Recent Developments in the Removal of Phosphorus from the Solids Stream

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Why Remove Phosphorus from Solids Stream?

- Phosphorus Recycle Control
- Biosolids Dewatering
- Struvite Reduction
- Phosphorus Index
- Product Recovery
Dewatering

Struvite: Magnesium Ammonium Phosphate (MAP) 

\((\text{NH}_4\text{MgPO}_4 \cdot 6\text{H}_2\text{O})\)

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**Post-Digestion Pre-Dewatering Phosphorus Recovery**

**Feed Sludge** → **Anaerobic Digestion** → **AirPrex® Struvite Precipitation** → **Dewatering** → **Return Liquor**

**Struvite Recovery** → **Biosolids Cake**

**Mg**

**Polymer**

Struvite: Magnesium Ammonium Phosphate (MAP)

\((\text{NH}_4\text{MgPO}_4 \cdot 6\text{H}_2\text{O})\)
How Air Prex® Works

Digester effluent is fed to AirPrex reactor
Reactor is aerated which strips the CO₂ from the reactor and raises the pH
Magnesium is dosed to the reactor causing struvite to precipitate
AirPrex effluent, stripped of phosphorus, is sent to dewatering centrifuges

Anaerobic Digestion

Struvite settles and is pumped out and cleaned

CO₂

Mg

Biosolids

Centrate

Struvite
Operations and Testing at Denver Metro

• Pilot unit onsite for two months (2016)
• Reactor operation at flow of 11 gpm
• Mg:P molar dosing in range 0.7:1 to 1.7:1
• Dewatering centrifuge operated 6-8 hours a day
• ~3,000 water and solids samples analyzed
• Thermodynamic modeling to estimate nuisance struvite formation before/after AirPrex® reactor
• Biowin modeling – effects of P recycle
• OP and TP were observed to decrease in the centrate as the Mg:P molar dosing ratio increased to 1.4:1
• At 1.7:1 Mg:P molar ratio, OP was lowest, while TP increased – potentially due to fines loss

Source: Denver Metro
• Reducing recycle soluble phosphorus concentrations from 400 mg P/L to 30 mg P/L would result in a decrease in secondary effluent OP.

Source: Denver Metro
Dewaterability Impacts

• Cost Centers:
  
  $ Polymer consumption
  $ Wet mass of biosolids for hauling and dispersal

• Tracked cake total solids and polymer consumption
  
  • Polymer dose varied in 5 active pound/dry ton increments
  • Higher average centrifuge hydraulic pressures for AirPrex® treated digested biosolids

Source: Denver Metro
Solids Correction – Dry Mass

- Fraction of struvite in biosolids matrix - $f_b \sim 80\%$
- Fraction of struvite fines in centrate - $f_c \sim 0\%$
- Fraction of struvite that settles and is pumped out as product - $f_p \sim 20\%$

$\text{NH}_4\text{MgPO}_4\cdot 6\text{H}_2\text{O Generated in AirPrex}$

Total solids = $\Delta OP \times \left( \frac{MW_{\text{struvite}}}{MW_p} \right)$

$f_p + f_c + f_b = 1$

Source: Denver Metro
AirPrex® – Dewaterability

- 20 data points analyzed
- 8.7% reduction in wet tons hauled
- 17.6% decrease in polymer consumption
Biosolids Dewatering Cost Impacts

- 8.7% reduction of biosolids hauled

Untreated Biosolids
21 Hauled Truckloads

After AirPrex Treatment
19 Hauled Truckloads

Difference of 2 truckloads per day or 730 truckloads per year!

- Approximately 15–20% decrease in polymer use

Source: Denver Metro
Significant reduction of struvite mass predicted between untreated and AirPrex® treated

Source: Denver Metro
### AirPrex® Pilot Testing Results

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phosphorus Recycle Control</strong></td>
<td>Reliable OP and TP Reduction</td>
</tr>
<tr>
<td><strong>Polymer</strong></td>
<td>~17% polymer reduction</td>
</tr>
<tr>
<td><strong>Biosolids Dewaterability</strong></td>
<td>~8.7% reduction hauled mass</td>
</tr>
<tr>
<td><strong>Truck Hauls</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Digesters</strong></td>
<td>~25% reduction digester struvite</td>
</tr>
<tr>
<td><strong>Struvite Reduction</strong></td>
<td>Significant reduction in dewatering nuisance struvite</td>
</tr>
<tr>
<td><strong>Dewatering</strong></td>
<td>Accumulation of phosphorus in biosolids</td>
</tr>
<tr>
<td><strong>Phosphorus Index</strong></td>
<td>Low recovery of product</td>
</tr>
<tr>
<td><strong>Product Recovery</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Denver Metro
Conclusion

• Testing Essential to Estimate Performance
• Questions?