Options to recover P from sludge and use of sludge based products in agriculture

Inge Regelink, Phillip Ehlert, René Rietra & Paul Römkens

Financed by:
- TKI Deltatechnologie
- Stowa
- Waterschap Rijn en IJssel
- Waterschap Aa en Maas
- GMB BioEnergie

WAGENINGEN
UNIVERSITY & RESEARCH

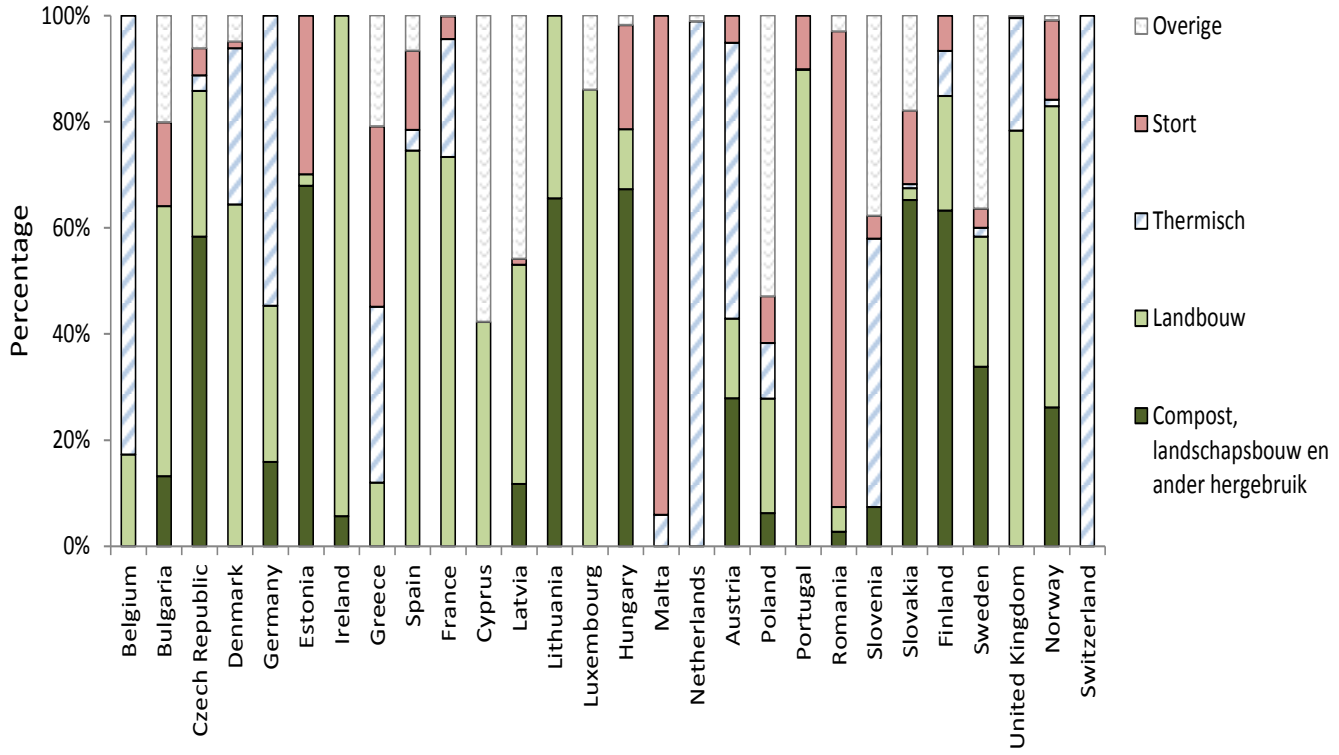
Goals

- Sustainable and cost efficient treatment of sewage sludge
- Re-use of nutrients and organic matter in products suitable for application in agriculture

Project objectives:

- Explore options for re-use of low-P treated sludge in agriculture
- Experimental work to recover P from sludge (experimental)
- Assess impact on soil (HMs) through experimental and model

Current Use of Sludge in EU



Data: Eurostat 2012

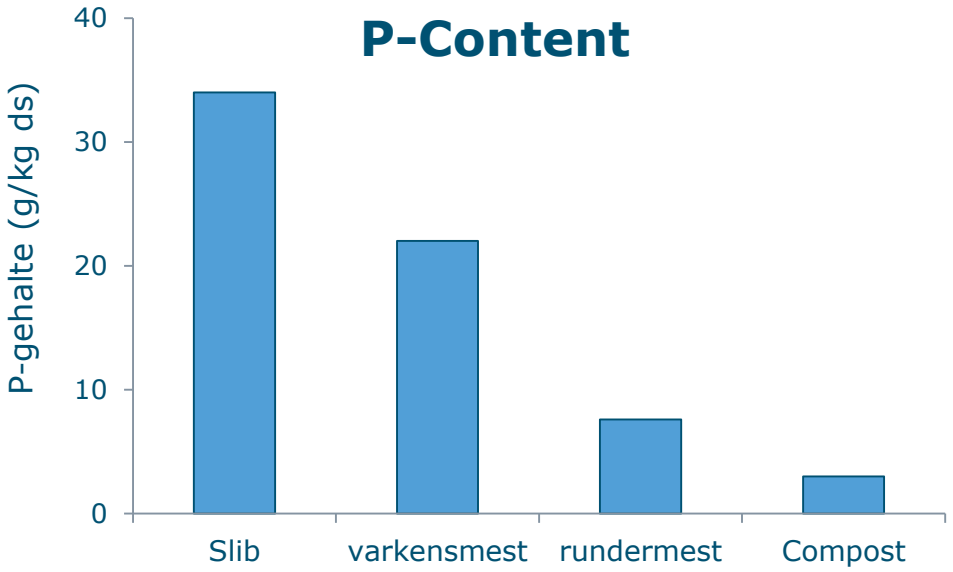
WAGENINGEN
UNIVERSITY & RESEARCH

Some characteristics of sludge and sludge-cake/biogranulates

Product	D.S.	O.S.	P	P_2O_5	N-tot	K_2O	Mg	Fe	pH	Ec
	(%)	(% d.s.)	---------- g/kg d.s. ----------						(-)	mS/cm
Slibkoek – data CBS[1]	25	68	34	78	56	-	-	-	-	-
Slibkoek – eigen data[2]	22	75	27	61	43	3,5	4,7	12-50	6,7	4 -7
Biogranulaat(composted sludge)	62	51	35	80	37	7,0	9,4	45	7,7	9,3

WAGENINGEN
UNIVERSITY & RESEARCH

Sludge: Agricultural value

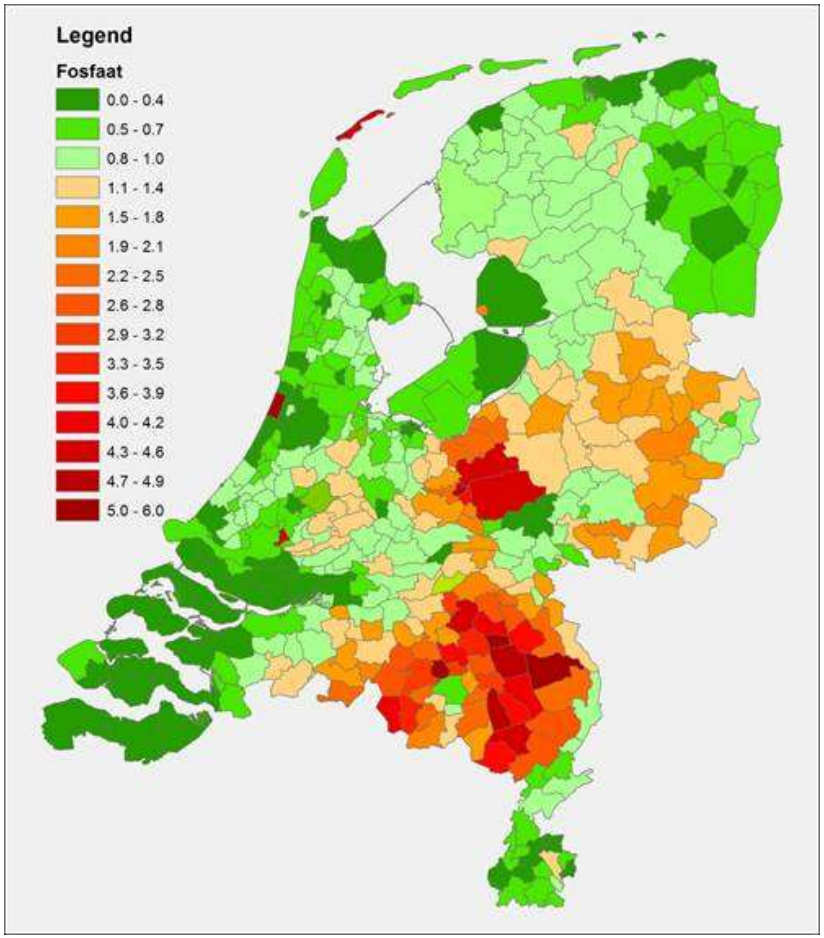


- P content sludge high when compared to manure
- After treatment sludge still can be considered ‘fertiliser’ and has to compete with manure
- Use of biogranulates as soil improver not possible due to high P content, for export possibly interesting

WAGENINGEN
UNIVERSITY & RESEARCH

Is there room for additional P in NL?

P production divided by the P application margin (fosfaatgebruiskruimte)



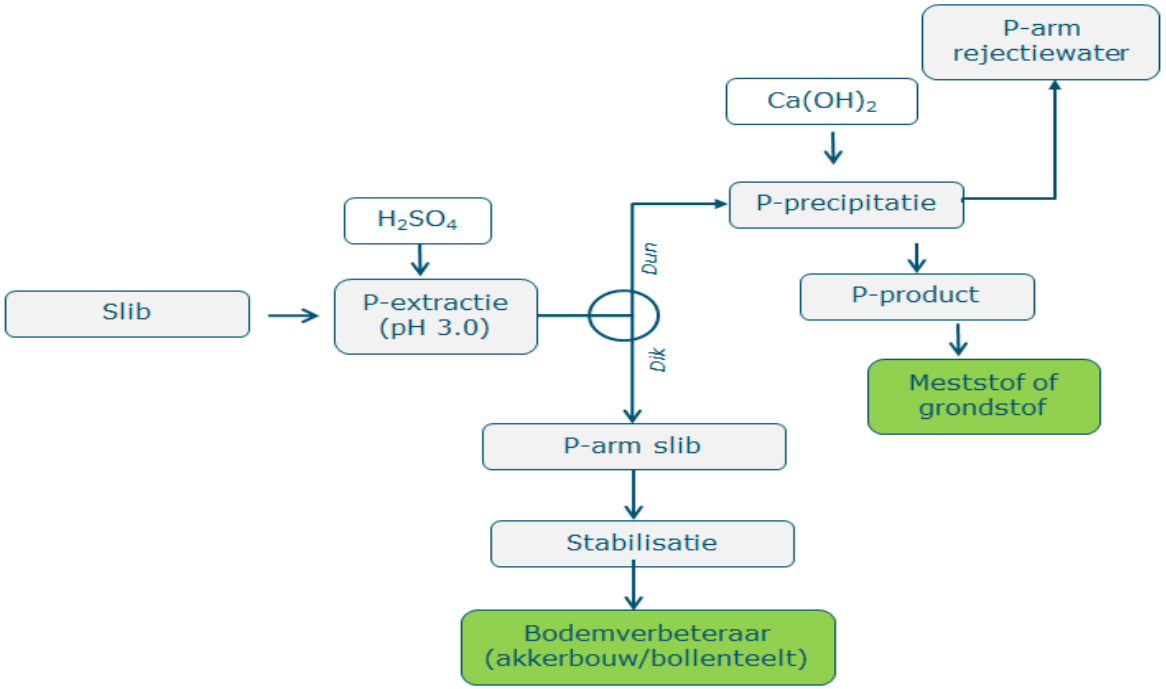
(De Koeijer et al., 2017)

WAGENINGEN
UNIVERSITY & RESEARCH

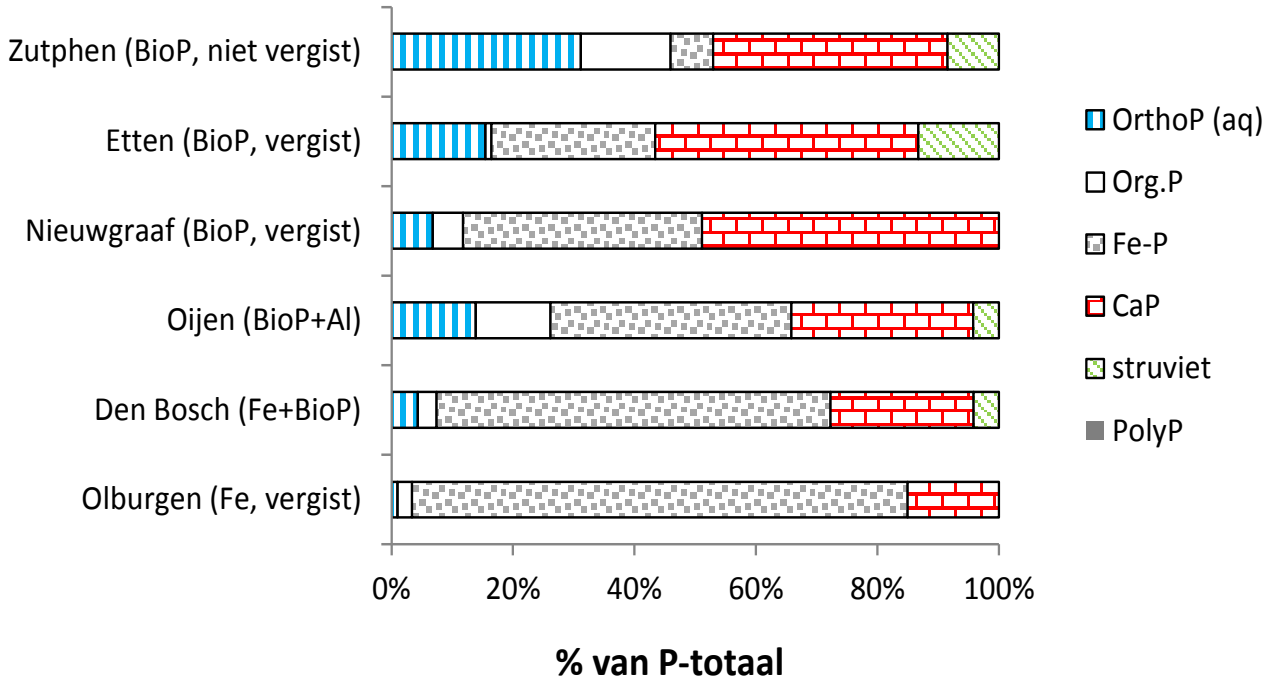
P extraction protocols tested

- Removal of P using sulphuric acid
- Separation step
- Recovery of P from water phase using CaO

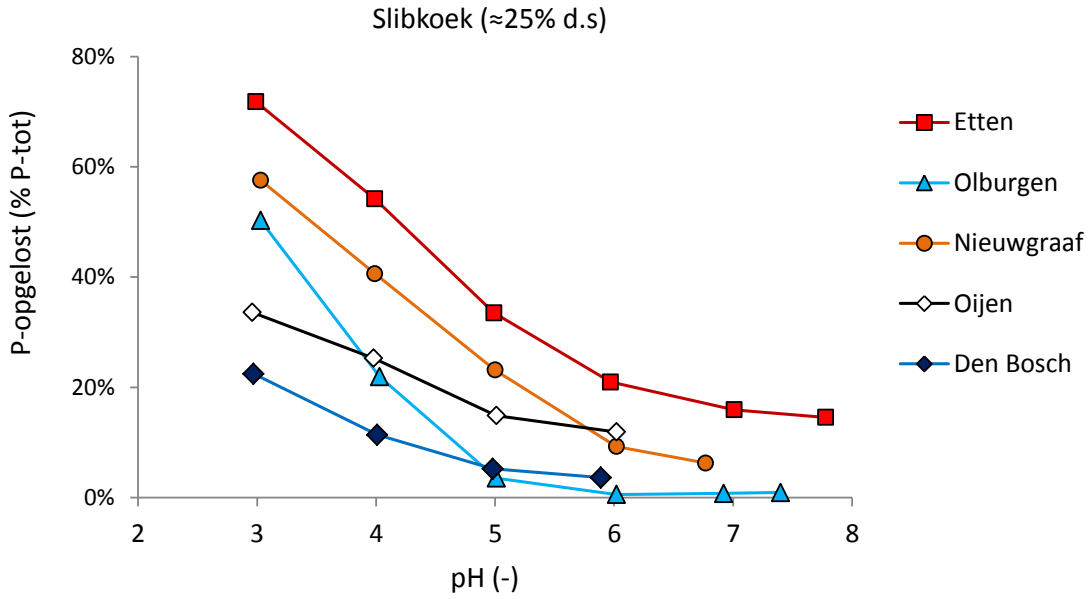
General Principle of P recovery



Speciation of P in sludge prior to extraction



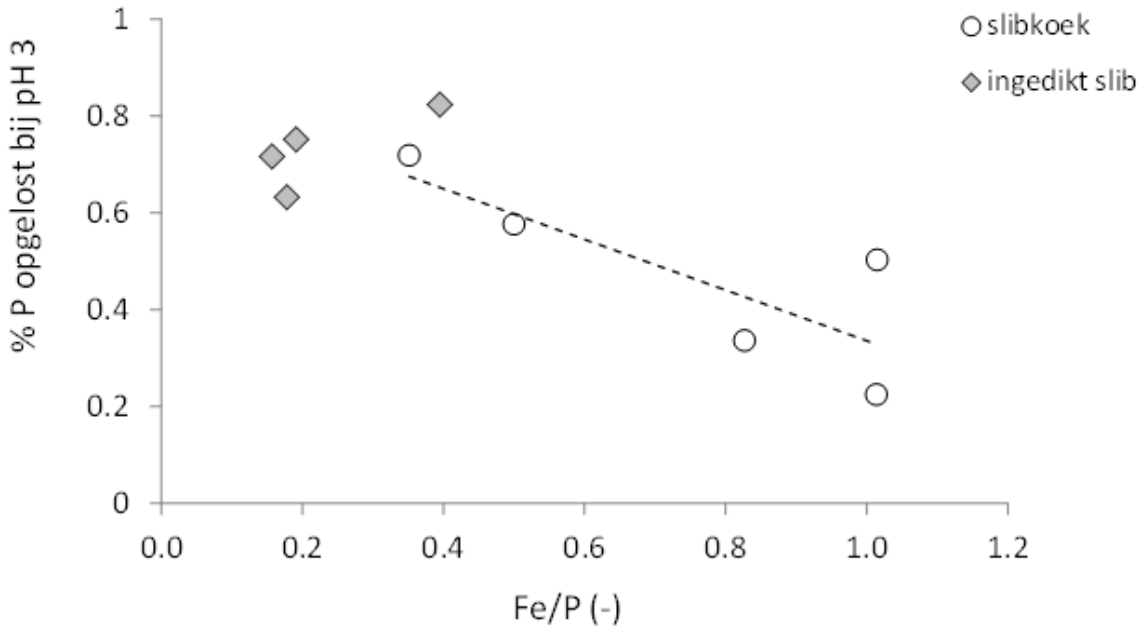
Recovery efficiency of P using H2SO4/CaO



- Fe-poor sludge: up to 80% recovery possible
- Ca-P components in sludge will dissolved, HM's mostly remain in sludge solid phase

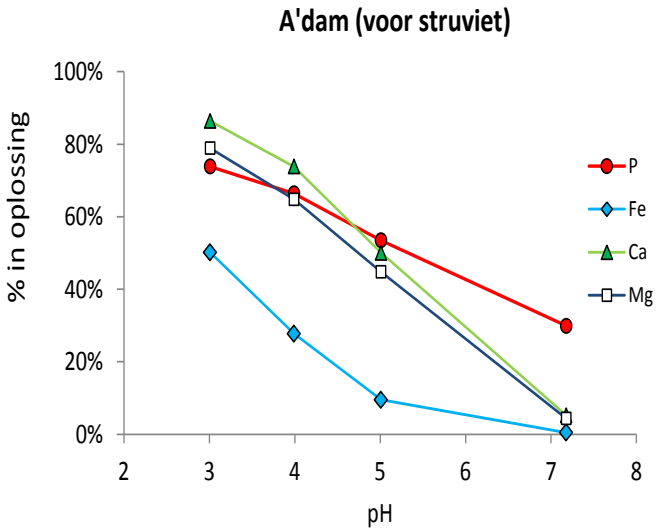
WAGENINGEN
UNIVERSITY & RESEARCH

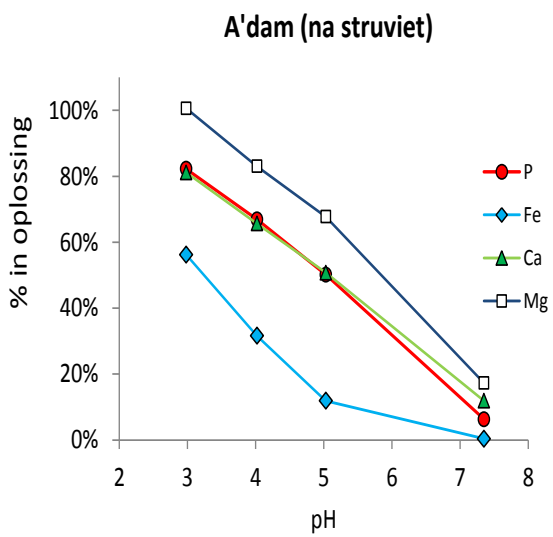
Effect of Fe content in sludge on P recovery



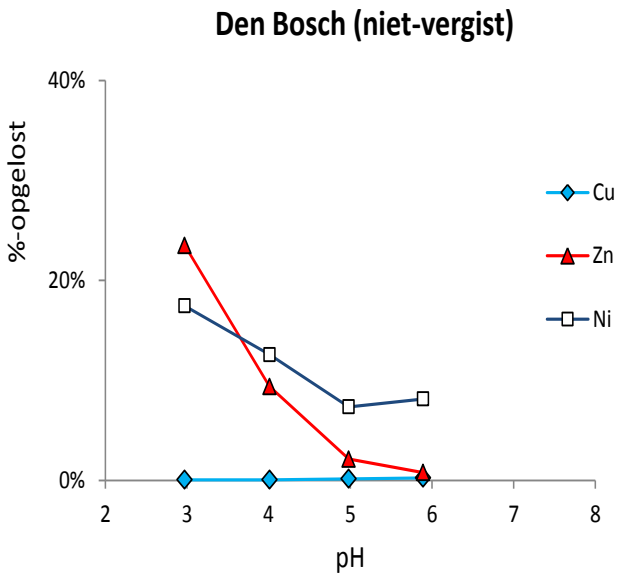
WAGENINGEN
UNIVERSITY & RESEARCH

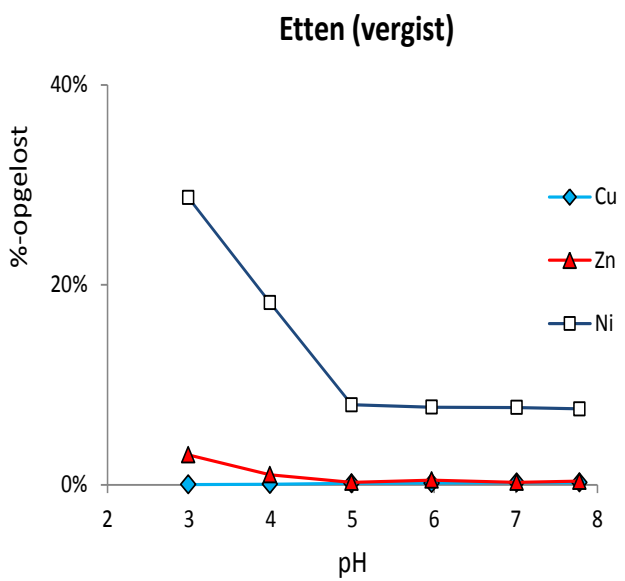
Impact of struvite recovery on P recovery





Release of metals during P recovery





WAGENINGEN
UNIVERSITY & RESEARCH

Optimal P-recovery scheme

Fosfaat-extractie op slibkoek	
P-recovery (t.o.v. P-totaal slib)	60-70%
Acid consumed	36 L H_2SO_4 (96%) per ton sludgecake
Base added	30 kg CaO (88%) per ton sludgecake (incl. sulfate-removal)
Decrease mass of sludge	9%
Costs for acid/base application	€ 8,60 per ton sludgecake

WAGENINGEN
UNIVERSITY & RESEARCH

Quality Issues: Heavy Metals

Parameter	Dutch Quality Standard	Average metal content urban waste water sludge
Cd (mg/kg)	1,25	1.2
Cr (mg/kg)	75	41
Cu (mg/kg)	75	409
Hg (mg/kg)	0,75	0.70
Ni (mg/kg)	30	28
Pb (mg/kg)	100	107
Zn (mg/kg)	300	978
As (mg/kg)	15	11
Doseringslimit (ton drogestof/ha/jaar)	Arable land: 2 Grassland: 1	

WAGENINGEN
UNIVERSITY & RESEARCH

Content in Sludges used in experiments

Meststof	O.S.	N	P_2O_5	Cd	Cr	Cu	Hg	Ni	Pb	Zn	As
	(% d.s)			---------- (mg/kg d.s.) ----------							
Sludge (gemiddelde NL)[1]	68	56	78	1.2	41	408	0.7	27	106	977	1.2
Biogranulate	55	37	79	1.1	56	518	1.0	33	108	1430	8.7
Cow manure	76	89	17	0.3	6.4	182	0.1	4.5	4.8	248	0.6
Pig Manure	68	50	50	0.4	8.1	444	0.1	9.2	5.6	990	1.9
GFT compost	33	12	6.6	0.4	23	41	0.1	11	52	175	4.5
Green waste compost	27	8.4	4.6	0.4	16	23	0.1	9	33	120	4.6
Low-P sludge (50% P-reduction)	68	56	39	1.2	41	408	0.7	27	106	782	1.2
Low-P sludge (75% P-reduction)	68	56	19	1.2	41	408	0.7	27	106	782	1.2
Dutch Quality Standard				1.25	75	75	0.75	30	100	300	15
Proposed EU standard Organic Fertilisers				1.5	2 (CrVI)	(600)	1	50	120	(1500)	-

WAGENINGEN
UNIVERSITY & RESEARCH

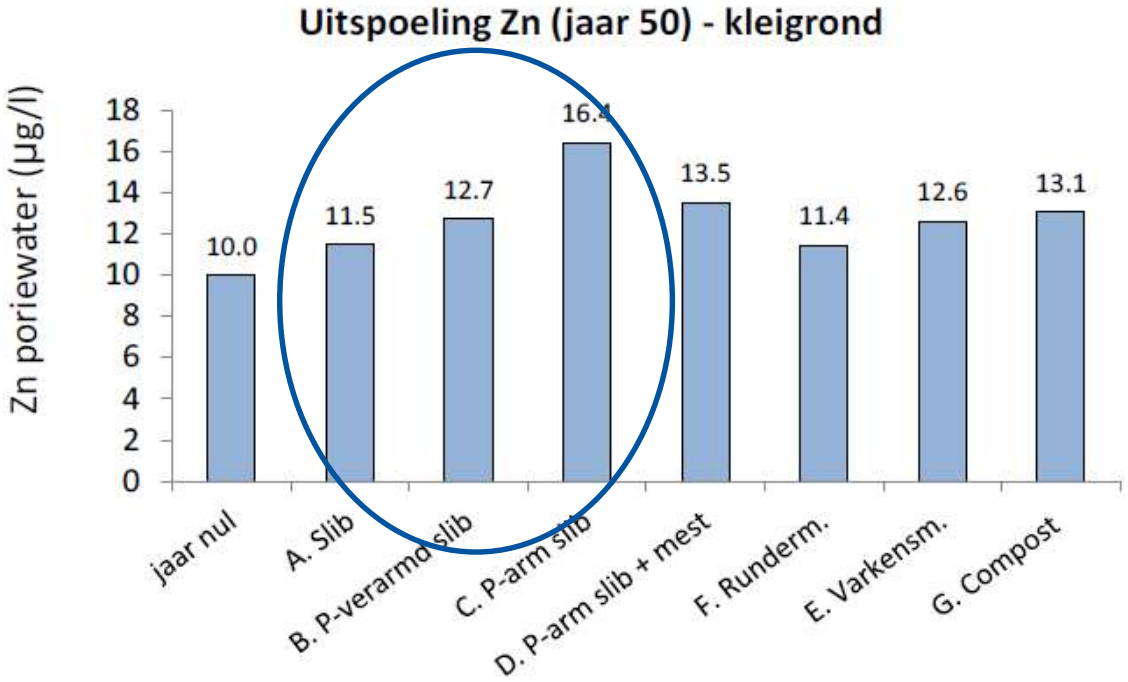
Heavy Metal Load to Soil

	Scenario	Dosering	P aanvoer	N aanvoer	O.S. aanvoer
		(ton d.s./ha/jaar)	(kg P_2O_5/ha)	(kg N/ha)	(kg/ha)
A	Slib (huidig P gehalte)	0.8 ton slib	60	43	524
B	P-verarmd slib (50% P-verlaging)	1.5 ton slib	60	86	1048
C	P-arm slib (75% P-verlaging)	3.0 ton slib	60	172	2096
D	P-arm slib + mest	1.0 ton slib + 2 ton rundermest	60	157	2218
E	Rundveemest	3.0 ton rundermest	60	150	2280
F	Varkensmest	1.2 ton varkensmest	60	108	816
G	GFT-compost + rundermest	4.4 ton compost + 2.6 ton rundermest	60 (81)[2]	135	3219

	Scenario	Cd	Cr	Cu	Hg	Ni	Pb	Zn	As
		---------- (g/ha/y) ----------							
A	Slib (huidig P gehalte)	0.9	32	314	0.5	21	82	753	1
B	P-verarmd slib (50% P-verlaging)	1.8	63	629	1.1	34	163	1204	2
C	P-arm slib (75% P-verlaging)	3.7	126	1414	2.2	68	327	2409	4
D	P-arm slib + mest	1.7	54	777	0.9	31	116	1278	2
E	Rundveemest	0.8	19	546	0.4	14	14	744	2
F	Varkensmest	0.4	10	533	0.2	11	7	1188	2
G	GFT-compost + rundermest…	2.3	117	595	0.6	59	243	1344	21
	Norm slib UBM (norm * dosering)[2]	2.5	150	150	1.5	60	200	600	30

WAGENINGEN
UNIVERSITY & RESEARCH

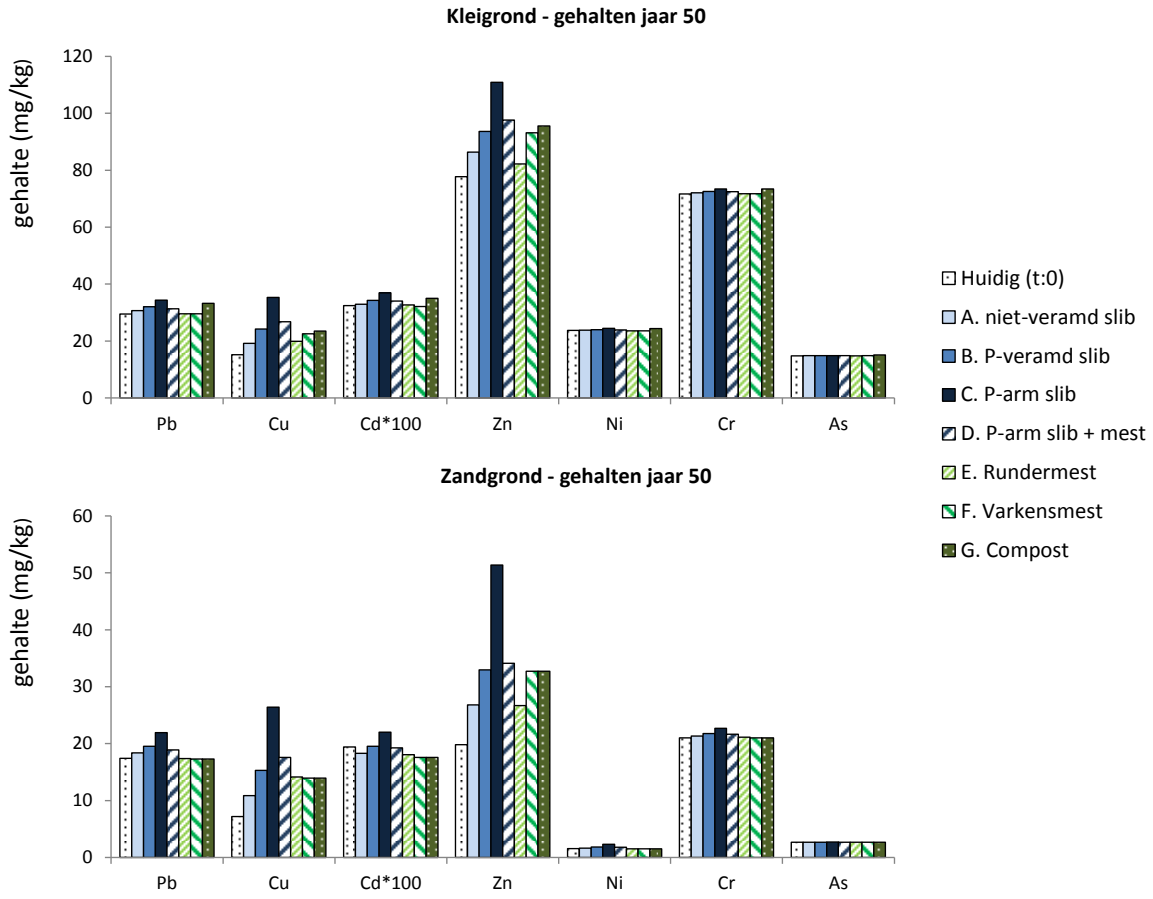
Use of sludge in agriculture: impact assessment



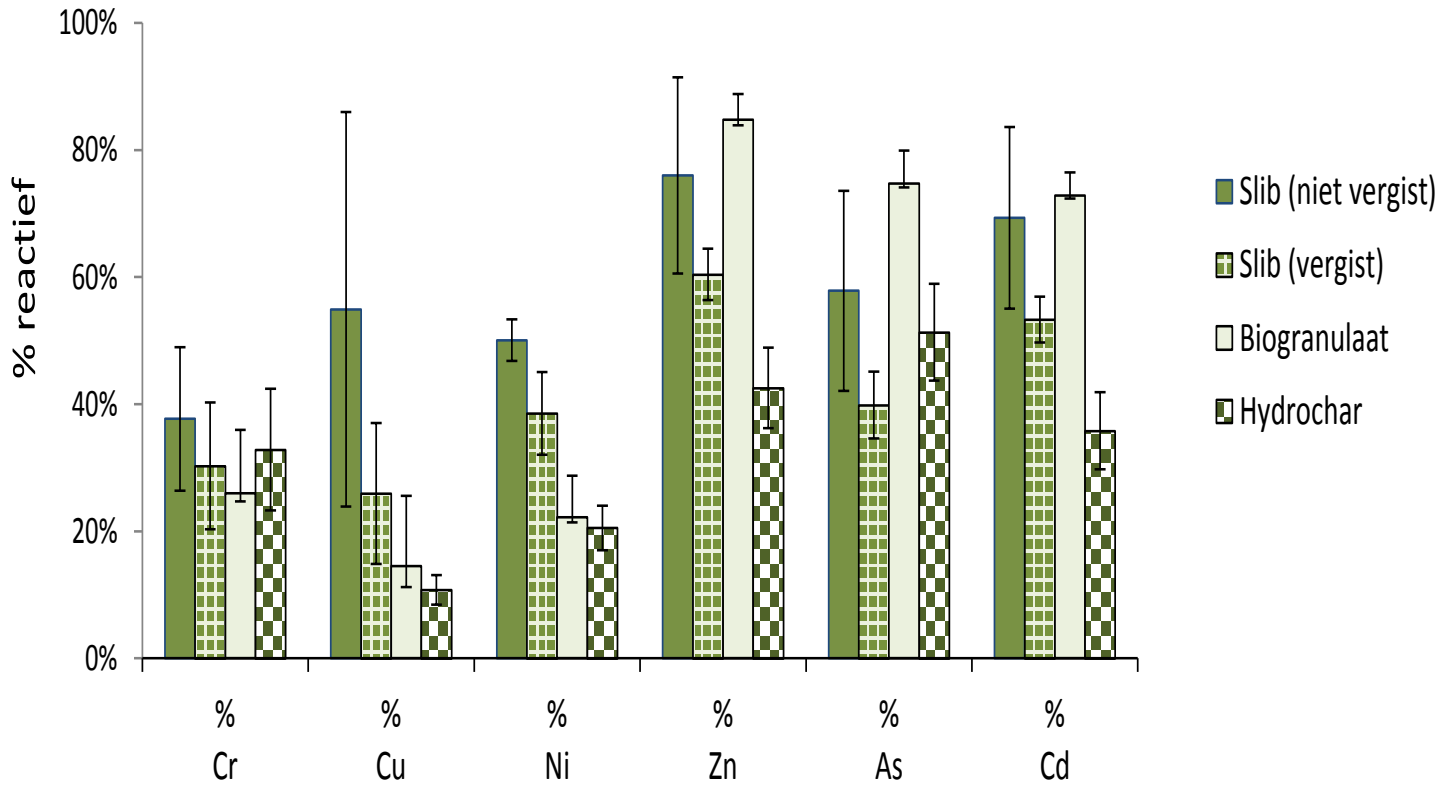
- Load to soil is lower (non treated sludge) or equal to (50% reduced P sludge) when compared to load via animal manure
- Limited impact on soil quality, but increase in emission to water (depending on treatment)

WAGENINGEN UNIVERSITY & RESEARCH

Model study: long term changes in soil metal content



Chemical availability of metals in soil



Use of Sludge in Agriculture?

- HM's in sludge still exceed current standards (Dutch decree) for Cu and Zn but this is equally true for manure (but not regulated)
- Sludge still mainly to be used as fertiliser due to high P content even after treatment so it has to compete with (cheap) animal manure
- Application options in NL therefore limited
- Economically, application of slurry seems most cost efficient
- Possibly export of sludge based granulates (as P fertiliser)

Future developments

Outlook

- 9% decrease sludge biomass and additional options for re-use (*i.e.* co-burning)
- low-P sludge as fertiliser (long-term)

Additional issues

- P-recovery at RWZI (before/after digestions/dewatering)
- Alternatives to be used as acid/base? (waste, no sulfate)
- Improved technology/business case development/environmental impact

WAGENINGEN
UNIVERSITY & RESEARCH

The Future

EU-project Systemic (2017-21)

- Goal: Efficient use of nutrients (Towards a more circular economy)
- Five large scale demo projects (manure/sludge/biowaste)
- NL: Demopilot P-extraction pig manure (Groot Zevert, Achterhoek)

Focus on:
Technology, business case, environmental imapct, policy needs

WAGENINGEN
UNIVERSITY & RESEARCH

Thank you!

Full report available at:

http://library.wur.nl/WebQuery/wurpubs/fulltext/420057

Systemic:

https://systemicproject.eu/

WAGENINGEN
UNIVERSITY & RESEARCH