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1. INTRODUCTION

Current resource recovery strategies [1]:

- Metal salt addition for phosphorus precipitation
- Ultrafiltration

Disadvantages:

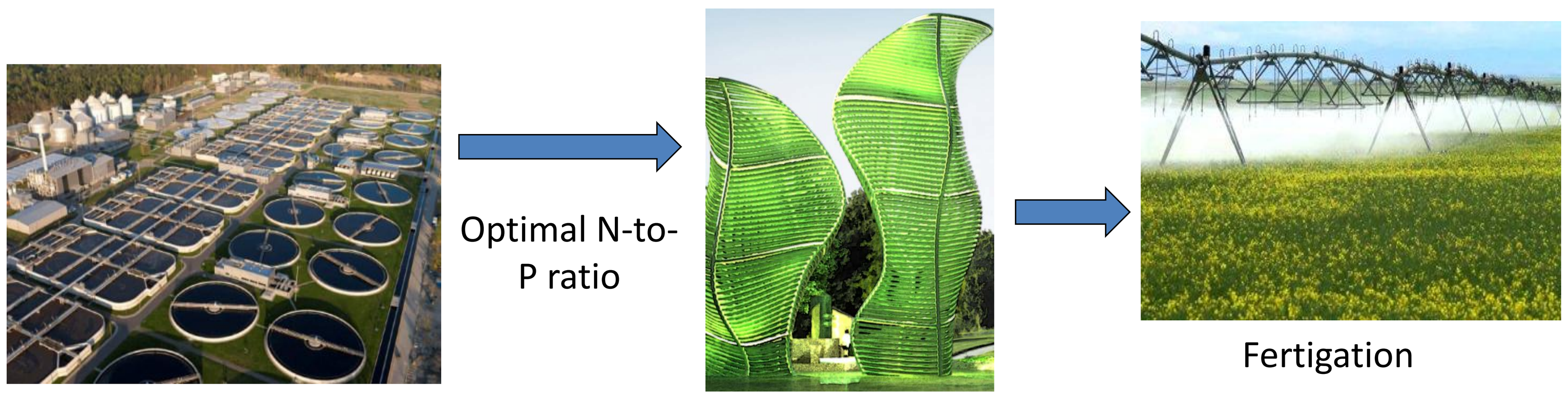
- High energy demand
- Requires metal salts

Resource recovery through a 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

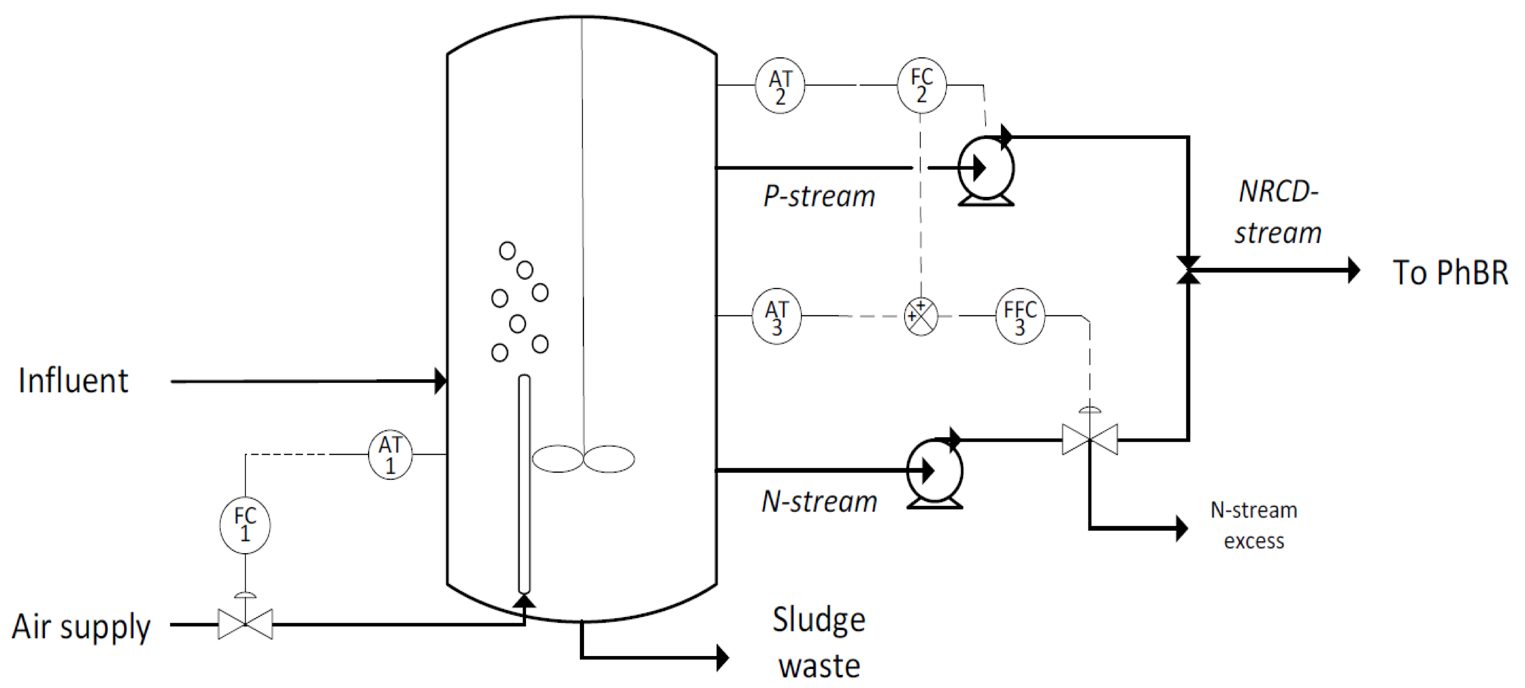
Advantages:

- Complete biological process
- Comparably lower environmental impact



Objective: How to keep a stable and optimal N-to-P ratio in the feed to the photobioreactor?

2. CONTROL STRUCTURE DESIGN

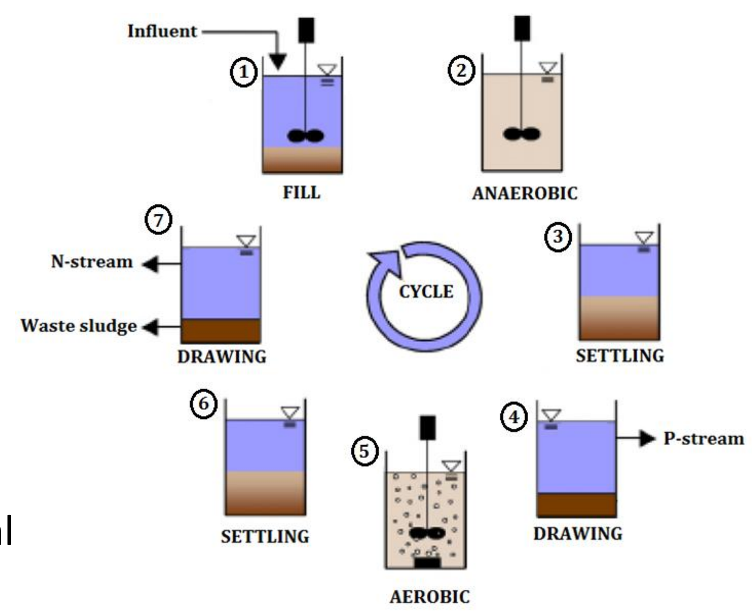


System description:

- 8-L volume sequencing batch reactor (SBR) operated at hydraulic retention time 18 h.
- Model calibrated at solid retention time (SRT) 8 days.

Process optimization:

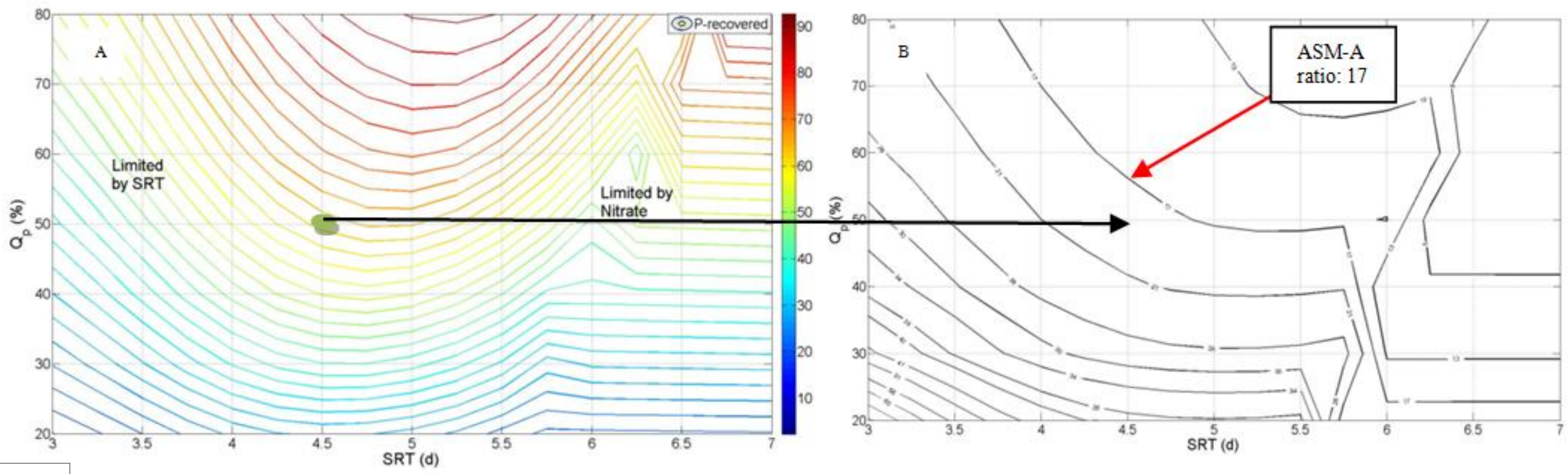
- Optimal P-recovery at SRT of 4.5 days and Qp=0.5·Qin. At other conditions PAO activity is limited by:
  - SRT
  - Nitrate recirculation to the anaerobic reactors
- The EBP2R is able to yield to N-to-P ratios optimal for cultivation of different green-microalgae:
  - Mixed algal culture used for ASM-A model calibration has an optimal N-to-P=17 [3]
- To accomplish with the nutrient requirement the N-stream has to be partially diverted to a completely autotrophic nitrogen removal (CANR) process.

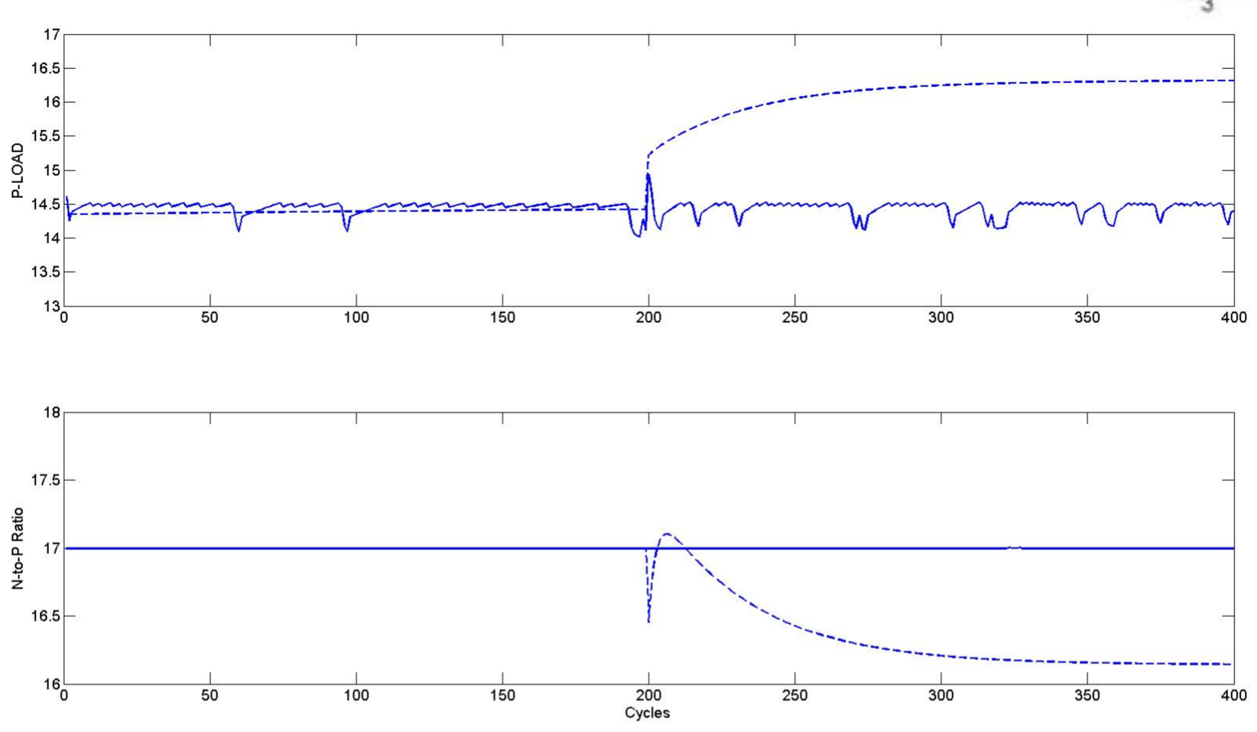


Control structure:

Pairing of manipulated and controlled variables :

- Phosphorus control loop: pump in the P-stream controls the phosphorus load to the photobioreactor (PBR). *Run-to-run control strategy*
- N-to-P ratio control loop: valve splits the N-stream flow between the PBR and the CANR system. *Ratio controller operating during the batch*
- Dissolved oxygen control loop: air supply (modeled as kLa) controls the oxygen level in the aerobic tank. *Control during the batch*
- SRT : ideally controlled by wasting a constant fraction of the total biomass.





Dashed line: open loop simulation; solid line: closed loop simulation

Performance:

System response to step disturbances in the influent:

- Total phosphorus (± 20%): in open loop the disturbance affects both P recovered and N-to-P ratio; the control system rejects the influent disturbance.
- Total nitrogen (± 30%) : in open loop the disturbance affects only the N-to-P ration; the control system rejects the influent disturbance.
- Total COD (± 20%) : in open loop the disturbance impact is comparably low; the control system rejects the influent disturbance.

Comparison with continuous layout [4]:

- The SBR leads to higher maximum phosphorus recovery: 80-90% vs 60% recovery in the continuous system
- The SBR is more flexible rejecting disturbances associated to the phosphorus load into the reactor

3. CONCLUSION

- **Control structure** for the EBP2R has been **developed and tested** under step influent disturbances
- **Higher phosphorus recovery** allows **better rejection of disturbances** in the influent **phosphorus load** compared to the continuous system
- **Future research** should address the **controllability of the PBR** and the **upstream online optimization** according to the PBR performance

ACKNOWLEDGEMENT

INWATECH

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