Solution Architect for Global
Bioeconomy & Cleantech Opportunities

arvi
Material Value Chains

16.01.2016

Ivan Deviatkin

Doctoral student, Department of Sustainability Science, School of Energy Systems, Lappeenranta University of Technology

Getting most out of the thermal drying of sewage sludge to stay within the planetary boundaries for the nitrogen cycle

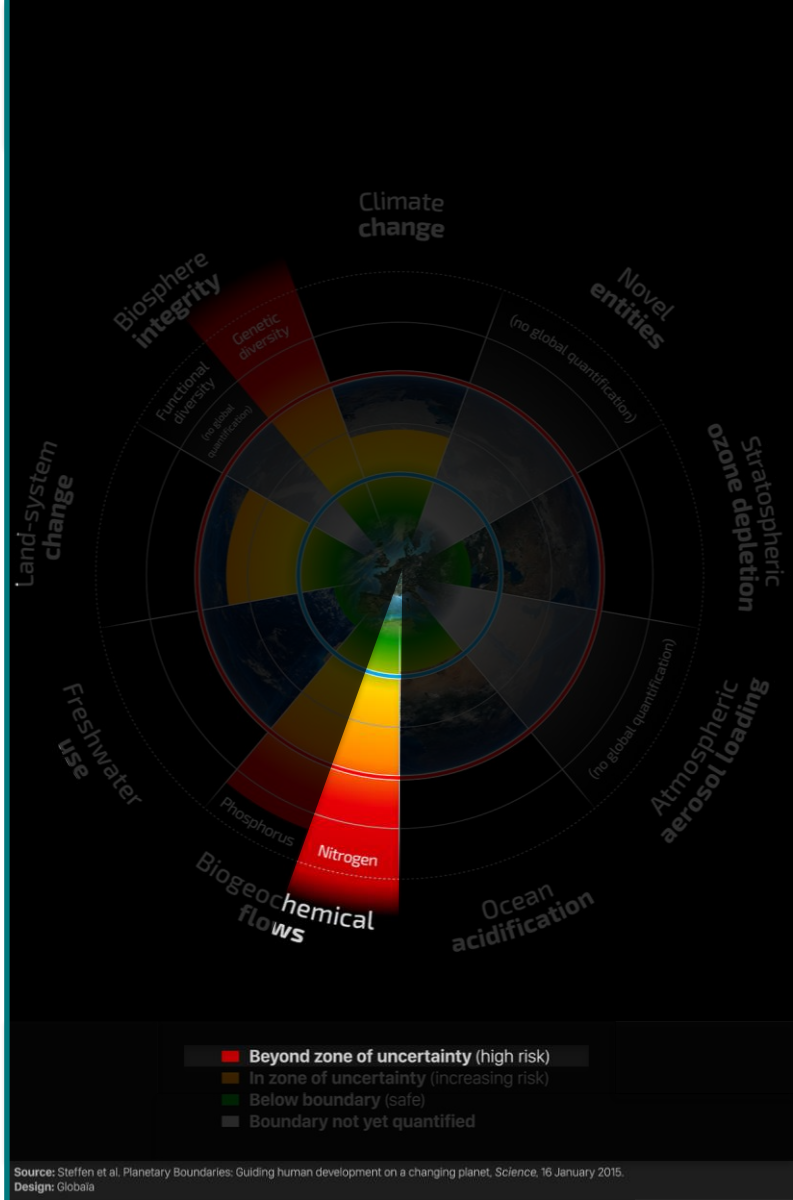
Planetary boundaries

1.0-2.5 mg N/L – limit to prevent eutrophication.

To keep it such, the planetary nitrogen fixation boundary is set to 62-82 Mt N/year.

Currently, the fixation rate is 121 Mt N/year, where 82 Mt N comes from synthetic fertilizers.

Therefore, 20-26 Mt N from synthetic fertilizers should be avoided.

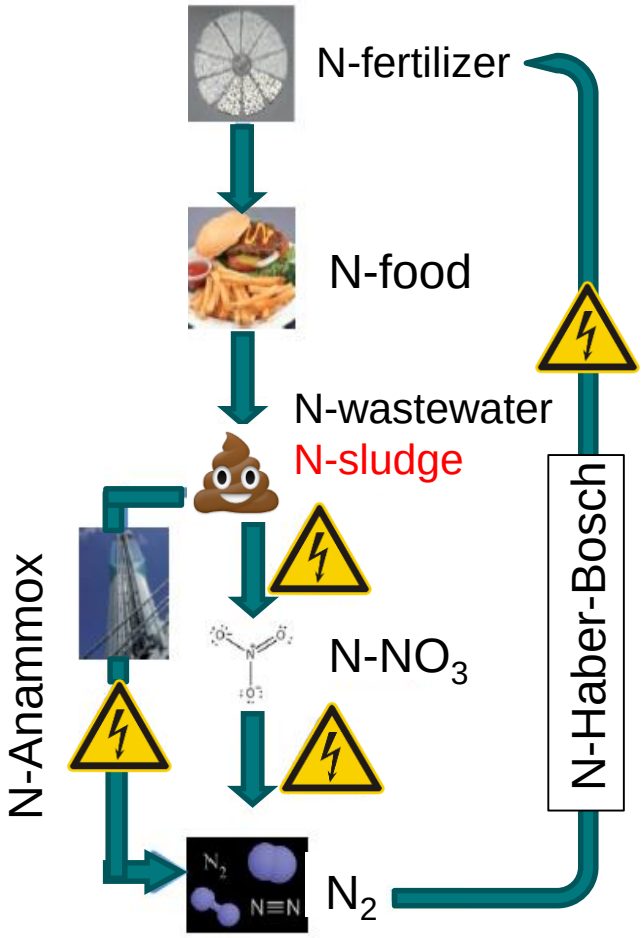


arvi
Material Value Chains

Where to get N, if not a synthetic one?

Stream	N content, mg/L
Liquid manure fractions	≈ 3,500
Digested manure	≈ 3,500
Organic waste	≈ 1,200
Reject water from WWTP	≈ 750
Industrial waste streams	*
Condensate from sludge drying	*

Great attention was drawn to N recovery from liquid flows neglecting direct recovery from gaseous flows!



van Eekert, M., Weijma, J., Verdoes, N., de Buisonje, F., Reitsma, B., van den Bulk, J., van Gastel, J., 2012. Explorative research on innovative nitrogen recovery.

Research idea (!) and questions (?)

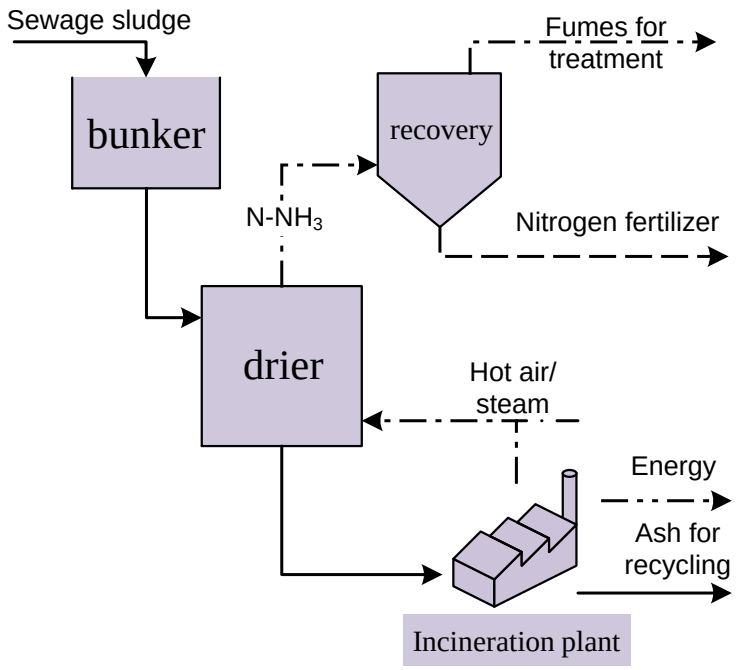
(!) sludge drying and incineration is a common practice, so nitrogen recovery during thermal drying of sludge (and similar streams) was seen favorable.

(?) how much N is released from sewage sludge, digestate, and biosludge from a pulp and paper mill

(?) what is the impact of T on the N release

(?) which recovery methods could be practiced

(?) intensifying N release through condensate stripping

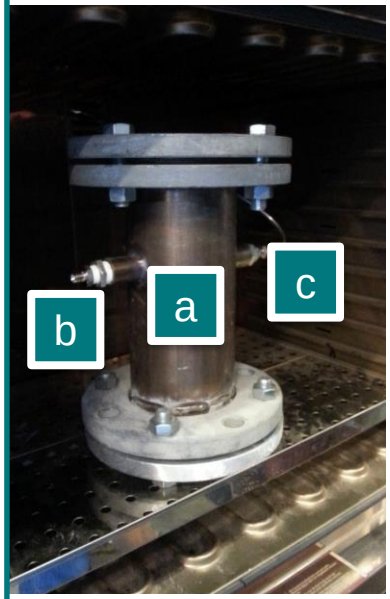


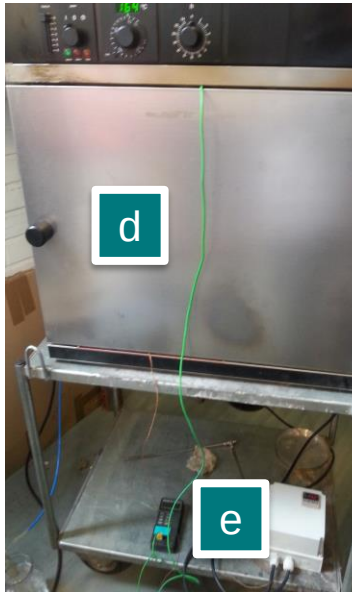
Nitrogen release during batch drying 1

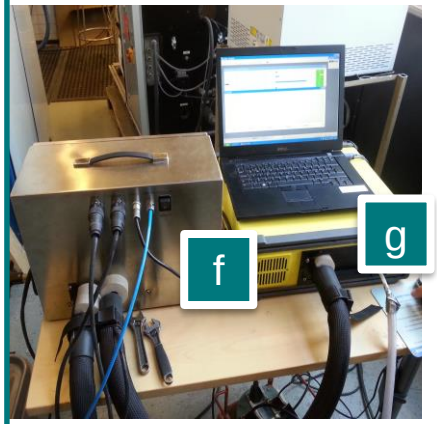
Experimental setup on the Figure →

Sewage sludge	Toikansuo WWTP, LPR
Digestate	Kouvolan Vesi Oy, Kouvola
Biosludge	UPM Kymmene, LPR

Nitrogen species	Digestate	Exhaust fumes	Condensate
Total nitrogen (N_{tot})	Modified Kjeldahl test	n.d.	Nitrogen (total) cell test
Soluble nitrogen (N_{sol})	WE + Nitrogen (total) cell test	n.a.	n.d.
Ammonium (NH_4^+)	WE + Ion chromatography	n.a.	Ion chromatography
Ammonia gas (NH_3)	n.a.	FTIR	n.a.

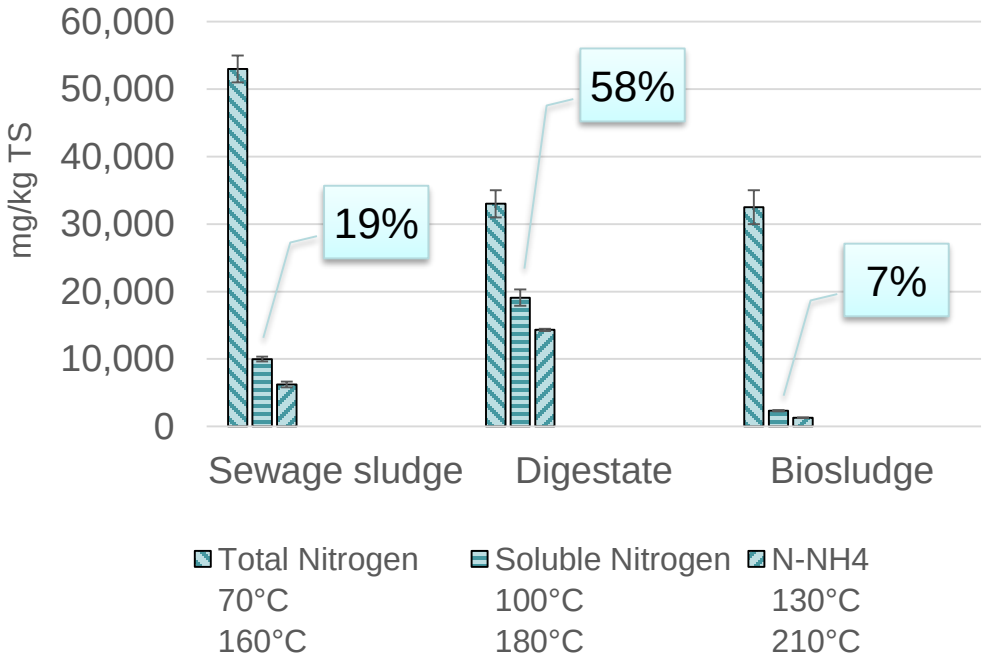


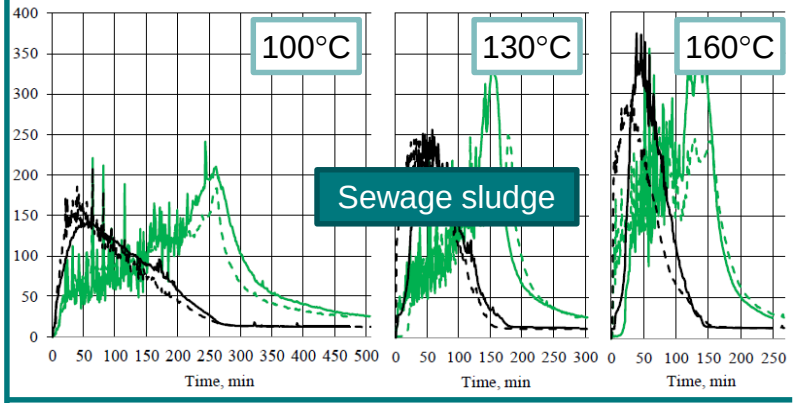


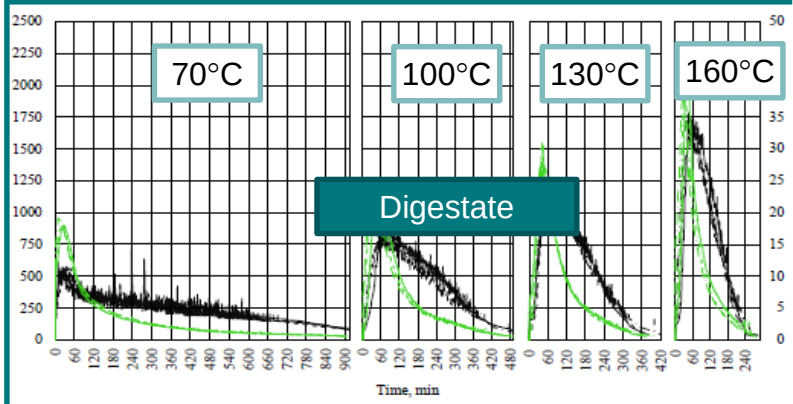


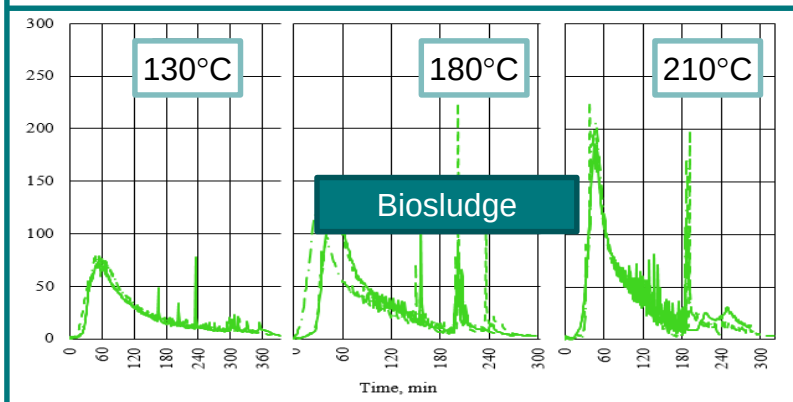
Legend:
a – vessel with sludge
b – inlet pipe
c – outlet pipe
d – electric oven
e – thermometer
f – praparation unit
g – Gasmet analyzer

Nitrogen release during batch drying 2

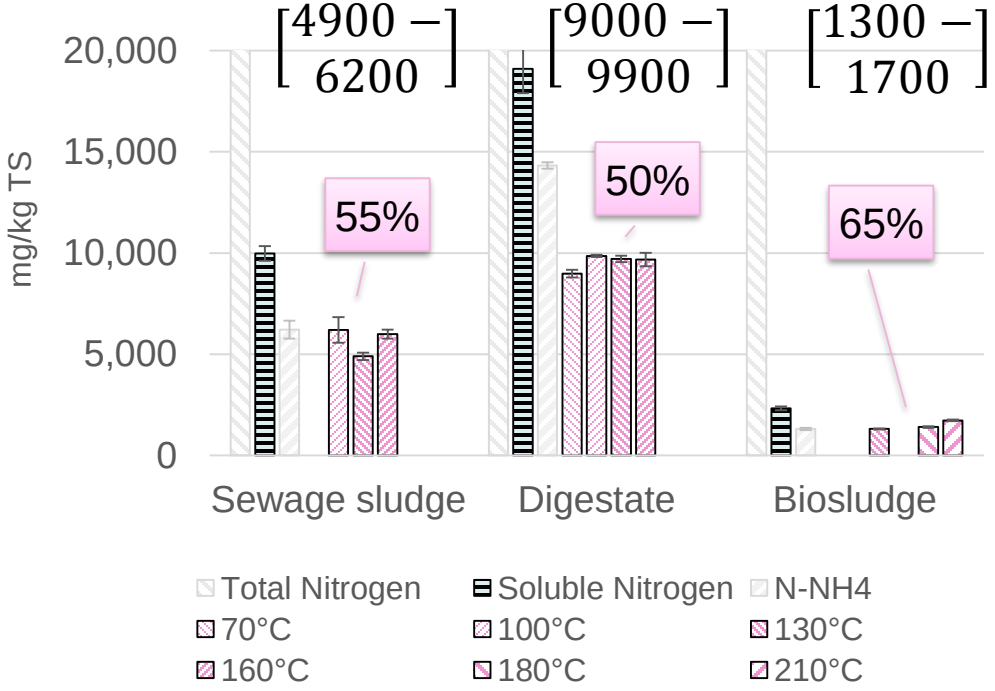


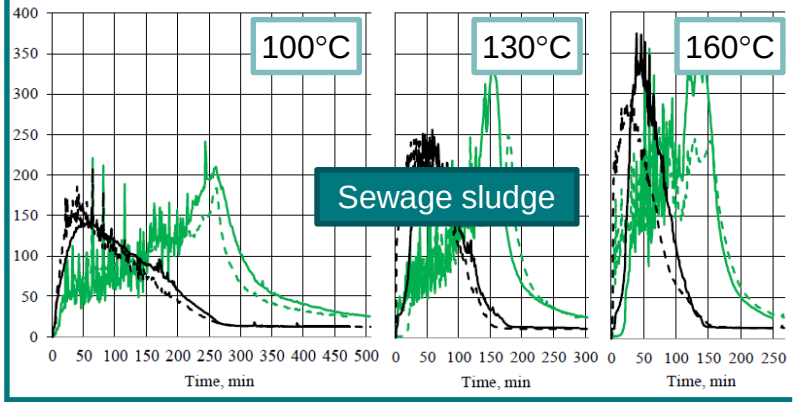


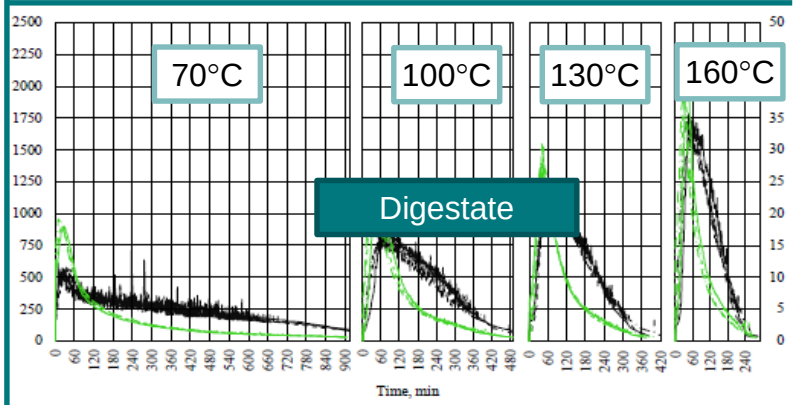


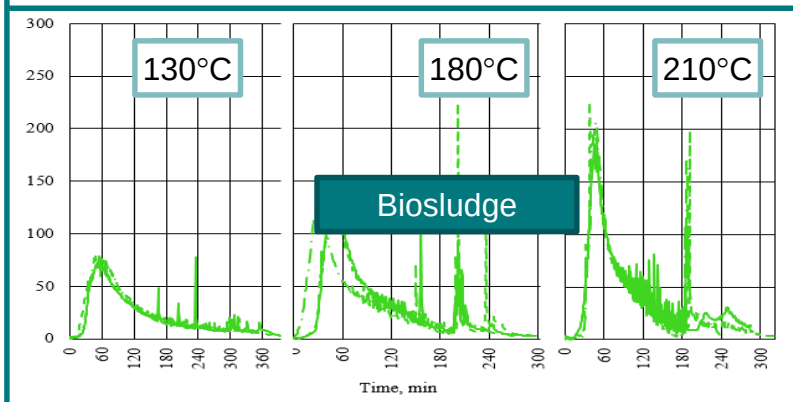


Nitrogen release during batch drying 3









Nitrogen release during continuous drying 1

Experimental setup on the Figure →

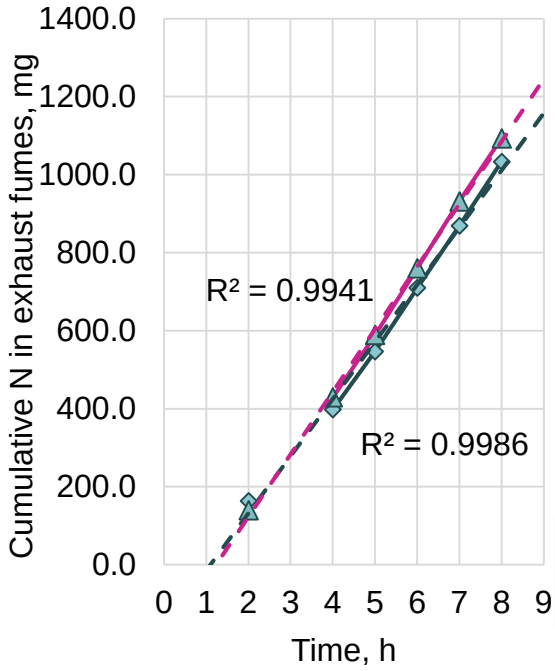
Two (+1) tests. Feeding at 1.38±0.17 kg/h.
MC of raw sludge was 83.7±0.1% and of dried sludge – 31.1±0.1%.
Each experiment lasted for 8 hours.

Ammonia measurement at 2h, 4h, 5h, 6h, 7h, 8h.
Acid traps for NH_3 capture. Ion chromatography.

Biochar was used for ammonia capture

arvi
Material Value Chains

Nitrogen release during continuous drying 2



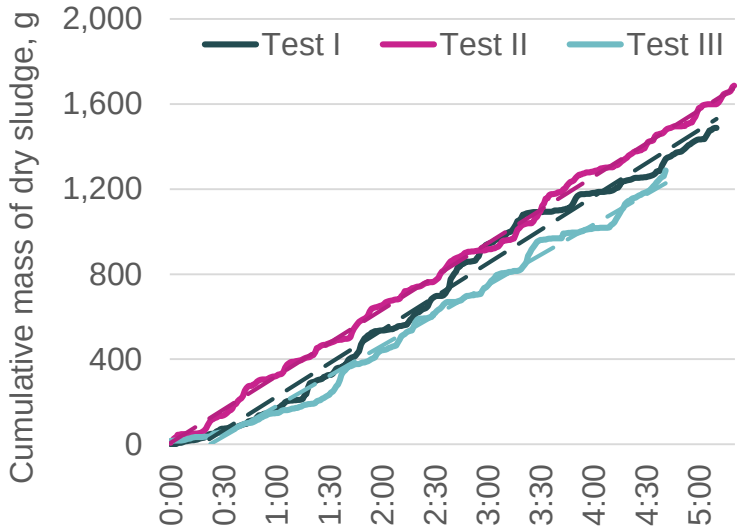
So we get:

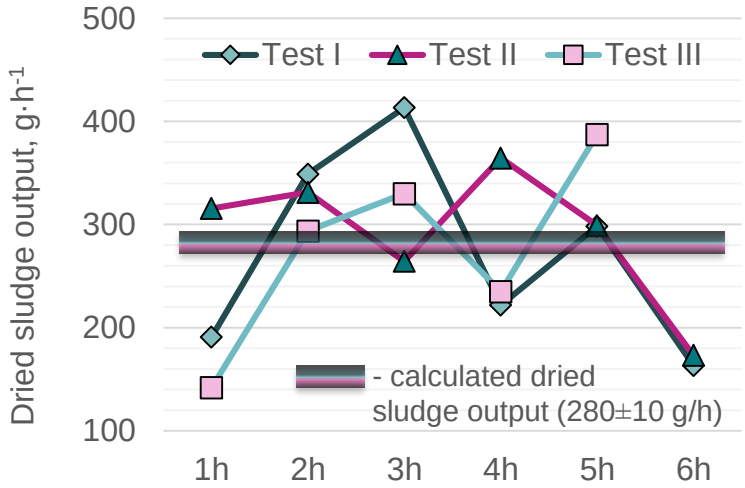
2.12±0.03 mg N/ g dried sludge

0.21±0.01 g dried sludge/ g wet sludge.

Therefore, we can get:

450±30 g N/t wet sludge





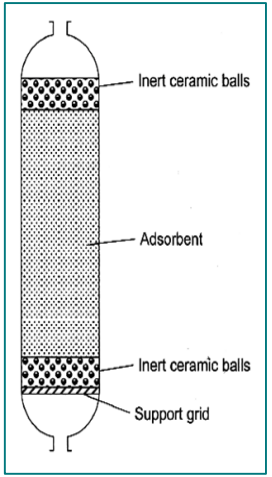
General recovery methods

Adsorption on biochar:
organic materials doped with N

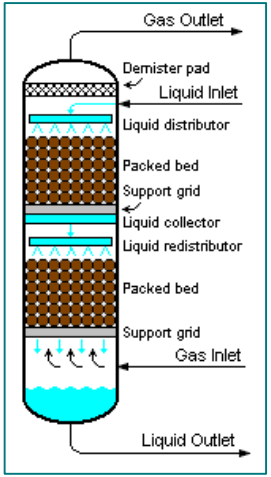
Absorption:

- ammonium sulphate solution,
- ammonium nitrate solution,
- ammonium chloride solution,
- etc.

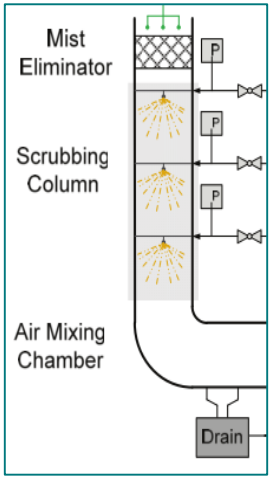
Aqua ammonia



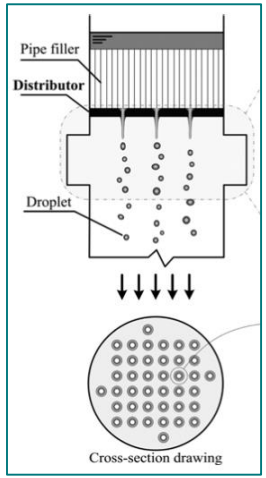
Packed adsorption



Packed absorption

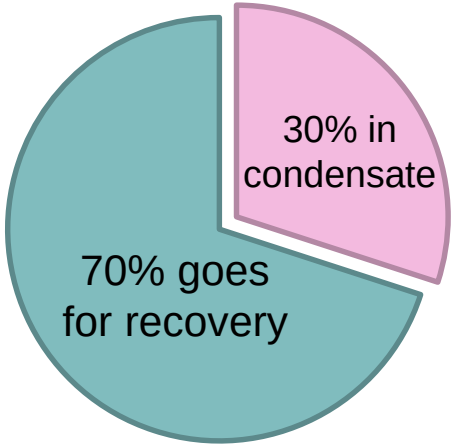


Sprayed absorption

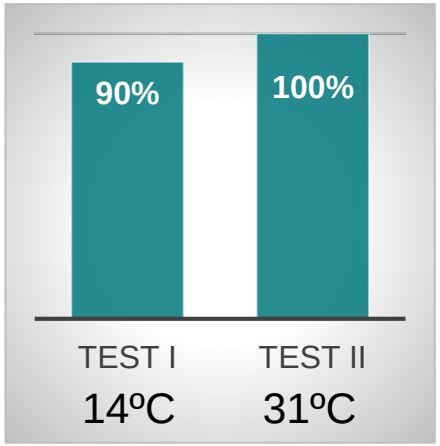


Droplet absorption

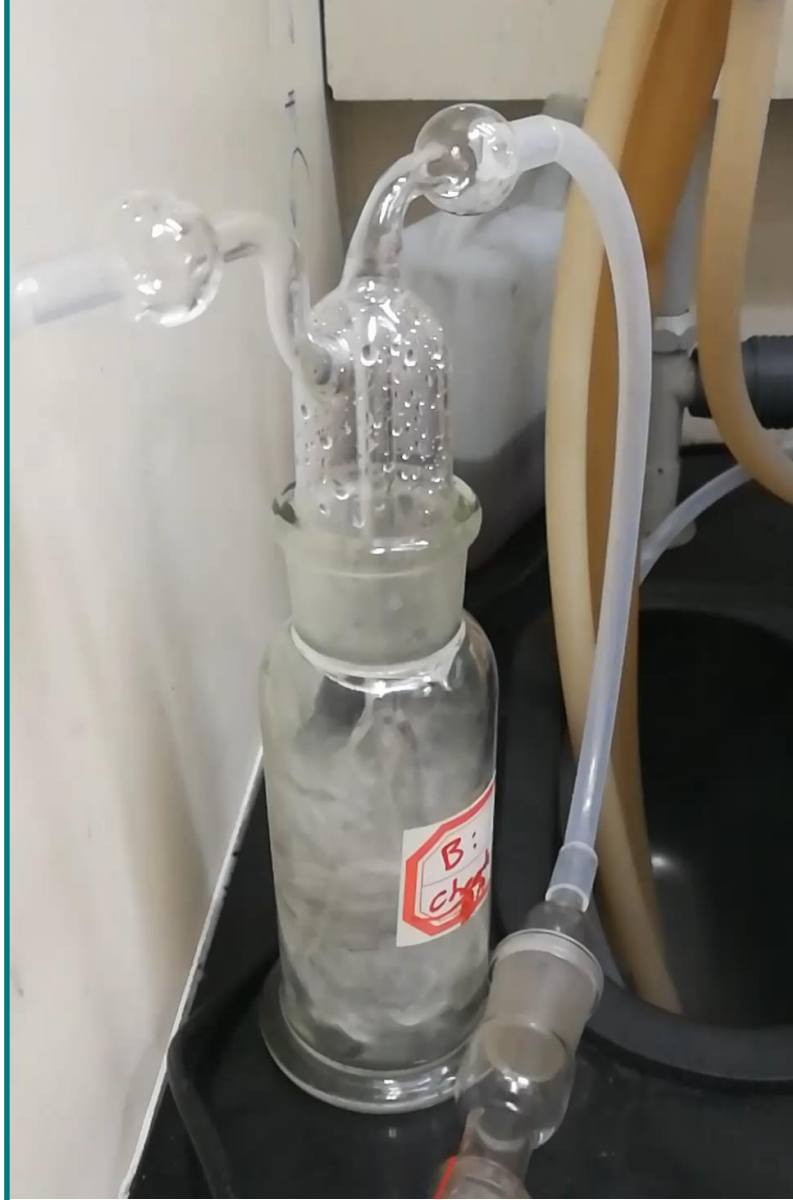
Intensifying ammonia release



Let us strip it!



Thus, there is the need to release 30% N back for recovery!



What do we get after all?

Sludge is a reliable source of nitrogen as its amount is ever-growing worldwide.

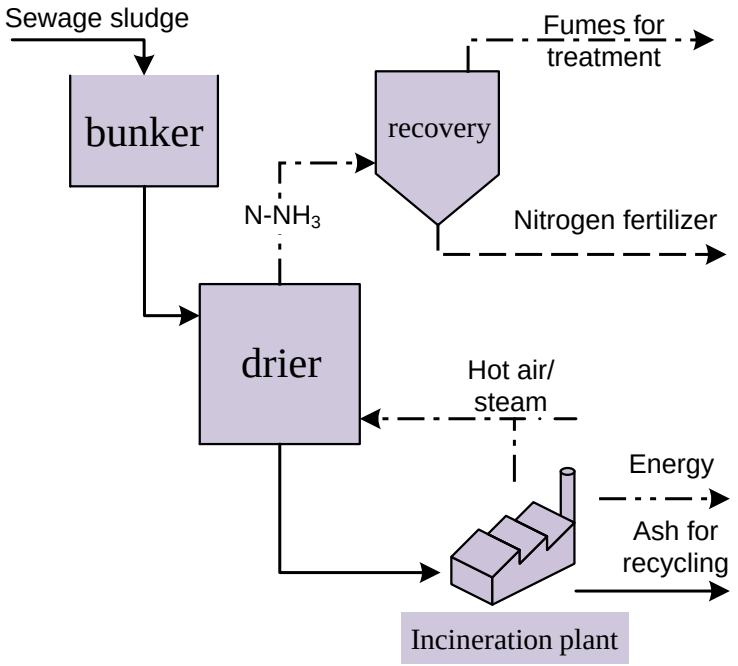
When we incinerate sludge, we have a good possibility to recover nitrogen.

50-65% of soluble nitrogen is release as ammonia during the drying process.

Nitrogen released could be recovered by ad/absorption.

Moreover, great possibilities for symbiosis exist. The process could be retrofitted to:

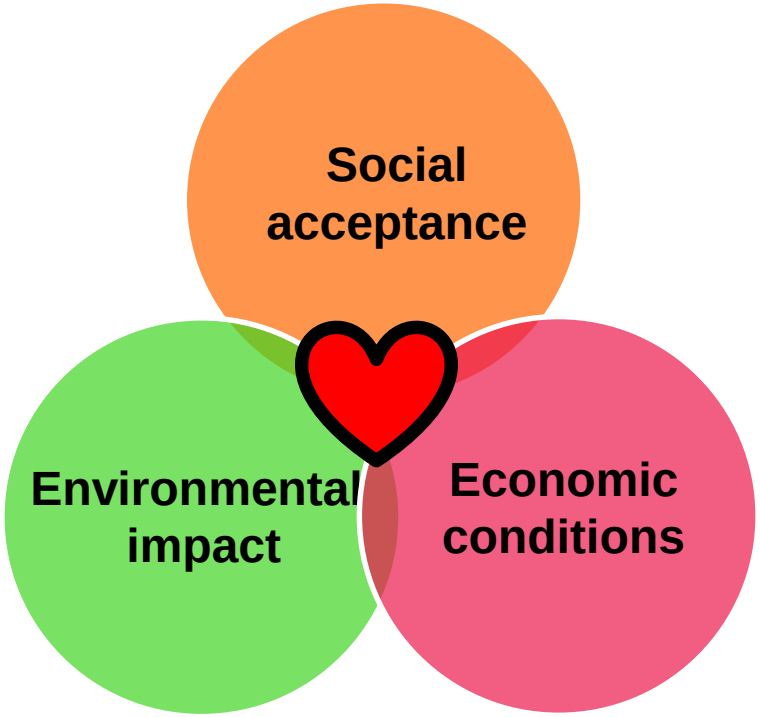
- a sludge incineration plant to get nitrogen released;
- a WWTP for nitrogen stripping from condensate.



Future research needs

1. Technical study on recovery possibilities
2. Economical analysis
3. Environmental impact assessment

SYSTEM ANALYSIS



arvi
Material Value Chains

Thank you for your attention!

Questions?