ADVANCING A NOVEL PROCESS FOR POST-ANOXIC DENITRIFICATION

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INTRODUCTION

Reclaimed water standards are becoming increasingly stringent, pushing wastewater treatment facilities (WWTFs) to expand. For total nitrogen removal, WWTFs must integrate internal flow recycling and increase bioreactor volumes. With regard to phosphorus removal, WWTFs must incorporate chemical treatment systems, which significantly increase capital and operational costs as well as the sludge production. With current treatment approaches, the benefit of improved effluent quality is offset by increased energy usage, increased operational costs, and decreased operational flexibility; this arguably adds cost both to the environment and to the taxpayer. In our view, for a truly sustainable society, water reclamation and reuse objectives should be centered on efficient quality in relation to energy consumption, facility footprint, capital and operational costs, and process control and flexibility.

STUDY OBJECTIVES

1) Assess the effectiveness of the proposed post-anoxic denitrification with EBPR process
2) Identify the carbon source driving denitrification
3) Assess specific denitrification rates (SDNRs) under variable operating conditions
4) Determine the importance of EBPR and VFA augmentation
5) Evaluate the stability of the processes in terms of phosphorus removal and nitrate removal under variable loading conditions
6) Investigate operational changes that optimize the process
7) Characterize the bacterial population for Phosphorus Accumulating Organisms (PAOs) and Glycogen Accumulating Organisms (GAOs)

PROPOSED PROCESS

Post-Anoxic Denitrification associated with EBPR:

The proposed process would operate similar to conventional post-anoxic denitrification, but without carbon addition. Instead, the process makes use of Enhanced Biological Phosphorus Removal (EBPR) carbon reserves to efficiently remove phosphorus, ammonia, and nitrate from the wastewater.

ADVANTAGES OF POST-ANOXIC EBPR

- Eliminates need for internal recycle flows
- Reduces facility footprint
- Eliminates need for anoxic carbon addition
- Achieves high Phosphorus and Nitrogen removal efficiencies
- High operational flexibility and Control
- Readily retrofitted to existing SBR facilities

RESULTS

1. Effectiveness of Post-Denitrification with EBPR

2. Carbon Source Driving Post-Anoxic Denitrification

3. Importance of VFA and EBPR

4. Effects of Excess VFA augmentation

5. Towards Process Optimization

CONCLUSIONS

- Post-anoxic denitrification can accomplish near-complete soluble inorganic N and P removal (>99%). Process success is enhanced at elevated aeration rates, but significant removal can be achieved at reduced aeration.
- Intracellular glycogen, synthesized associated with EBPR, is an important carbon source used by the mixed microbial consortium to achieve denitrification. A positive correlation between the SDNR and intracellular glycogen concentration was observed.
- Furthermore, glycogen oxidation for denitrification does not compromise subsequent anaerobic VFA uptake and PHA storage, which is critical to EBPR.
- A mixed VFA substrate (HAc, HPr, HBu, and HVa) appears to be more beneficial to process performance than single substrate feeds to the reactors.
- Post-anoxic secondary P release can occur with NOx depletion. However, P release was only observed when SOT was prevented, and the rate of release was such that P release was only moderately increased.
- The proposed process configuration is potentially sensitive to low influent ammonia (~20 mg/L), but stable performance can be maintained by minimizing SOT.
- All tested reactor configurations achieved significant P removal despite variability over time in the relative PAO fraction, and also showing a relatively significant GAO population.

The post-anoxic biological nutrient removal process represents a potentially sustainable wastewater treatment process: high nutrient removal efficiencies coupled with a small facility footprint, no recycle flows, and no post-anoxic carbon supplementation translate to lower energy requirements and better effluent quality. In addition to reducing energy consumption and operating costs, current EBPR facilities can be readily retrofitted with the proposed process and therefore significantly reduce capital costs associated with a typical process upgrade.