Long Term Treatment Performance of High Efficiency Sidestream Phosphorus Removal/Recovery System

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We are Worldwide Experts in Water Treatment

The innovation, commitment and experience Ovivo brings to the water and wastewater community is what makes us the Worldwide Experts in Water Treatment. Our tagline also reflects our higher purpose: to guide the future of the water treatment industry while helping the true value of water be understood in everyday life.
Topics

• **Opportunity**
• Solution
• Data and Case Studies
• Conclusions and Q&A
Typical Activated Sludge Process

Primary Clarifier → Biological Reactor → Secondary Clarifier

Influent → Primary Sludge → Biosolids Treatment → TWAS → Thickener

Primary Sludge → RAS → WAS

Effluent → Dewatering
Biosolids Optimization Options

Primary Solids

TWAS

Pre-Treatment

Anaerobic Digestion

Dewatering

Biosolids

Effluent

TWAS Biosolids (Optional)
Biosolids Management Optimization Options (Anaerobic)

Primary Solids

Pre-Treatment
- LysoTherm
- BioAlgaNyx™

Digestion
- Mixing (LM / DT)
- Gas Storage
- Covers

Post-Treatment
- DigestivorePAD™
- LysoTherm
- EloPhos

Sidestream
- AnammoPAQ™
- PhosPAQ™

Dewatering

TWAS

Biosolids

(Optional)

Primary Solids
Biosolids Management Optimization Options (Aerobic)

Primary Solids

Pre-Treatment
- BioAlgaNyx™

TWAS

Digestion
- G-TAD
- M-TAD
- Mem-TAD
- Covers

Dewatering

Biosolids
<table>
<thead>
<tr>
<th>Pre-Treatment</th>
<th>Equipment Supply</th>
<th>Thickened Aerobic Process</th>
<th>Post Treatment</th>
<th>SideStream Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Anaerobic</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Higher VSR (Less Solids)</td>
<td>X, X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Higher Gas Production</td>
<td>X, X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Better Mixing</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>More Gas Storage</td>
<td></td>
<td></td>
<td></td>
<td>X, X</td>
</tr>
<tr>
<td>New Cover</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Struvite Issues</td>
<td></td>
<td></td>
<td></td>
<td>X, X</td>
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<tr>
<td>Nitrogen Removal</td>
<td></td>
<td></td>
<td></td>
<td>X, X</td>
</tr>
<tr>
<td>Phosphorus Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better Dewatering</td>
<td>X, X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickened Aerobic Digestion</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- BioAlgaNyx®
- LysoTherm®
- LM™ Mixer
- Eimix® Mixer
- Ultrastore™ Gasholder
- Steel Covers
- Airbeam Cover
- G-TAD
- M-TAD
- Mem-TAD
- DigestivorePAD™
- EloPhos
- AnamoPAD™
- PhosPAD

**Equipment Supply**
- G-TAD
- M-TAD
- Mem-TAD
- DigestivorePAD™
- EloPhos
- AnamoPAD™
- PhosPAD

**Pre-Treatment**
- Aerobic
- Anaerobic
- Higher VSR (Less Solids)
- Higher Gas Production
- Better Mixing
- More Gas Storage
- New Cover
- Struvite Issues
- Nitrogen Removal
- Phosphorus Removal
- Better Dewatering

**Thickened Aerobic Process**
- Post Treatment
- SideStream Treatment

**Thickened Aerobic Digestion**

**Post Treatment**

**SideStream Treatment**
- G-TAD
- M-TAD
- Mem-TAD
- DigestivorePAD™
- EloPhos
- AnamoPAD™
- PhosPAD
Potential of Resource Recovery in WWTP
‘Resource factory’

- Sewage
- Industrial Effluent
- Sludge reject liquor

1. Primary Clarification
2. Activated Sludge Process
3. Secondary Clarification

- Sludge Hydrolysis
- Anaerobic Digestion
- Sludge Dewatering
- Phosphaq™ MAP Reactor
- Anammox Reactor

- Biopaq® UASB
- Thiopaq® Scrubber

- Anaerobic Biomass
- Biogas Energy
- Biogas Energy
- Sulfur fertiliser
- Biosolids fertiliser
- MAP fertiliser
- Anammox Biomass

- Low Nutrient Low BOD Reject Liquor
- Savings on: Energy, Sludge, Chemicals, CAPEX
Biosolids Optimization Options

Primary Solids

TWAS → Pre-Treatment → Anaerobic Digestion → Dewatering → Biosolids

Optional line:

TWAS → Pre-Treatment

Effluent:

Pre-Treatment → Sidestream Treatment → Effluent

TWAS Biosolids (Optional)
Impetus for Sidestream Treatment

- Anaerobic digester sidestream
  - 1,000+ ppm Ammonia-N
  - 100+ ppm PO4-P
- THP could significantly increase the Ammonia and TP levels
- Sidestream can add 10-30% load (N&P) on main stream
  - ~1% to 3% flow of Q
- Nite/Denite requires energy + C
- Nuisance struvite scaling
The A Team
STATE OF THE ART TECHNOLOGY delivered by WORLDCLASS EXPERT IN WATER TECHNOLOGY

Municipal Deammonification and Phosphorus Removal/Recovery - AnammoPAQ™ and PhosPAQ™

- Phosphorus Removal
- Anaerobic Treatment (ANAMMOX, BioPAQ etc.)
- Desulphurization
- Aerobic Treatment
- UBOX AD/Aerobic
- Filtration

- Anaerobic Digestion
- Aerobic Digestion
- MBR
- Headworks
- Sedimentation
- Carrousel

Ovivo is the exclusive licensee of the Paques PHOSPAQ™ system in North America
Phospaq™ - Why and Where?

Why Phospaq™?
• Recovery of P (as phosphate will become scarce)
• Meeting P consent levels by WWTPs
• Cost-effective compared to alternatives, e.g. dosing of iron salts
• Struvite is an excellent slow release fertilizer: N/P/Mg
• Pre-treatment for deammonification process

Applications:
• Food industry
• Starch processing plant
• Distilleries
• Biosolids Reject water treatment
Topics

• Opportunity
• Solution
• Data and Case Studies
• Conclusions and Q&A
PHOSPAQ™ Reactor

- Continuously aerated single tank
- Controlled formation of coarse struvite crystals
- Compact installations (small footprint)
- Automated Control
PHOSPAQ™ - Process

\[ \text{MgO} + \text{NH}_4^+ + \text{PO}_4^{2-} \rightarrow \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O} \ [\text{Struvite}] \]
PHOSPAQ™ - Functions

• Removal of PO4-P

• Production of Slow release fertilizer (Strivite MgNH₄PO₄)

• Prevention of down stream scaling

• Removal of inhibiting compounds in THP reject

• Increase alkalinity by adding Mg(OH)₂
PHOSPAQ™ reactor

Aerated reactor
Advanced Separation system

\[ \text{MgNH}_4\text{PO}_4 \cdot 6 \text{H}_2\text{O} \]

\[ \text{NH}_4^+ \text{ PO}_4^{3-} \text{ BOD} \]

\[ \text{MgO} \]

\[ \text{Air} \]
PHOSPAQ™ reactor

MgO

CO₂ stripping
Shear-induced crystallization

NH₄⁺ PO₄³⁻ BOD

Coarse bubble aeration

pH

Air

MgNH₄PO₄ · 6 H₂O

MgO

CO₂

CO₂
**PHOSPAQ™ reactor**

The diagram illustrates the process of struvite crystallisation. The reactor contains solutions of 

- **NH₄⁺** (ammonium ion) and **PO₄³⁻** (phosphate ion)
- **Mg²⁺** (magnesium ion)

These ions react to form struvite (MgNH₄PO₄·6H₂O) crystals. Oxygen (Air) is also introduced to aid in the crystallisation process.

**Chemical Reaction:**

- **MgO** is added as a catalyst.
- The ions react as follows:
  
  \[
  \text{Mg}^2+ + \text{NH}_4^+ + 3\text{PO}_4^{3-} \rightarrow \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}
  \]

**Process Description:**

1. 
   
   - **NH₄⁺** and **PO₄³⁻** ions are fed into the reactor.
   - 
   - **Mg²⁺** ions are added as needed.
   - 
   - Oxygen (Air) is introduced for catalytic purposes.

2. 
   
   - The ions react to form struvite crystals.
   - The crystals are precipitated out of the solution.

3. 
   
   - The crystals are collected and processed.

**Diagram Elements:**

- **PHOSPAQ™ reactor** container
- **MgO** addition arrow
- **NH₄⁺** and **PO₄³⁻** input arrows
- **Mg²⁺** input arrow
- **Air** addition arrow
- **MgNH₄PO₄·6H₂O** crystal formation

**Struvite Crystallisation**

The process is referred to as **Struvite Crystallisation**.
PHOSPAQ™ reactor

Crystal formation
Crystal growth
Settling and removal of big crystals

Air Struvite removal

MgO

MgNH₄PO₄ · 6 H₂O

NH₄⁺ PO₄³⁻ BOD

Air

Struvite removal
Topics

• Opportunity
• Solution

• **Data and Case Studies**
• Conclusions and Q&A
Full-scale case studies

**Lomm, NL**
- 125 kg PO$_4$-P per day
- Wastewater from potato factory
- UASB - Phosphaq™
- 300 m$^3$ reactor

**Olburgen, NL**
- 200 kg PO$_4$-P per day
- Biosolids reject water and Wastewater from potato factory
- UASB - Phosphaq™ - AnammoPAQ™
- 2$\times$300m$^3$ reactors
PHOSPAQ™ Lomm

UASB  
Food processing  

Biogas

PHOSPAQ

MAP
PHOSPAQ™ Lomm

PO$_4$-P concentrations

Influent — Effluent

$\text{PO}_4$-P (mg/L) vs. time (days)
# PHOSPAQ™ Lomm

- Struvite 720 kg/d
- 75% recovery of PO$_4$-P

<table>
<thead>
<tr>
<th></th>
<th>year 1</th>
<th>year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent load (kg P/d)</td>
<td>125</td>
<td>113</td>
</tr>
<tr>
<td>Recovered struvite (kg P/d)</td>
<td>94</td>
<td>85</td>
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</table>
PHOSPAQ™ - ANAMM0PAQ™ Olburgen

UASB
Trade liquor

DIGESTER
Biosolids

PHOSPAQ

ANAMMOX

Biogas

MAP
PHOSPAQ™

Recovery of phosphorus by formation of MAP (struvite)

\[
\text{MgO}_{aq} + \text{NH}_4^+ + \text{PO}_4^{-} \rightarrow \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O} \quad [\text{MAP}]
\]

Slow release fertiliser
P Removal

PO4-P Concentrations (mg/l) and PO4-P Removal (%)

- P-Influent
- P-Effluent
- P-Removal

ANAMMOPAQ™

Olburgen, NL
N Removal

Ammonia-N Concentrations (mg/l) and Ammonia-N Removal (%)

- Nkj-Influent
- Nkj-Eff
- 7 per. Mov. Avg. (Nkj-Removal)
PHOSPAQ™ - ANAMMOPAQ™ Olburgen

- Struvite 1,200 kg/d
- 82% recovery of PO$_4$-P
- 92% removal of NH$_4$-N

<table>
<thead>
<tr>
<th>Influent load</th>
<th>year 1</th>
<th>year 2</th>
<th>year 3</th>
<th>year 4</th>
<th>year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (kg/d)</td>
<td>162</td>
<td>184</td>
<td>196</td>
<td>191</td>
<td>182</td>
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<tr>
<td>Recovered P (kg/d)</td>
<td>84</td>
<td>133</td>
<td>149</td>
<td>155</td>
<td>148</td>
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</table>
Collected struvite dewatered

Dry matter up to 70% after drying during storage
Struvite quality

- Average crystals size of 0.7 mm
- Field crop tests by DLV Plant institute
- Tested on potatoes, carrots, sprouts
- Equal performance to existing P fertilizers
- Now sold to fertilizer company
- Complies to EU fertilizer requirements

<table>
<thead>
<tr>
<th></th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Hg</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
<th>As</th>
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</thead>
<tbody>
<tr>
<td>EU standard (mg/kg P)</td>
<td>31</td>
<td>1875</td>
<td>1875</td>
<td>19</td>
<td>750</td>
<td>2500</td>
<td>7500</td>
<td>375</td>
</tr>
<tr>
<td>struvite product (mg/kg P)</td>
<td>0.9</td>
<td>17</td>
<td>42</td>
<td>&lt;0.3</td>
<td>26</td>
<td>6.6</td>
<td>336</td>
<td>&lt;6</td>
</tr>
<tr>
<td>Content compared to EU standard</td>
<td>3%</td>
<td>1%</td>
<td>2%</td>
<td>&lt;2%</td>
<td>3%</td>
<td>&lt;1%</td>
<td>4%</td>
<td>&lt;2%</td>
</tr>
</tbody>
</table>
New Projects - 2013

Severn Trent, UK
550 kg PO₄-P per day
Biosolids reject water and trade liquor
UASB - Phospaq™ - AnammoPAQ™

De Dommel, NL
110 kg PO₄-P per day
THP treated Biosolids reject water
THP - CSTR - Phospaq™ - AnammoPAQ™
Severn Trent - UK

- Municipal reject water and industrial trade liquor

1. Maximising recovery of methane from COD

2. Recovery of phosphorus on Biosolids Centrate

3. AnammoPAQ™ removal of remaining ammoniacal nitrogen
De Dommel, NL

- Biosolids reject water after THP (Cambi)

1. Phospaq reactor for **phosphorus** and **BOD removal**

2. AnammoPAQ™ for **ammoniacal nitrogen** removal
De Dommel
Topics

• Opportunity
• Solution
• Data and Case Studies
• Conclusions and Q&A
Conclusions

• PHOSPAQ™ is an effective method to recover phosphorus

• Proven reliable performance backed-up by long-term experience

• Recovered struvite meets EU fertiliser requirements and is currently used as a fertiliser

• Combining PHOSPAQ™ & ANAMMOPAQ™ is an efficient way to recover phosphorus and remove ammoniacal nitrogen
In Case of Questions Please Contact

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