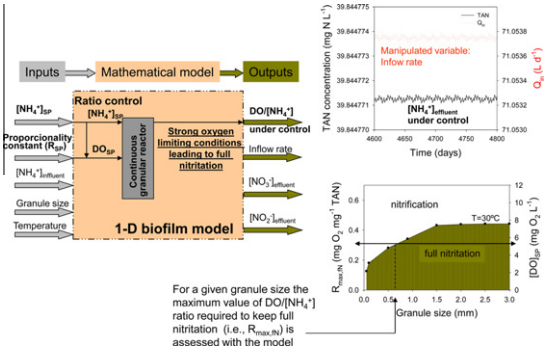
HIGHLIGHTS

- Nitritation with granular reactor under ratio control was described mathematically.
- Closed-loop control of ammonium concentration enhance stability of full nitritation.
- Granules size larger than 1 mm enhances full nitritation.
- Full nitritation with granular reactors is feasible at low temperatures.

GRAPHICAL ABSTRACT



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ABSTRACT

A mathematical biofilm model was developed to describe nitritation in aerobic granular reactor operating in continuous mode. The model includes the automatic closed-loop control of ammonium concentration in the effluent. This is integrated in a ratio control strategy to maintain the proportion between the dissolved oxygen (DO) and the total ammonia nitrogen (TAN) concentrations in the reactor effluent at a desired value. The model was validated with a large set of experimental results previously reported in the literature. The model was used to study the effect of DO and TAN setpoints on the achievement of full nitritation, as well as to establish the appropriate required range of the DO/TAN concentration ratio to be applied. Nitritation at 20 °C was tested experimentally and simulated with the model. Additionally, the importance of controlling the TAN concentration was highlighted with different scenarios, in which periodic disturbances were applied mimicking a poor control situation.

1. Introduction

Nitritation is a key process for the correct performance of the biological nitrogen removal via nitrite. When a separate reactor is devoted to nitritation, ammonium concentration in the reactor is of fundamental importance. Ammonium concentration in the reactor affects the conversion of the nitritation reactor because it may provide either ammonium or oxygen limiting conditions (Harremöes, 1978; Çeçen and Gönenç, 1995; Jianlong and Ning, 2004; Bernet et al., 2005; Pérez et al., 2005; Sliekers et al., 2005; Bougard et al., 2006; Guo et al., 2009; Bartrolí et al., 2010, 2011; Brockmann and Morgenroth, 2010; among many others). A second aspect to take into account is the potential inhibition of ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB) by free ammonia (FA). Moreover, the following treatment step for complete nitrogen removal via denitrification or anaerobic ammonium oxidation will also benefit from a constant and suitable ammonium concentration in the effluent of the nitritation reactor. What to do to maintain a constant ammonium concentration in

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