EBMUD Anammox Pilot Test Results

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BACWA Annual Member Meeting
January 30, 2015
Outline

• Background
• Anammox Pilot Testing
• Next Steps
• Acknowledgements
EBMUD Wastewater Service Area

- Serves 650,000 people
- Includes seven “satellite” communities
- Covers 88 square miles
- Main Wastewater Treatment Plant (MWWTP): dry weather flow ~50 mgd
Background
Sidestream at EBMUD MWWTP

Centrate Return

- ~1.2% of Plant Flow
- Typical WWTPs: 15-25% Plant N Load
- Temperature (>30 ºC)
- Insufficient Alkalinity and Carbon for Nitrification/Denitrification
**Background**

**Benefits**

Benefits:
- Compact process
- ~60% oxygen savings
- 75-85% total nitrogen removal without chemical addition
- 80% reduction in biomass production
Anammox Pilot Testing

Goals

• Evaluate feasibility of using anammox to treat EBMUD centrate
  - EBMUD centrate: approximately 2,000 mg N/L
  - Typical for other WWTPs: 800 – 1,500 mg N/L

• Determine feasibility of growing anammox bacteria from activated sludge

• Conduct a side-by-side evaluation of attached- versus suspended-growth anammox technologies

Photo courtesy of ANITA™ Mox by Krüger

Photo courtesy of DEMON® by WWW
Anammox Pilot Testing

Set Up

Reactor 1: Suspended-growth
(260-gallon sequencing batch reactor)

Reactor 2: Attached-growth
(260-gallon moving bed biofilm reactor)
**Anammox Pilot Testing**

**Start Up**

**Reactor 1: Suspended-growth**
(Started in June for nitritation first, then July 2013 for anammox with 1-gal anammox seed from HRSD)

Added 1-gal anammox seed to 260-gallon reactor (0.4%)

**Reactor 2: Attached-growth**
(Started in September 2013, with NO anammox seed)
### Anammox Pilot Testing

#### Data Collection

<table>
<thead>
<tr>
<th>Variables</th>
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<tbody>
<tr>
<td><strong>Key sidestream characteristics</strong></td>
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<tr>
<td>Ammonia-N concentration</td>
</tr>
<tr>
<td>Alkalinity/N ratio</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
<tr>
<td>Total and soluble COD</td>
</tr>
<tr>
<td>TSS</td>
</tr>
<tr>
<td><strong>Process control strategy</strong></td>
</tr>
<tr>
<td>pH range</td>
</tr>
<tr>
<td>DO range</td>
</tr>
<tr>
<td>Temperature</td>
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<tr>
<td><strong>Process performance</strong></td>
</tr>
<tr>
<td>Specific ammonia loading rate</td>
</tr>
<tr>
<td>Ammonia removal efficiency</td>
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<tr>
<td>Inorganic nitrogen removal efficiency</td>
</tr>
<tr>
<td>Process stability</td>
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<tr>
<td>Energy consumption</td>
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</tbody>
</table>

Inorganic Nitrogen: sum of $\text{NH}_4^+$, $\text{NO}_2^-$, and $\text{NO}_3^-$. 


Anammox Pilot Testing

Results (15 months from June 2013 – September 2014)

• Anammox bacteria grew well on EBMUD centrate, prior to the process upset

• Anammox bacteria could be grown from nitrifying activated sludge
  - Reached half of the design loading rate in 6-9 months

• The attached-growth showed advantages over the suspended-growth anammox reactor
  - Allowed a higher ammonia loading rate in a shorter time
• Anammox bacteria appeared vulnerable to sharp loading swings, which resulted in high nitrite levels leading to process upsets
Anammox Pilot Testing
Lessons Learned

- Operating the anammox reactors requires a high level of monitoring and adjustment
- Anammox process is not as resilient as expected

True failure is when you fail and don’t learn your lesson
Estimated anammox reactor volume would be equivalent to two to three 2-MG digesters to treat EBMUD’s sidestream.
Next Steps

• Work with sister agencies to complete pilot testing of viable sidestream treatment technologies

• Identify and monitor the development of more reliable and cost-effective sidestream treatment technologies

• Conduct sidestream treatment cost & benefits analysis for POTWs
Acknowledgements

• U.S. EPA Region 9 for providing partial funding support for the pilot testing and overseeing a regional Sidestream Nutrient Removal Study
  - EPA Project Managers:
    Terrence Fleming and Luisa Valiela
  - EPA Quality Assurance Manager:
    Joseph Eidelberg

• EBMUD project partners
Questions/Comments

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Backup
Bench and Pilot Testing by POTWs

**EBMUD:**
- Anammox
  - Suspended growth
  - Attached growth

**SFPUC:**
- Anammox
  - Suspended growth
  - Attached growth
  - Zeolite

**DD:** CANDO

**OLSD:** Zeolite anammox

**USD:** Krüger ANITA™ Mox
# Anammox Design Considerations

<table>
<thead>
<tr>
<th>ANITA™ Mox Influent</th>
<th>Optimal</th>
<th>Possible</th>
<th>Challenging</th>
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</thead>
<tbody>
<tr>
<td>Temperature, °C</td>
<td>20-35</td>
<td>15-20</td>
<td>&lt;15 or &gt;35</td>
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<tr>
<td>Ammonia-N, mg/L</td>
<td>200-2,000</td>
<td>50-200</td>
<td>&lt;50 or &gt;2,000</td>
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<td>sbCOD/N ratio</td>
<td>&lt;0.5</td>
<td>0.5-1.0</td>
<td>&gt;1.0</td>
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<tr>
<td>TSS, mg/L</td>
<td>&lt;1,000</td>
<td>1,000-2,000</td>
<td>&gt;2,000</td>
</tr>
<tr>
<td>Alkalinity, mg/L CaCO₃: NH₄-N, mg/L</td>
<td>&gt;5</td>
<td>4-5</td>
<td>&lt;4</td>
</tr>
</tbody>
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Source: Krüger vendor