Phosphorus recovery in Finland

Case RAVITA

12.6.2018 Maija Vilpanen

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 N_2

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

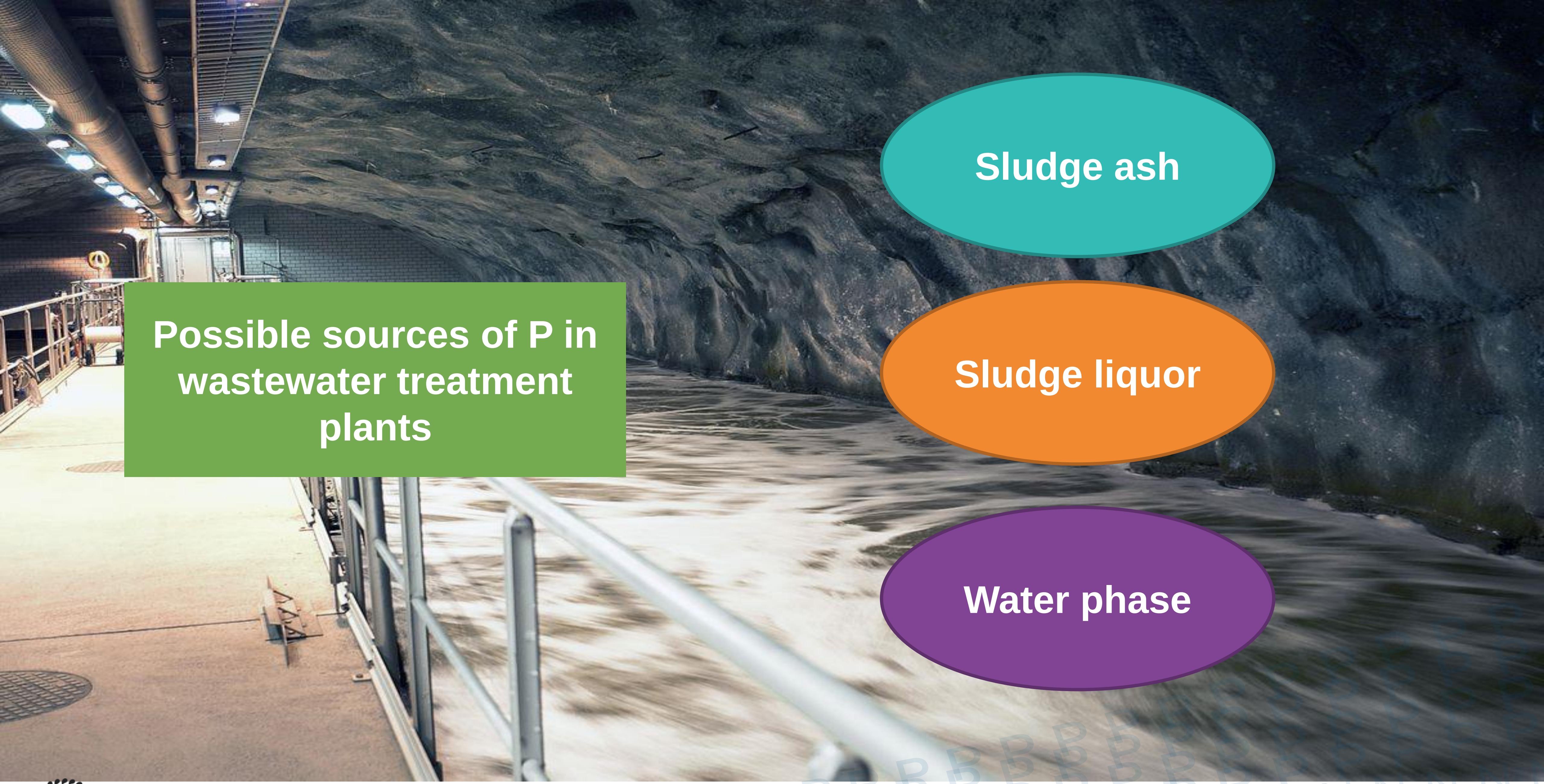
Reject water from anaerobic digestion has high concentrations of ammonia, which is usually considered a problem

→ 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

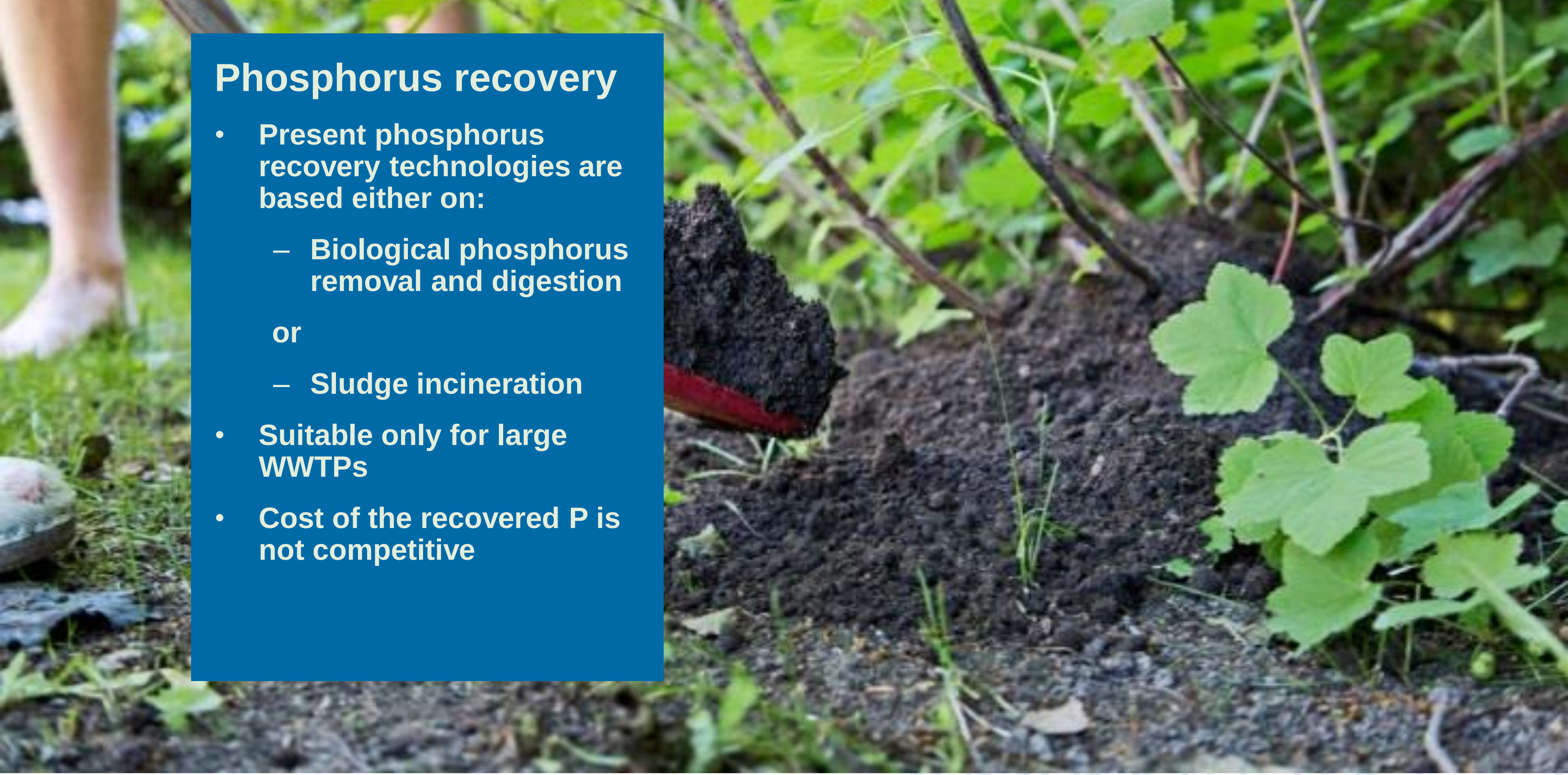


Possible sources of P in wastewater treatment plants

Sludge ash

Sludge liquor

Water phase



Phosphorus recovery

- Present phosphorus recovery technologies are based either on:
  - Biological phosphorus removal and digestion

  or

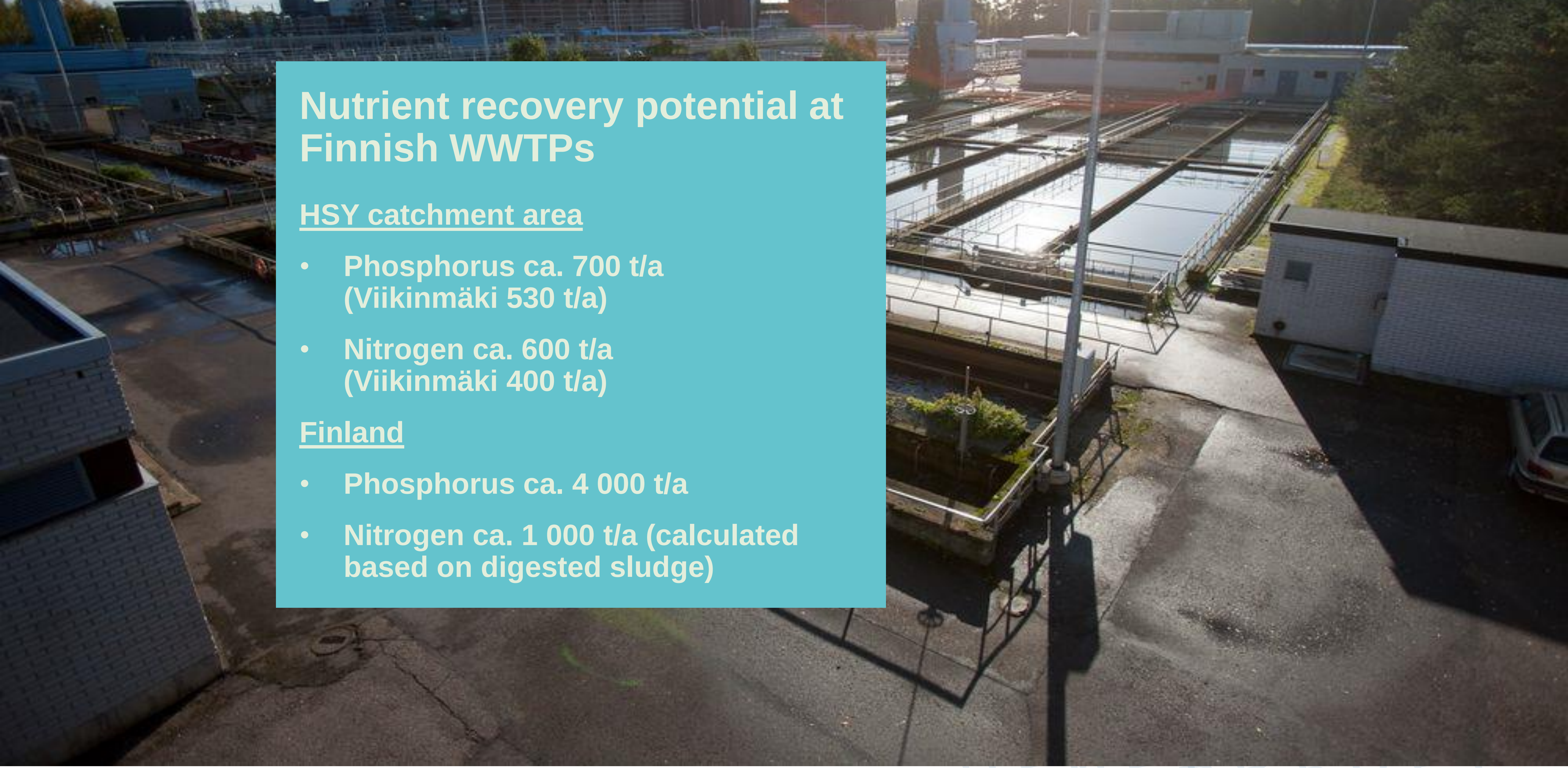
  - Sludge incineration
- Suitable only for large WWTPs
- Cost of the recovered P is not competitive

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

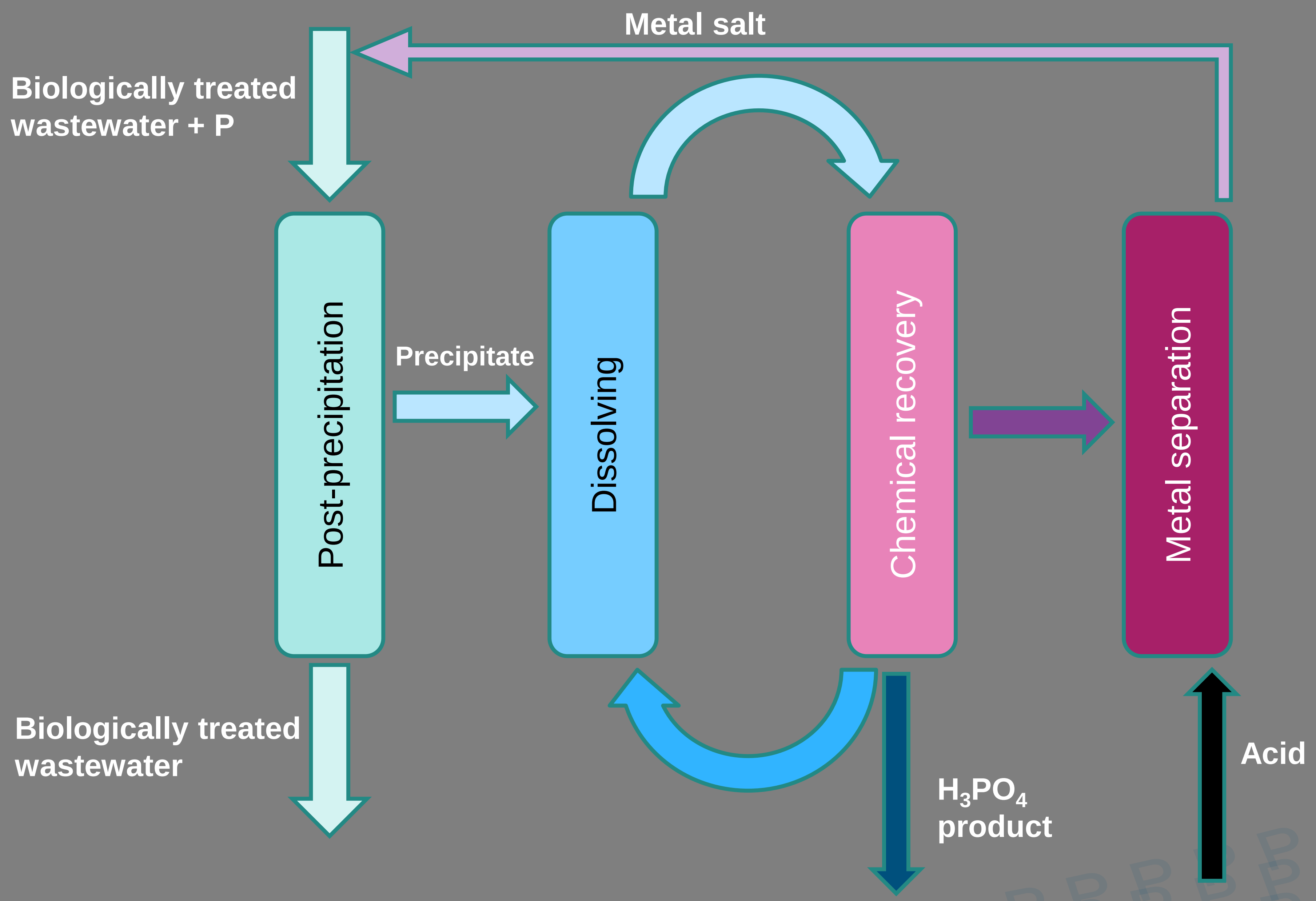
- **Phosphorus ca. 4 000 t/a**
- **Nitrogen ca. 1 000 t/a (calculated based on digested sludge)**

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

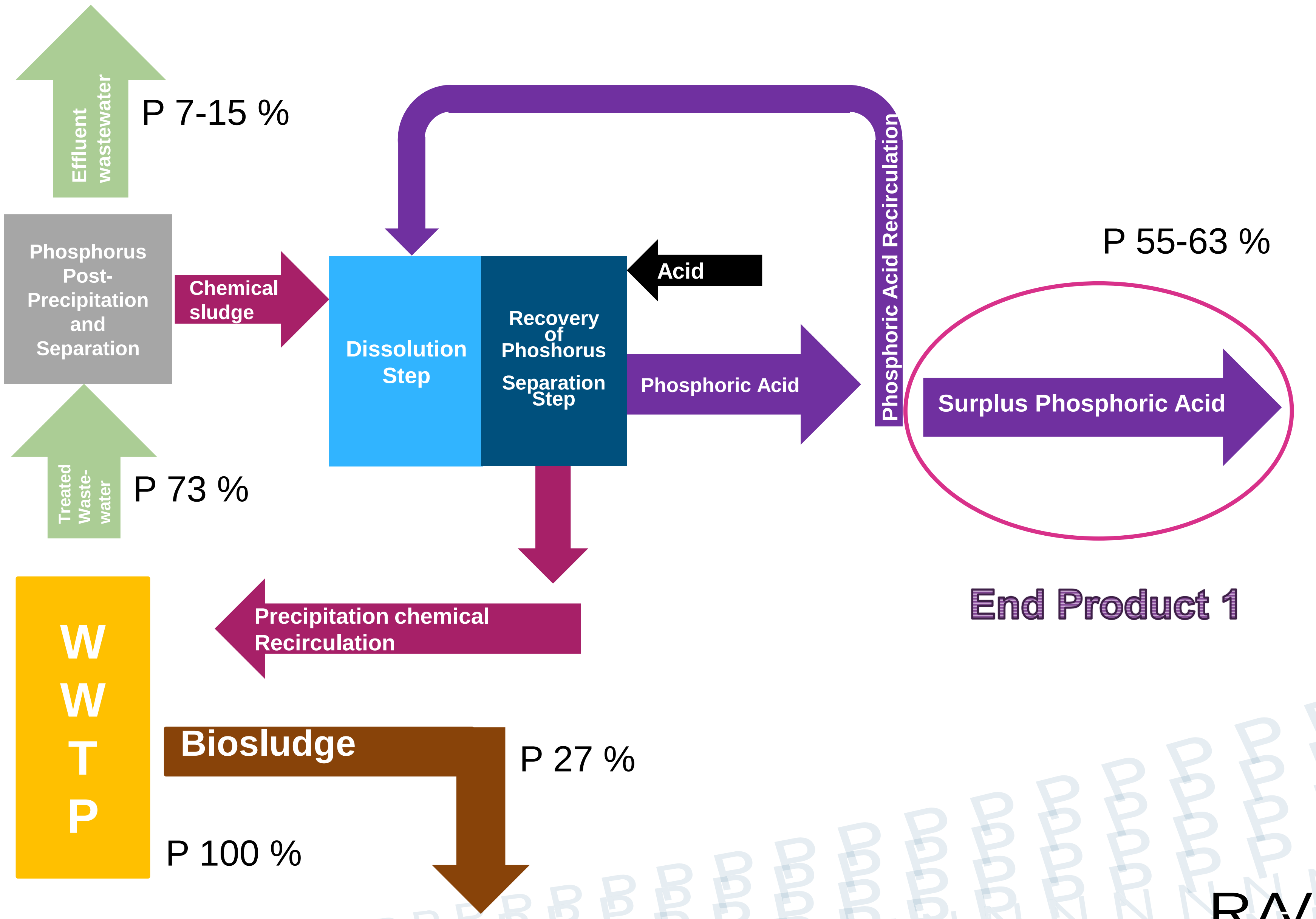
- No need for Bio-P, sludge incineration or digestion
- Fits all kinds of WWTPs
- Size neutral
- Maximizes phosphorus recovery
- Nutrients are not integrated into the sludge
- Enables nutrient harvesting
- Enables circulation of precipitation chemical



- 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 Recovery Process

RAVITA Phosphorus Recovery Ideology



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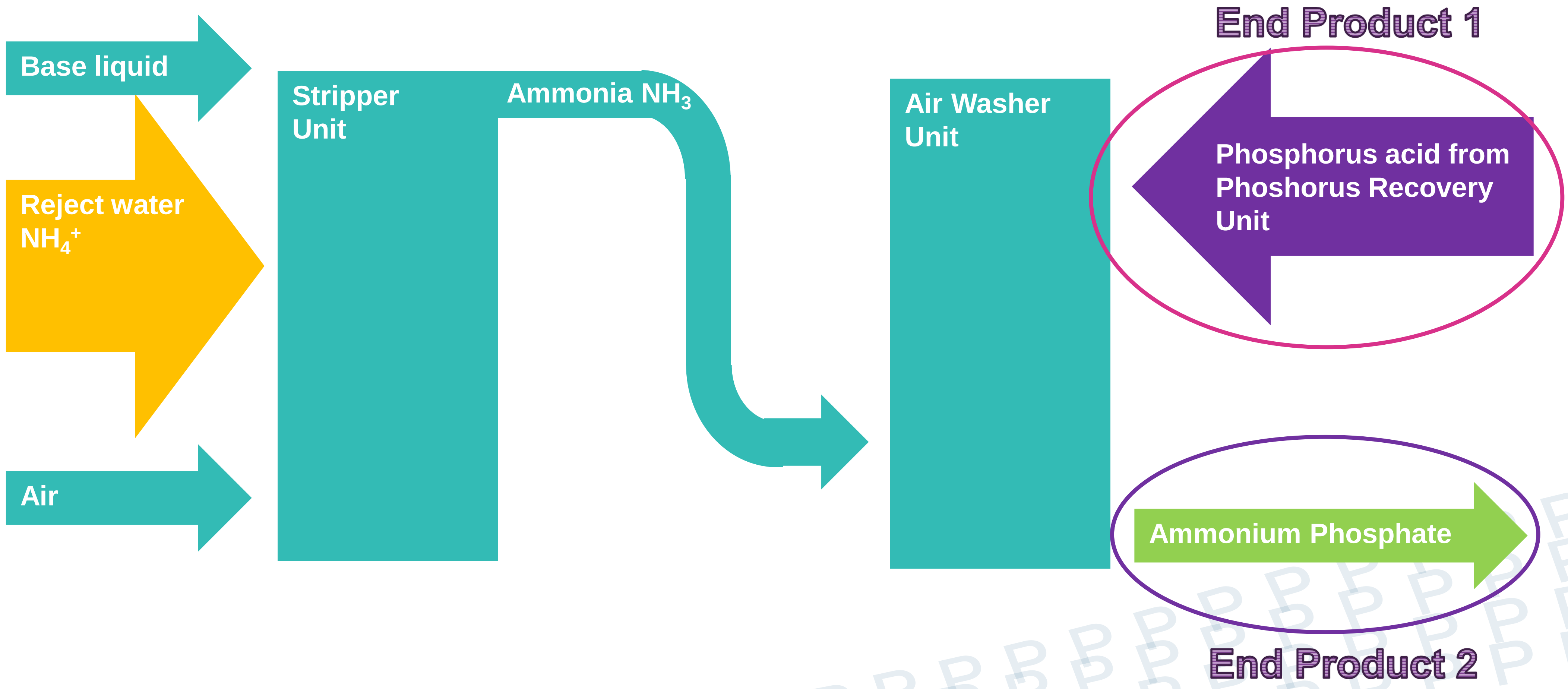
RAVITA Combination of phosphorus and nitrogen recovery



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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

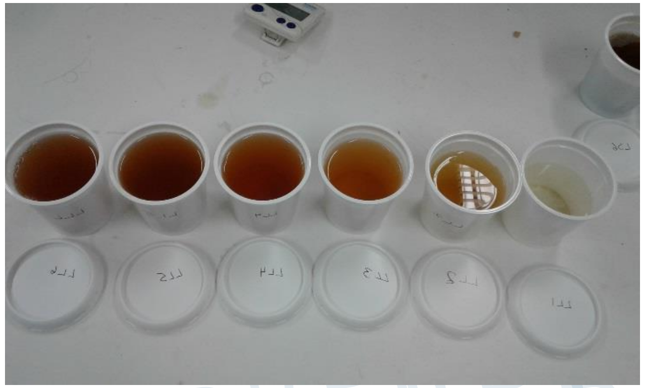
- – Post-precipitation of phosphorus increases the risk of P release due to tertiary process phase
- – New innovation requires still piloting and testing

- Pilot size: 1 000 P.E.
- Flow rate: 7.5 m^3/h
- Coagulation, flocculation
- Separation by Hydrotech disc filter

RAVITA pilot at Viikinmäki WWTP

- 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 and development status



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Research on RAVITA process

Post-precipitation Separation Drying	Dissolution	Separation & Recovery (Solvent extraction)
Viikinmäki WWTP 1000 PE pilot plant	University of Jyväskylä Laboratory scale	
• Chemical concentrations • Retention time • Sludge circulation • Mixing intensity	• Acid type • Acid volume • Acid concentration • Temperature • Dissolution time • Number of steps • Sludge age	• Solvent type • Solvent concentration • A/O ratio • Organic phase/Al ratio • Number of extraction step
• >80% of phosphorus removed • Floc formation • 85 g P/SS • Drying is challenging	• 95 % of phosphorus • 99 % of aluminium can be dissolved	• 97 % of aluminium can be transferred back to organic phase • Fe is being researched

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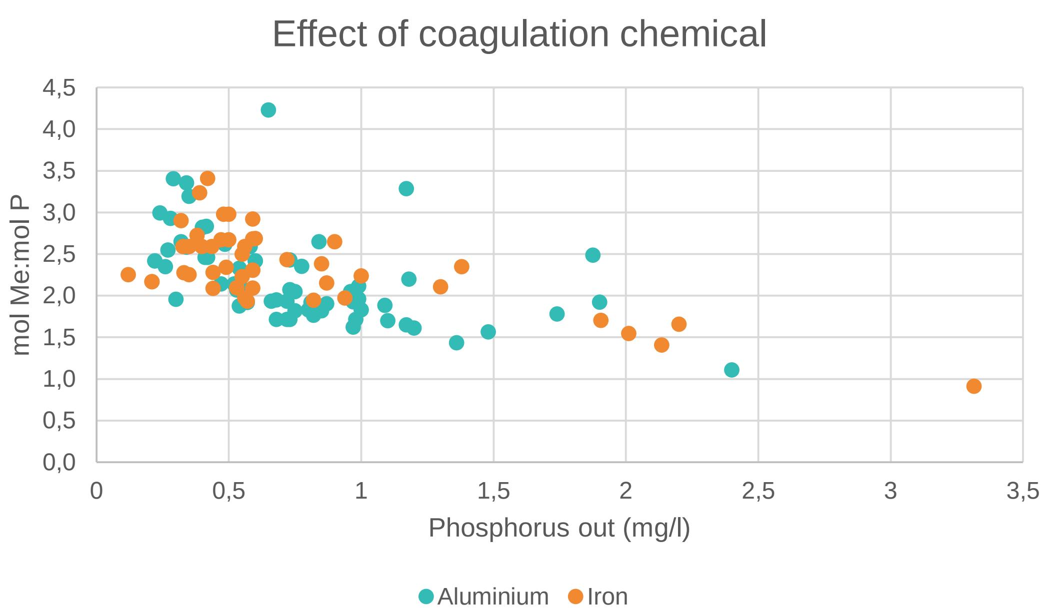
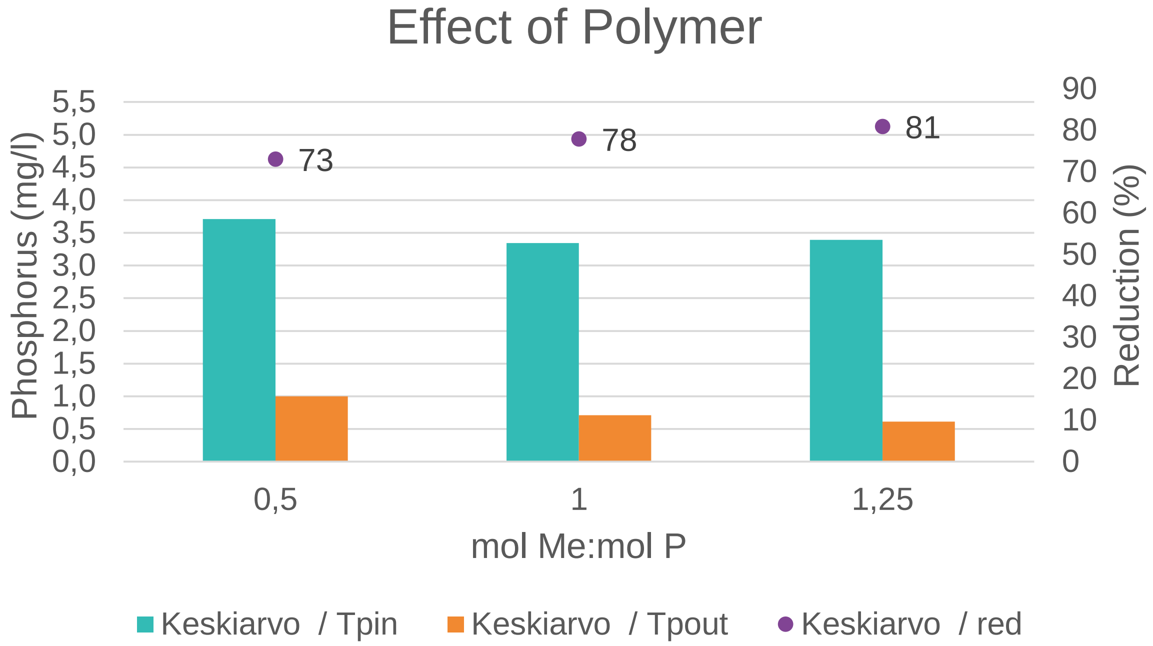
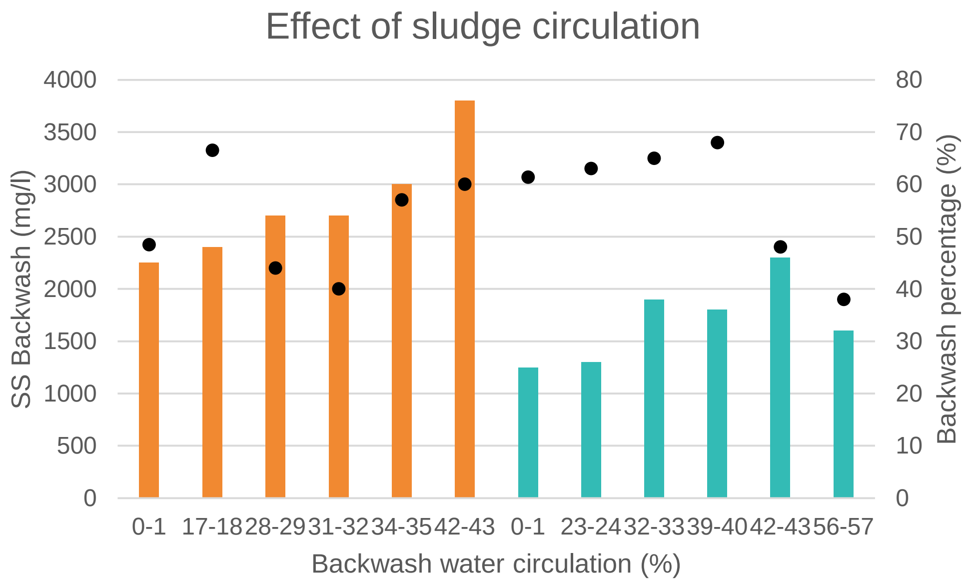
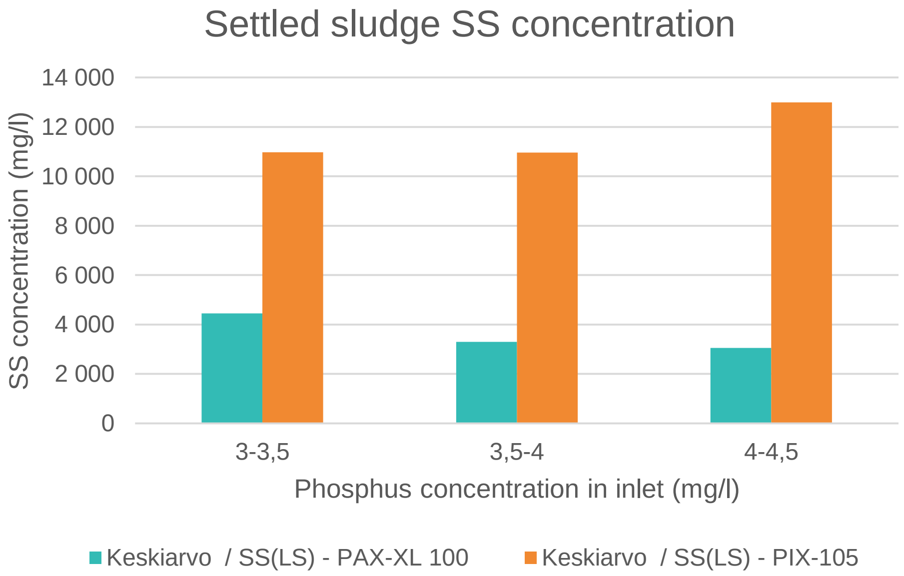
Optimization of coagulation









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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

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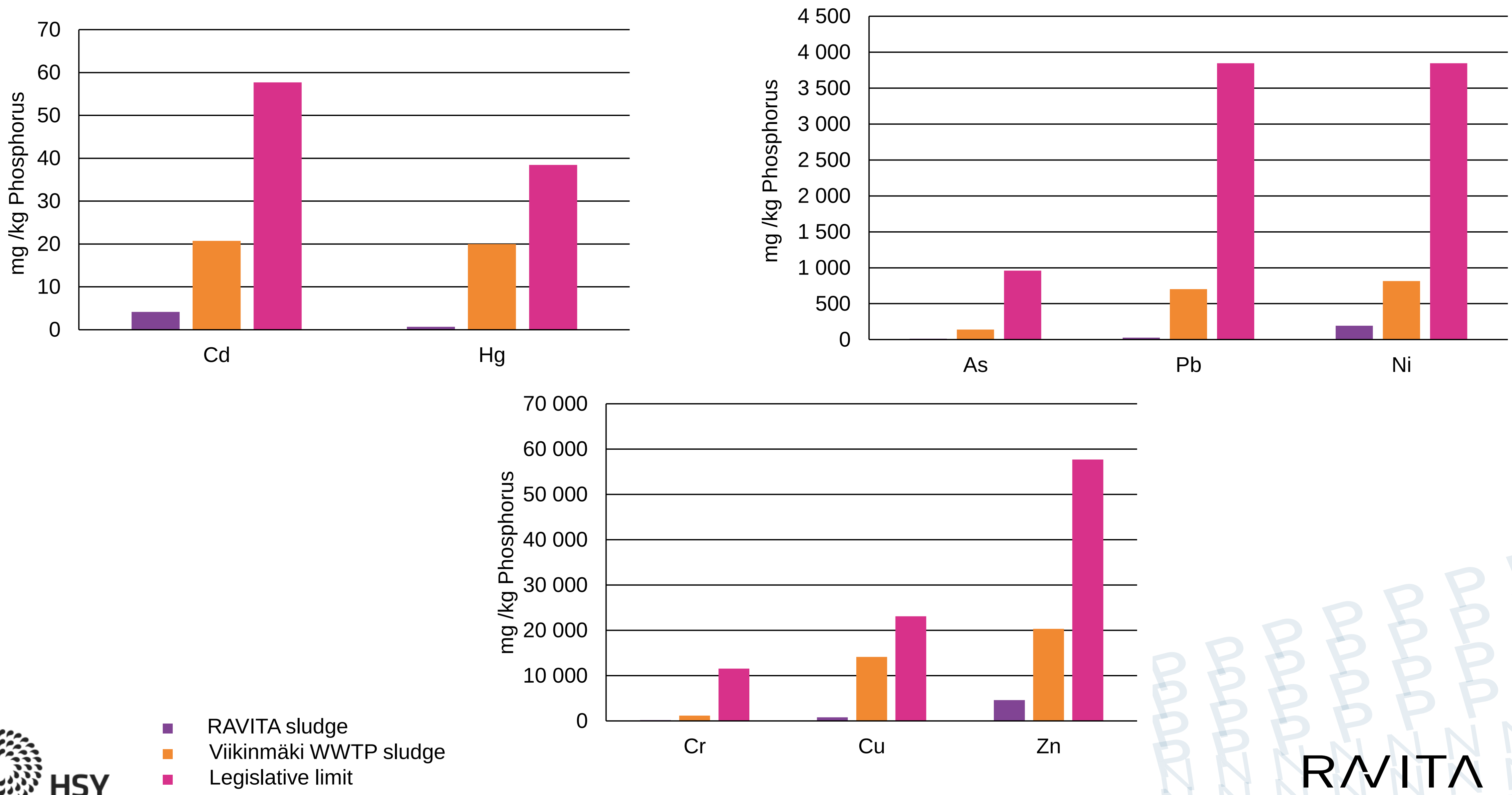
- Heavy metals and organic micropollutants were analysed

- Heavy metal conc. low
- Only BDE and Alkylphenols were detected
  - Concentrations are low

- More research is needed to ensure low concentrations

Results	RAVITA	Sweden	Norway	Finland
Polybrominated diphenylethers	ng/kg k.a			
tetraBDE#47	550	N.A	N.A	N.A
PentaBDE#99	540	50 000	25 000	16 000
DecaBDE#209	8 400	300 000	400 000	490 000
Alkylphenols	mg/kg			
(meta+para)-cresol	8,9	N.A	N.A	28

Heavy metals in RAVITA sludge



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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

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RAVITA Future steps

RAVITA

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GOVERNMENT KEY PROJECT

RAVITA

THANK YOU!

The RAVITA project has been granted funding from the Finnish Ministry of the Environment RAKI Programme.

The RAKI RAVITA DEMO plant has been chosen as a part of the Government’s key project on the circular economy.

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

BONUS RETURN
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Helsingin seudun ympäristöpalvelut -kuntayhtymä
Samkommunen Helsingforsregionens miljötjänster
Helsinki Region Environmental Services Authority