Optimizing P removal at South Shore Water Reclamation Facility

Wisconsin Wastewater Operators Association Conference October 23, 2013
Presenters

Sid Arora
Process Control Engineer

Khris Radke
Process Control/Quality Control Supervisor
*(South Shore Water Reclamation Facility)*

Marty Dierker
Operations Supervisor
*(South Shore Water Reclamation Facility)*

Bob Moser
  Operations Manager

Veolia Water Milwaukee, LLC
Historical & Current Conditions
South Shore Water Reclamation Facility

Influent

Iron Addition

East Plant

West Plant

Veolia Water
South Shore WRF P Removal—Historical Perspective

- Iron salts are added to the primary influent (PI) flow after screening & grit removal
  - Phosphorus Percent Removal in primaries depends on iron salt
    - higher when ferric chloride is used and
    - lower when pickle liquor is used

- Pickle Liquor/Ferric Chloride are mixed with dilution water and fed to the primary influent channels.

- Chorine (Sodium hypochlorite) can be added to oxidize the pickle liquor iron (This option has not been used in years due to the cost of chlorine)

- South Shore Effluent discharged into Lake Michigan
South Shore WRF P Removal

- Residual iron in the plant’s sludges are needed to meet the guaranteed iron in Milorganite

- Residual iron in the plant’s primary sludge helps reduce H2S in the plant’s digesters & digester gas

- Effluent phosphorus limit since the 1970’s = 1 mg/L TP

- Effluent TP limits changed recently
  - 0.80 mg/L Starting January 2013 (6-month Average)
  - 0.60 mg/L Starting November 2016 (6-month Average)
Evaluation of Conditions Favorable for Bio-P at SS
Volatile Fatty Acids

**Why is it Important?**
- Organic Material entering anoxic zone should be soluble and readily available to Phosphorus Accumulating Organisms (PAOs)
- Volatile Fatty Acids (VFAs) uptake and PHA? storage is the primary mechanism that give PAOs a selective advantage

**Recommended range in Literature**
- 5-10 mg/L of VFAs for every 1 mg/L of phosphorus removed.  
  *(BNR Operation in WWTPs MOP 29)*

**South Shore Primary Effluent Data Results**
- VFA concentration 85 mg/L During fall of 2011
- VFA concentration 75 mg/L During fall of 2012
- VFA:P ratio at SS 20:1 during 2011 and 2012 pilot tests
**BOP : P Ratio**

**Why is it Important?**

- An adequate amount of organic material must be available to support PAOs

**Recommended range in Literature**

- $\text{BOD}_5 : \text{P}$ ratio of at least 20:1, or
- $\text{COD} : \text{P}$ ratio of at least 45:1, is needed for EBPR 
  *(Janssen et al., 2002)*

**South Shore Primary Effluent Data Results**

- Primary Effluent $\text{BOD}_5 : \text{P}$ ratio = 36:1
- Primary Effluent $\text{COD} : \text{P}$ ratio = 67:1
Nitrates in RAS

Why is it Important?

- If nitrate (combined oxygen) enters the anaerobic zone, uptake of VFAs by the PAOs and phosphorus release is adversely impacted.
  - VFA are consumed by Denitrifiers

Recommended range in Literature

- $\text{NO}_3=0 \text{ mg/L}$

South Shore RAS NO$_3$ Results

- NO$_3$ concentration measured during the test period was 4 mg/L
Optimizing P Removal At South Shore
Optimize Iron Feed Starting in 2010

- Optimizing Iron Use by taking advantage of Aeration Basins Phosphorus Removal

- Aeration basins can remove around 30-40% of influent phosphorus (without anoxic zones)

- % P removal depends on primary effluent BOD:P Ratio and Soluble BOD

- Iron Salts Consumption reduced by 35%
Partial Bio P Starting Spring 2012

- Quasi-anaerobic/anoxic zones were created in the first zone of all aeration basins
  - Reduced air in first 12.5% of aeration basin

- Iron feed to the primary influent was maintained

- Air bumping for 2-4 hrs Weekly in the front zone of each aeration basins
  - To minimize solids settling and re-suspend settled solids in the front zone
Full Scale Bio P Pilot Fall 2011 and Fall 2012

Purpose of the testing:
- Feasibility of Bio P at South Shore WRF
- Capability to meet proposed effluent P limit of 0.80 mg/L (6 month Ave)

Bio P Pilot Test Configuration:
- Anoxic Zone was created by lowering the air in first 12.5% of aeration basins in half of the Plant.
- After sometime iron feed was stopped
- Then Anoxic Zone was created in other half of the Plant
- After sometime Iron Feed was stopped
2011 EBPR Pilot – Initial Setup

East Plant (all Aerobic)

West Plant (Anaerobic at Influent end followed by Aerobic)
2011 Final and 2012 EBPR Pilot Setup

East Plant (Anaerobic at Influent end followed by Aerobic)

West Plant (Anaerobic at Influent end followed by Aerobic)
South Shore EBPR – Sampling and Testing

- Primary Effluent (West & East Plants): BOD, Total Phosphorus, Ortho P and VFA

- Secondary Effluent (West & East Plants): Total Phosphorus, Ortho P and Nitrates

- Final Effluent: Total Phosphorus and Ortho P

- RAS: Nitrates
Aeration Basins Profiling-DO, Ortho P and NO3

To Clarifier

Sample #1
Sample #2
Sample #3
Sample #4

Anaerobic

Aerobic

RAS

Influent
Pilot Study Results
Aeration Basins Profiling for DO, Ortho P and Nitrates- 2011 Pilot

Aeration Basin 4 Profiling

Aeration Basin 12 Profiling

Aeration Basin 17 Profiling
2011 West Plant vs. East Plant Ortho Phosphorus

Effluent Ortho-P During EBPR

- **West Plant - No Iron**
- **East Plant - With Iron**

Dates and Observations:

- 08/28/2011 - Quasi Anaerobic/Anoxic Zone in West Plant
- 09/19/2011 - Half Plant EBPR Started, All Iron to East Plant
- 10/10/2011 - Quasi Anaerobic/Anoxic Zone in East Plant
- 10/25/2011 - Full Plant EBPR Started, No Iron to Plant
2011 EBPR Results

Variation in Influent and Effluent Total Phosphorus - 2011

- **Influent**
- **Final Effluent**

Dates and Events:
- **8/29/2011 Quasi Anaerobic-Anoxic Zone West Plant**
- **9/19/2011 Half-Plant EBPR in West Plant**
- **10/10/2011 Quasi Anaerobic-Anoxic Zone East Plant**
- **10/25/2011 Full-Plant EBPR**
- **11/15/2011 EBPR Testing Stopped**
2012 EBPR Results

Variation in Influent and Effluent Total Phosphorus - 2012

- 3/8/2012: Quasi Anaerobic-Anoxic Zone in Entire Plant
- 9/25/2012: Half-Plant EBPR in East Plant
- 10/17/2012: Full-Plant EBPR
- 10/31/2012: EBPR Testing Stopped
## South Shore Final Effluent Phosphorus

<table>
<thead>
<tr>
<th>Average for Period</th>
<th>SS Final Effluent Phosphorus, mg/L</th>
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<tbody>
<tr>
<td><strong>Bio-P Test 2011</strong></td>
<td></td>
</tr>
<tr>
<td>Test Period</td>
<td>0.42</td>
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<tr>
<td><em>(Sep. 19 to Nov. 14, 2011)</em></td>
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<tr>
<td>Outside of EBPR test period for 2011</td>
<td>0.51</td>
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<tr>
<td><strong>Bio-P Test 2012</strong></td>
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<tr>
<td>Test Period</td>
<td>0.33</td>
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<tr>
<td><em>(Oct. 11 to Oct. 31, 2012)</em></td>
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<tr>
<td>Outside of the EBPR test period for 2012</td>
<td>0.67</td>
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<tr>
<td>2006 – 2010 Average</td>
<td>0.60</td>
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Results Summary

- Enhanced Biological Phosphorus removal is feasible at South Shore

- Bio P is capable of meeting the new effluent P limit of 0.80 mg/L (6 month Ave)

- Some free oxygen or nitrates did not appear to affect EBPR performance to a significant extent

- South Shore WRF service area includes northern and Western Suburbs
  - Very long detention time in sewer (>12 hrs)
    - Higher VFA than typical
Overall Iron Use Reduction and Effluent P
Iron (lb Fe) Used for SS Phosphorus Removal (2006-2012)
Iron (lb Fe) per Lb P Removed
(2006-2012)
South Shore Effluent P 2006-Present
(Monthly and Annual Averages)
Summary
Summary

- SS Aeration basins can remove around 30-99.9% of influent phosphorus biologically.

- Iron use can be optimized by pushing some P to aeration basins.

- Partial Bio P has proven to be a low cost P removal option.

- Enhanced biological phosphorus removal is a “green” solution to remove phosphorus.
Thank you for your time!