Background

• Testing conducted at the Ridgewood Estates WWTP – Milford, Michigan
• Test Period: Nine months (October – June)
• Testing Program: Physical/Chemical Phosphorus Removal through a Membrane Bioreactor (MBR) System. Reduction of nitrogen compounds and Bio-P (attempted)
Pilot Plant Objectives

• Show capability of MBR system to reduced effluent TP to < 0.03 mg/l
• Demonstrate ability of system to removed conventional pollutants including nitrogen species
• Demonstrate long-term system operation with little or no maintenance
• Produce design information regarding sustainable flux at varying MLSS concentrations and waste temperatures
Membrane Bioreactor (MBR)

- High Quality Effluent
- Small Footprint
- Simple to Operate
Membrane Bioreactors

Modification of the traditional activated sludge process
Combine aeration, clarification and filtration into a single step (reduced footprint)
Process and System Overview

- Automatic 3-mm fine screen
- Anoxic (AX) Basin
- Pre-Aeration (PA) Basin
- Membrane Bioreactor (MBR) Basin
Pilot Study Process Configuration

AX Zone → P1 → PA Zone → MBR

Feed → Recycle → Permeate
Pilot Study Process Configuration (Alternate – Phase 2)
MBR System
Anoxic (AX) Basin
Pre-Aeration Basin
MBR with Submerged Membrane Unit
Flat-Plate Membrane Structure
The Submerged Membrane Unit (SMU)
CIP Cartridge Distribution

- Cleaning takes approximately 2-4 hour / MBR basin, using a dilute solution of 0.5% Sodium Hypochlorite or Citric Acid
- In-situ cleaning of membranes without draining MLSS
- Chlorine dosage less than that typically used for filamentous microorganism control
- No tank liners required
# Wastewater Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Unit</th>
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<tr>
<td>CBOD5</td>
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<td>1095.0</td>
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<tr>
<td>NH3</td>
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<td>15.5</td>
<td>52.8</td>
<td>mg/l</td>
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<tr>
<td>T-P</td>
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<td>626.5</td>
<td>147.5</td>
<td>1970.0</td>
<td>mg/l</td>
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</table>

Note: Flow to pilot plant set at 1.5 gpm (2,160 gpd)
Testing Program - Phosphorus

• Data collected over a four month period
• Two alum dosing rates tested (1 gpd / 2 gpd)
• Effluent TP rise at 1 gpd alum
• Average effluent TP < 0.03 mg/l
• 43 effluent samples
• TP less than detectable in 28% of samples
• No SA conducted on optimal dose or point
Impact of Chemical Addition Location on Phosphorus Removal

Chemical addition point affects Al/P ratio

(Stensel, 2003)
Pilot Operating Conditions & Results

• MLSS
• Temperature
• Effluent BOD
• Effluent Nitrogen
• Effluent Phosphorus
Operational Overview

• MLSS: 6,940 – 26,180 mg/l
• Temperature: 6.2 – 15.8 degrees C
• HRT: 21 hours
• SRT: 57 days
• F:M 0.03 1/day or less
Effluent Overview

- **Effluent TSS**: 2.5 mg/l (ave)
- **Effluent BOD**: 16.8 mg/l (Phase 1), 5.4 mg/l (Phase 2)*
- **Effluent N**: 11.4 mg/l NH3-N (Phase 1), 0.3 mg/l NH3-N (Phase 2)*
  - 13.6 mg/l TIN (Phase 1), 2.6 mg/l TIN (Phase 2)*
- **Effluent P**: 0.05 mg/l (all data points)
  - 0.03 mg/l (at optimal dosage)

*Phase 2 included increased blower speed for full nitrification and increased recycle of nitrates back to AX*
MBR MLSS Concentration Profile
Recorded Water (Sludge) Temperatures
Permeate BOD Profile
Permeate Nitrogen Profile

![Graph showing nitrogen profile over time with markers for EFF TIN, INF TIN, and EFF NH3 concentrations. The x-axis represents dates from 10/14 to 7/7, and the y-axis represents concentration in mg/l. The graph includes a vertical line indicating the transition to Phase 2.]

1/11/2013
Phosphorus Trending

![Phosphorus Trending Graph](image-url)
Membrane Performance

• Sustained Flux: 10 gfd
• Excellent results despite variable MLSS and low T
• Transmembrane Pressure (TMP):
  • 0.4 – 0.6 psi (ave)
  • 1.6 – 1.8 psi (peak)
• Permeability:  42 gfd/psi (ave) during both phases
• Membrane Maintenance:
  • No irreversible or permanent fouling detected
  • Only one clean-in-place (CIP) procedure in 9 months
  • 3-hour cleaning period using 0.5% bleach solution
Conclusions

• Show capability of MBR system to reduced effluent TP to < 0.03 mg/l. **YES**
• Demonstrate ability of system to removed conventional pollutants including nitrogen species. **YES (somewhat)**
• Demonstrate long-term system operation with little or no maintenance **YES**
• Produce design information regarding sustainable flux at varying MLSS concentrations and waste temperatures **YES**
Thank You