

"Close the Gap: Overcoming Nutrient Scarcity in Agriculture"

Saskia Visser

Oscar Schoumans

Theun Vellinga

Inge Regelink



Dutch Agriculture



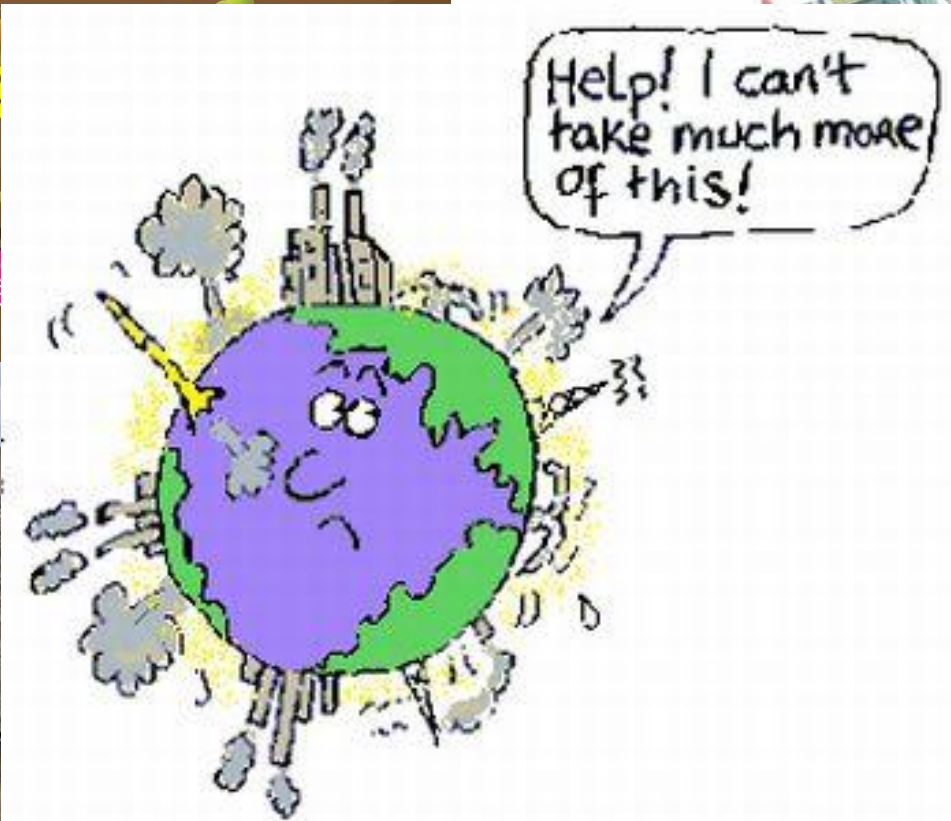
| MAGAZINE |

THIS TINY COUNTRY FEEDS THE WORLD

The Netherlands has become an agricultural giant by showing what the future of farming could look like.



The Netherlands is the world's...



Strategy: Circular agriculture



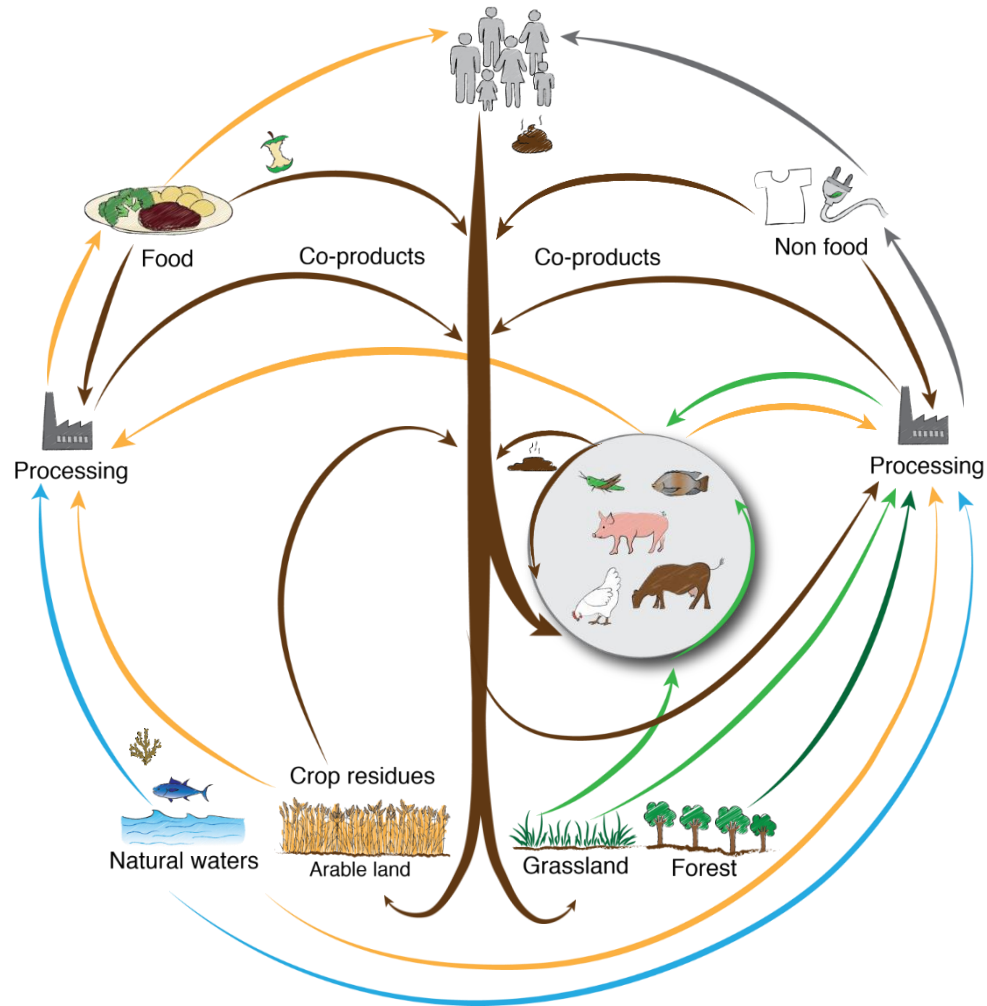
Landbouw, natuur en voedsel: waardevol en verbonden

Nederland als koploper in kringlooplandbouw



A form of sustainable agriculture where the cycle of substances is closed. This means that all substances that disappear from an area as a result of agriculture are also returned to the area.





Dutch ambitions related to soil & nutrients

By 2030:

- Use of fossil-based fertilisers and pesticides is significantly reduced/abandoned
- Nutrients in both animal and human excreta are more efficiently used in the production circle
- No more discharge of nutrients to surface water.
- All agricultural soils are sustainably managed, with attention for (soil)biodiversity.



Bodemkwaliteitsbeoordeling van landbouwgronden in Nederland - Indicatorset en systematiek, versie 1.0

Woord vooraf

Marjoleine Hanegraaf, Erik van den Elsen, Janjo de Haan & Saskia Visser

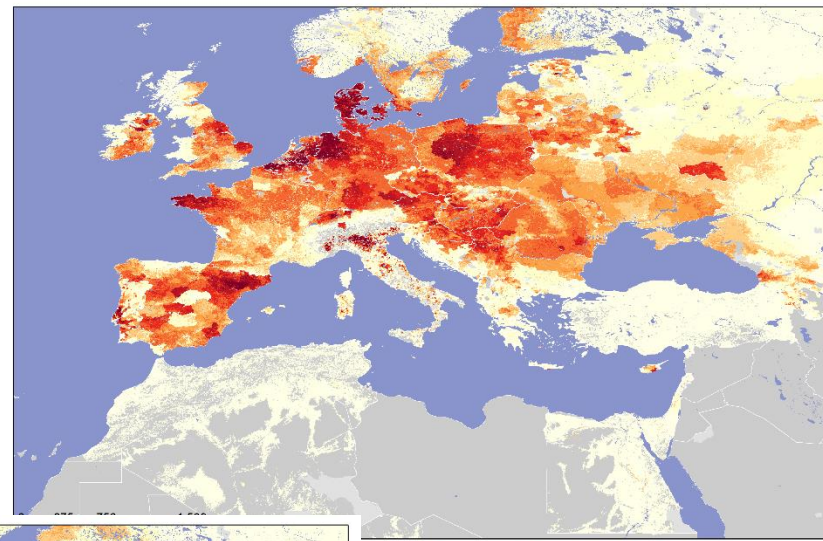
Gebied	Indicator	Af
Fysisch	1 1 Watervasthoudend vermogen	A
	2 2 Aggregaatstabiliteit	A
	3 3 Textuur	A
	4 4 Indringingsweerstand	A
	5 5 Droge bulkdichtheid	+
Chemisch	6 1 OS-gehalte	A
	7 2 C-gehalte	A
	8 3 pH	A
	9 4 Ntotaal	A
	10 5 Nmin	A
	11 6 P voorraad + beschikbaar	A
	12 7 K voorraad + beschikbaar	+
	13 8 OS (stabile fractie)	+
Biologisch	14 1 Potentieel Mineraliseerbare N (PMN)	A
	15 2 Aaltjes - diversiteit en aantallen	A
	16 3 Schimmels - soorten en aantallen	A
	17 4 Heet water extraheerbare Carbon - HWC ¹	A
	18 5 Bacteriële biomassa	+
	19 6 Schimmelbiomassa	+
	20 7 Regenwormen (aantallen en diversiteit)	+
Algemeen	21 1 Visuele beoordeling (Fys/Chem/Biol)	+

Plenty of reasons to avoid manure:

- A threat to public health and biodiversity:
 - carrier of pathogens
 - carrier of heavy metals
 - full of reactive N
 - full of pharmaceuticals
 - full of unappreciated odour
- A source of
 - energy (biogas, dung cakes)
 - organic matter
 - Nutrients: N, P, K, Ca, Mg, Na, S, Cu, Co, Se, Zn, etc.

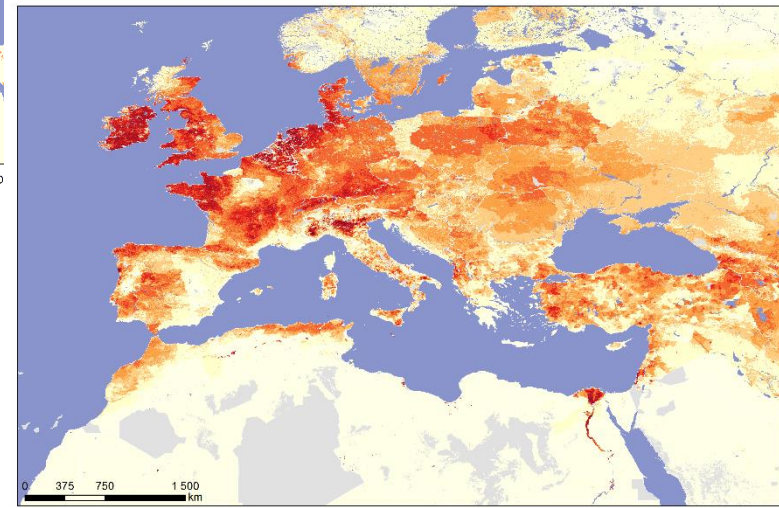
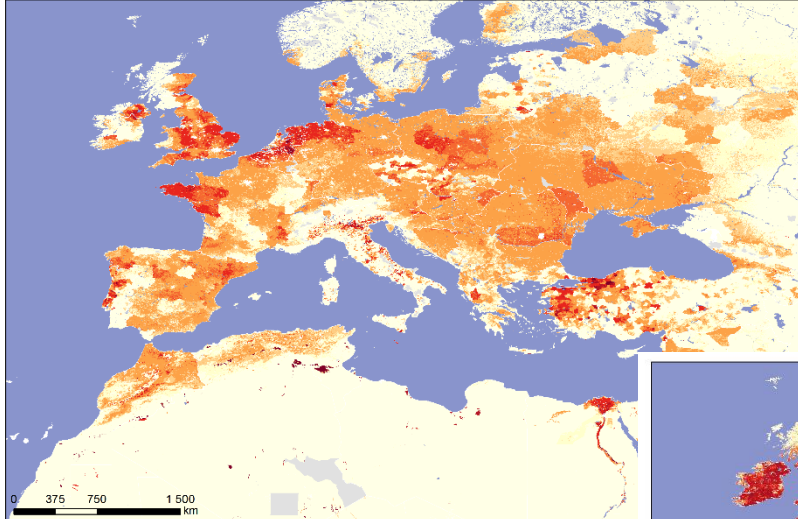
We cannot
avoid manure

Livestock concentrations



Heads per km²
Pigs

- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 250
- > 250



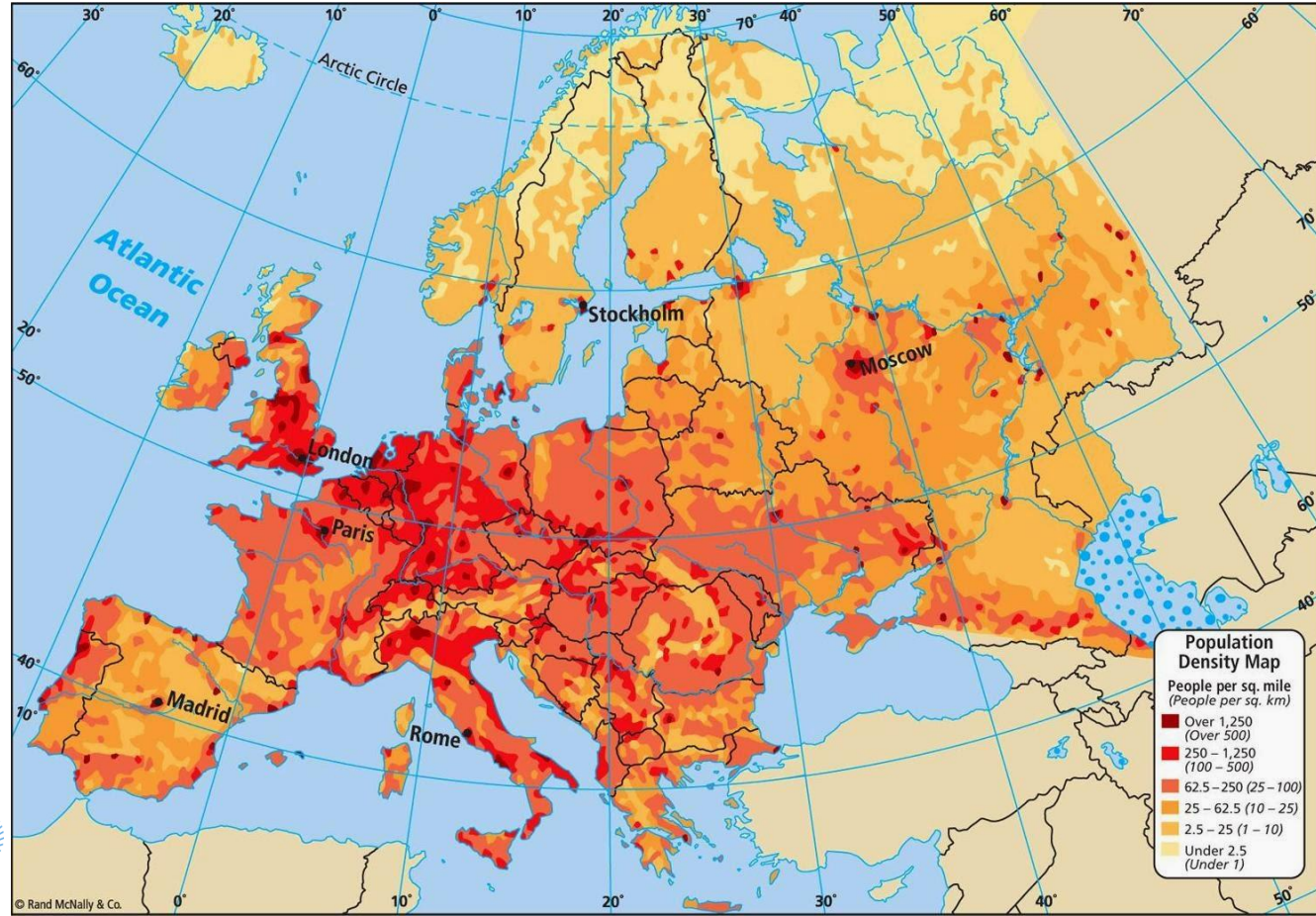
Cattle

- 0
 - 1 - 5
 - 10 - 20
 - 50 - 100
 - > 250
 - < 1
 - 5 - 10
 - 20 - 50
 - 100 - 250
- Heads per km²

- < 1
- 1 - 25
- 25 - 50
- 50 - 100
- 100 - 500
- 500 - 1 000
- 1 000 - 5 000
- 5 000 - 10 000
- > 10 000

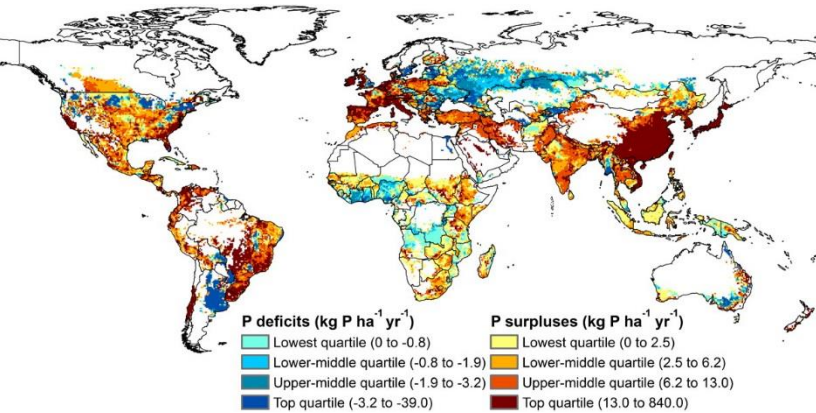


Population concentrations



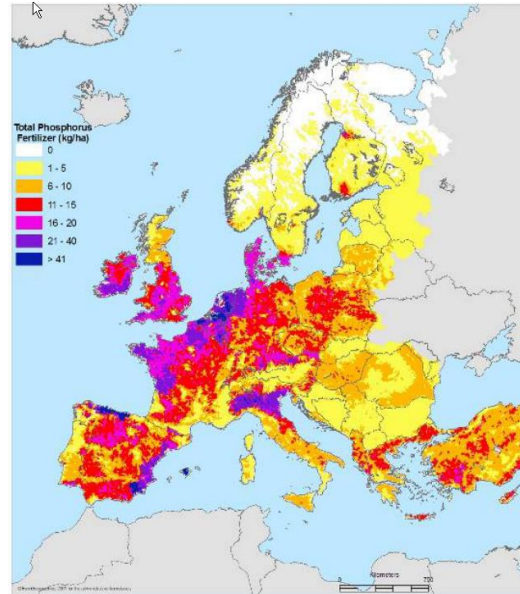
P imbalances: optimizing cycles?

World: P surpluses & deficits



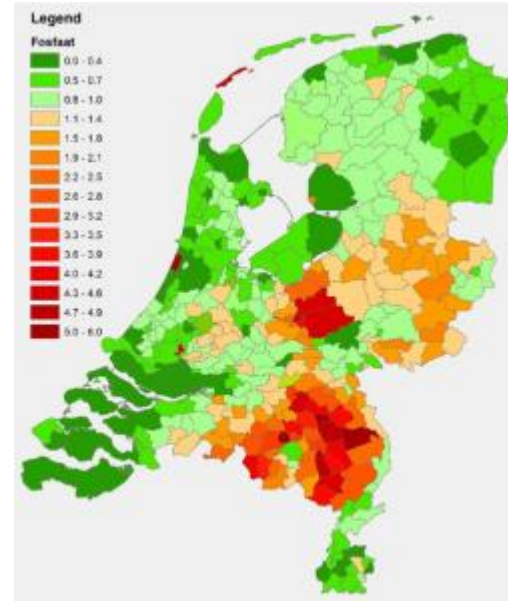
Graham K. MacDonald et al. PNAS 2011;108:7:3086-3091

Europe: Total P application



Bouraoui F., Grizzetti B., Aloe A., 2009.

Netherlands: P manure production



T. De Koeijer, H. Luesink en H. Prins, 2016

Phosphorus use in the EU-27

Schoumans et al, 2015

Gross balance EU27 (roughly)					
IN	kton	%	OUT & Accumulation	kton	%
No-food & detergents	100	4%	Products (exported)	600	23%
Crops & food products	600	23%	Waste & losses	1200	46%
Animal feed & P additives	400	15%	Accumulation	800	31%
Mineral fertilizer	1500	58%			
	2600	100%		2600	100%


- High P input mainly to agricultural production system (73%)
- High P losses (46%; including organic waste) (mainly Human consumption & Food processing; total 42%)
- High P accumulation 31% (mainly in soils; 29%)

P USE EFFICIENCY HAVE TO INCREASE WITH 50 – 70% TO FEED EU / WORLD

EU: negligible rock phosphate mines completely depended on P import!!!

*P reserves worldwide: 70 billion tons
World mining: 0.270 billion tons / year
("260 years") Source: USGS, 2019*

2. 5R-Strategy for optimizing the nutrient balance

1. **Reduce** nutrient inputs, where possible
2. **Reuse** nutrients from organic residues (inc. manures)
3. **Recover** nutrients from biomass waste streams 
4. **Reduce** nutrients losses to surface water
5. **Redefine** systems, where needed

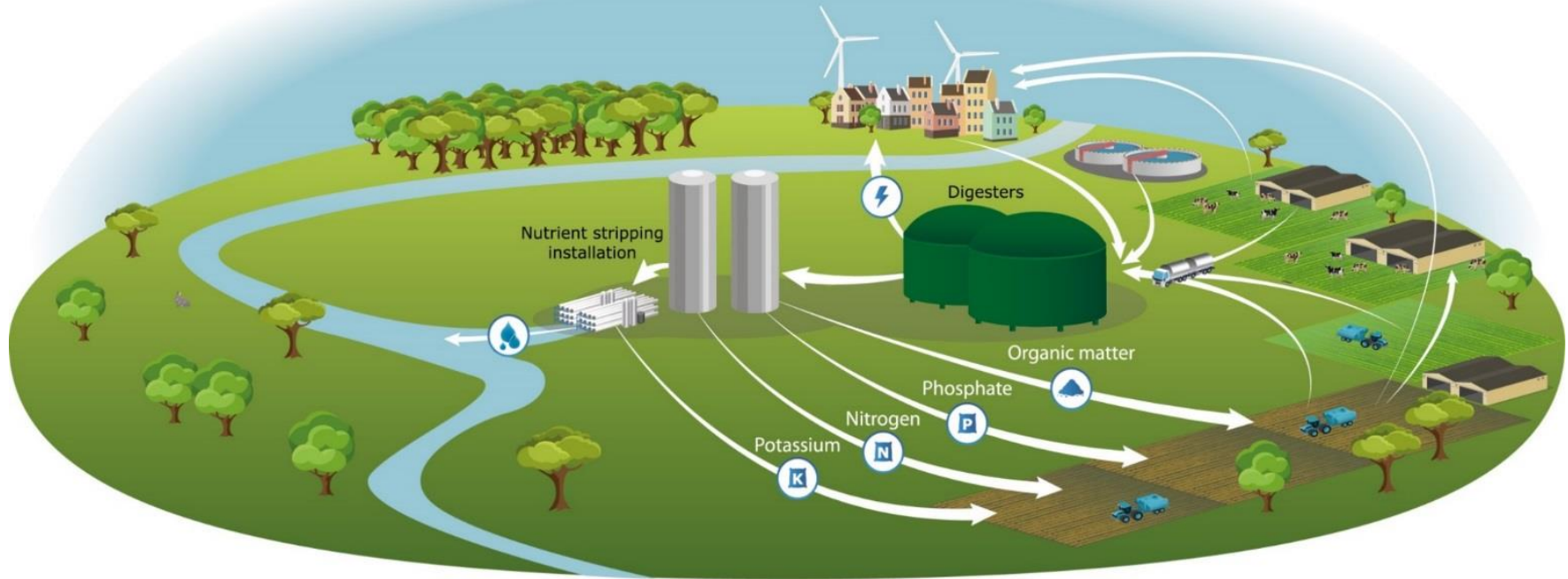
SYSTEMIC



Horizon 2020

Systemic **large-scale** eco-innovation to advance **circular economy** and mineral recovery from **organic waste** in Europe

Circular Solutions for Biowaste



Technical Innovation at demonstration plants

Feedstocks

- Pig manure
- Poultry litter
- Sewage sludge
- Energy crops
- Agro-industrial residues

Innovative Technologies

- Reverse Osmosis (RO)
- Evaporation
- N-stripping
- P-stripping

End Products

- Biogas
- NK concentrates
- $(\text{NH}_4)_2\text{SO}_4$ fertiliser
- Struvite & Ca phosphate
- Organic fertilisers and soil improvers
- Organic fibres



Downloads: (www.systemicproject.eu)

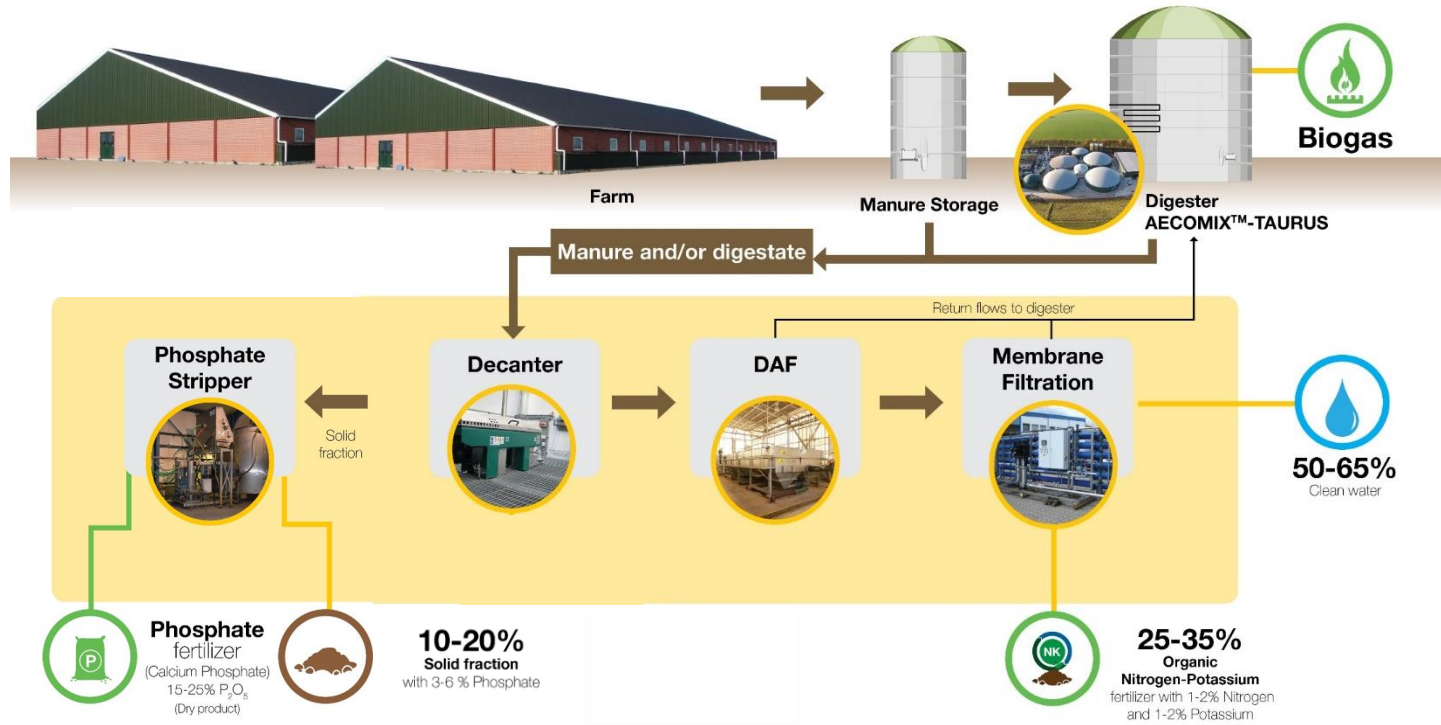
- Technical Factsheets of demoplants
- Newsletter of demoplants

Demonstration plant Groot Zevert Digestion (NL)

- Location: Beltrum (Eastern Netherlands) and built in 2004
- Agriculture: 65% grassland and 35% arable (region Achterhoek)
- Feedstock: Manure >75% (mainly pig) and food & feed waste
- Max capacity: 140 000 tons/year
- Digester cap.: 15 000 m³ (mesophilic: 35-38 °C & 20 days)
- Nutrient recovery: P recovery (Ca~P or struvite), RO (NK concentrate; water)
- Philosophy:
- Reduce export of manure surplus over long distances (D)
 - Maximize fertilization effects on agricultural land
 - o Soil improver with a low N & P-content
 - o NK concentrate as substitute for synthetic fertilizers
 - o P precipitate as secondary resource P-fertilizer industry



Demonstration plant Groot Zevert Digestion (NL)



MMM2: Groene Mineralen Centrale



Decanter centrifuge



Microfiltration



Reverse Osmosis



Storage for solid fraction



Storage of liquids



Ion exchange

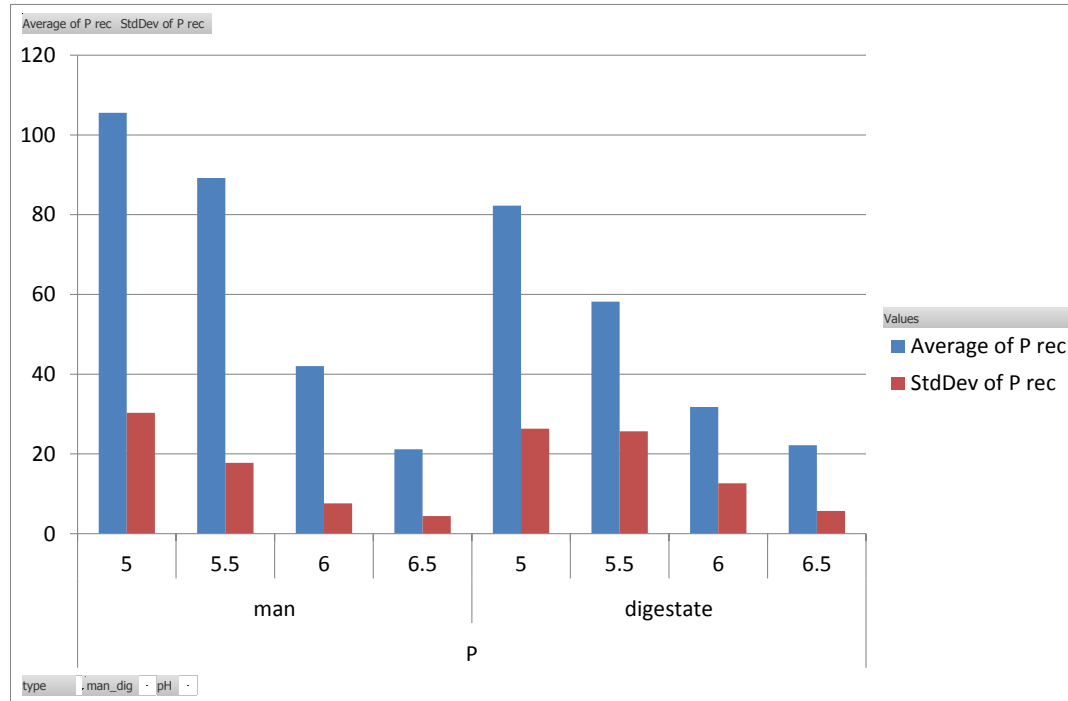
Microsoft Word

Version 16.0.9126.2356

Microsoft Windows 10 Enterprise 32-bit Build 6.2.9200



Mineral P recovery as Ca~P (pig slurry)



The recovery of P in the collected product (at 4 pH's) compared to the mineral P content of the source material (manure or digestate).

Demonstration plant Groot Zevert Digestion (NL)

Product composition (preliminary results)

	Ingoing digestate	GZV Recovered products		
		NK-fertilizer	Soil Conditioner	P-fertilizer
Dry matter (DM %)	5.8		32	82
Organic Matter (%)	65% of DM	1-3	89% of DM	45% of DM
N-total (g/kg)	6	8-15 NH ₄ -N	5.0	20
P ₂ O ₅ -total (g/kg)	3.5	0.2-0.4	3.2	140
K ₂ O-total (g/kg)	4	8-20	0.2	5
Volume (%)	100	5-10	20	2

Save costs transport:

- Solid fraction (20.000 m³); no long distance transport to Germany any more (> 400 km) a 25 €/m³: savings 0.5 M€ /y
- Liquid fraction (80.000 m³) is reduced by 50%:
Volume 40 000 m³ / y and 10-15 € / m³ → savings 0.4 – 0.6 M€ /y

New innovations: Polymeers from sludge

NOS NIEUWS • BINNENLAND • WOENSDAG, 22:57

**Slib uit afvalwater nu grondstof
voor sieraden, verf en zelfs
stropdassen**



kaamera
nereda® gum

Summarise:

- Circular agriculture as answer to societal challenges demands closing resource (nutrient) loops & calls for resource security
- We need to think of manure as a valuable source of nutrients and organic matter
- Many innovations in development
- Need for new regulations to be able to sustainably close the loops at regional level
- We can do it



Challenges?

Current & Future

!!!! A lot !!!!

