Topics

- Traditional Ditch Configurations
- Mechanism of Bio P Removal
- Pollutant Parameters for Bio P
- ORP
- Bio P Ditch Configuration
- Bio P Considerations
- DO Control Settings
- Examples
- Summary
Traditional Configurations

- Complete Mix
- Tanks in Series
- Extended Aeration
- Single or Multi-Channel
- Mechanical Surface Aeration
- Orbal® Configuration
Traditional Configurations

- Hybrid Plug Flow - Complete Mix
- Specific Selector Zones for P and N Removal
Traditional Configurations

Mechanical Aeration

- Brush
- Disc
- Surface

Manufacturers
- Lakeside
- Envirodyne
- Evoqua
- Aeration Industries
- Other
Traditional Configurations
Mechanical Aeration
Traditional Configurations
Mechanical Aeration

Limitations

- Bio P Removal, No True Anaerobic Zone
- Tradeoff between Nitrification and Bio P
- Mixing Coupled With Aeration
Mechanisms of Bio P

Source: WEF
# Pollutant Parameters for Bio P

<table>
<thead>
<tr>
<th>Substrate Parameter</th>
<th>Substrate-to-TP Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>cBOD</td>
<td>25:1</td>
</tr>
<tr>
<td>COD</td>
<td>40:1 to 45:1</td>
</tr>
<tr>
<td>VFA</td>
<td>4:1 to 16:1</td>
</tr>
<tr>
<td>rbCOD</td>
<td>10:1 to 16:1</td>
</tr>
</tbody>
</table>
ORP

- Solution’s Capability to Oxidize or Reduce Another Solution
- Oxidize – Lose e
- Reduce – Gain e
- Based on Reference Electrode
  - Salt Bridge
Bio P Release
-100 mV to -225 mV

Bio P Uptake
+25 mV to +250 mV

Nitrification
+100 mV to +250 mV

Denitrification
+50 mV to -50 mV
**ORP**

- **Anaerobic** region (-800 mV)
  - Methanogenes
  - Sulfur Reduction

- **Anoxic** region
  - Acid Formation
  - Phosphorus Release
  - Denitrification

- **Aerobic** region (+200 mV)
  - Nitrification
  - Aerobic Oxidation

**Simultaneous Nitrification-Denitrification Range**
Bio P Configuration - Existing
Bio P Configuration - Existing
Bio P Considerations

- Need Some DO for Nitrification
  - No Bio P, 50 % N Bacteria Outer Channel
  - Bio P, 25 % N Bacteria Outer Channel
    - Middle Channel More N Work
- Mixing
  - 0.75 FPS
- Biosolids
  - Side stream control
Control Settings

- Traditional DO Settings
  - Outer – 0 mg/L
  - Middle – 1.0 mg/L
  - Inner – 2.0 mg/L

- Optimized DO Settings
  - Outer Channel – <0 mg/L
  - Middle – 0.4 mg/L
  - Inner – 1.5 mg/L
Examples Slinger, WI

- Orbal Facility, ADF = 0.8 MG
- Removed Outer Discs
- Changed Control Settings
- Installed ORP Probe
- Mixer (In Place of 1 Outer Disc Aerator)

Influent
- BOD – 300 mg/L
- TP – 6 mg/L
Examples Slinger, WI
Examples Slinger, WI

- Effluent Total Phosphorus (mg/L)
- Target Value

- PAC Addition
  - No Chemical
  - PAC Addition
  - PAC Addition w/ Polymer
  - PAC Addition + PAC w/ Polymer at Splitter Box

- PAC Addition

Graph showing the effluent total phosphorus (mg/L) from 5/1/2016 to 7/1/2018 with different chemical addition scenarios.
Examples Slinger, WI

- PAC Addition w/ Polymer
- PAC Addition
- PAC Addition + PAC w/ Polymer at Splitter Box
- PAC Addition + PAC at Splitter Box

Effluent Total Phosphorus (mg/L)
EXAMPLES HARTFORD, WI

- Orbal Facility, ADF = 2.2 MG
- Disc Aerator VFDs added
- Removed Outer Discs
- Changed Control Settings
  - Save $30,000/Yr.
- Installed ORP Probe
- Changed Coagulant
- Influent
  - BOD – 130 mg/L
  - TP – 7-8 mg/L
Examples Hartford, WI

Chart showing influent phosphorus concentration (mg/L) from 8/21/2014 to 4/21/2015, with data points for total phosphorus (blue diamonds) and ortho-P (red squares).
EXAMPLES Hartford, WI

Effluent Solids Conc. (mg/L)

Effluent Phosphorus Conc. (mg/L)

- Total Phosphorus
- Ortho-P
- Future Limit
- Total Suspended Solids
Examples Hartford, WI

Ortho Phosphorus Concentration (mg/L)

- Influent
- Outer Channel
- Middle Channel
EXAMPLES Silver Lake SD, WI

- Orbal Facility, ADF 300,000 gallons
- Reduced O Delivery to Outer Channel
- Confirmed Shift of N –DN from Outer to Middle
- Eff TP = 0.25 mg/L, w/o Chemical
- UW Madison Research
  - PAO P cells
    - High at Inner Channel
    - Low at Outer Channel

Source: Evoqua Water Technologies
EXAMPLES McMinnville, OR

- Orbal Facility, ADF = 3.1 MG
- Reduced O Delivery to Outer Channel
  - Similar to Hartford, WI
- Eff TP = 0.2 mg/L, w/o Chemical
- Eff TP = <0.07 mg/L, w/ Alum
- VFAs Not High in Outer Channel
  - Extended HRT

Source: Evoqua Water Technologies
Summary

- Enhancements
  - ORP
  - Removing Outer Discs
  - Optimized Controls
  - VFDs
  - Energy Savings
- True Anaerobic Conditions Not Necessary
- N and Bio P Tradeoff
Acknowledgements

- Village of Slinger
- City of Hartford
- Evoqua Water Technologies
QUESTIONS

DAVID ARNOTT
PHONE: 262.542.5733
EMAIL: darnott@ruekert-mielke.com

MARK VAN WEELDEN
PHONE: 262.542.5733
EMAIL: mvanweelden@ruekert-mielke.com