Puhdistamolietteet hyötykäyttöön

Puhdistamolietteen kuivaus infrapunasäteilyllä ja mikroaaloilla

Comparison of infrared and microwave treatment in sludge conditioning

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Kestävää kasvua ja työtä -ohjelma

Vipuvoimaa EU:lta 2014–2020

Euroopan unioni
Euroopan aluekehitysrahasto

BACKGROUND I – *Literature review*

INFRARED (IR) IRRADIATION

✓ sludge drying

? sludge treatment

TECHNOLOGY

VS.

MATERIAL

MICROWAVE (MW) IRRADIATION

✓ sludge treatment (solubilization)

X sludge drying

SEWAGE SLUDGE

❑ primary sludge

❑ secondary / waste-activated sludge

❑ anaerobically digested sludge

ANIMAL MANURE

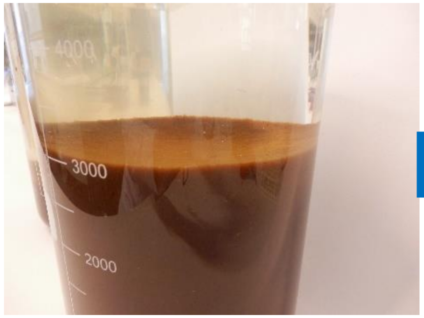
Research goals and experimental results I

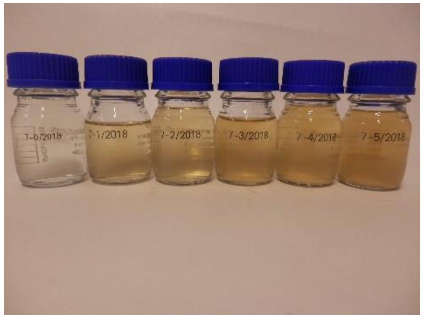
Solubilization of secondary sludge using MW irradiation

Sludge solubilization = mechanical damage of bacterial cells with release of intracelular content to liquid phase and breaking down macromolecules into smaller ones

RESULTS:

- we achieved 25% solubilization rate of organic matter measured as COD (chemical oxygen demand) → similar to other reported in articles with similar experiment design
- At the same time release of iron (concentration up to 500 mg/L) observed → resulting in yellow color of samples after treatment





Research goals and experimental results II

Presence of volatile fatty acids after treatment of secondary sludge with MW irradiation

Volatile fatty acids (VFA) = fatty acids with less than six carbon atoms (acetic acid = etikkahappo, propanoic acid = propaanihappo, butyric acid = voihappo)

- Idea from Serrano et al., 2016 where presence of VFA was observed in samples after treatment with MW irradiaiton
  - Used in pharmaceutical, food, and chemical industry
  - Global market demand: 18 500 kilotons in 2020 and raising (Atasoy et al., 2018)

RESULTS:

- Concentration of VFA in soluble phase after MW treatment ~ 150 mg/L (in article from 500 to almost 4000 mg/L)

*anaerobic digestion of wastewater → 2,5-10 g/L (Reyhanitash et al., 2017)

**release of VFA after MW treatment could improve anaerobic digestion of treated sludge → experimental confirmation needed

Research goals and experimental results III

Effect of MW irradiation on phosphorus solubilization

Background:

PO_4^{3-} - phosphate released from treated sludge

with addition of Mg - magnesium

NH_4^+ - ammonia from another waste stream (sludge or liquid from anaerobic digester)

$(NH_4)Mg(PO_4)\cdot 6(H_2O)$

STRUVITE

Crystalline material

Can be used directly as fertilizer or as source for production of fertilizers

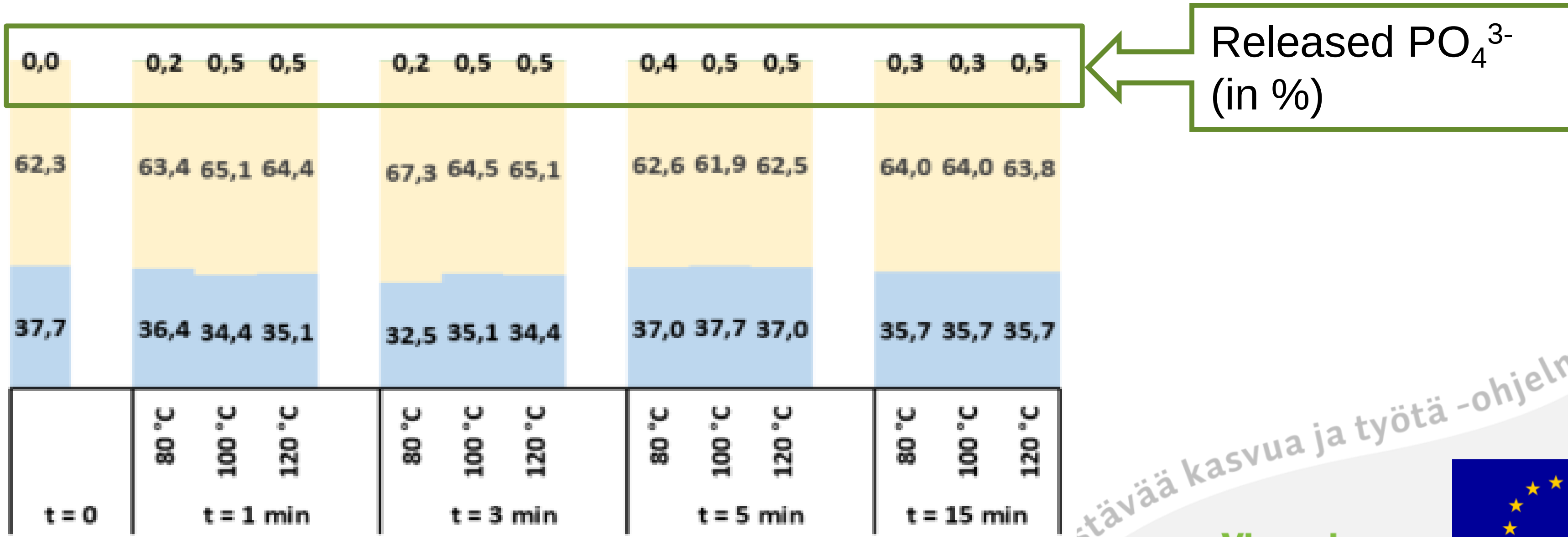
Can be formed during treatment of wastewater
Clogging of pumps, pipes, and other equipemnt

Research goals and experimental results III

Effect of MW irradiation on phosphorus solubilization

RESULTS:

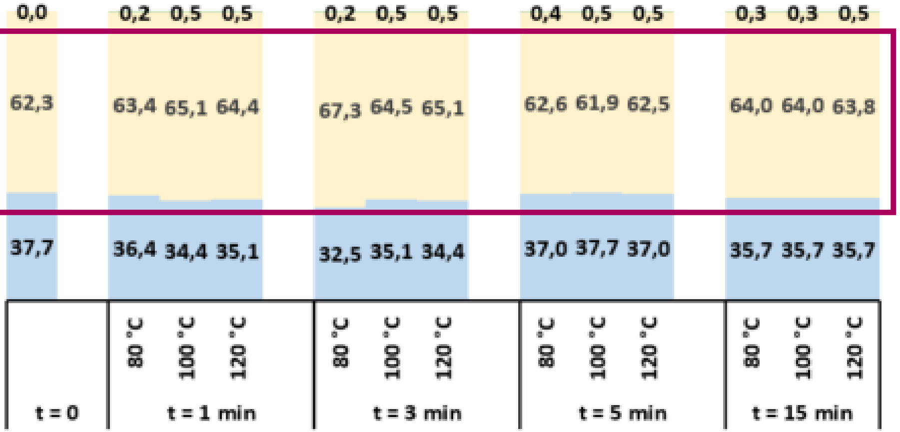
- release of soluble PO_4^{3-} (phosphate) neligible comparing to total phosphorus concentration (less than 1%)
- combining treatment with acid hydrolysis resulted the same observation



Other results and findings…

~ 60 % of phosphorus in form that
- is not soluble
- is not organically bound
- it needs harsh conditions to be solubilized

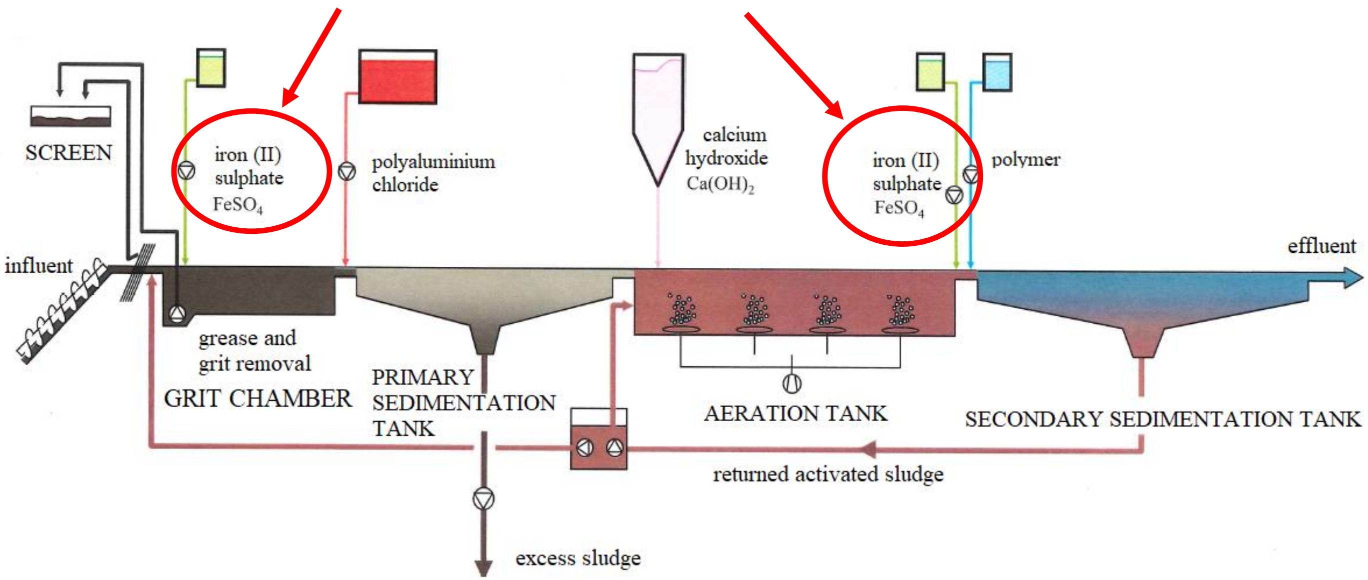
(diluted sample, acidified to pH=1 and thermally treated at 121°C for 30 minutes)



↑ microwave treatment

What is that fraction of phosphorus?
How it is formed?
What can we do with it?

Other results and findings…



Struvite (MAP or magnesium-ammonium-phosphate) recovery only possible in municipal wastewater treatment plants with enhanced biological phosphorus removal (EBPR). (Wilfert et al., 2018)

In case of chemical phosphate removal (CPR) reactive phosphate precipitate with metals as salt:

- Iron salts ($Fe(III)PO_4$, $Fe(II)_3(PO_4)\cdot 8H_2O$) VIVIANITE
- Aluminium salts ($AlPO_4$)
- HA = hydroxyapatite ($Ca_5(PO_4)_3(OH)$)

Other results and findings…

About vivanite

Vivianite vs. struvite:

STRUVITE	VIVIANITE
Enhanced biological phosphorus removal (EBPR) process	No strict operating conditions required
Optimal pH= 8,0-9,5 (addition of alkali required)	Optimal pH= 6,0-9,0
Recovery efficiency ~ 30-40 %	Recovery efficiency ~ 60 % Could be enhanced
NH_4+ presence and Mg addition needed	Fe can already be present in wastewater
	Fe salts addition relatively cheap
Price: 500 €/t	Price: 10 000 €/t

Source: Wu et al., 2019

Use:

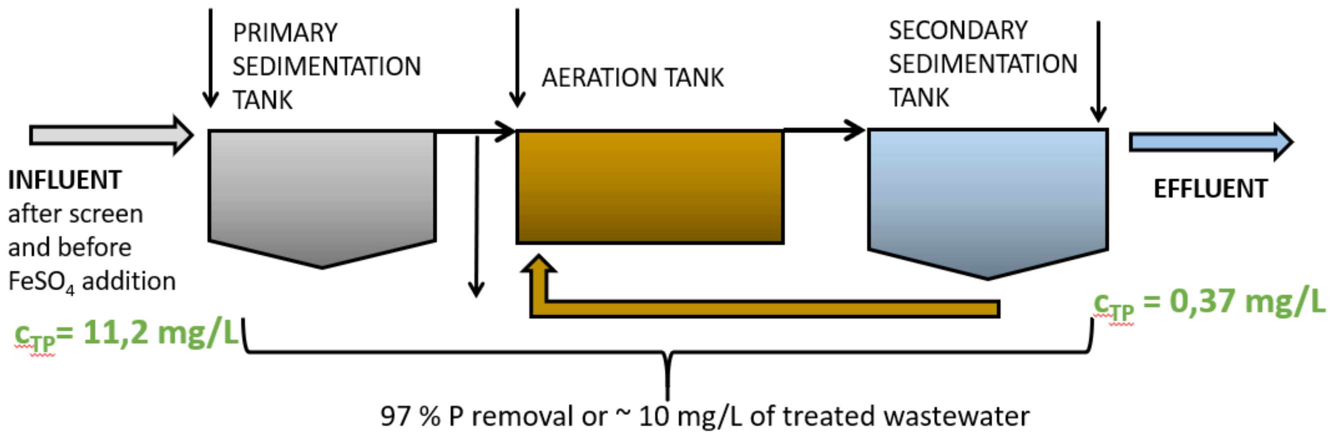
- ✓ source for the manufacture of lithium iron phosphate LiFePO4 → precursor for fabrication of Li-ion batteries
- ✓ slow-release fertilizer

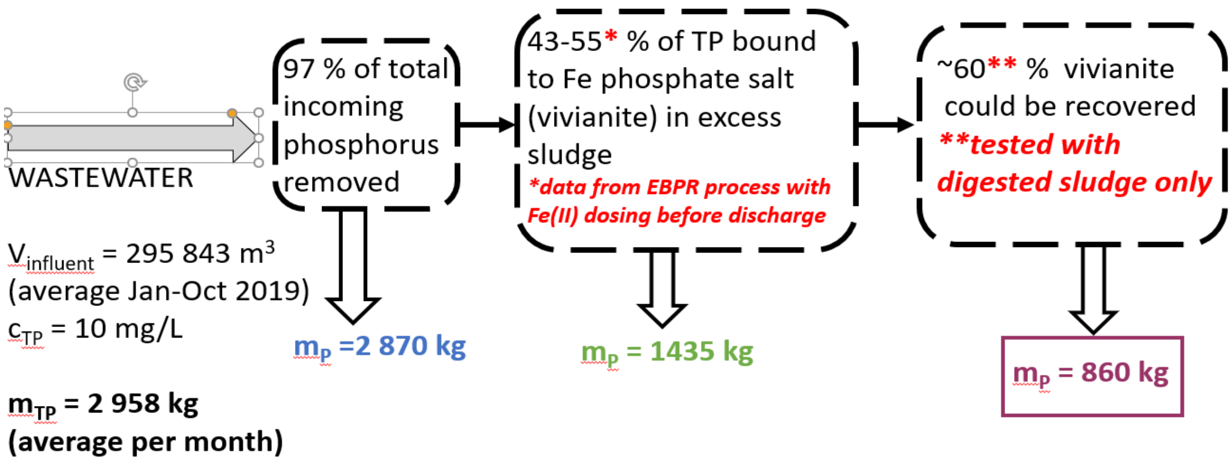
+ can reduce chlorosis caused by iron deficiency in certain crops

- ➢ can be used for recovery of P and Fe → P can be used for fertilizer production and Fe reused in wastewater treatment

Other results and findings…

Potential for P recovery through vivianite in Mikkeli wastewater treatment plant (WWTP)





Mikkeli WWTP has potential for recovery of ~ 1 ton of phosphorus per month

Conclusions

- Sole treatment of secondary sludge with MW irradiation does not provide any significant benefits for wastewater treatment process.
  - Destruction of biomass could improve biogas yield → assumption need to be tested experimentally
- Release of volatile fatty acids was found to be negligible comparing to fermentation processes thus, recovery from this stream is not feasible.
- Use of MW irradiation for phosphorus release alone and coupled with acid hydrolysis did not promote release of orthophosphate from secondary sludge.

Future research directions

- **In what form is phopshorus present at different stages of wastewater treatment proces?**

→ on-going research, article in preparation

→ primary, secondary and anaerobic sludge will be analyzed for different phosphorus fractions

→ mass balanced will be calculated

- **Study of possibilities for vivanite recovery (magnetic separation, centrifugation)**

NOVELTY – it is possible to recover vivianite from secondary sludge before anaerobic digestion?

- **Study of process parameters that influence vivanite formation**
- **Study of recovered material (strucure, impurities, possible further use)**

Thank you !

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Kestävää kasvua ja työtä -ohjelma

Vipuvoimaa EU:lta 2014–2020

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