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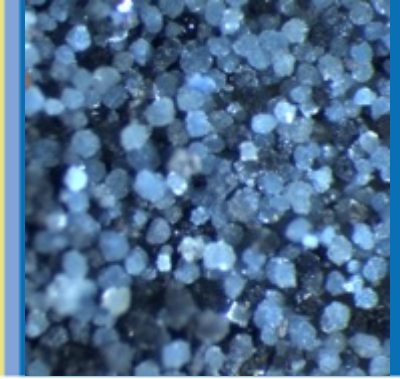
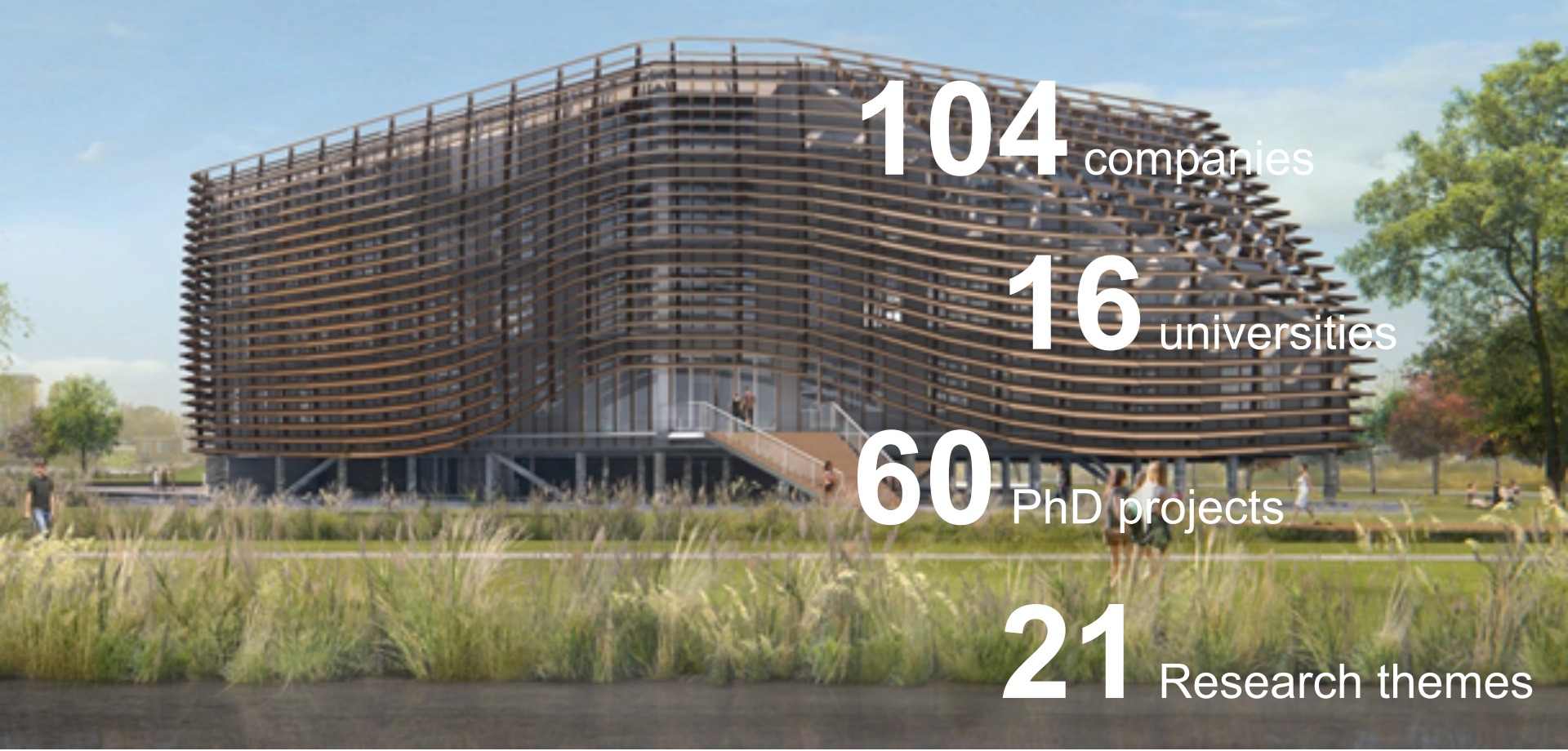
for sustainable water technology



Fe and P interactions: often overlooked but key to P removal and recovery

Leon Korving

ESPP Phosphorus workshop, Liege, October 9, 2019


104 companies
16 universities
60 PhD projects
21 Research themes

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For P recovery: Fe is bad….

Because:

- Sewage plants that use Fe (or Al) cannot recover struvite
- It limits the P recovery potential of struvite recovery
- In soils FeP is not bioavailable:
  - Therefore FeP limits efficient use of P in biosolids
  - Should not be present in recovery products

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But…

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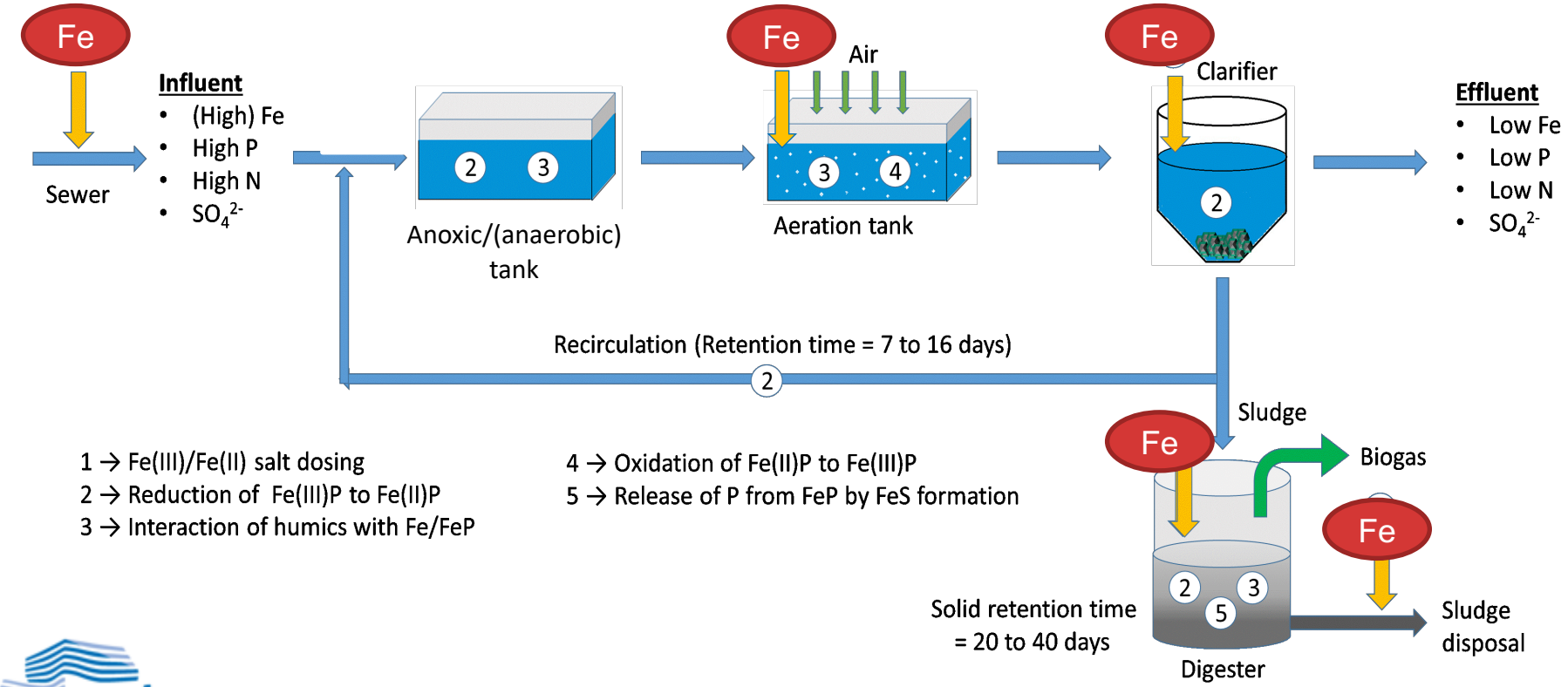
Fe: omnipresent in sewage treatment



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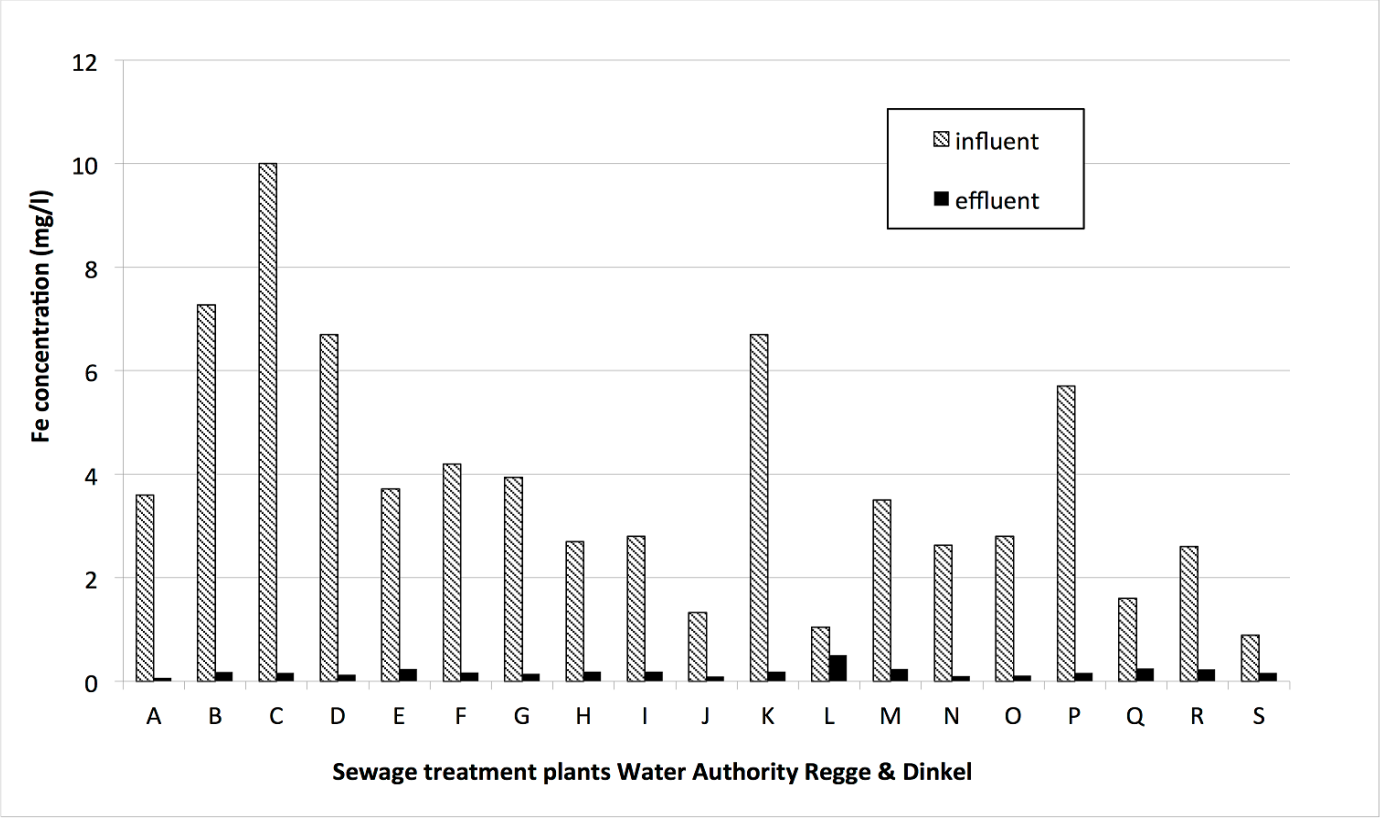
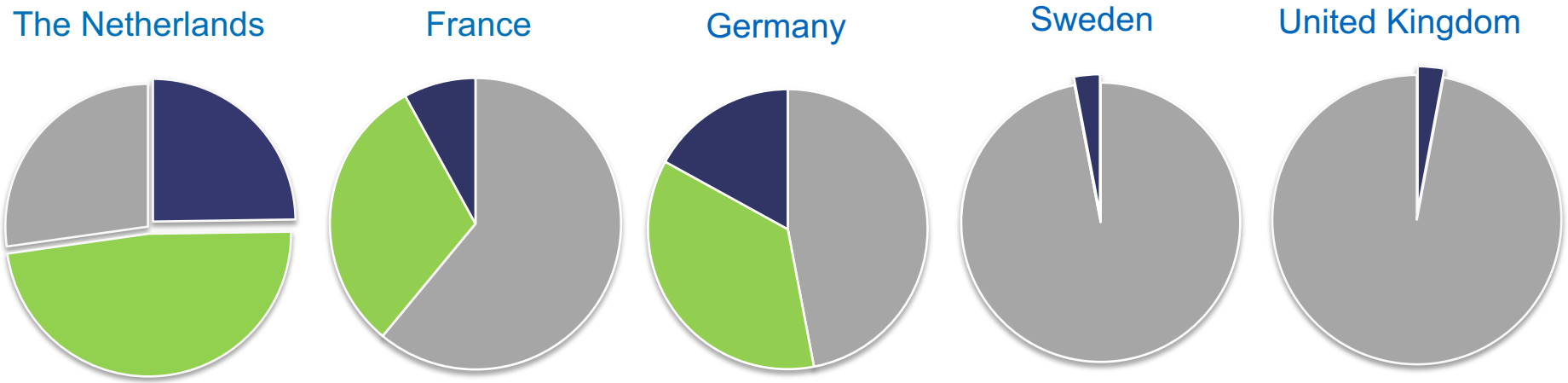
Wilfert et al, 2015, doi.org/10.1021/acs.est.5b00150

Fe in sewage influent



Korving et al, 2019, DOI: 10.1007/978-981-10-8031-9_21

Types of P-removal



Chemical P precipitation (often Fe) is widely used

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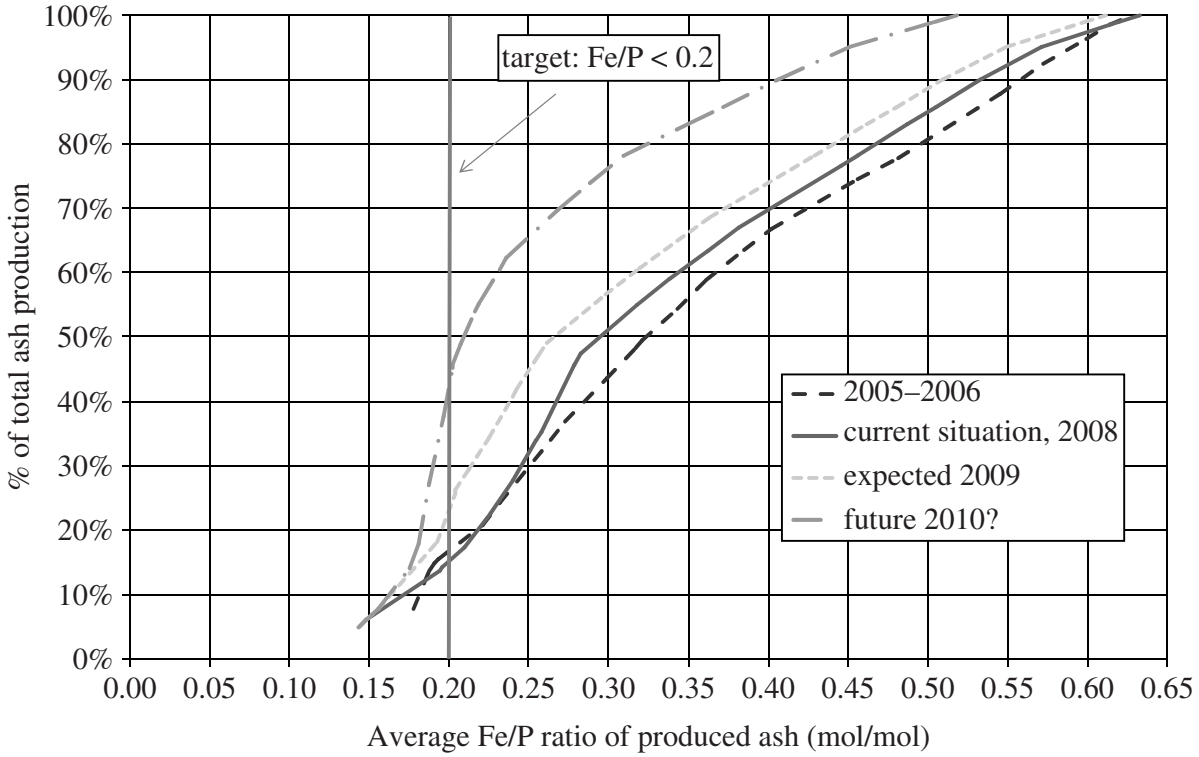
Korving et al, 2019, DOI: 10.1007/978-981-10-8031-9_21

Lot's of Fe in sewage sludge (ash)

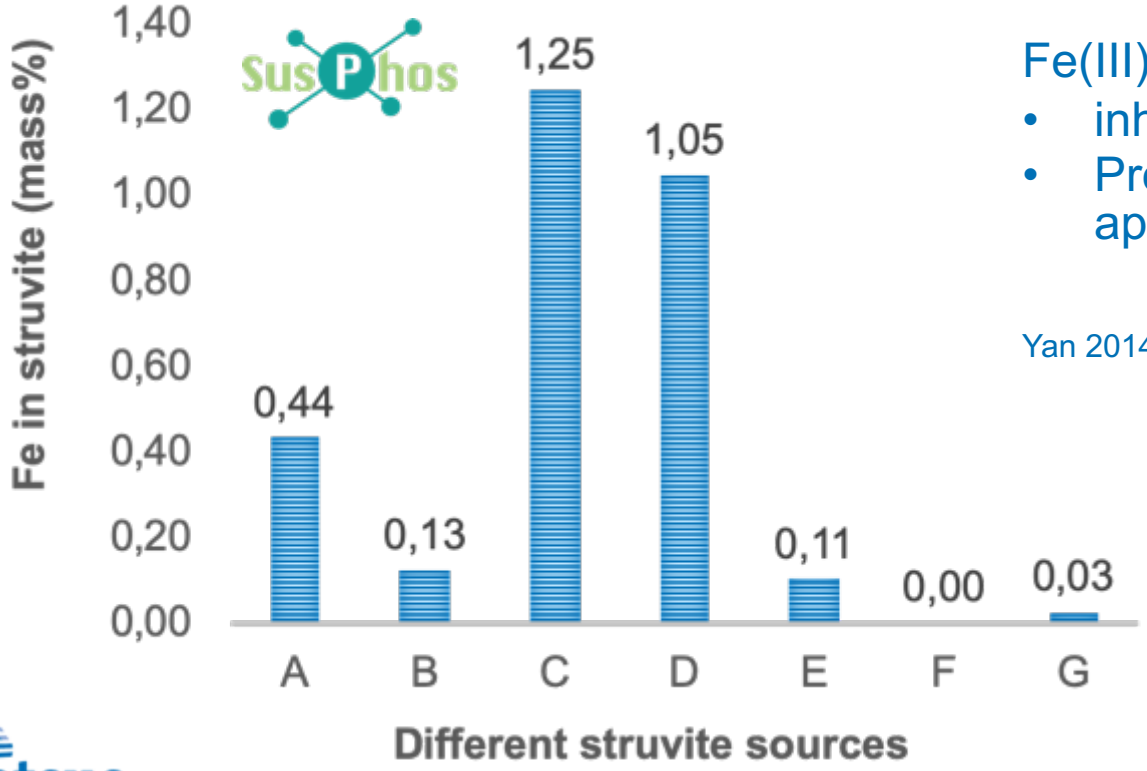
Fe in ash SNB

(25% of all sewage sludge in NL)



Schipper en Korving, 2009

Presence of Fe in struvite



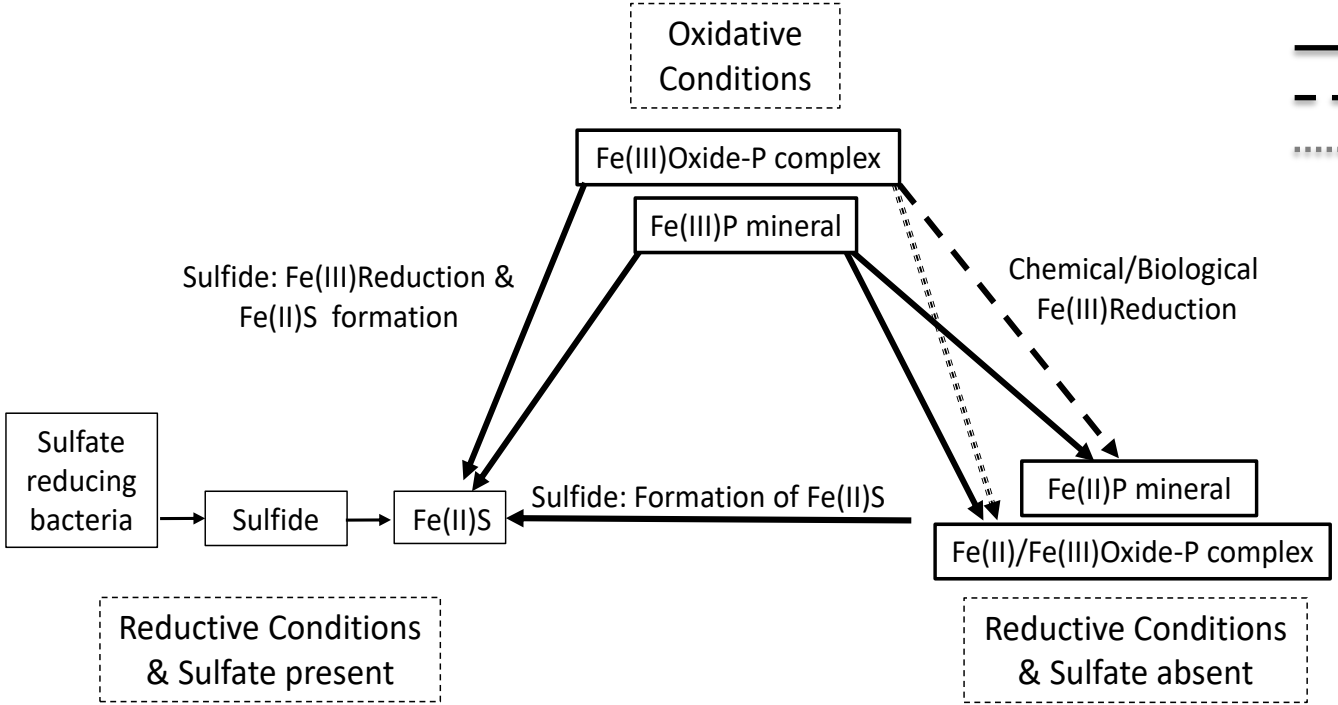
Fe(III) can:

- inhibit nucleation of struvite
- Promote irregular appearance of crystals

Yan 2014, Hutnik 2010

Data courtesy of Marissa de Boer, Susphos, 2019

Fe and P: complex interactions



And: complex interactions with humic acids

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Wilfert et al, 2015, doi.org/10.1021/acs.est.5b00150

Role of Fe in biosolids

EU perspective:

- Mixed views, focus on availability of P
- Most common: Fe is bad because the P is not available to plants

  Kidd 2007, Romer 2006, Krogstad 2005
- Others: P can be available, it depends

  Prochnow 2008, Nanzer 2014, Kahiluoto 2015

US perspective:

- Fe is good because it limits surface run-off of P

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Korving et al, 2019, DOI: 10.1007/978-981-10-8031-9_21

Acid leaching from sewage sludge ash

Behavior of Fe or Al-rich ashes is different

- P: start release at pH 3-4, maximum leaching at pH=2
- Al: start release at pH 4
- Fe leaching down to pH=2 is minimal.
- 30-40% lower acid consumption reported for high Fe ashes (compared to high Al ashes)

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Korving et al, 2019, DOI: 10.1007/978-981-10-8031-9_21

pH changes to sewage sludge

Acidification to release P:

- Different behaviour for Fe and Al
- Varying solubilisation efficiencies

Alkaline treatment

- Lower release
- Release efficiencies vary significantly

⇒ No clear picture

⇒ Need to better understand speciation of P

Effect of acidification. Gifhorn sludge (Hermanussen, 2012)

pH	Solubilization (% of total)		
	P	Fe	Al
4	55	40	0
3	70	70	25
2	90	95	85

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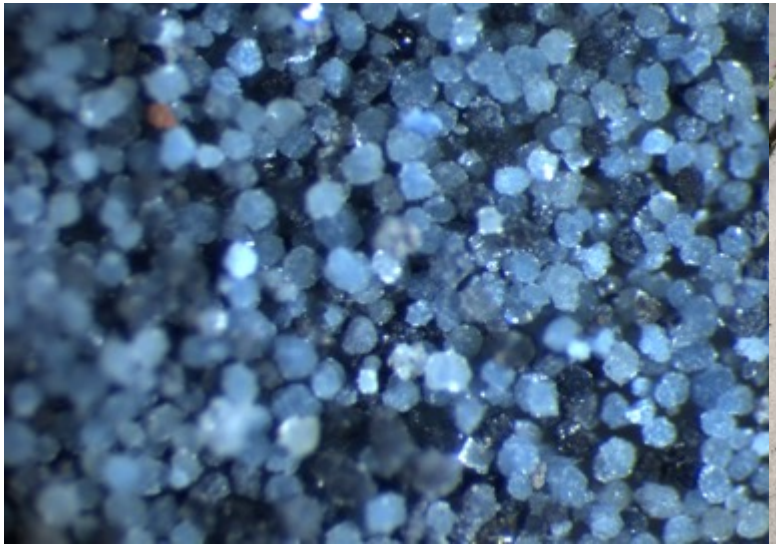
Korving et al, 2019, DOI: 10.1007/978-981-10-8031-9_21

Vivianite: key mineral

$Fe_3(PO_4)_2 \cdot 8H_2O$



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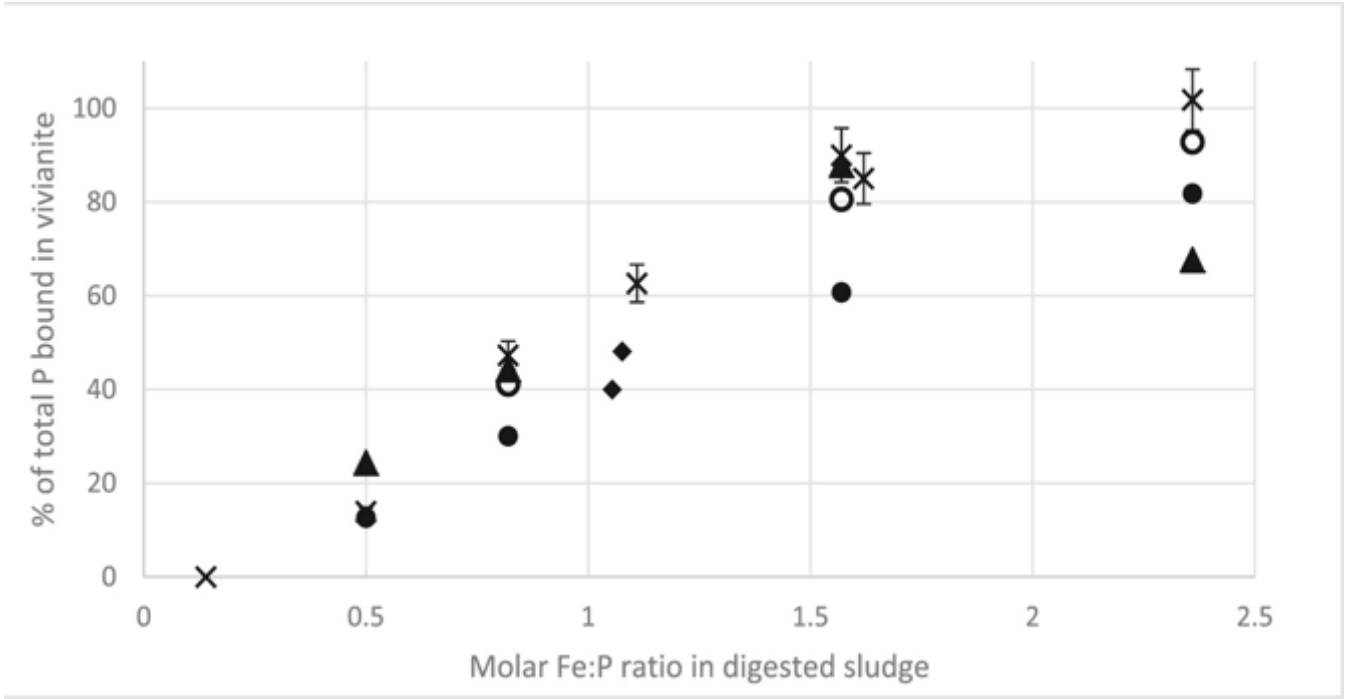
Up to 90% of P in vivianite



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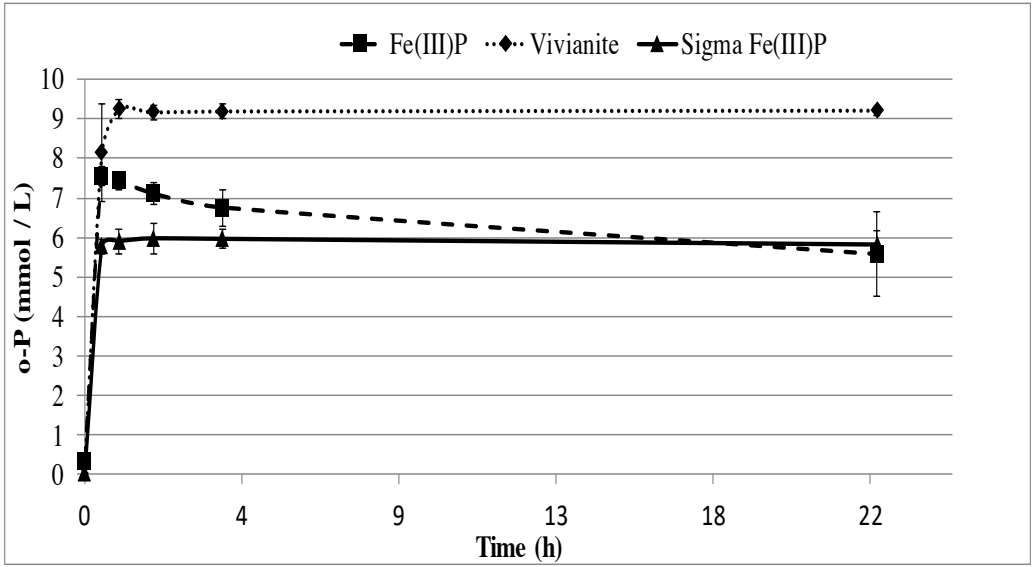
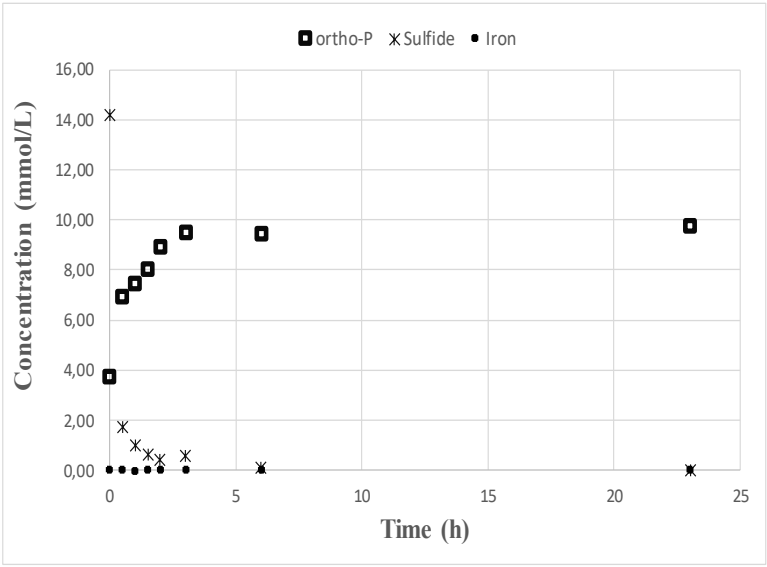
Wilfert, 2018, DOI: 10.1016/j.watres.2018.07.020

Sulphide to release P

Release from pure FeP



Release from digested sludge



Potential to increase P recovery via enhanced P release

Wilfert, 2019

Paramagnetism of vivianite

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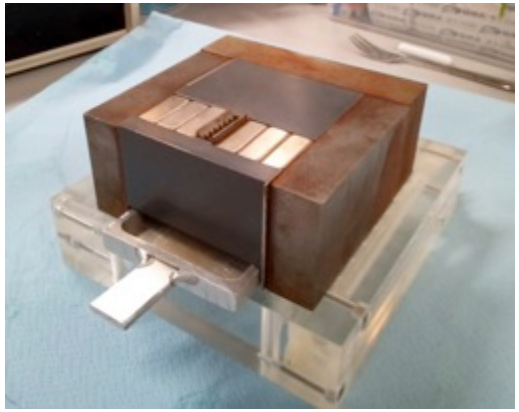
ViVoMAG

Magnetic recovery of vivianite



Lab
2016-2017

Bench
2018

Pilot
2018-2019

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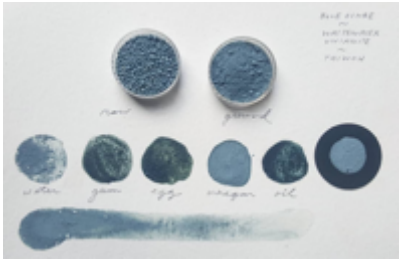
Vivianite valorization

(Research in progress)

- Direct uses
  - Fe-fertilizer (iron chlorosis)
  - Organic paint
  - LiFePO4 batteries

- Splitting in Fe and P
  - Alkaline treatment with KOH
  - Susphos: flame retardent



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SusPhos

ViVoMAG

Eutrofication

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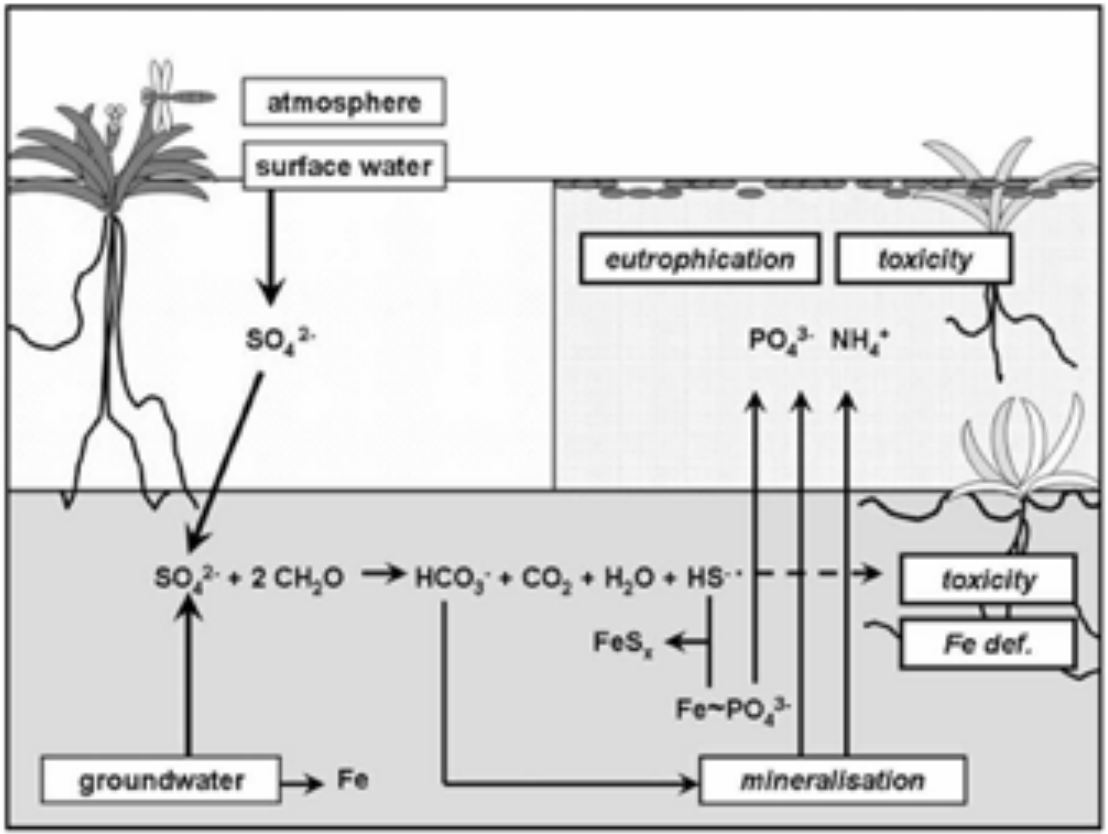
Mobilisation of P in lakes



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Removal from agricultural drainage

Iron oxide coated sand

Up to 90 % phosporus removal

Deltares

aqua minerals

Hoogheemraadschap van Rijnland

ALTERRA WAGENINGEN UR

ARCADIS

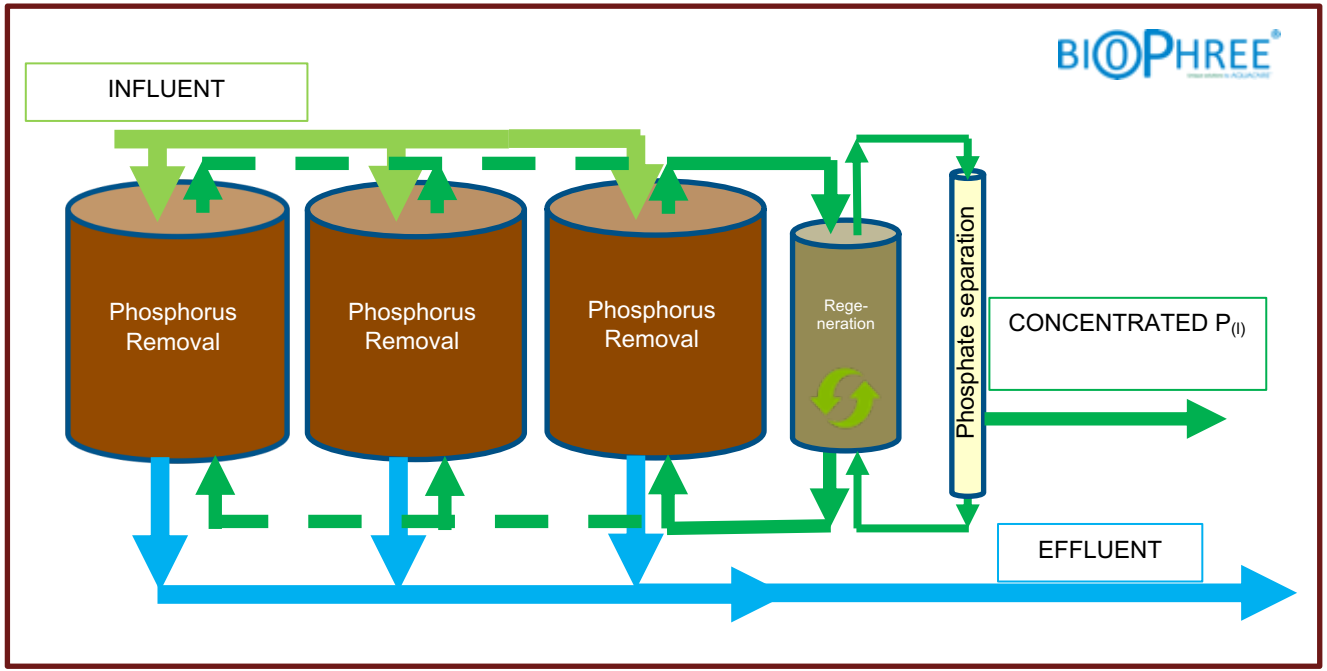
Regenerative adsorption

Regeneration reduces costs, recovers P

Prize winning:

THE GEORGE BARLEY WATER PRIZE

BONUS RETURN



Fe-based adsorbents

Regeneration via alkaline treatment

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AQUACARE Science in water! EUROPE & SERVICE

Take home message

- Fe and P interactions have impact on P recovery
- This interaction can be good or bad
- Role of Fe should be taken into account when evaluating effects on P-recovery
- Avoiding Fe seems to be impossible. Therefore understand and use it's interactions with P

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Where water meets chemistry

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Outotec

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combining scientific excellence with commercial relevance