Study Objective & Intro

• Resolve Problem of Effluent Total Phosphorus SPIKING in a Biological Phosphorus Removal (BPR) System
• Proposed Solution – Automatically Feeding a high rbCOD product
• LaCrosse - Logical Place for Study
  – Has Effluent TP Spiking -- Already Using high rbCOD product on Weekends
  – Close to Home
La Crosse WWTP

- Design - 20 MGD
- Present - 10 MGD
- **Liquid** - Fine Screen/Grit/Primaries/BPR/UV
- **Solids** – Co-Thicken Gravity Thickeners/Aerobic Digestion/GBT Thickening/Storage/Liquid Injection
- Major Contributor – City Brewery, high rbCOD
High rbCOD Product added to Primary Clarifier Effluent Trough

Molasses Formulate Product

La Crosse BPR System - A2O
BPR Operational Difficulties

- Eff Spiking P on Weekends or Beginning of Week
- BPR Works Well 75% of Time

Bar chart showing operational difficulties from June 2, 2011, to July 6, 2011.
Investigate/Analyze Difficulties

• Survey/Investigate BPR systems using P profile testing
  – What is P profile testing?
    • Snapshot in time
  – Why use it for this investigation
    • P-Release in Anaerobic Zone
    • P-Uptake in Aerobic Zone
      – Are there Trends?
    • Simple analyses—on-line analyzers available
P-Release in Anaerobic Zone

WEF (2010), Nutrient Removal WEF Manual of Practice No. 34 (Page 523, Section 2.3.4)

• “..higher overall release..better P removal”

• "The release of P can result in P concentration in the anaerobic zone from two to four times the influent concentration and still result in good P uptake in the aeration basin."
Performing P Profiles - BPR Systems

• Ran Multiple P Profiles on LaCrosse System and at numerous other WWTPs
• Taking pulse of system
• Multiple profiles/day multiple days - weekends

• Understand BPR under Various rbCOD Loading Conditions
QLF Specialty Products...Phosphorus Profiles of a BPR System Which has Lost and Then Regained rbCOD Loading Over a Weekend
Analyze Results for Patterns

• Need a Mathematical Expression
  – For a baseline to measurement BPR performance

• Back to **ANAEROBIC ZONE** - Healthy BPR System
  – PAO’s uptake VFAs and P Release
  – Small P-Release – low influent rbCOD
  – High P-Release – high influent rbCOD
Analyze Results for Patterns

• Using ONLY anaerobic zone P release as a sole measure of BPR health had problems;
  – Changing influent P concentrations
  • Side streams can give False High P-Release
  – Need to Compare anaerobic P-Release to something--WEF
Analyze Results for Patterns

• Created Mathematical Expression
• Anaerobic Zone P-Release divided by BPR Influent P
• For this study we will refer to it as Phosphorus Release Ratio - PR²
• Can PR² be used to measure the health and performance of a BPR system? WEF - PR² between 2 and 4 GOOD
P Uptake Compared to PR² - Is NOT Adjusted for Detention Time

These 2 lines appear to correlate well, but base on the what's going on THEY SHOULDN'T

Anaerobic Zone P divided by Influent P = P-Release Ratio (PR²)
Measurement of Satisfying BPR rbCOD Demand

Last Aerobic Zone
PO₄ as P, mg/l
Measurement of BPR Performance
P Uptake Compared to PR^2 - Is Adjusted for Detention Time

**Anaerobic Zone P divided by Influent P = P-Release Ratio (PR^2)**

Measurement of Satisfying BPR rbCOD Demand

**Last Aerobic Zone PO_4 as P, mg/l**

Measurement of BPR Performance

<table>
<thead>
<tr>
<th>Time</th>
<th>PO_4 as P, mg/l</th>
<th>PR^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon 7:10 AM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 9:15 AM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 11:20 AM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 1:18 PM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 3:00 PM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 4:15 PM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 7:30 PM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 11:00 PM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tues 3:50 AM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tues 7:25 AM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- P Release Ratio, PR^2
- Aerobic Zone 3 OP as P, mg/l
Multiple P Profiles Adjusted for System Detention Time were Performed - Results

• Increase/Decrease of rbCOD has almost instantaneous effect on Anaerobic Zone P-Release - $PR^2$

• $PR^2$ Appears to Predict BPR Performance - Effluent DRP Concentrations
Plans and Setup for Trial

- Related PR² findings to Method of Automatic Control
- Added Ramp Control - SCADA system
- Needed: An on-line analyzer – monitor 2 sample points with one analyzer
- Worked with Instrument vendor to supply an analyzer
Primary Effluent orthophosphate Input, mg/l

Anaerobic Zone orthophosphate Input, mg/l

Aeration Basin Effluent orthophosphate Input, mg/l

PLC Controller
Calculate P-Release Ratio

Output Control
EnhanceBioP+N - Feed Based on P-Release Ratio Set Point
Ferric - PID Loop Control

Molasses Formulation
Feed Pump to Primary Effluent

Ferric Chloride Feed Pump to Aeration Tank Effluent Tough
SCADA System Inputs and Dashboard
ON-LINE PROCESS ANALYZER

USED TO CONTINUOUSLY MONITOR 2 SAMPLE POINTS, BPR INFLUENT AND ANAEROBIC ZONE
On-Line Analyzer Info

- 2 sample points
- In Situ filters
- Analyzes for orthophosphorus and nitrate
- Sampling Frequency – one every 15 minutes
- Analyte data can be used for monitoring and control
1 - BPR Influent Analyzer Sample Point
2 - Anaerobic Zone Analyzer Sample Point
3 - Nitrate Recycle Pump
4 - There is not wall at this location. It is divided into 2 zones for sampling purposes
1. BPR influent sample point, primary effluent was pumped through drum to provide this sample point
2. Anaerobic Zone sampling point
3. Anaerobic Zone sample filter
Trial

• Length – 4 weeks
  – Focus on the weekends when rbCOD loading changes
  – DID FEED AUTOMATICALLY DURING WEEK TOO AT HIGHER PR$^2$ SET POINT

• First Worked out Bugs, took 3 weeks
  – Learning the best dose setting required trial/error
  – Accidentally let on-line analyzer reagent run out
  – Etc
1-PR² set point too low and ramp control set too react slow.
2-PR², QLF Pump Speed, and Effluent OP - level out
3-rbCOD Product - OFF – PR² ↓ Effluent OP ↑
4-Monday - Industrial rbCOD loading returns, drives PR² ↑ and Effluent OP ↓
All Control Settings Fine Tuned
Successful Run

- rbCOD Product Pump Speed = %
- PR2-Ratio
- Final Eff. Ortho P
- Avg PR2-Ratio
- 2 per. Mov. Avg. (PR2-Ratio)
Conclusion

• Successful - Fed high rbCOD product automatically to maintain consistently low effluent DRP

• Each BPR system will have its own optimum PR² and its own unique rbCOD Demand to achieve that PR²

• Auto feed high rbCOD system will not FIX Extreme rbCOD shock loads, operational issues and toxic loads - cover with automatic chemical feed system
Conclusion

• Benefits related to automated feed
  – Keep biology HAPPY – THEN IT PERFORMS
  – Providing rbCOD when necessary
  – Process covers multiple BPR sins
    • Nitrates in RAS or from recycle ammonia spikes – DATA FROM ANALYZER
    • Oxygen in RAS
    • P spikes in recycle
  – System works on rbCOD DEMAND not on influent rbCOD:TP ratio
    • Stops feeding – When Influent rbCOD is Adequate or High
Other Potential Benefits of Automatically Feeding High rbCOD

These need more investigation/assessment

- **Reduced** sludge production when compared to using chemical for P control
- **Reduced** effluent TSS because biological loading to system is stabilized
  - Eff TSS during the successful weekend of auto feeding study was very low – 1 to 2 mg/l usually 3 to 5 mg/l - FIRST TIME EVER
Other Potential Benefits of Automatically Feeding High rbCOD

These need more investigation/assessment

• Reduced heavy metals in sludge due to reduced ferric requirement
• Improved solids dewatering when compared to systems that use alum
Closing Thoughts

• How much rbCOD does a system need, and when?
• BPR rbCOD demand (PR²) vs. rbCOD:TP
• Compare Chlorine Residual and PR²
  – **Chlorine residual** is an **indirect operational test**
    (Fecal) is demand met? -- nitrite ↑ demand
  – PR² may also be an indirect measure of how much the
    BPR rbCOD Demand is satisfied
    • BPR systems have Real time Demands based on
      changing conditions in anaerobic zone
    • Changing rbCOD, P, NO₃ and O₂ loadings
• Establish the optimal PR² by comparing the PR² levels
to effluent DRP