AirPrex™: Biosolids Treatment Optimization Process with the option of Phosphate Recovery

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President, CNP – Water and Biosolids Corp.
Contents

• Biological Phosphate-Removal

• Influence of Phosphate on
  Magnesium-Ammonium-Phosphate (MAP/ Struvite) crystallization
  Sludge properties / Sludge dewatering
  P- Recovery

• Phosphate precipitation as Struvite with AirPrex®

• AirPrex™- Installations → References

• Use of Struvite

• AirPrex® demonstration unit

• Summary and Outlook
Phosphorus flows and concentrations in WWTPs

**Inlet**
100 % ~ 1.80 g P/(E*d)

**Outlet**
10 % ~ 0.18 g P/(E*d)

**Primary Sludge**
10 % ~ 0.18 g P/(E*d)

**WAS**
80 % ~ 1.45 g P/(E*d)

WAS is main carrier for phosphate

Quelle: UBA, 2007
Negative Impacts of Bio-P

- Internal recycling of ortho-phosphate (PO$_4$-P)
- Uncontrolled Struvite crystallization and deposits
- Negative influence on sludge dewatering (lower DS and / or higher Polymer usage)
Influence of Ortho-Phosphates on the water absorption capacities of digested sludge

Water absorption by hydrogels (EPS) - Stabilisation due to phosphates and increased pH values

Consequence:
Increased water absorption capacity and therefore decreasing sludge dewatering efficiency → lower cake solids and higher polymer consumption
PO₄-P concentration and dewatering

![Graph showing the relationship between PO₄-P content in the sludge water (mg/l) and DS discharge decanter (%)]

**PO₄-P Content in the Sludge Water [mg/l]**

**DS Discharge Decanter [%]**

- X-axis: PO₄-P Content in the Sludge Water [mg/l]
- Y-axis: DS Discharge Decanter [%]
Uncontrolled Struvite precipitations
Formation of Struvite (MAP)

Chemical equation:

\[
\text{Mg}^{2+} + \text{NH}_4^+ + \text{HPO}_4^{2-} + 6\text{H}_2\text{O} = \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O} + \text{H}^+
\]

<table>
<thead>
<tr>
<th>Molar weights [g/mol]: Struvite: 245</th>
<th>Mg</th>
<th>NH₄</th>
<th>PO₄</th>
<th>6 H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.3</td>
<td>18.0</td>
<td>95.0</td>
<td>108.0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Share in per cent [%]:</th>
<th>9.9</th>
<th>7.3</th>
<th>39.0</th>
<th>43.8</th>
</tr>
</thead>
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Share in per cent [%]:
- Mg: 9.9
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- 6 H₂O: 43.8
Struvite Crystallisation
Relation P- content and pH

\[ \text{Mg}^{2+} + \text{NH}_4^+ + \text{H}_2\text{PO}_4^- + 6\text{H}_2\text{O} = \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O} + 2\text{H}^+ \]

- \( \text{Mg}^{2+} : 40 \text{ mg/L} \)
- \( \text{HCO}_3^- : 2500 \text{ mg/L} \)

Graph showing the Struvite precipitation area and \( \text{Mg}^{2+} \) in solution
Possible areas for P-recovery

Areas for recovery:
1. Sludge
2. Sludge liquor
3. Sludge ash

Diagram shows:
- Inlet
- Grit chamber
- Primary Clarification
- Aeration
- Secondary Clarification
- Effluent
- Returned WAS
- Biological Phosphate Removal (Bio-P)
- Process water
- Biogas
- Digester
- Release of Ortho-P
- Dewatering
- Incineration
## Pros and Cons of different P-Recovery processes

<table>
<thead>
<tr>
<th></th>
<th>Sludge recovery (AirPrex™)</th>
<th>Sludge water recovery</th>
<th>Ash recovery</th>
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<tbody>
<tr>
<td>Phosphate product</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>(quantity)</td>
<td></td>
<td></td>
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<tr>
<td>(quality)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Interruption of P-recycling</td>
<td>+</td>
<td>+</td>
<td>X</td>
</tr>
<tr>
<td>(internal)</td>
<td></td>
<td></td>
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<tr>
<td>Prevention of scaling</td>
<td>+</td>
<td>X</td>
<td>X</td>
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<td>in pipes and pumps</td>
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<tr>
<td>Optimization of the</td>
<td>+</td>
<td>X</td>
<td>X</td>
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<tr>
<td>dewatering process</td>
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Integration of the AirPrex™- Process

- Raw sludge
- Biogas
- Sludge tank
- Magnesium salt
- Air stripping
- Struvite
- Dewatering
AirPrex®- Process Overview

1. Aeration to strip CO\textsubscript{2} out + recirculate sludge
2. Addition of Magnesium Chloride (MgCl\textsubscript{2})
3. MAP - Crystallisation and sedimentation
4. MAP - Separation and washing
Why AirPrex™?

- Optimization of the sludge dewatering process
- Elimination of unwanted Struvite-crystallization
- Secondary objective: Struvite-Production

- The method is chosen to optimize the overall dewatering process
Cost-Benefit Analysis

A. Bio P only: 4,095,000 $ p.a.
B. Bio P + Struvite precipitation: 3,510,000 $ p.a.

Savings/year, just by improving the dewatering rate (Basis: cost for sludge disposal= 60 $/t)
AirPrex™ - Process ➔
The ideal location for maximum savings
AirPrex™ - Berlin-Wassmannsdorf (Germany)

Berliner Wasserbetriebe (BWB), Germany
Berlin-Wassmannsdorf WWTP (120 MGD)

Capacity AirPrex™: 367 GPM digested sludge
Struvite production: 5,000 lbs/d
Start-up: 2009
Problem: uncontrolled Struvite precipitation
AirPrex™ - Berlin-Wassmannsdorf

Struvite as bulk delivery

Struvite packaged for sale to public
AirPrex™ - Moenchengladbach (Germany)

Niersverband, Germany
MG-Neuwerk WWTP (80 MGD)

Capacity AirPrex™: 275 GPM digested sludge
Struvite production: 3,000 lbs/d
Start-up: 2009
AirPrex™ - Moenchengladbach

Quelle: Niersverband
AirPrex™- Echten WWTP (Netherlands)

Reest & Wieden, NL
Echten WWTP (30 MGD)

Capacity AirPrex™: 75 GPM digested sludge
Struvite production: 1,000 lbs/d
Start-up: 2011
AirPrex™ - Amsterdam WWTP (Netherlands)

Waternet, NL
Amsterdam-West WWTP (170 MGD)

Capacity AirPrex™: 460 GPM digested sludge
Struvite production: 10,000 lbs/d
Start-up: 03/2014
Use of Struvite

• Struvite:
  By-product with a good use as a fertilizer
• Nutrients have been proven in accordance with the German law (certified as fertilizer)
  → low heavy-metal content
  → slow release of nutrients (no wash-away effect)
Summary and Outlook

• The specific phosphate precipitation by Struvite crystallization (AirPrex™) leads to the following advantages
  • Minimize the crystallization potential
  • Positive impact on the sludge dewatering by a constant P-Elimination rate between 90 and 95%
  • AirPrex™ is an approved and reliable technology with large-scale references
  • Good quality fertilizer as a by-product

• AirPrex™ in combination with hydrolysis and the separate digestion of WAS opens the door for more optimization on c n p - processes
Thermal-Chemical Hydrolysis Process (TCHP) PONDUS, Kenosha, WI
Thank you for your attention and interest!

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