From discussion to implementation

Nutrient Recovery from Sewage
The Way Forward

by Christian Kabbe
Sewage (sludge) is a renewable nutrient resource still waiting to be tapped into its full potential in sustainable ways.
Pillars of Nutrient Recovery & Recycling

Challenge: Enabling techn. alternatives to complement /compensate traditional route!
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Sewage Sludge - Destinations in Europe - Diversity

Total sludge quantity covered: appr. 10 million tons of dry solids per year!

Global Compendium of P Recovery – state of play

http://www.globalwaterresearchcoalition.net/_r3453/media/system/attrib/file/766/Phosphorus%20Recovery%20Factsheet%20January%202019.pdf
Global implementation – the compendium (status Jan 2019)

More than 100 full-scale plants operational world-wide! > 80 recover Struvite (> 60 are municipal)
Availability of Solutions? ... Yes! there are ...

Where?

Integrated recovery at WWTP

Re-dissolution modules

Without enforced re-diss.

Poly-phosphate re-diss. prior digestion

Thermal hydrolysis

Chemical re-dissolution

Recovery modules

Crystallization in sludge matrix

Crystallization in sludge liquor or adsorption at CSH after dewatering

Pre-treatment

Sewage sludge mono-incineration

Thermal alternatives

Chemically

Glatt® SERAPLANT NPK

METAWATER HAP

AshDec, EuPhoRe Mineral Phosphates

RecoPhos (InduCarb) P₄

RecPhos (InduCarb) P₄

EcoRin P-rich slag

Thermal alternatives

Conv. Fertiliser Manufact. SSP/TSP/NP/NPK/PK

Ash2Phos & CleanMAP DCP, MAP, SSP, ...

EcoPhos and TetraPhos tech. grade H₃PO₄

Solvent Extraction tech. grade H₃PO₄

P recovery & recycling

Chemically

AshDec, EuPhoRe Mineral Phosphates

RecoPhos (InduCarb) P₄

EcoRin P-rich slag

Thermal

Thermophos P₄

Mephrec P-rich slag

KUBOTA P-rich slag

Down-stream recovery from sewage sludge

Agriculture

Landscaping

Direct application

Full-scale

Demo/Pilot
Nutrient Recovery Cascades for P & N + Energy are state of the art!

Source: amended from Kraus 2016
Nutrient Recovery Cascades for P & N + Energy are state of the art!

Drivers are:
- Operational needs/reduced maintenance
- Benefits like reduced sludge volume for disposal -> reduced cost
- Synergies with energy recovery
- Improved overall WWTP performance to meet stricter P consents
Challenges and **keys to Success and Sustainability?**

Only technologies, yielding **homogenous products** or raw materials, **independent from input material quality** and mutually meeting both criteria, **energy efficiency** and **resource efficiency** will have a chance for wide-spread application under sustainability aspects.

**Keys:**
- ✓ Heavy metal depletion (**high quality products**)  
- ✓ Moderate energy (and chemicals) consumption (**cost**)  
- ✓ Market for “known” recovered P (**commercial products**) (**real value and price**)
Germany 2017+: a template to adapt, but not just to copy as is

- 2017 – new fertilising ordinance (DÜV) limits nutrient loads applied to land and acutely reduces sludge disposal capacities -> cost explosion!

- New fertiliser ordinance (DÜMV) sets stricter quality criteria (less sludge conform) – monitoring cost

- 2017 – new sewage sludge ordinance (AbfKlärV) enters into force
  - 2023 – all WWTP have to submit sludge management concepts considering P recovery
  - 2029 – P recovery oblig. for all WWTP above 100,000 p.e. (ban from land application)
  - 2032 – P recovery oblig. for all WWTP > 50,000 p.e.
    - Even smaller WWTP have to recover P, if no land application possible
    - On-site WWTP: P recovery to deplete below 20 g P/kg DM or at least by 50%
    - After thermal-pretreatment recoverable separate storage of ash/concentrate or recovery process with >80% recovery rate

What is missing?
- No marketable recycling concepts included
- No measure to secure proper ash quality (all sludge can be inc. in mono-inc.)
- Reverence value for P should refer to mineral sludge phase, not to DS
- Who pays for what? (Inc. and recovery from ash monopoly?)
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- 2017 – new sewage sludge ordinance (AbfKlärV) enters into force
  - 2023 – all WWTP have to submit sludge management concepts considering P recovery
  - 2029 – P recovery oblig. for all WWTP > 300,000 p.e. (ban from land application)
  - 2032 – P recovery oblig. for all WWTP > 100,000 p.e.
    - Even smaller WWTP have to recover P, if no land application possible
    - On-site WWTP: P recovery to deplete below 20 g P/kg DM or at least by 50%
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Aarhus, 18 Jan 2019; Presentation by Christian Kabbe
Hotspots for P recovery & Recycling for WWTP > 50,000 p.e.
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Influent → Grit chamber → Primary clarification → Aeration → Secondary clarification → Effluent

Waste activated sludge → P re-dissolving pre-treatment

Thickening → Process water

Anaerobic digestion → Biogas → Dewatering

2a → 2c → 2b

Agriculture (1)

Incineration (3)

Integrated in WWTP

Site by Site

Downstream WWTP

Clusters
Hotspots for P recovery & Recycling for WWTP > 50.000 p.e.

Integrated in WWTP

Site by Site
Hotspots for P recovery & Recycling for WWTP > 50,000 p.e.

Integrated in WWTP

Site by Site

Downstream WWTP

Clusters

1. agriculture
2. P re-dissolving pre-treatment
3. incineration

Process:
- influent
- grit chamber
- primary clarification
- aeration
- secondary clarification
- effluent

Secondary clarifier

Primary clarifier

Grit chamber

Anaerobic digestion

Biogas

Waste activated sludge

Dewatering

Thickening

Process water

2c

2b

2a
Hotspots for P recovery & Recycling for WWTP > 50.000 p.e.

2029/32+
- Land appl. prohibited
- Co-incineration only for sludge with < 2%P
- Mono-incineration allowed without restriction, but P recovery from ash afterwards required

Priority for utilities:
- Long term disposal security
- Cost control
- Lowest financial risk

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Germany 2017+ substantial increase of mono-incineration

- Currently appr. 668 kt DS mono-incineration capacity 2017 (municipal sludge)

- After 2029/32 at least 1.200.000 Mg DS capacity needed to comply with sludge reg (Ecoprog 2017) … likely more

- Most new capacities between 2022 and 2027 (already +600 kt DS in prep. announced)

  -> future SSA quantity > 500.000 Mg/a (>45.000 Mg P/a)

Challenges/bottlenecks for implementation:

- Suppliers increased equipment prices substantially (cost explosion)

- Capacity of engineering consultants (with recent references?)

- Negative image of incineration
No Recycling without **Value Chains** from sludge to products

Waste, raw material or product? -> Question of volume, homogenity and **still** of origin!

**Commodities**
- Sludge/biosolids
  - organic fertiliser
  - NP fertiliser in some MS (very interesting for organic farming!)
  - approved P fertiliser (component)
  - generally barely plant available, rather raw material – processing needed
- MAP/DAP
- MGP / $P_4$

**Household, industry** → **WWTP** → **Raw material** → **Fertiliser** → **Agriculture**

End-of-Waste border line

Supply

Cost? Profits?

Recycling

Other industries

Demand
Thank you

Urban Resilience TAG Europe

Copenhagen, 23 January 2019
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