Phosphorus recovery in Finland
Case RAVITA
Phosphorus

According to different sources, phosphorus deposits will only last for 40-100 years

Most countries are dependent on imported P

In Central Europe, some WWTPs are required to recover P
  • Germany, Switzerland, Austria

Only large WWTPs currently have potential for P recovery

Cost of recovered P is not competitive to synthetic fertilizers
Nitrogen

No lack of raw material in the future

• 78% of the atmosphere is N2

However, the manufacturing of N fertilizers is energy intensive

• Around 1-2% of the world's annual energy supply is consumed in the Haber-Bosch process

Reject water from anaerobic digestion has high concentrations of ammonia, which is usually considered a problem

→ Increases N load at WWTP
→ Increases energy consumption in aeration
Wastewater treatment in Finland

- There are 350 WWTPs (>100 PE)
  - Only 17 larger WWTPs (>100 000 PE)

- Phosphorus removed chemically by co-precipitation

- Sludge treatment
  - Digestion (2/3 of sludge)
  - Composting
  - Thermal drying, chemical treatment

- No recovery of phosphorus or nitrogen, no incineration of sludge
Possible sources of P in wastewater treatment plants

- Sludge ash
- Sludge liquor
- Water phase
Phosphorus recovery

• Present phosphorus recovery technologies are based either on:
  – Biological phosphorus removal and digestion
  or
  – Sludge incineration
• Suitable only for large WWTPs
• Cost of the recovered P is not competitive
Nitrogen recovery

- Present nitrogen recovery technologies are mainly based on ammonia stripping from reject water
- Sludge treatment by digestion is required
- Stripping requires high pH and/or high temperature
Nutrient recovery potential in Finland

- Present technologies are very poorly applicable for Finland
  - Would require either sludge incineration or biological P removal

- Recovery potential meets only large WWTPs, which have nutrient removal as well as special process combinations

- Cost of the primary raw materials for nutrient manufacturing are still low
Nutrient recovery potential at Finnish WWTPs

HSY catchment area

- Phosphorus ca. 700 t/a
  (Viikinmäki 530 t/a)
- Nitrogen ca. 600 t/a
  (Viikinmäki 400 t/a)

Finland

- Phosphorus ca. 4 000 t/a
- Nitrogen ca. 1 000 t/a (calculated based on digested sludge)
Future technology needs in Finland

• Nutrient recovery technologies need to be suitable for:
  – WWTPs with chemical precipitation for P removal
  – WWTPs without digestion
  – Nutrient harvesting
    – Also for plants without any nutrient removal

• Needs to be size neutral
RAVITA innovation

• No need for Bio-P, sludge incineration or digestion
• Fits all kinds of WWTPs
• Size neutral
• Maximizes phosphorus recovery
• Nutrients are not integrated into the sludge
• Enables nutrient harvesting
• Enables circulation of precipitation chemical
RAVITA Recovery Process

- Post-precipitation of phosphorus with metal salt
- Separation of precipitate
- Chemical recovery and separation step
- Re-use of precipitation chemical
- Phosphorus acid as final product
RAVITA Phosphorus Recovery Ideology

Effluent wastewater

Phosphorus Post-Pretreatment and Separation

Dissolution Step

Chemical sludge

Recovery of Phosphorus Separation Step

Phosphoric Acid

Precipitation chemical Recirculation

Phosphoric Acid Recirculation

Surplus Phosphoric Acid

End Product 1

Waste water

Biosludge

Phosphorus Post-Pretreatment and Separation

P 7-15 %
P 73 %
P 100 %
P 55-63 %
P 27 %
RAVITA Combination of phosphorus and nitrogen recovery

Base liquid
Stripper Unit
Ammonia NH₃
Air Washer Unit
Air
Reject water NH₄+

End Product 1
Phosphorus acid from Phosphorus Recovery Unit

End Product 2
Ammonium Phosphate

HSY
RAVITA Pros & Cons

+ No need for Bio-P, sludge incineration or digestion
+ Fits all kinds of WWTPs
+ Size neutral
+ Maximizes phosphorus recovery
+ Nutrients are not integrated to the sludge
+ Enables nutrient harvesting
+ Enables precipitation chemical circulation

- Post-precipitation of phosphorus increases the risk of P release due to tertiary process phase
- New innovation requires still piloting and testing
- Pilot size: 1 000 P.E.
- Flow rate: 7.5 m³/h
- Coagulation, flocculation
- Separation by Hydrotech disc filter
• Research work: Jyväskylä University
• Development work: HSY
• Main tasks:
  – Chemical sludge production
    – Optimization of the production and separation
  – Chemical sludge processing:
    – Dilution and separation process optimization
    – Technical options evaluation
• Future tasks:
  – Prototype for chemical sludge processing
  – Co-operation with Aalto university related NP Harvest
## Research on RAVITA process

### Post-precipitation
- Separation
- Drying

**Viikinmäki WWTP 1000 PE pilot plant**

- Chemical concentrations
- Retention time
- Sludge circulation
- Mixing intensity

- >80% of phosphorus removed
- Floc formation
- 85 g P/SS
- Drying is challenging

### Dissolution

**University of Jyväskylä Laboratory scale**

- Acid type
- Acid volume
- Acid concentration
- Temperature
- Dissolution time
- Number of steps
- Sludge age

- 95 % of phosphorus can be dissolved
- 99 % of aluminium can be dissolved

### Separation & Recovery

- (Solvent extraction)

- Solvent type
- Solvent concentration
- A/O ratio
- Organic phase/Al ratio
- Number of extraction step

- 97 % of aluminium can be transferred back to organic phase
- Fe is being researched
Effect of coagulation chemical

Effect of Polymer

Effect of sludge circulation

Settled sludge SS concentration

Optimization of coagulation
Hazardous substances in RAVITA

- Hazardous substances are one of the main concerns in recycling nutrients from municipal wastewater
- RAVITA contains less hazardous substances than sludge
- Main part of the micropollutants are already biologically degraded or attached to the sludge before RAVITA’s post-precipitation step
- Post-precipitation does not precipitate those substances, but some attach to the chemical sludge
- More research still needs to be done
Heavy metals and organic micropollutants were analysed

Heavy metal conc. low

Only BDE and Alkylphenols were detected
  - Concentrations are low

More research is needed to ensure low concentrations

<table>
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<th>Results</th>
<th>RAVITA</th>
<th>Sweden</th>
<th>Norway</th>
<th>Finland</th>
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Heavy metals in RAVITA sludge

![Graph showing heavy metal concentrations in RAVITA sludge and Viikinmäki WWTP sludge compared to legislative limits.](image-url)
TECHNICAL steps
• RAVITA DEMO plant
  – Increase of technology readiness level (TRL), now 5-6
  – Dissolution and separation of RAVITA sludge into the DEMO scale
• Energy and mass balances
• More analyses of the end product quality
  – Hazardous substances and microplastics

BUSINESS steps
• Ecosystem mining for potential partners (out of the box) and clients
• End users ideas and comments needed to complete the business concept
THANK YOU!

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RAVITA was one of the winners in BONUS return competition 2018.