Sustainable materials and energy from sewage sludge

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ECN acts as a bridge between science and corporate innovation

Mission
We develop knowledge and technologies that enable a transition to a sustainable energy system

Not-for-profit research institute
Founded in 1955
5 Commercial licensing deals / year
500 Employees
+/−20 patents a year
€ 80 M annual turnover
What is sewage sludge?

- By-product of sewage treatment
- It can be
  - digested
  - landfilled
  - incinerated
  - applied on agricultural land
- In The Netherlands 356 WWTPs produce 1.5 Mton/year sewage sludge
Legislation changes cause increase in amount of sludge

- Legislation and Codes of Practice restrict disposal
  -> avoid soil & water pollution
- ADAS Safe Sludge Matrix (restriction on the type of sewage sludge to land) -> ensure food safety
- Sludge (Use in Agriculture) Regulations 1989 -> ensure food safety
- Sewage Sludge Directive 86/278/EEC
  -> encouragement of reuse of sewage sludge
  -> avoid health risks
- EU Landfill Directive 1999/31/EC -> avoid methane emissions
Why is phosphorus (P) important?

- Sewage sludge and manure contain large amounts of phosphorus
Sewage sludge - The challenges

- Reduce the amount of sludge that is produced
- Recover nutrients (phosphorus)
- Maximise energy production
Water Authority Zuiderzeeland

- Population: 400.000
- Largest city: Almere
- 5 sewage treatment plants
  - with digestion
  - without digestion
- 56,000 ton/year sewage sludge
- “Sewage is not a waste stream but a source for sustainable energy, materials and clean water”
What is TORWASH®?

Heat + Washing = TorWash

150-250°C + Pressurized water = Exposed salts Brittle biomass Compressible fibres
TORWASH® = Wet torrefaction + Washing

Sewage Sludge → Liquid Effluent → Solid Biofuel
Experimental approach

20-L autoclave vessel

- Filtration
- Liquid effluent
- Solids
- Anaerobic digestion tests

Mechanical Pressing & Characterisation
- Mass yield
- Dry matter content
- Calorific Value
- Elemental analyses

Sewage Sludge
TORWASH® of Almere sludge
Distribution of elements

- **K and Cl:** >90% in effluent
- Nutrients mostly in effluent
- Si, Al, Ca, Fe to solids
- Heavy metals stay in solids → incinerator

* Mass and Energy in solid product
TORWASH® effluent digestion tests

- Batch tests at OPURE
  - 18-25 days
  - Filtered effluent after TORWASH®

- Measurements
  - COD measurements before and after
  - biogas production
  - methane content → methane production

- For TORWASH® assessment purposes, digestibility is defined as the COD conversion
Sewage sludge – current situation

Sewage sludge

incinerator

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TORWASH® → Digestion

- **Sewage sludge**: 8-12 wt% dry matter
- **Press**: Dewatered cake
- **Anaerobic Digester**: >60 wt% dry matter
- **Liquid Effluent**: To power & electricity

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Back to the challenges

- Reduce the amount of sludge that is produced
- Recover nutrients (phosphorus)
- Maximise energy production
The TORWASH® promise
Almere as an example

<table>
<thead>
<tr>
<th></th>
<th>Dry matter</th>
<th>Volume [ton]</th>
<th>Disposal costs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifuge</td>
<td>8%</td>
<td>56 000</td>
<td></td>
</tr>
<tr>
<td>Existing Press</td>
<td>21%</td>
<td>21 000</td>
<td>M€ 1.3</td>
</tr>
<tr>
<td>Best Press</td>
<td>24%</td>
<td>19 000</td>
<td>M€ 1.1</td>
</tr>
<tr>
<td>TORWASH®</td>
<td>65%</td>
<td>3 100</td>
<td>M€ 0.2</td>
</tr>
</tbody>
</table>

* € 60 per ton “as received” in all cases

- Amounts of sludge reduced from 21 to 3 kton/year
- Potential savings on disposal costs € 1.1 million/year
How about P recovery and energy production?- The Almere case

• From TORWASH® effluent:
  – Recovery of 80 kg/y of phosphorus -> 183 kg/y of phosphate
  – 0.3 MWe by combustion of produced biogas

• From TORWASH® presscakes/pellets
  – 0.4 MWe by combustion

• 800-900 ton/y CO₂ reduction potential
TKI-BBEG EnCore

EnCore
(Efficiente Cascadering en Opwerking Rioolslib voor Energie-neutrale bedrijfsvoering)

- Pilot scale TORWASH® + anaerobic digestion (40 kg/h)
- Proof-of-feasibility
- Quantification P recovery
- Quantification energy production
Digestion → TORWASH®

1. Sewage sludge → 8-12 wt% dry matter
2. Sewage sludge digested in the Anaerobic Digester
3. Slurry digested sewage sludge
4. Filter
5. TORWASH® Reactor
6. >60 wt% dry matter
7. Press
8. Liquids recycling
9. Dewatered cake
10. Pressed sludge
11. Incinerator → To power & electricity

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Thank you for your attention!
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