Evaluating Step-feed for Enhanced Biological Phosphorus Removal (EBPR) in Tropical climate

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Abstract
Many studies indicate that the employment of the enhanced biological phosphorus removal (EBPR) in tropical climate is challenging. Glycogen-accumulating organisms (GAOs) were found to gain dominance over polyphosphate accumulating organisms (PAOs) when the temperature increased from 20 °C to 30 °C (Lopez-Vazquez, Hooijmans et al. 2009). However, a few successful EBPR processes operated at high temperature shed some light on the feasibilities (Ong, Chua et al. 2014).
Recently, stable EBPR performance was found in a full-scale water reclamation plant (WRP) located in Singapore with an average temperature of 28~30°C (unpublished). The WRP adopts a step-feed activated sludge process treating municipal wastewater, in which the influent is equally distributed into the anoxic zones of five basins. This study investigates P-removal performance and microbial communities in two step-feeding sequencing batch reactor (SBR) systems fed with different carbon sources and aims to have a deeper understanding on the impact of feeding strategy in tropical climate.
The two SBRs had a working volume of 6 L and were operated with a cycle time of 6 h consisting of 3 loops of 2 minutes feeding, 30 minutes anaerobic phase and 75 minutes aerobic phase, as well as 4 minutes sludge discharge, 25 minutes settling, and 10 minutes effluent discharge. In each cycle, 3 liters of synthetic wastewater were evenly distributed into the 3 loops. The process was controlled at a hydraulic retention time (HRT) of 12 h and solids retention time (SRT) of 10 days. Dissolved oxygen (DO) in the aerobic phase was controlled between 2~3 mg/L. Operating temperature was maintained at 30~31 °C. pH was controlled between 7.2 and 8.0 throughout the study. COD and $P\text{-}PO_4$ concentrations were 400~420 mg COD/L and 20~22 mg $P\text{-}PO_4$/L respectively in the feed. Carbon sources for the two SBR were acetate and propionate respectively.
P removal efficiency reached 98% with acetate (A-SBR) and 95% with propionate (P-SBR) as carbon source after 80 days operation (Fig. 1). Cyclic study indicated that both of acetate and propionate were consumed completely within 10 min in each loop of the anaerobic phase. At the mean time, PHAs (mainly PHB in A-SBR and PHV in P-SBR) were synthesized. At 80th day, the P-release/C-uptake ratio were 0.89, 0.71, and 0.64 mol P/C-mol at the end of anaerobic phase within each loop in A-SBR, while the ratios were 0.74, 0.65, and 0.65 mol P/C-mol in P-SBR. The P-uptake/P-release ratios were 1.067, 1.084, and 1.084 mol/mol in each loop of A-SBR, while the ratios in P-SBR were 1.029, 1.236, and 1.138 mol/mol. These results indicated that lower COD could enhance P removal performance. Microbial populations in the reactors were identified with fluorescence in situ hybridization (FISH) using PAOmix probe, GAOmix probe, and Eub338mix. The FISH images indicated that PAOs population dominated (about 70%) in the microflora and only a few GAOs (less than 5%) were detected in both reactors (Fig. 2).

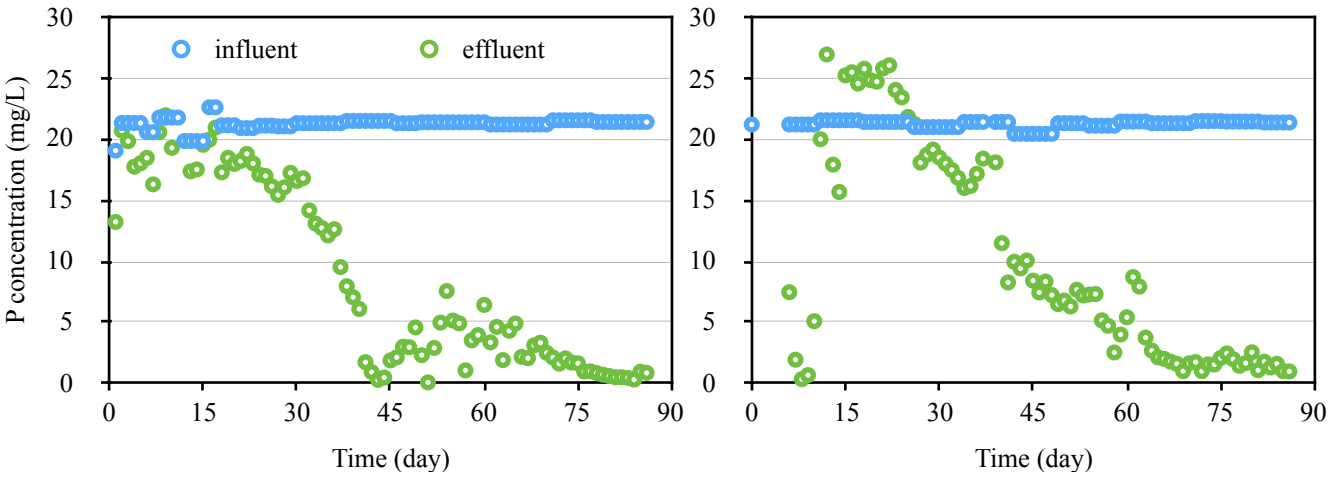

Fig. 1 Phosphorus concentrations in the influent and effluent of two SBRs with the different carbon source: acetate (left) and propionate (right).

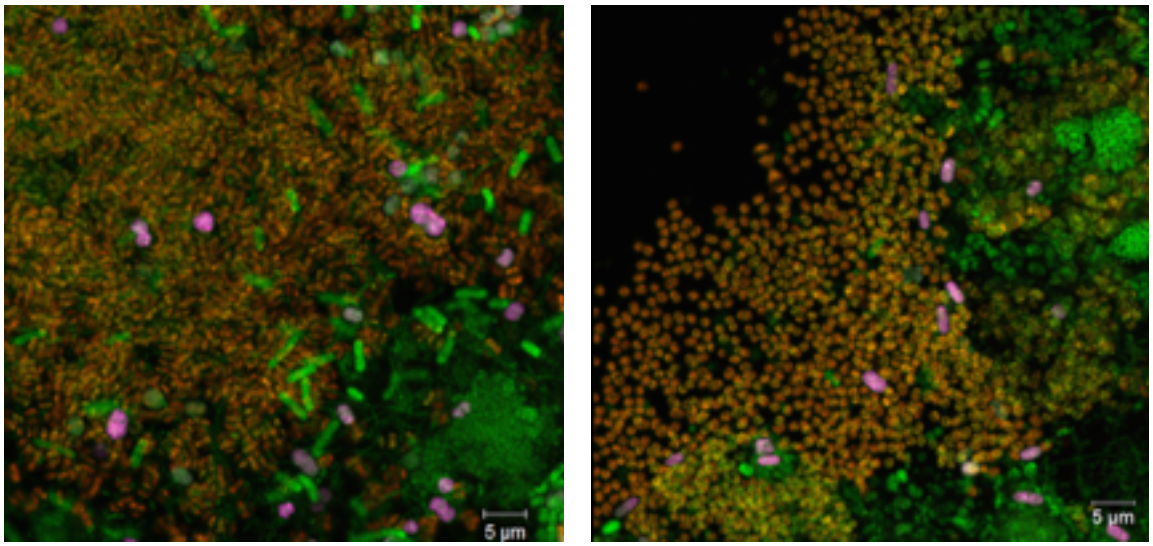

Fig. 2 Representative FISH image from SBR sludge fed with acetate (left) and propionate (right) hybridized with PAOmix (yellow), GAOmix (pink) and EUB338mix (green).

Therefore, we have reason to believe that step-feed process, which resulting in lower COD concentration and load ratio, should be an important contributing factor for high temperature EBPR. This study would be contributed for the EBPR running in tropical climates. However, long-term performance of the high temperature EBPR should be evaluated.

Keywords
Enhanced Biological Phosphorus Removal; High temperature; Tropical climate; Step-feed; Lower COD

References:

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