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The effect of free nitrous acid on key anaerobic processes in enhanced biological phosphorus removal systems

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HIGHLIGHTS

- FNA has a detrimental effect on the anaerobic metabolism of both PAOs and GAOs.
- FNA has a stronger adverse effect on acetate uptake by PAOs than by GAOs.
- FNA causes faster depletion of the anaerobic energy pool of PAO than that of GAOs.
- FNA may potentially provide a competitive advantage to GAOs over PAOs.

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ABSTRACT

In this study, the effect of nitrite/FNA on the anaerobic metabolism of polyphosphate accumulating organisms (PAOs) and glycogen accumulating organisms (GAOs) is investigated. The results clearly show that FNA has a detrimental effect on the acetate uptake rate by both PAOs and GAOs, but this adverse effect is much stronger on PAOs than on GAOs. Also, when FNA was increased, phosphate release to acetate uptake ratio by PAOs increased substantially (250–300% compared to control), which was accompanied by decreases (40–60%) in glycogen degradation and PHA production to VFA uptake. In contrast, these ratios for GAOs remained constant or increased slightly towards the highest FNA concentration applied. These results indicate that the anaerobic metabolism of PAOs is more adversely affected than that of GAOs when FNA is present. This might provide a competitive advantage to GAOs over PAOs in enhanced biological phosphorus removal systems when nitrite is present.

1. Introduction

Removal of phosphorus from wastewater is necessary for avoiding eutrophication. Enhanced biological phosphorus removal (EBPR) is widely accepted as one of the most economical and sustainable processes to remove phosphorus from wastewater for its low operation costs and low sludge production compared to chemical phosphorus removal. The micoorganisms responsible for EBPR processes are known to be polyphosphate accumulating organisms (PAOs). They can take up carbon sources, primarily volatile fatty acids (VFAs), in the anaerobic phase and store them in the form of poly-hydroxy-alkanoates (PHAs). PAOs gain energy primarily from the degradation of their intracellular polyphosphate (Poly-P), which is released to the bulk liquid as orthophosphate. In the subsequent anoxic or aerobic phase, PAOs grow and take up orthophosphate to recover their Poly-P levels by using the stored PHA as the carbon and energy sources. Phosphorus removal is achieved by withdrawing excess sludge at the end of the aerobic phase, when PAO cells contain high levels of Poly-P. As a competitor to PAOs, glycogen accumulating organisms (GAOs) can also be developed under alternating anaerobic and aerobic conditions in EBPR systems. However, the GAO metabolism does not involve anaerobic P release and subsequent aerobic (or anoxic) P-uptake. Anaerobically, the energy for GAOs is primarily generated by the degradation of their intracellular glycogen pools. Under the subsequent aerobic or anoxic conditions, GAOs oxidize PHA for cell growth and glycogen replenishment without P-uptake (Liu et al., 1994). Therefore, GAOs are able to compete with PAOs for the same carbon source, which may lead to EBPR deterioration. However, the PAO–GAO competition in an EBPR system is not fully understood at present, and indeed many factors may play a role (Oehmen et al., 2007).

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