Agenda

➢ Biological phosphorus removal review
➢ Case studies
  ▪ Characterization impacts
  ▪ BNR configurations
  ▪ Operational tools
biological phosphorus removal
Bio-P

- Enhanced Biological Phosphorus Removal (EBPR)

Electron Donor
(Volatile Fatty Acids)
Bio-P

- Enhanced Biological Phosphorus Removal

Electron Donor (Volatile Fatty Acids)
Bio-P

- Enhanced Biological Phosphorus Removal

Electron Donor
(Volatile Fatty Acids)
Enhanced Biological Phosphorus Removal

- **Electron Donor** (Volatile Fatty Acids)
- **Electron Acceptor #1** (Oxygen (Full bodied lager))
- **BACTERIA**
Enhanced Biological Phosphorus Removal

Electron Donor
(Volatile Fatty Acids)

Electron Acceptor #1
Oxygen
(Full bodied lager)

Electron Acceptor #2
Nitrate
(Light beer)
Enhanced Biological Phosphorus Removal

- Electron Donor (Volatile Fatty Acids)
- Electron Acceptor #1: Oxygen (Full bodied lager)
- Electron Acceptor #2: Nitrate (Light beer)
- Electron Acceptor #3: EBPR (Water)
Enhanced Biological Phosphorus Removal

- **Electron Donor**
  - (Volatile Fatty Acids)

- **Electron Acceptor #1**
  - Oxygen
  - (Full bodied lager)

- **Electron Acceptor #2**
  - Nitrate
  - (Light beer)

- **Electron Acceptor #3**
  - EBPR
  - (Water)
Enhanced Biological Phosphorus Removal

Electron Donor
(Volatile Fatty Acids)

Electron Acceptor #1
Oxygen
(Full bodied lager)

Electron Acceptor #2
Nitrate
(Light beer)

Electron Acceptor #3
EBPR
(Water)

EBPR:
Lowest energy
Limit #1 and #2 at front of basin

BACTERIA
Enhanced Biological Phosphorus Removal

**Electron Donor**
(Volatile Fatty Acids)

**EBPR:** Lowest energy Limit #1 and #2 at front of basin

**Electron Acceptor #1**
Oxygen (Full bodied lager)

**Electron Acceptor #2**
Nitrate (Light beer)

**Electron Acceptor #3**
EBPR (Water)

MIXERS

DENITRIFICATION
Configurations

- UCT’
  - EBPR
  - Denit.
  - Nitrification
  - IMLR 1
  - RAS

- MUCT
  - EBPR
  - Denit.
  - Denit.
  - Nitrification
  - IMLR 1
  - IMLR 2

- 5 Stage Bardenpho
  - EBPR
  - Denit.
  - Nitrification
  - Denit.
  - IMLR 1

- A2O
  - EBPR
  - Denit.
  - Nitrification
  - IMLR 1

Options:
- Optimal P removal
- Both
- Optimal N removal
Things to Consider

- Wastewater characteristics
- BNR configuration
  - Approaches and goals
- Operational “tricks”
wastewater characteristics
Wastewater Characteristics

All BOD is not created equally
Wastewater Characteristics

All BOD is not created equally

VFAs (and rbCOD):
Key for Bio-P
Wastewater Characteristics

Plant 1: Beloit, WI
- Small collection system
- High food waste content
- $\text{rbCOD}:\text{tCOD} = 0.3$
Wastewater Characteristics

**Plant 1: Beloit, WI**
- Small collection system
- High food waste content
- rbCOD:tCOD: 0.3

**Plant 2: TRA CRWS**
- Large collection system
- Warm weather
- rbCOD:tCOD: 0.25
Wastewater Characteristics

**Plant 1: Beloit, WI**
Small collection system
High food waste content
rbCOD:tCOD: 0.3

**Plant 2: TRA CRWS**
Large collection system
Warm weather
rbCOD:tCOD: 0.25

**Plant 3: Medford, WI**
Small collection system
Limited industry
rbCOD:tCOD: 0.1
Wastewater Characteristics

**Plant 1: Beloit, WI**
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Warm weather
rbCOD:tCOD: 0.25

**Plant 3: Medford, WI**
Small collection system
Limited industry
rbCOD:tCOD: 0.1

Average influent BOD: 250 to 300 mg/L
Wastewater Characteristics

A/O Process

Requirements: baffle wall, mixers
Plenty of soluble “food:”
Enough to go around:
Process is simplified
bnr configurations
Sun Prairie, Wisconsin
WHY SOME BIO-P PLANTS WORK BETTER THAN OTHERS

Fraction of rbCOD that is VFA

rbCOD/P ratio

Standard curve (Barnard et al, WEFTEC 2005)
Configuration

Modified VIP/UCT Bio-P Process

- Internal Recycle
- PE
- RAS
- Aerobic Zones
- Anaerobic Zones
- Anoxic Zones
Performance

- 1125 Days without Ferric Addition
- 14 Days with Ferric Addition

Zero Permit Violations

Graph:
- Target Effluent TP, mg/L: 1.0
- Average Effluent TP, mg/L: 0.5
Configuration

WHY SOME BIO-P PLANTS WORK BETTER THAN OTHERS

Fraction of rbCOD that is VFA

Janesville

Standard curve (Barnard et al, WEFTEC 2005)
Biological Nutrient Removal Design

Slide Number 31
Fermentation incorporated
- Offset BOD:P issue
- High level of N and P removal
### Startup and Operation

- **Fermenter overflow**
  - Flow of 0.9 MGD
  - 7% of forward flow
  - Currently generating 1000 lbs/day VFA

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<td><strong>Average</strong></td>
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operational “tricks”
Do your mixers need to run all the time?

July 2013: power out in aeration basin (mixers off)
Mixing still observed

Do we really need 20 total horsepower of mixing in the selector zone?

October 2013:
Manual cycling of mixers every 2 hours
Mixers Alternated On/Off

Increased ORP variability, still anaerobic
Mixers: cycle on/off every two hours

ORP drop

Mixed liquor fermentation?

Sheboygan WWTP
Sheboygan, Wisconsin

Anaerobic selector zone

Mixers On/Off

ORP (mv)

Time (hours)
Low DO Operation

Conventional

- DO = 3 mg/L
- DO = 2 mg/L
- DO = 2 mg/L
Low DO Operation

**Conventional**

**Low DO**

- **DO = 3 mg/L**
- **DO = 2 mg/L**
- **DO = 1.5 mg/L**
- **DO = 0.75 mg/L**
- **DO = 2 mg/L**
- **DO = 0.75 mg/L**
Trinity River Authority

CRWS Treatment Plant

189 mgd average day flow capacity

Modified one of twelve aeration basins to BNR in 2012

AO process, relies on simultaneous nitrification and denitrification (SND)
Nitrogen Removal

Nitrogen Removed (mg/L)

Conv. DO

Low DO (0.75 – 1 mg/L)

7/1/2012 9/30/2012 12/30/2012 3/31/2013
Phosphorus Removal

<table>
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<th>Condition</th>
<th>TP (mg/L)</th>
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<td>2.90</td>
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<tr>
<td>Selector + Conventional DO</td>
<td>0.70</td>
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<tr>
<td>Selector + Low DO</td>
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Average Effluent TP (mg/L)
takeaways...
Takeaways

- **Wastewater characterization**
  - Not all BOD is created equal
  - BOD variability is a key consideration

- **Configuration**
  - Select the configuration to meet your goals

- **Operational “tricks” to consider**
  - Mixer cycling
  - Low Do operation
Questions?

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