Struvite - a technique for P recovery

Malmö October 28, 2016
Gunnar Thelin
EkoBalans in brief

- Sustainable solutions for the recycling of plant nutrients from wastewater treatment, biogas production, and food industry
- Recycled nutrients are refined into high quality fertilizers and returned to agriculture or other plant production
- EkoBalans solutions are based on research on plant nutrition, nutrient balances in cropping systems, and nutrient recycling at Lund University

_EkoBalans combines qualified expertise in plant ecology, chemical engineering, agriculture and forestry_
Today's handling of plants nutrients and organic residues is largely unsustainable and inefficient:
One-way high-consumption of finite resources, lack of recycling, and eutrophication of soil and water.
Our goal

Agriculture
  ➔
Agricultural waste
  ➔
Food waste
  ➔
Sewage sludge

Sustainable nutrient recycling

EKO BALANS PROCESS

Biogas production
  ➔
Dewatering
  ➔
Phosphorus extraction
  ➔
Nitrogen extraction
  ➔
Recycled fertilizer products

Biochar
  ➔
Pyrolysis
  ➔
Drying

Overdosing in agriculture

Ocean biogas production

Dewatering
EkoBalans’ technologies

- Phosphorus extraction as struvite
- Short retention time and high recovery rate = small footprint / low CAPEX

- Nitrogen extraction as solid ammonium sulfate by stripping and crystallization
- Combines existing proven technologies

- Sludge detoxification by pyrolysis
- Cadmium reduced by 90%, pathogens and organic pollutants destroyed
Struvite: $\text{MgNH}_4\text{PO}_4*6\text{H}_2\text{O}$

- 12.6 % P; 5.7 % N; 9.9 % Mg
- Sometimes termed MAP
- **One** mineral - Ca-phosphates many minerals
- Crystalline, non water soluble but highly plant available P
- Specific density: 1.7 kg/dm$^3$
- Good adhesive and settling properties

*Struvite from the eco:P-process*
Most often recognized as this.....
... or as “sand” in digesters

Digester sediment
70 % DS, 12 % LOI

The same sediment after drying
Struvite 70 % of DS
Controlled struvite precipitation – several alternatives

Source

• Directly on digestate, manure etc
• On dewatering reject (centrate, sludge liquor)
• On biosludge dewatering reject before digestion at WWTPs with Bio-P
• After chemical treatment to maximize P release

Technology

• Continuous flow in and out of precipitation tank, build and harvest large crystals
• Batch based system and harvest microcrystals – EkoBalans
The eco:P process

- Dewatering reject
- Aeration = pH↑
- MgCl₂
- Struvite precipitation
- Cleaned reject
- Hydrocyclone separation
- Struvite
**eco:P process data**

- pH 7.5: 80% P reduction, pH 8: >90% P reduction
- Retention time shortened from 60 to 20 min
- Capacity increased from 2 to 5 m³/h with shortened retention time
- pH variation does not affect struvite quality
- pH increase by aeration
- Aeration lowers Mg consumption (less MgCO₃ formation)
- Hydrocyclone: efficient separation
**eco:P struvite**

- Microcrystalline powder
- Spreadable as is or raw material for fertilizer production
- 12.5% P; 5.5% N; 9.5% Mg
- High nutrient plant availability
- Organic content usually <1%
- Cd below detection limit
- Other heavy metals in lower concentrations than in artificial fertilizers

*Struvite from the eco:P-process*
**eco:P characteristics**

- Simple, robust process, not sensitive to variations in pH, works at high and low P concentration
- High phosphorus recovery rate AND short retention time = small footprint
- Microcrystalls = short retention time
- pH increased by aeration, no NaOH
- Cost efficient solution
- Microcrystalls = suitable for mixing with N, K, etc
- Microcrystalls = high plant availability
EkoBalans fertilizer products

- Recycled phosphorus and nitrogen from the eco:P and eco:N processes
- NPK-mix can be customized
- Artificial fertilizer quality
- No contaminants
Struvite precipitation on final sludge dewatering reject at WWTPs with Bio-P

- WW in
  - P 100%
  - Primary sludge: P 15%
  - Digestate
  - Sludge dewatering: P 70%
  - Reject: P 25%
  - Struvite
  - Maximum P extraction: 25% of incoming P

- Return sludge: P 80%
- Surplus sludge: P 5%
- Water out: P 5%
Integrated system: struvite precipitation on biosludge dewatering reject before digestion

- WW in
  - Primary sludge: P 15%
  - Digestate: P 30%
  - Sludge dewatering: P 40%
  - Reject: P 5%
- Digester
- P-release & hydrolysis
  - Return sludge: P 80%
  - Sludge dewatering: P 50%
- Water out: P 5%
- P 100%
- P 5%
- P 55%

Maximum P extraction: >50% of incoming P
### Economy

*Economy at conversion from chemical to biological phosphorus removal and eco:P installation at a 100,000 p.e. WWTP*

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>OPEX struvite extraction</td>
<td>€/yr 15,000</td>
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<tr>
<td>Revenue for sold struvite</td>
<td>€/yr 30,000</td>
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<tr>
<td><strong>Cost reduction</strong></td>
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<tr>
<td>Chemicals</td>
<td>€/yr 130,000</td>
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<tr>
<td>Sludge disposal</td>
<td>€/yr 100,000</td>
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<td>Energy savings</td>
<td>€/yr 70,000</td>
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<tr>
<td>Nitrogen removal</td>
<td>€/yr 55,000</td>
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<tr>
<td><strong>Net improvement</strong></td>
<td>€/yr 370,000</td>
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<tr>
<td>Investment eco:P</td>
<td>€ 900,000</td>
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<tr>
<td><strong>ROI</strong></td>
<td>yrs 2.4</td>
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**Economy**

*Economy when installing eco:P at a WWTP for 100.000 p.e. with biological phosphorus removal*

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (€/yr)</th>
<th>Total Cost (€)</th>
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<tbody>
<tr>
<td>OPEX struvite extraction</td>
<td>15 000</td>
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<tr>
<td><strong>Revenue</strong></td>
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<td></td>
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<tr>
<td>- Sold struvite</td>
<td>30 000</td>
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<tr>
<td>- Increased gas production</td>
<td>70 000</td>
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<tr>
<td><strong>Cost reduction</strong></td>
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<td></td>
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<tr>
<td>- Sludge disposal</td>
<td>80 000</td>
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<tr>
<td>- Less struvite clogging</td>
<td>60 000</td>
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<tr>
<td>- Nitrogen removal</td>
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<td><strong>Net improvement</strong></td>
<td>280 000</td>
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<td>Investment eco:P</td>
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<tr>
<td><strong>ROI</strong></td>
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</tbody>
</table>
What is needed for widespread implementation of sustainable P recycling?

INCENTIVES
Thank you for your attention!

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