An Innovative Activated Sludge System for Enhanced Nutrient Recovery via Downstream Cultivation of Green Microalgae

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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):
1. INTRODUCTION

Current resource recovery strategies [1]:
- Metal salt addition for phosphorus precipitation
- Ammonia stripping and recovery as salt
- Ultrafiltration
- Reverse osmosis

Resource recovery through two-stages bacterial-algal system [2]:
- Enhanced biological phosphorus removal and recovery system (EBP2R) to produce growth media with targeted N-to-P ratios.
- Optimal algal cultivation, thereby intracellularly storing both N and P.
- Direct application on land for fertigation

2. OBJECTIVES

The goals of this study are to:
1) provide the model-based design of the EBP2R system
2) optimize the nutrient recovery capacity
3) analyze the sensitivity of the nutrient recovery performance with regard to the influent wastewater quality and biological processes through global sensitivity analysis (GSA)

3. METHODS

- System description:
  - P-stream: phosphorus rich stream diverted form the anaerobic tanks
  - N-stream: ammonia rich stream obtained by keeping a comparably low aerobic SRT
  - Co-stream: wastage of the sludge to the anaerobic digester
  - System is modeled using the activated sludge model 2d (ASM-2d) [3]
  - GSA: Morris screening [4]
  - Estimates the distribution of the elementary effects (EE) of each input parameter to the model output
  - Ranking is established based on the mean of the absolute values of EE (μ*)

4. RESULTS

Exploring the system behavior:
A. Increase in P-recovery up to a maximum load as function of the Qp
B. Maximum P-recovery corresponds to the onset of PAOs wash-out
C. PAOs are washed-out due to the nitifier activity
D. Nitifiers grow at high P-stream flows because the aerobic SRT increases due to solids up-concentration in the aerobic reactor

5. CONCLUSIONS

- Phosphorus recovery by the EBP2R is controlled by 3 different factors: system SRT, phosphorus availability in the aerobic reactor and nitrate recycling to the anaerobic tanks. The optimal operation conditions through scenario simulations are an SRT of 5 days and Qp of 0.3 Qin. This results in 70% of the influent P recovered.
- The EBP2R can be used to construct different N-to-P effluent ratios. Using a typical municipal influent wastewater, the constructed effluent quality can be optimized in terms of nutrient balance for different green micro-algae, such as Scenedesmus dimorphus or Haematococcus pluvialis.
- GSA show that after optimization of the EBP2R, the variability of the P recovery and the effluent N-to-P ratio in the EBP2R primarily depends on the influent wastewater quality rather than on the kinetics or stoichiometry of the biological processes in the EBP2R system.

References:

Acknowledgement:
- The research was financially supported by the Danish Council for Strategic Research, as part of the Integrated Water Technology (InWaTech) project; a collaboration between the Technical University of Denmark (DTU) and the Korea Advanced Institute of Science and Technology (KAIST).
- The authors wish to thank Dr. Xavier Floress-Alama (PROCESS CAPER, Technical University of Denmark) for providing the AMMON Matlab code used to carry out this study.

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