Enhanced Biological Phosphorus Removal w/ MicroC®

LNBA/ NRCA Operator Training

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July 2026

Agenda

I. Why remove Phosphorus?
II. Types of Phosphorus Removal
III. Fundamentals of EBPR
IV. Using MicroC® for EBPR
V. Case Study

The Problem: Eutrophication

- Phosphorus is a required nutrient for healthy aquatic and marine ecosystems
- In excess can cause Harmful Algae Blooms (HABs)
- Depletes oxygen to aquatic/marine life and blocks sunlight to submerged plants
- Ingestion and inhalation is toxic to humans
- An issue all over the United States but especially along the eastern seaboard and Great Lakes

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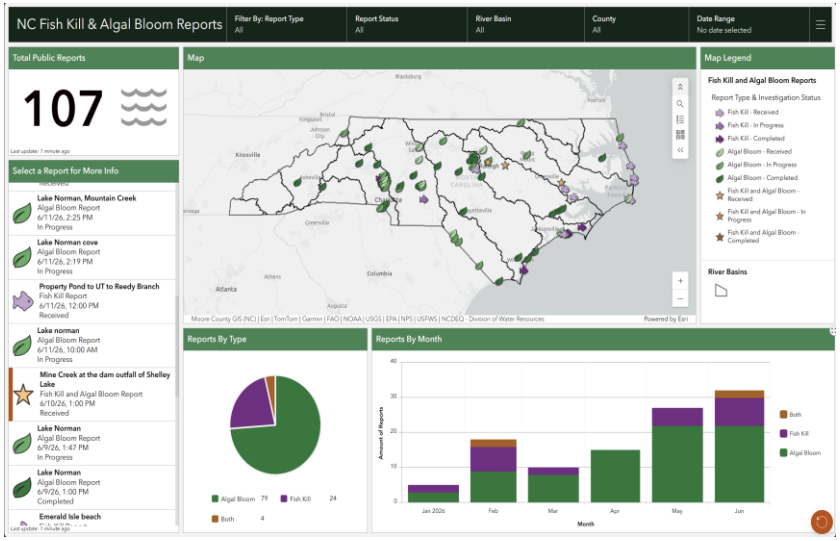
Eutrophication in NC

- Harmful Algae Blooms (HABs) increasing each year with warming waters in NC
- Can occur in waters ranging in size from community ponds to coastal sounds and bays
- HABs and fish kills are tracked on the DEQ website and can also be reported there



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Phosphorus in Wastewater

Sources:

- A pollutant in point source and non-point source discharges
- Wastewater phosphorus originates from human waste, foods, soaps and detergents
- Typically enters plant process in the form of Orthophosphate (PO_4)

Removal Categories:

- MLVSS bulk uptake
- Chemical Coagulation/ Precipitation
- Enhanced Biological Phosphorus Removal

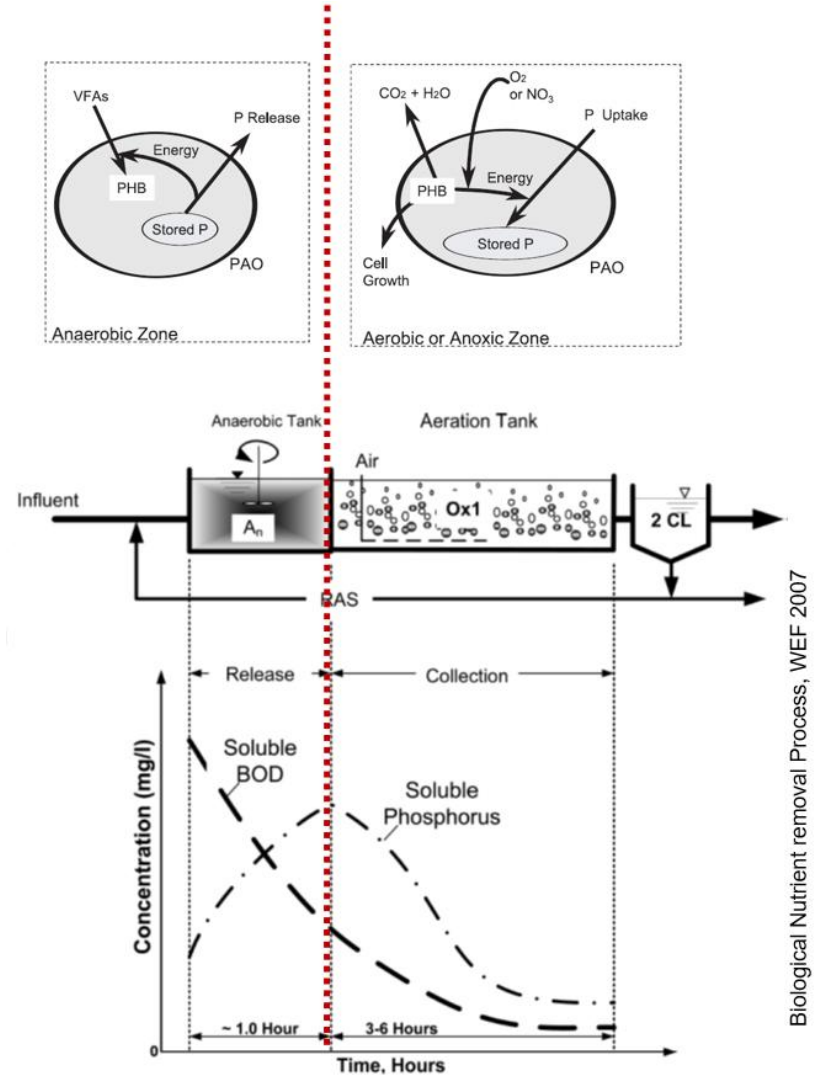
EBPR Process Fundamentals

Required Constituents:

- Phosphate Accumulating Organisms (PAOs)
- Volatile Fatty Acid (VFA)
- Anaerobic/ Aerobic conditions [cyclic]

Steps:

- Anaerobic: high soluble VFA leads to PAO phosphorus release
- Aeration: lack of VFA/ carbon leads to PAO phosphorus uptake in excess



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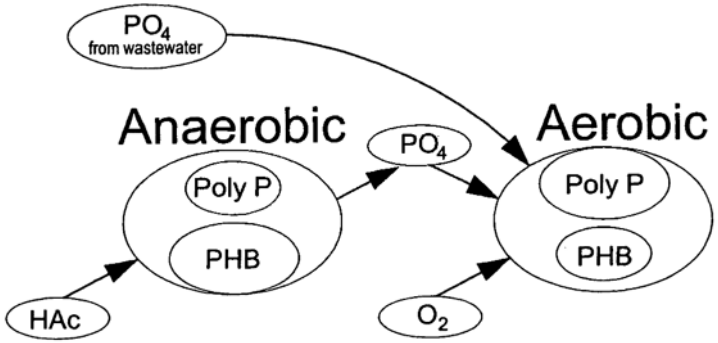
Phosphate Accumulating Organisms (PAOs)

Common Species:

- Accumilobacter
- Tetrasphaera

- Collect up to 30% of their weight in Phosphorus
- Typical bacteria are closer to 5%



GAO Competition

- Warm weather
- Low pH
- Slower growth
- Acetate

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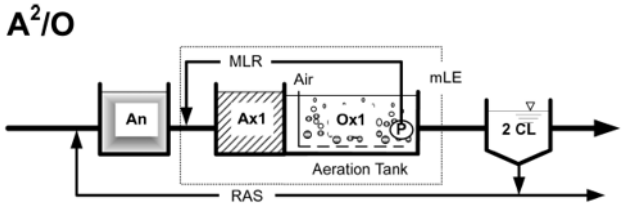
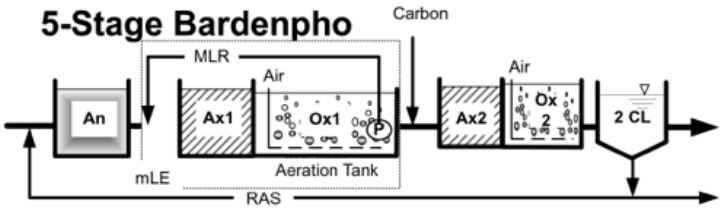
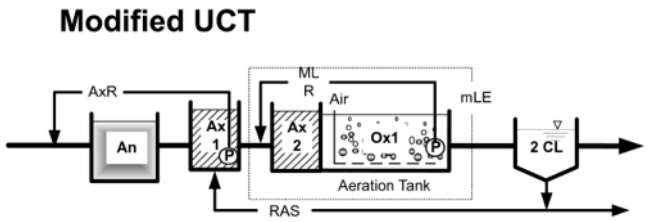
EBPR Process Configurations

- Typically done in plants with dedicated anaerobic zones
- Ideal anaerobic retention
  - 1-2 hours
  - 3-4 hours for fermentation
- Can be done in an anoxic zone with long retention times and low NOx
- Some newer, advanced designs even aim to denitrify the RAS







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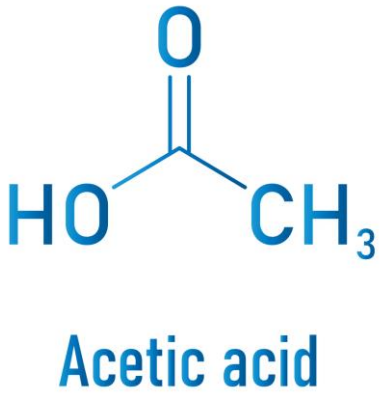
EBPR Advantages

- Less sludge than chemical precipitation typically
- Lower operational costs typically than pure chemical removal if nitrogen is also removed
- Does not lower plant alkalinity like metal salts
- Safety – Ferric Chloride
- Can remove 90% or more of influent phosphorus loading

VFA/Carbon Sources

- Volatile Fatty Acids
  - Fermented rbCOD
  - Glycerin-based carbon sources (MicroC® 2000)
  - Acetic Acid

- Plants Naturally have rbCOD in influent
- rbCOD concentration and BOD fraction vary significantly between plants
- Typically, just need to supplement to sustain consistent EBPR



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MicroC 2000 and EBPR

- Taken up via two potential pathways
  - Indirectly as a fermented VFA with extended anaerobic conditions
  - Directly as a replacement VFA source via a separate EBPR pathway
- Discovered the direct pathway by accident empirically
  - Internalize glycerin to form PHA

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Stoichiometry

The following ratios are the stoichiometric assumption used to evaluate EBPR (Metcalf & Eddy, 2004):

- 1.06 g acetate/g bsCOD
- A cell yield of 0.3 g VSS/ g acetate
- A cell phosphorus content of 0.3 g P/g VSS
- 10 g of bsCOD required to remove 1 g of phosphorus by the biological storage system.

*** bsCOD = biodegradable soluble COD**

Choosing an Initial Dosing Rate

- Determining baseline VFA or rbCOD in anaerobic
- Combined baseline plus additional VFA should reach 20:1 carbon to phosphorus
- Walk back ratio as empirical efficacy is determined

Example:

- Flow = 5 MGD
- TP = 5 mg/L
- Anaerobic rbCOD = 50 mg/L
- Glycerin = 9 lbs. COD/gal

Target COD 20:1	**Additional COD**	**lbs. COD**	**Gal of Carbon**
20 x 5 mg/L TP = 100 mg/L COD	100 – 50 = 50 mg/L COD	5 MGD x 50 mg/L x 8.34 = 2,085 lbs. COD/day	2,085 lbs./day / 9 lbs. COD/gal = 232 gpd

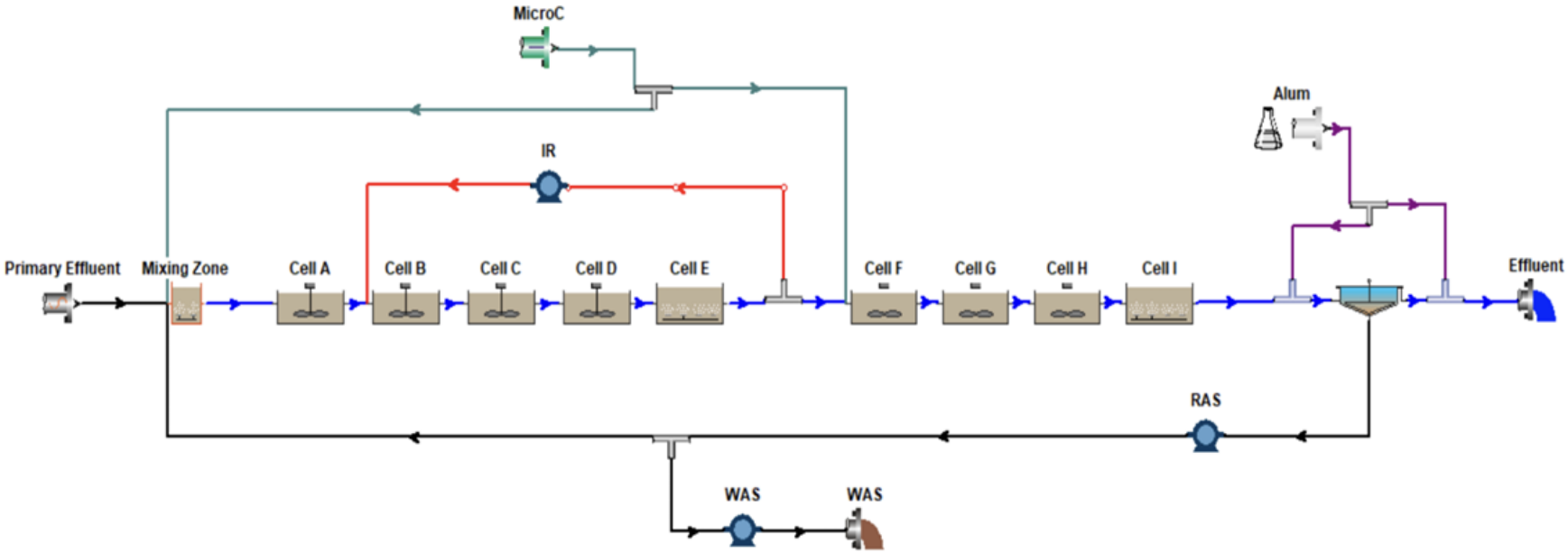
Parameters of Importance

- Low NOx concentration in RAS
- True Anaerobic conditions (ORP -250 mV or less)
- Phos Release
- Net uptake as measured before secondary clarifiers
- Ensuring there is not too high a feed of metal salts to primary

Case Study 1 – Virginia 4 Stage

- **Flow:** 15 MGD design / 11 MGD average
- **Process:** Activated Sludge – 4/5-Stage Bardenpho
- **Permit:**
  - TN < 5 mg/L
  - TP < 0.5 mg/L
- **Challenges:**
  - Short HRT ~30 min Anaerobic
  - Variable rbCOD influent
  - Intermittent EBPR performance

Plant Process



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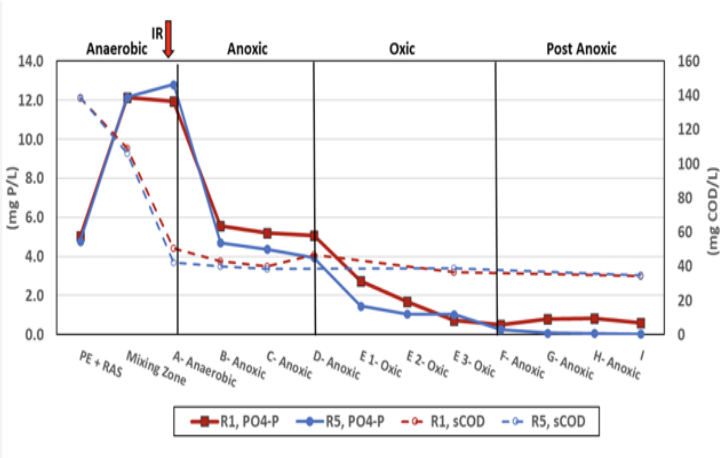
Results

- Added 100 gpd MicroC 2000
- Biological phosphorus removal increased to 98%
- Effluent TP remained below 0.5 mg/L
- Alum dosage went from 500 GPD to <50 gpd
- Successful operation at both 4 and 5 stage operation



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Case Study 2 – Maryland MBR

- **Flow:** 15 MGD design / 7.5 MGD average
- **Process:** Activated Sludge – 5-Stage MBR
- **Permit:**
  - TN < 4 mg/L
  - TP < 0.3 mg/L
- **Challenges:**
  - Short HRT ~15 min Anaerobic
  - P Removal completely reliant on 650 gpd ferric chloride

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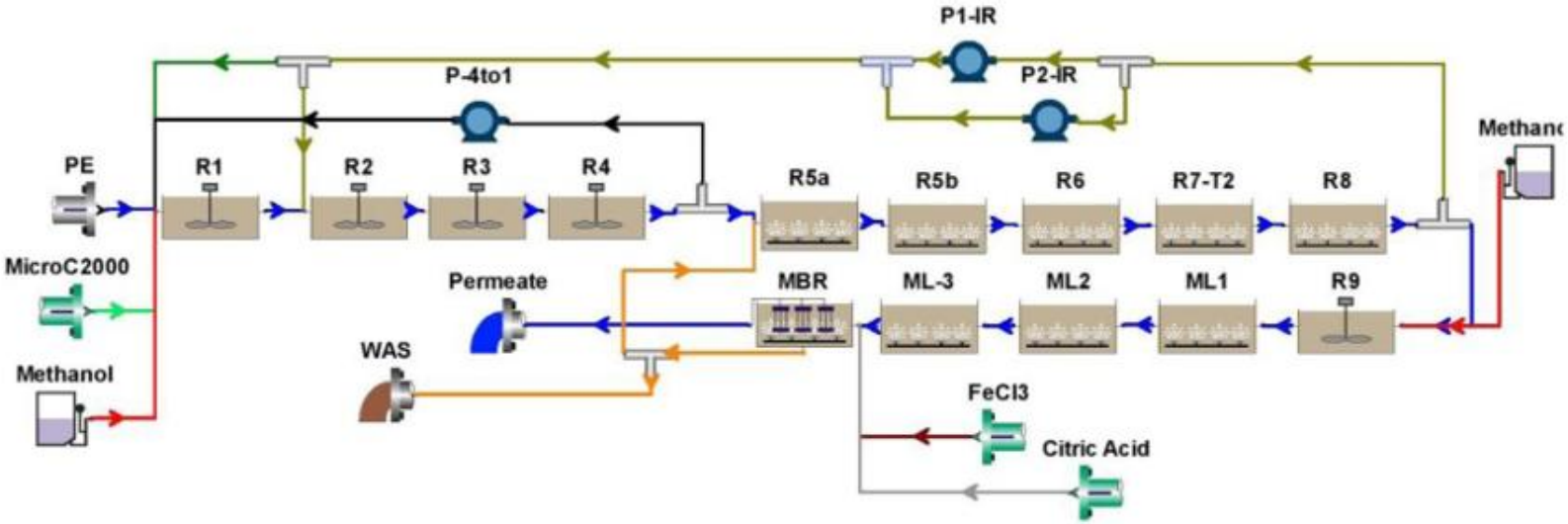
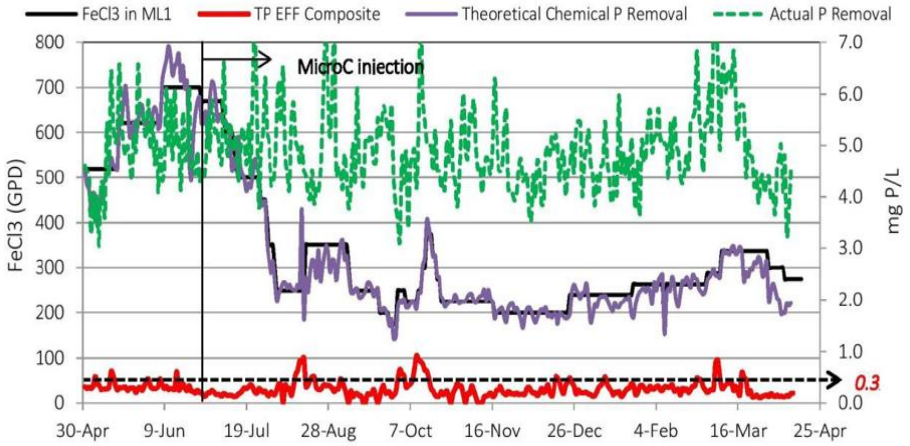
Plant Process



Results

- Added **225 GPD MicroC® 2000** to primary effluent
- Converted Reactor 5A to intermittent aeration
- Average effluent TP maintained to 0.27 mg/L
- Consistent EBPR achieved
- Chemical reductions:
  - Ferric reduced by 70%
  - Methanol reduced by 35%
  - Citric acid reduced by 50%



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Questions?

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