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Effect of long-term starvation conditions on polyphosphate- and glycogen-accumulating organisms

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HIGHLIGHTS

- ▶ PAOs and GAOs can survive long-term starvation conditions.
- ▶ PAOs are more affected than GAOs during the first days of starvation.
- ▶ Loss of activity instead of cell death is responsible for activity decrease.
- ▶ Both groups can recover their activities after wastewater reintroduction.

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ABSTRACT

Endogenous processes such as biomass decay and intracellular polymers degradation of polyphosphate-accumulating organisms (PAOs) and glycogen-accumulating organisms (GAOs) were investigated. Cultures enriched in *Accumulibacter* (a well known PAO) or *Competibacter* (a well known GAO) were subjected to 21 and 26 days of alternating anaerobic/aerobic conditions respectively. The main energy source for PAOs during starvation was their intracellular polyphosphate released into the medium during the first 14 days of starvation. In contrast, GAOs used their intracellular glycogen during the 26 days of starvation. Biomass decay rates were 0.029 d^{-1} for PAOs and almost negligible for GAOs. The reduction in acetate uptake rate during the starvation period, referred to as activity decay, was 0.25 and 0.047 d^{-1} for PAOs and GAOs, respectively. Once wastewater was reintroduced, both populations recovered their initial substrate uptake rate after 1 day. The results obtained show that PAOs are more affected than GAOs by starvation conditions.

1. Introduction

Wastewater load fluctuations are common in domestic wastewater treatment plants (WWTPs) and industrial installations where large fluctuations of wastewater flow linked to industrial activity occur (Metcalf and Eddy, 1978). These fluctuations have a direct effect on bacterial growth and metabolism as bacteria have to withstand long periods of famine conditions that affect the levels of intracellular storage compounds in the biomass. This aspect is especially important in enhanced biological phosphorus removal processes (EBPR) where the metabolism of polyphosphate-accumulating organisms (PAOs) and glycogen- accumulating organisms (GAOs) relies on these compounds. EBPR is achieved by recycling PAOs through anaerobic and aerobic conditions. PAOs take up volatile fatty acids (VFAs) under anaerobic conditions and store polyhydroxyalkanoates (PHA). The energy required for this process is obtained from the hydrolysis of polyphosphate (polyP) and also from the degradation of intracellular glycogen which also provides reducing power (Mino et al., 1987; Smolders et al., 1994). The phosphate concentration in the medium increases during this anaerobic phase. In the following aerobic period, the stored PHA is oxidized and the energy obtained in this process is used for uptake of P from the medium, replenishment of the glycogen pool and bacterial growth.

PAOs often coexist with GAOs which are also able to store carbon sources anaerobically but without any P release and subsequent uptake (Liu et al., 1996). GAOs take up VFAs under anaerobic conditions and store them as PHAs. They obtain all the energy necessary for this process from glycogen degradation. Under aerobic conditions, GAOs oxidize PHA for cell growth and glycogen replenishment. Therefore, GAOs can survive and grow in EBPR systems and directly compete with PAOs for carbon

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