Repurposing Infrastructure for Phosphorus Removal

Patrick Dunlap, PE
Black & Veatch

CSWEA Education Seminar
April 13, 2021
Agenda

- Evolution of EBPR understanding
- S2EBPR
- Example applications
Evolution of EBPR Understanding
Biological Phosphorus Removal

- A two-step process of phosphorus release and uptake under alternating anaerobic and aerobic conditions.

- Phosphorus is released in the anaerobic zone to 25 to 40 mg/L, taken up in the aeration basin to as low as 0.05 mg/L soluble P.
Initial pilot testing by James Barnard indicated the importance of influent VFA and influent selector

- Note orthophosphates profile through plant with high release in 2nd Anoxic zone
- Performance could not be replicated in laboratory
- Barnard postulated that organisms (PAO) should pass through anaerobic phase with low ORP and P release, which triggered EBPR
- Suggested Phoredox process by adding anaerobic zone up front
Proposed flow schematics were developed based on original thinking

These were followed by others such as UCT, JHB & Westbank
Phosphate accumulating organisms (PAOs) are focused on BOD storage in anaerobic conditions.

Why does VFA have to come from the influent?
S2EBPR
S2EBPR generates carbon from biomass to drive EBPR

- Deep ORP selects for a more diverse PAO ecology, which provides access to a wider range of COD fractions
WRF Report in 2018 explored the mechanisms for S2EBPR

- Explored the diversity of PAO ecology and metabolism
  - Several OTUs
- Flexibility for multiple carbon sources (not just VFA)
- Identified rates for consideration
  - Phosphorus uptake and release rates
  - Carbon release rates
- Began to shift our understanding of modeling needs

Key outcome: PAOs are more diverse than historically assumed, and sidestream reactors can take advantage of this diversity
A subset of PAOs are likely capable of fermentation, driving EBPR in non-ideal wastewaters

- Only need to ferment a portion of our biomass
- External carbon from primary sludge fermenters can accelerate the process
- “New” fermentative PAOs have more diverse carbon needs, and can access rbCOD and VFA
- fPAOs and PAOs can co-exist to drive phosphorus removal

External Carbon

RAS or ML

Hydrolysis

VFA

rbCOD

Fac

FPAO

PAO
WRF 4975 is focused on practical considerations for sidestream enhanced biological phosphorus removal

- 21 participating utilities globally
- $1.3 M research project value
- Identified as one of the top 10 Water Innovations for 2020
- Principal Investigator: Leon Downing, BV
- Co-PI: April Gu, University of Cornell
- Goals:
  - Develop design criteria for the processes
  - Identify operational tools for EBPR
  - Recommend process modeling guidelines
Næstved WWTP: Originally a classical contact BioDeniPho plant
In 1999 reconstructed to the SSH EBPR process

New flow direction of the RAS into the anaerobic tanks

Courtesy of Gert Peterson
Example applications, focused on repurposing infrastructure
Sidestream enhanced biological phosphorus removal DIVERSES carbon source for EBPR

1. Move the anaerobic zone to the sidestream with a portion of RAS
2. Relies on the carbon contained within biomass to drive PAO battery charging
3. If insufficient carbon in biomass, add external carbon
Why is sidestream enhanced biological phosphorus removal impactful?

- Moves selective pressure for phosphate accumulating organisms into sidestream reactor
- Potential to significantly reduce capital for new facilities (RRWRD example)
- Potential to improve stability for existing phosphorus removal facilities (CWS example)
North Carolina Site
Suburban DC area: repurposing an abandoned gravity thickener

Note: FiT data is more accurate
This new layout results in new RAS management/treatment, but can limit aerobic tankage impacts.
RAS fermentation testing in Wisconsin

RAS fermentation zone is returned to the aeration basins, not the MBBR

Cranberry wastewater feed to the fermentation zone
ANSA/TSA
Appears that you can have too much or too little

Fermenter SRT
Similar trend? You can have too little, but also too much?
Initial target: 1.5 to 2 days

rbCOD Impacts
Still need COD, but good performance with low rbCOD fractionation
RAS VSS load is an indicator of COD loading into the fermenter, and is providing a design guideline.

**Preliminary Results**

- **SSR 1 - Full Scale, no Current Limit**
- **SSR 2 - Full Scale with Alum Polishing**
- **SSM 1 - Full Scale**

VSS Load Into Fermenter: Make Enough PHA for P Uptake

P Load to System

Side-Stream RAS Fermentation (SSR)
What considerations are ideal for S2EBPR?

- Available tankage
  - Sidestream configuration enables flexibility in tank location
  - Effluent phosphorus compliance without impact flow stream
  - **Starting point**: can you divert 20% of your RAS flow and have an 18 hour HRT in the available tank?

- Variable wastewater quality
  - S2EBPR is robust across a range of rbCOD values
  - **Starting point**: if your influent COD:P is greater than 50:1, but your rbCOD fraction is less than 15%, S2EBPR is likely a good fit
Thank You

Contact Us

Patrick Dunlap
+1 913 458 8182
DunlapPJ@bv.com