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Advanced nitrogen and phosphorus removal in the pre-denitrification anaerobic/anoxic/aerobic nitrification sequence batch reactor (pre-A_2NSBR) treating low carbon/nitrogen (C/N) wastewater

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HIGHLIGHTS

- Solved the bottleneck of high ammonia residues in the conventional A_2NSBR process.
- Achieved advanced nitrogen and phosphorus removal with low C/N domestic wastewater.
- ORP, pH and DO were demonstrated closely related with the nutrient removal.
- DPAOs was enriched with a high denitrifying phosphorus removal efficiency of 96.86%.

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ABSTRACT

In order to treat domestic wastewater with high ammonia but low carbon source (low C/N ratio), a novel two sludge pre-A_2NSBR system (anaerobic/anoxic/aerobic nitrification) was firstly developed by exchanging the sequence of aerobic nitrification and anoxic phase of the conventional A_2NSBR process (anaerobic/aerobic nitrification/anoxic). The system was operated for 186 days to treat real domestic wastewater with low carbon/nitrogen (C/N = 4.03). Anoxic duration was adjusted and post-aeration phase was added to enhance nitrogen and phosphorus removal. Results indicate that adding post-aeration phase is indispensable to achieve enhanced phosphorus removal, the pre-A_2NSBR system achieved a high denitrifying phosphorus removal efficiency of 96.86% with efficient utilization of limited carbon source. Specifically, the ammonia effluent was 0.46 mg/L, which solved the bottleneck problem of high ammonia residues in conventional A_2NSBR process. The fluorescence in situ hybridization (FISH) results showed that PAOs was enriched and GAOs was inhibited in the A_2SBR, nitrifiers also became dominant in the N-SBR. Moreover, the profiles variation of real-time online indicator such as pH, ORP and DO were demonstrated closely related with the nutrient removal performance, and based on this, it is possible or expected to establish the real time control strategy in the future.

1. Introduction

Denitrifying phosphorus removal technology has attracted much attention recently, which is developed based on the DPAOs (denitrifying phosphate accumulating organisms) who are capable of storing poly-beta-hydroxy-alkanoates (PHA) using the energy released by the hydrolysis of the poly-phosphate anaerobically, at the same time phosphate was released into the wastewaters, in the subsequent anoxic phase, nitrate was used as electron acceptors instead of oxygen for phosphate uptake [1–3]. Because denitrification and phosphorus removal was performed simultaneously in the same anoxic environment, 50% chemical oxygen demand (COD) and 30% energy requirement is saved, 50% sludge production is reduced [4], which showed advantages compared with conventional activated sludge process in treating domestic wastewater with low C/N ratio [5] (carbon/nitrogen).

Many processes were proposed and achieved excellent nutrient performance based on the abovementioned denitrifying phosphorus removal technology. According to whether nitrifiers and DPAOs could coexist in the same environment, these processes are divided into single sludge system such as UCT [6], SFBNR [6,7] and

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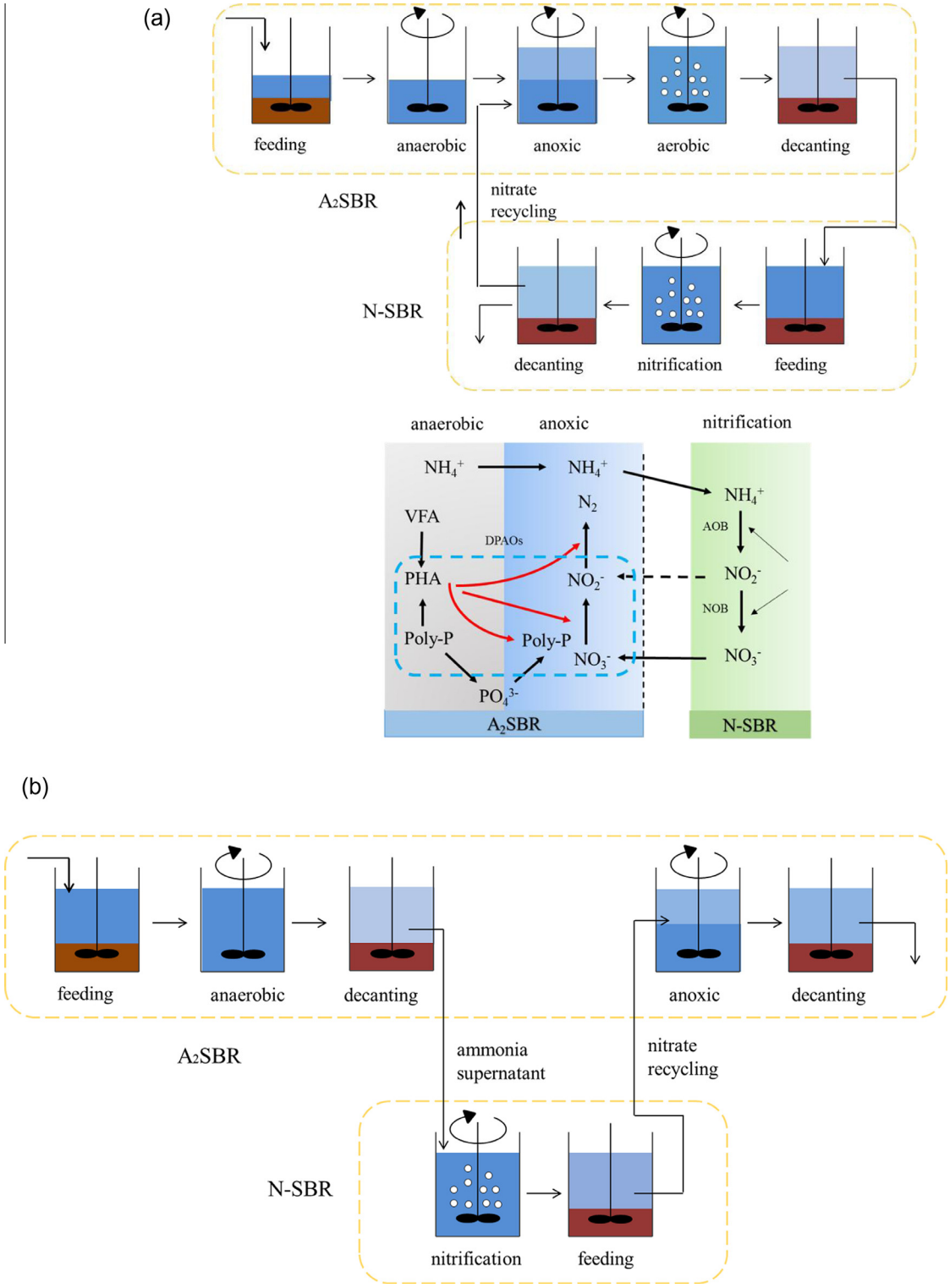

Fig. 1. (a) Operational mode and schematic diagram of the pre-A_2NSBR (anaerobic/anoxic/aerobic nitrification) process: (b) operational mode and schematic diagram of the conventional post-A_2NSBR (anaerobic/aerobic nitrification/anoxic) process.

$(AO)_2$SBR [8], or two sludge system such as A_2N (also named DEPHANOX) [9] and A_2NSBR [10]. In the two sludge systems, nitrifiers and DPAOs are separated completely in two reactors to achieve nitrification and denitrifying phosphorus removal, respectively [11]. Previous research has confirmed that two sludge system is more optimal in accumulating DPAOs and nitrifiers as well as achieving good performance for nitrogen and phosphorus removal, it successfully solved the SRT contradiction that a long SRT is required for good nitrification performance, however for a bio-P removal a higher sludge production or a short SRT is more advantageous [12,13].

However, the conventional two sludge system such as A_2NSBR and A_2N (also named DEPHANOX) process belong to the post-denitrification process [14], which are operated as anaerobic/aero-