Nutrient recovery at large scale demoplants

NBV Webinar Towards agricultural circularity for nitrogen
10 July 2020, Inge Regelink (Inge.Regelink@wur.nl)
Content

- Intro: Nutrient balances, manure surplus
- Nutrient recovery technologies at demonstration plants
- Life Cycle Assessment and Environmental Impact
Circular Agriculture

Goal:
- Lower emissions to soil, water and atmosphere

Measures:
- Reduce the use of non-renewable fertilizers (P) and fertilizers produced by means of fossil energy (N, Haber Bosch process)
- Manure and other organic waste streams as fertilizer
Manure surplus in The Netherlands

**Production**

- **Cattle**
  - Million kg P: 47
  - Million kg N: 292
- **Pigs**
  - Million kg P: 18
  - Million kg N: 89
- **Poultry**
  - Million kg P: 13
  - Million kg N: 54

**Surplus**

- **% obv P**
  - Cattle: 6%
  - Pigs: 37%
  - Poultry: 100%
Unexploited sources of nutrients

Use of synthetic fertiliser: 230 million kg N and 5 million kg P

**Surplus pig manure**
- N: 18 million kg
- P₂O₅: 12 million kg
- Export

**Waste water**
- N: 94 million kg
- P₂O₅: 31 million kg
  (18 kg N in sewage sludge)
- Nitrification/denitrification, incineration of sludge.

**Poultry manure**
- N: 47 million kg
- P₂O₅: 26 million kg
- Export and incineration

**Organic waste**
- N: 90 million kg
- P₂O₅: 30 million kg
- Ends up in residual waste and is incinerated
Application rate limits

- Limit for total P
- Limit for N from animal manure (170 or 230/250 kg N/ha)
- Limit for N (effective N from manure and other fertilizer)

Separation of N-NH4, N-org and P (and OC, K, S)

Nutrient ratio in biobased fertilisers should be adjusted to meet crop demand
Nutrient recovery in practice: Demoplants

- BENAS (Germany): Recovery of ammonium sulphate
- Groot Zevert (Netherlands): Recovery of NK concentrate
- AmPower (Belgium): Solid and liquid NPK fertiliser

Circular Solutions for Biowaste

www.systemicproject.eu
2017 til Nov-2021
**Feedstock:** Maize sillage and poultry manure

**Energy:** Biogas is converted in electricity. Residual heat is used on-site in the N stripper

**Products:**
- Ammonium-sulphate
- Low-N digestate
- Low-N fibres
- €€ 10% more biogas, sell of AmS, less transport liquid digestate
N stripping and recovery as AmS

- Residual heat to increase temperature to speed up ammonia volatilization
- $\text{NH}_3 - \text{CO}_2$ equilibrium controls pH
- Usually, ammonia is recovered by sulphuric acid

$\text{NH}_4 \rightarrow \text{NH}_3 + \text{H}^+$

$\text{HCO}_3 + \text{H}^+ \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
N stripping and recovery as AmS

- Temperature increase to speed up ammonia volatilization
- \( \text{NH}_3 - \text{CO}_2 \) equilibrium controls pH
- BENAS implemented new processes to recover ammonia with gypsum (waste product from industry)

\[
2\text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} + \text{CaSO}_4 \rightarrow \text{NH}_4\text{SO}_4 (l) + \text{CaCO}_3 (s)
\]

Products: Liquid Ammonium sulphate and solid calcium carbonate
Time for a five-minute break!
Feedstock: Pig manure and co-products

Energy: Biogas to nearby dairy factory

Products:
- NK concentrate
- Solid fraction
- P-fertiliser
- Low-P organic matter
- Water

- NK fertiliser as alternative for synthetic N
- Less transport, lower costs
JRC advice End-of-Manure status for recovered products with >90% N-NH$_4$/N
Demo trials

- Biobased Fertilisers Achterhoek:
  - Blends of NK concentrate with ammonium sulphate and urea,
  - low-emission injection to reduce emissions
  - Monitoring of crop uptake and nitrate leaching
Feedstock: Pig manure and co-products

Energy: Biogas to nearby dairy factory

Products:
- NK concentrate
- Solid fraction
- P-fertiliser
- Low-P organic matter
- Water
- NK fertiliser as alternative for synthetic N
- Less transport, lower costs
Separation of phosphorus and organic matter

- Export of P-rich solid fraction expensive
- Now treated with sulphuric acid to leach out phosphate (>80% removed)
- Phosphate recovery with calciumhydroxide
- Low-P soil improver or peat replacer
Low-nutrient organic fibres as alternative for peat in potting soil (GZV and Benas)

Sustainable alternatives for excavation of peat

Criteria on structure, smell, pH, salt, stability, nutrients, contaminants,.. Etc

Additional leaching required to reduce salt (EC)

High market value
AmPower: Biogas and organic fertiliser from biowaste

Feedstock: Organic residues agri-industry and households (no manure)

Energy: Biogas converted into electricity. Waste heat used in dryer and evaporator

Products:
- Dried organic fertiliser
- Concentrated liquid NPK fertilizer

Business case: Reduce volume and hence costs for long-distance transport
Environmental Impact Assessment

- Agronomic efficiency (P availability, N mineralisation, NUE)
- Determine emissions of NH₄ and N₂O from biobased N fertiliser
- Heavy metals, ‘emerging’ pollutants

<table>
<thead>
<tr>
<th></th>
<th>EF (% mineral N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure</td>
<td></td>
</tr>
<tr>
<td>Shallow injection grassland</td>
<td>16</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>11</td>
</tr>
<tr>
<td>KAS (calcium ammonium nitrate)</td>
<td>2.4</td>
</tr>
<tr>
<td>DAP (diammonium phosphate)</td>
<td>7.4</td>
</tr>
</tbody>
</table>

Source: National emission model for agriculture (NEMA) - 2019

Pot experiment with struvite and DAP
Life Cycle Analysis (LCA)

- Overall effect on greenhouse gas emissions (CO$_2$, N$_2$O, CH$_4$)
- Phosphorus is non-renewable
- Nitrogen is abundantly available: GHG emissions of recovery process should be lower than Haber-Bosch process
- Nutrient recovery compared with a reference scenario
Life Cycle Analysis

- Example LCA for NK concentrates from pig manure (no digestion)
Example NK production from pig manure (no anaerobic digestion)

Electricity consumption outweights reduction in transport

But, methane emissions from manure storage on farm (not included) exceed overall emissions of treatment

Prevention of CH$_4$ emissions from manure/products should have priority
- Sources of nutrients: Manure, waste water and organic waste
- Upscaling of nutrient recovery requires positive business case
- Assessment of environmental impact and effects on GHG emissions
More Info

www.systemicproject.eu
www.groenemineralencentrale.nl

Contact:
Inge.Regelink@wur.nl
LinkedIn