Dutch Experience of sludge management and P-recovery pathways

Environ 2018 – 28 March 2018, Cork, Ireland

Josien A. Ruijter, MSc, HVC
Content

1. Sewage water treatment in NL
2. Sludge management
3. P-recovery pathways
1. Dutch water management

- Small country (17 milj inhab, 41,500 km$^2$ =, 2 x smaller dan Ireland), delta area, fertile soils
- 4 levels of governments:
  - National (deep underground > 500 m, national water bodies)
  - Provinces (management of groundwater)
  - Municipalities (ground water in urban areas, sewerage systems)
  - 22 Water authorities → oldest WA > 762 years old!
- Water authorities responsibilities:
  - Water quantity (agriculture!)
  - Flood protection (dikes/dams)
  - Treatment of sewage water
  - surface water quality
1. Environmental Laws & regulations

Industrialisation

• **1875: Hinderwet (about “danger, damage and annoyance”)**

Increased population pressure, pollution, Rhine is sewer of Europe, after WWs construction of SWTPs, eutrophication of surface waters

• **1970: WVO (Law on pollution of surface water) → polluter pays principle!**

Increased awareness and improved environmental management

• **2009: Waterwet (Water law)**
1. Trends WWTPs In Netherlands

- 330 SWTPs, > 99% of municipal waste water is treated
- After 1996 law → adjustment of SWTPs wrt P and N removal
- More biological treatment, less chemical use
- 50% of sludge is digested
2. Sewage sludge processing ways

1,5 milj ton dewatered sludge

- Sludge 4-5% DM
- Dewatering 22-24% DM
- Drying (fossil gas) to 95% dm
- 1 x co-incineration
- 2 x mono-incinerators (HVC & SNB)
- Super critical gasification
- P-rich ashes
- P-rich ashes
- Heat to city network HVC
- Cement industry

agriculture

2 x biological drying to 65% DM
2. Trend of sludge processing in NL

- Since 1 Jan 1995 ending of sludge to agriculture (decree on quality and use of ‘other’ nutrients). Disposal of sewage sludge is strongly limited by regulation (1997).
- Dutch Water authorities took initiative to set up 2 sludge mono-incinerators, started operations in 1993 and 1995:
  - SNB (5 water authorities in prov of Brabant)
  - HVC (5 water authorities in West-NL)
2. Current situation on sludge processing in NL

Treatment of ± 1,500,000 ton/year sludge (22 % DM)

- **Yellow** Mono-incineration (50%, 2 plants SNB & HVC)
- **Yellow** Drying and co-incineration (in Bio-Energy Plant/HVC, and in and cement plants) (25%, 4 plants)
- **Light pink** Composting (biological drying) and co-incineration in power plant (19%, 2 plants)
- **Green** Co-incineration in MSWI (6%, 1 plant)
### Slugde incinerators

<table>
<thead>
<tr>
<th>Start operations</th>
<th>1993 (HVC), 1995 (SNB)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>55,000 ton OM (HVC) / 60,000 ton OM (SNB)</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>Disk dryers fluidized bed furnaces 850-950°C – Lime dosing in furnace (SNB) Electrostatic Precipitators- acid scrubber- alkaline scrubber- activated carbon filters for mercury removal, bag filter. Scrup water to own chemical IWTP. Effluent to urban WWTP. Filter cake with heavy metals to special landfill site. Activated carbon treated to recycle mercury.</td>
</tr>
<tr>
<td><strong>Energy &amp; resource recovery</strong></td>
<td>steam for dryers; Turbine to produce Electricity; heat to urban WWTP for better Nitrogen removal. Salt &amp;ammonia recovery (SNB)</td>
</tr>
</tbody>
</table>
3. Ambitions Dutch water authorities

SWTP as resource of energy and recovery of valuable elements:
• Energy
• ALE
• Cellulose
• Bioplastics/PHA
• (rare) metals
• Phosphate

From fly ashes of SNB & HVC
Super critical gasification of sewage sludge

From condensate effluent sludge incin
3. Sewage sludge fly ashes

- HVC 22,000 ton ashes/y 25-27% P2O5
- SNB 35,000 ton ashes/y 20-22% P2O5

→ 14,000 ton P2O5/y
3. Global P-market

- Largest producers: China, Morocco, US, Russia, middle east (>70% of world’s total)
- Largest importers: India, EU, Indonesia, US, Brazil
  - Environmental issues with P-rock mining (Cd, Uranium, high water consumption)
  - Decrease in quality of P-rock
  - Geo-political uncertainties
  - P on EU list of critical materials
  - EU’s ambition to become less dependant on P-import
    - Increase P-efficiency in agriculture
    - Stimulate P-recovery
      - regulations
      - EU-programma’s (Phos4You)
Phosphorus flows in NL for 2011

110 kton P (=253 kton P2O5) import

42 kton P (=96 kton P2O5) surplus

14,000 ton P2O5 in ashes HVC/SNB
Equals ±6% of P-import
Equals ±15% of P-surplus
3. P-recovery: ash–route or struvite-route?

Struvite (ammonium magnesium phosphate)

• P-removal on WWTP with sludge digestion
• produced struvite 2500 ton/y in NL
  • Direct use or mixed with conventional fertilisers
  • Market: new product, prices low or fluctuating
  • Struvite as waste can be traded as nutrient/fertilizer
  • No general EU end-of-waste regulation, so for each situation separately to be defined.
• Strict monitoring on pathogens needed
• Struvite production at SWTP affects sludge incinerators and fly ash quality!
• Re-shaping of EU fertiliser regulation: in preparation for criteria voor struvite, biochar en fly ashes (Joint working groep STRUBIAS)

PhosPpaq, Anphos, Pearl, Crystallactor: reject water or stripper water

Airprex: from sewage sludge
3. P-recovery: fly ash-route

- HVC & SNB: 57,000 ton/y SSA
- 20-27% P2O5 in fly ashes
- 14,000 ton P2O5/year
- Allowed to be exported
- No pathogens
- Quality strictly monitored
- Additional recovery of Al and Fe salts
- Waste status
- Re-shaping of EU fertiliser regulation: in preparation for criteria voor struvite, biochar en fly ashes (Joint working groep STRUBIAS)

HVC & water authorities WWTPs: keep struvite in sludge, as to guarantee high % of P in SSA!
3. EcoPhos proces

- Cooperation since 2009. Plan to start to deliver SSA to new plant in 2020.
- Valorization of low-grade phosphate rock and secondary phosphate resources such as SSA on the basis of soft digestion by phosphoric acid
- Modular process:
  - Flexible wrt raw materials quality
  - Capable to produce a variety of products (fertilizer, feed and food grade phosphoric acid (PA), animal feed (DCP and MCP) and solid or liquid NPK fertilizers).
- Robust process
- No expensive chemicals and equipment
- Yield > 90% P2O5
- Advantage of SSA: less Cd en no uranium
3. EcoPhos process

Diagram showing the EcoPhos process flow:
- Ashes
- Chemicals
- HCl make-up
- H₂SO₄
- Ca(OH)₂
- Diluted H₃PO₄
- Module 6
- Module 4
- Module CCP
- Evap.
- Residue
- Condensate
- Technical grade
- Steam
- Al/Fe chlorides
- CCP Residue
- Purified CaCl₂
- Pure Gypsum
<table>
<thead>
<tr>
<th>Element</th>
<th>Unit</th>
<th>Typical Fly ash</th>
<th>Typical LG rock</th>
<th>Standard grade rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₂O₅</td>
<td>%</td>
<td>23.6</td>
<td>20-27</td>
<td>30-36</td>
</tr>
<tr>
<td>Ca</td>
<td>%</td>
<td>12.7</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Si</td>
<td>%</td>
<td>10</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Al</td>
<td>%</td>
<td>6</td>
<td>0.2</td>
<td>0.75</td>
</tr>
<tr>
<td>Fe</td>
<td>%</td>
<td>9.4</td>
<td>0.9</td>
<td>0.05</td>
</tr>
<tr>
<td>Mg</td>
<td>%</td>
<td>1.7</td>
<td>0.9</td>
<td>0.04</td>
</tr>
<tr>
<td>K</td>
<td>%</td>
<td>2.2</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>Na</td>
<td>%</td>
<td>0.77</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>As</td>
<td>ppm</td>
<td>35</td>
<td>9.3</td>
<td>16</td>
</tr>
<tr>
<td>Cd</td>
<td>ppm</td>
<td>3.8</td>
<td>49</td>
<td>14</td>
</tr>
<tr>
<td>Cr</td>
<td>ppm</td>
<td>130</td>
<td>200</td>
<td>120</td>
</tr>
<tr>
<td>Cu</td>
<td>ppm</td>
<td>1200</td>
<td>200</td>
<td>28</td>
</tr>
<tr>
<td>Ni</td>
<td>ppm</td>
<td>67</td>
<td>125</td>
<td>17</td>
</tr>
<tr>
<td>Pb</td>
<td>ppm</td>
<td>250</td>
<td>21</td>
<td>5.7</td>
</tr>
<tr>
<td>Ti</td>
<td>ppm</td>
<td>2900</td>
<td>160</td>
<td>360</td>
</tr>
<tr>
<td>Zn</td>
<td>ppm</td>
<td>3300</td>
<td>230</td>
<td>190</td>
</tr>
<tr>
<td>F</td>
<td>%</td>
<td>0</td>
<td>3.2</td>
<td>3.9</td>
</tr>
<tr>
<td>SO₄</td>
<td>%</td>
<td>7.7</td>
<td>2.7</td>
<td>&lt;2</td>
</tr>
<tr>
<td>TOC</td>
<td>%</td>
<td>0</td>
<td>3.35</td>
<td>0.3</td>
</tr>
<tr>
<td>CO₂</td>
<td>%</td>
<td>0</td>
<td>7.2</td>
<td>5</td>
</tr>
</tbody>
</table>
3. Quality Monitoring SSA

- Weekly mixed sampled analysed by independent laboratory
- (heavy) metals (ICP-MS)
- Twice per year in weekly mixed samples: dioxines
- Since 2014 all samples are stored
- Seasonal fluctuations!
Conclusions & recommendations

• Sludge quality is reflected in ash quality
• More insight in sludge quality needed → why seasonal fluctuations?
• More knowledge needed on effects of struvite production on sludge incineration (N in condensate effluent from SIP)
• Recovery of (rare) metals from SSA
  • Fe & Al chlorides via EcoPhos process
  • other valuable metals to be considered
• Clear regulations on application in EU needed (STRUBIAS)
• Mono-incineration is still state of the art!
We deliver Phosphorus made in Europe