Enhanced sewage sludge treatment with struvite recovery

Struvite as phosphate fertilizer

July 5, 2017
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• Waternet
• Phosphorus, problem or solution?
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Waternet is a mutual organization

City of Amsterdam
- Sewerage system
- Groundwater
- Drinking water
- Shipping and inland waterways

Amstel, Gooi and Vecht Water Board
- Dykes
- Water level
- Water surface area
- Cleaning waste water

Waternet foundation
220 pumping stations
105 locks
590 dams
1300 km of major waterways
6000 km of polder ditches
Active management of thousands of hectares of nature reserve
12 sewage treatment plants
3 WATER TOWERS

100,000 cubic metres of drinking water reservoirs
Over 465,000 supply points for drinking water
Average drinking water production of 235,000 cubic metres per day

600 sewage pumping stations
A 3500 km long sewerage system

1200 tons of waterborne waste per year in Amsterdam
2700 km of drinking water pipelines
300 km of pressure pipelines in Amsterdam
125,000 drinking water samples taken per year
WWTP Amsterdam West
recovery of phosphorus
Phosphorus, problem or solution?
Waste Water Treatment Plant Amsterdam West

- 1 million population equivalents for wastewater
- 2 million population equivalents for sludge
- 30,000 m³/h (peak capacity)
- 150,000 m³/day
- Production of 13,000,000 m³ biogas a year
- Intake of 160,000 tons of liquid sludge
- EBPR (MUCT)
Waste Water Treatment Plant Amsterdam West (process flow diagram)

Struvite formation
Sludge treatment WWTP Amsterdam West

- Primary sludge WAS
- Digesters
- Buffer
- Dewatering

- Scaling
- Sedimentation
- Wear and tear
Phosphorus problem

Problem definition:

• Scaling in pipelines and dewatering equipment

• Massive build up of crystals in sludge holding tank

• Analysis show struvite

\[ \text{MgNH}_4\text{PO}_4 \cdot 6 \text{H}_2\text{O (N-P-K, 5-28-0)} + \text{Mg 10 (as MgO)} \]
Why struvite crystallization at WasteWater Treatment Plant (WWTP) Amsterdam West?

- Enhanced Biological Phosphorus Removal
- Construction Digester
Enhanced biological P-removal

**Aerobic Zone**

= luxury P-uptake by building polyphosphates

**Anaerobic Zone**

= P-release by hydrolysis of polyphosphates

Digestion
CO$_2$ stripping through turbulence, drop of 20 meters, pH will rise
Struvite crystallization

- pH rise $\Rightarrow$ Higher supersaturation
- $\text{Mg}^{2+} + \text{NH}_4^+ + \text{PO}_4^{3-} + 6 \text{H}_2\text{O} \Rightarrow \text{MgNH}_4\text{PO}_4\cdot6\text{H}_2\text{O (MAP)}$
Research and LCA

• Research and LCA showed that removal of phosphorus in digested sludge was most promising

• Waternet tested two systems of sludge treatment systems
Process benefits

- Enhancement sludge dewaterability
- Less maintenance sludge handling
- Lowering phosphorus recycle to WWTP
- High quality struvite production
Pilot ‘Airprex’ & ‘NuReSys’
### Results pilot scale experiments

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before crystallization</th>
<th>After crystallization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PO$_4$–P (mg/L)</strong></td>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>7,2</td>
<td>7,8-8,0</td>
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<tr>
<td><strong>NH$_4$ (mg/L)</strong></td>
<td>680</td>
<td>630</td>
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</table>

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<thead>
<tr>
<th>Parameter</th>
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</tr>
</thead>
<tbody>
<tr>
<td>% DM</td>
<td>22</td>
<td>25-26</td>
</tr>
<tr>
<td>Polymer dosage kg/ t DM</td>
<td>14-16</td>
<td>11-13</td>
</tr>
</tbody>
</table>

Magnesium dosage Me/P ~1,8-2,0
Struvite quality

- Analysed and tested by ICL fertilizer
- “Useful product in production of tailor made fertilizers, especially when extra magnesium is needed”
Conclusions

- Process is useful in combination with Biological phosphorus removal
- Solves dewaterability and scaling problems
- Produces a ready to use product
Business case at WWTP Amsterdam West

- Benefits ~ € 1,200,000/a (dewatering + struvite € 0)
- Costs ~ € 700,000/a

Annual savings ~ € 500,000
Investments costs ~ € 3,000,000
ROI ~ 6 years
Airprex principle

Sludge → Anaerobic digestion → AirPrex → USB (buffer) → Centrifuge → Dewatered sludge

Biogas

MgCl₂

Air

MAP

Reject water
Process description

- pH rise by CO$_2$ stripping
- Adding MgCl$_2$ (32 % solution) for struvite crystallization
- Separation is easy because struvite density is 1,7 kg/m$^3$
Reactor design
Installation and Production
Full scale results

- Dewaterability up from 21 % DM to 23.5 % DM
- Production of struvite
- Ortho-phosphate removal of 95 %
- Scaling is nearly absent or easy to remove
- Struvite sold to ICL (Fertilizer company)
“We may be able to substitute nuclear power for coal, plastic for wood, yeast for meat and friendliness for isolation.....but for phosphorus there is neither a substitute nor replacement”

Isaac Asimov, 1974

Thank you