Cooperation for a Circular Economy: *SYSTEMIC in practice*

Oscar Schoumans,

Wageningen University & Research

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Enabling a Circular Economy: How to encourage a viable agricultural market for nutrients recovered from biowaste, online Webinar, 27th May 2021

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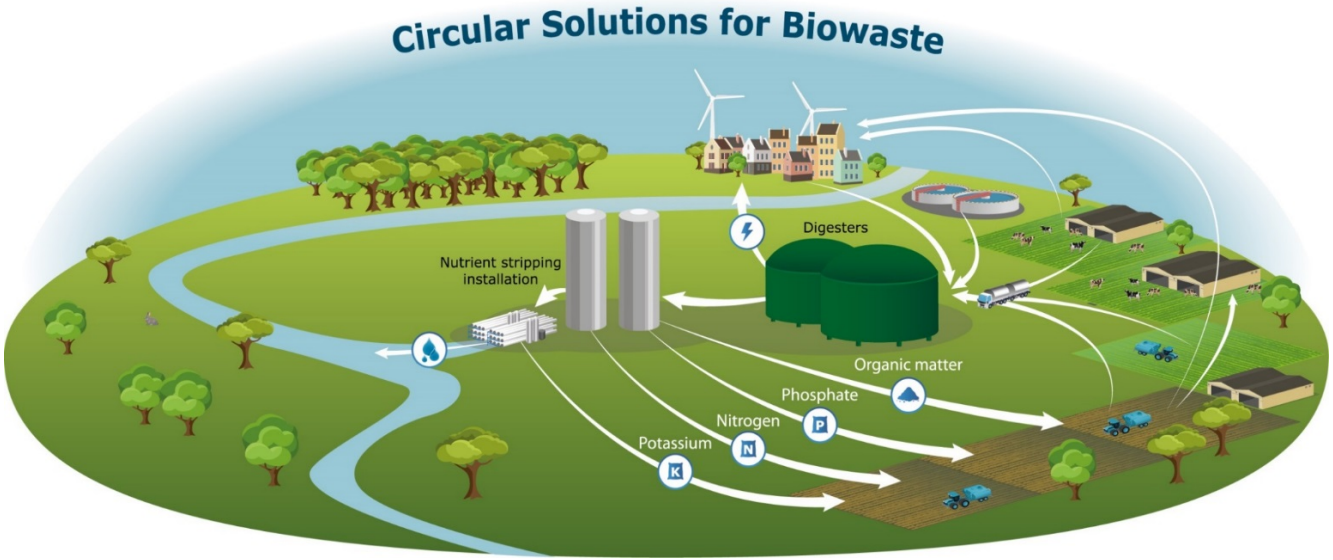
SYSTEMIC project

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



Developing a roadmap for the transition towards a circular economy for nutrients from organic waste streams

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SYSTEMIC in a nutshell

Visionaries / pioneers
5 demonstration plants

Sustainable approach
EIA & LCA

Economic feasible
Business cases
National support schemes

Outreach
28 plants as first followers



Minimize barriers – political embedding
Fertilising Products Regulation, Nitrates Directive, etc.



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Large Scale Innovative Demonstration Plants

Investment in Nutrient Recovery & Reuse (NRR) Technologies

(from pilot to full scale: 100.000 – 250.000 tonnes; high risks)

GZV GROOT ZEVERT VERGISTING

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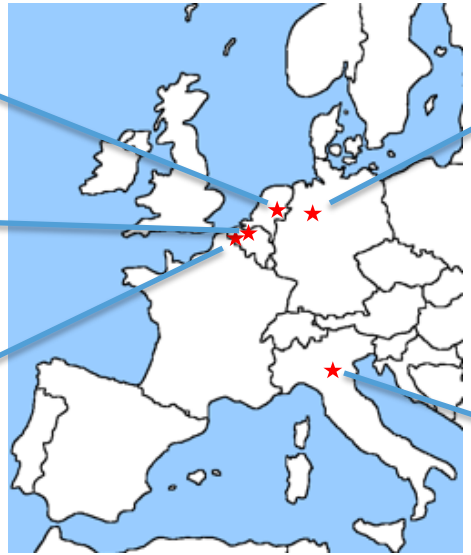
WATERLEAU



BENAS POWER

GNS

acqua & sole

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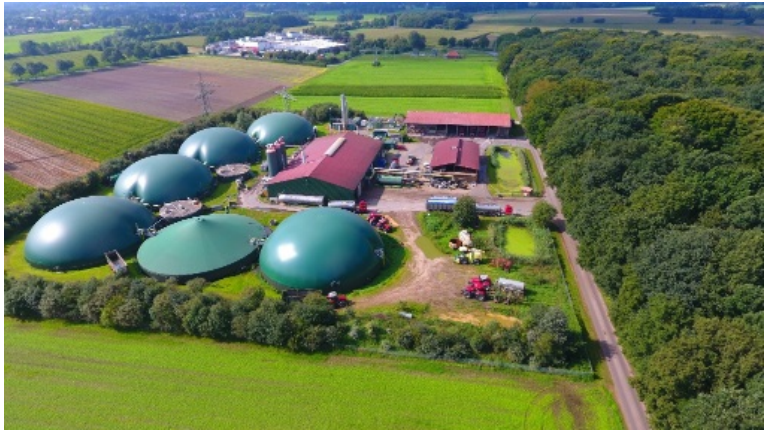
Technical Innovation at large scale Demonstration Plants

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

Innovative Technologies
- Reverse Osmosis (RO)
- Evaporation
- Nitrogen stripping
- Phosphorus stripping

Biobased Products
- NK concentrates
- $(NH_4)_2SO_4$ (ammonium sulphate)
- Calcium phosphate & struvite
- Organic fertilisers and soil improvers
- Organic fibres

Plus renewable energy
- Biogas
- Electricity
- Heat



All demonstration plants have to be market oriented

Just producing biobased products is no guaranty to survive!!!

Downloads: (www.systemicproject.eu)
- Technical Factsheets of demonstration plants
- Newsletter of demonstration plants

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Demonstration Plant: Acqua & Sole

Location: Vellezzo Bellini (Northern Italy) and biogas plant built in 2016

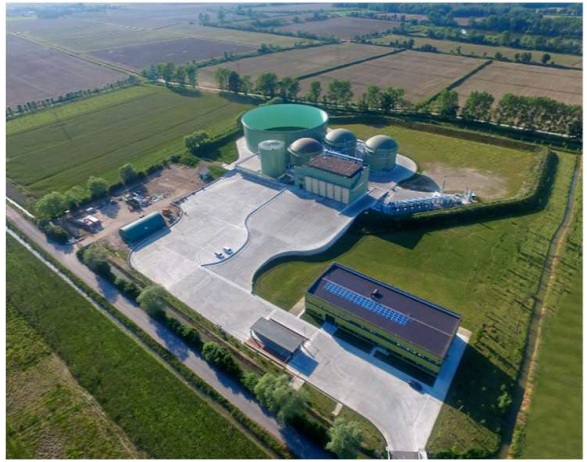
Feedstock: Sewage sludge >80% and domestic food waste (<20%)

Agriculture: Cereals, mainly rice

Nutrient recovery: NH_3-stripping from biogas into $(NH_4)_2SO_4$ (ammonium sulphate)

Philosophy:

- high NH_3 concentrations reduce biogas production
- minimize ammonia and odour emissions in the neighbourhood
- *Cooperation agreement!!! with farmers in the nearby area*
- Maximize effectivity of fertilisation on nearby 5000 ha agric. land
    - o digestate as soil improver (low NH_4-content; high Ntot/NH_4)
    - o $(NH_4)_2SO_4$ as substitute for synthetic fertilisers



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Demonstration Plant: Acqua & Sole

Percentage of crop needs with Acqua & Sole digestate fertilization			
Nutrient category	**Nutrient**	**Corn**	**Rice**
Macro nutrients	**N**	**63%**	**86%**
	P_2O_5	**100%**	**100%**
	K_2O	**25%**	**26%**
Meso nutrients	**CaO**	**100%**	**100%**
	MgO	**46%**	**83%**
	S	**100%**	**100%**
Micro nutrients	**B**	**80%**	**60%**
	Cu	**100%**	**100%**
	Fe	**100%**	**100%**
	Mn	**100%**	**57%**
	Si		**100%**
	Zn	**100%**	**100%**

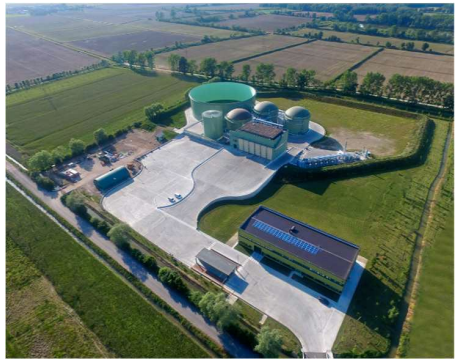
Agronomical and environmental comparable results

(Zilio et al., 2021; Pigoli at al., 2021)

Saving costs for farmers regarding mineral fertilisers

Conventional fertilizer	Cost €/t *	Quantity t/y	Total (€)
Urea 46% N	344	3 370	1 159 280
triple superphosphate 46% P_2O_5	369	2 520	929 880
Potash 60% K_2O	669	280	187 320
Total Saved Cost			**2 276 480**

** Source: CCIAA Modena, Average 2017*



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Demonstration Plant: Groot Zevert Digestion

Location:	Beltrum (Eastern Netherlands) and biogas plant built in 2004
Feedstock:	Manure >75% (mainly pig) and food & feed waste (<25%)
Agriculture:	65% grassland and 35% arable (region Achterhoek)
Nutrient recovery:	P recovery RePeat (calcium phosphate or struvite), Reversed Osmosis (NK concentrate and water)
Philosophy:	- Reduce export of manure surplus over long distances (D) against high costs

- *Pilot within the 6th Nitrates Action Plan (NL) to test the use of recovered products*
- Maximize effectivity of fertilisation on agricultural land in the region
  - o NK concentrate (blended as Tailor-Made Fertiliser) as substitute for mineral fertilisers
  - o P recovery> 80%: P precipitate as secondary resource for fertiliser industry or to be used as biobased fertiliser in P demanding areas.
  - o Stable organic matter with a low N & P-content (various options)

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Pilot Green Meadow Fertiliser (GMF) for Nitrogen

- Duration of pilot's derogation 2018-2021 from EU and Ministry of Agriculture, Nature and Food Quality within the framework of the Sixth Nitrates Directive Action Programme (new derogation is foreseen).
- Large support from agricultural sector for agronomic and environmental testing in region Achterhoek.
- Customised fertilisation with largely recovered nitrogen products: Agricultural sector is participating in the pilot and is using the TMF's in their fertilisation plans and is willing to pay.
- Demonstration and field trials; Agronomical comparable results (Ehlert & Van der Lippe, 2020).
- Low emission fertiliser application technology developed for application of tailor-made fertiliser.

Requirements Grassland

Nutrient	Parameter	Fertilisation prior to grasscut: 1	2	3	4	Total
Manure, ton/ha	average	26	16	13	1	56
	minimum	0	10	10	0	50
	maximum	35	25	25	11	61
N, kg/ha zand 320/klei 385	average	79	52	29	24	183
	minimum	69	47	18	0	182
	maximum	112	56	35	30	195
K_2O, kg/ha	average	135	----------90----------			
	minimum	40	----------60----------			
	maximum	180	----------100----------			
SO_3, kg/ha	average	28	----------4----------			
	minimum	0	----------0----------			
	maximum	35	----------35----------			

Green Meadow Fertiliser

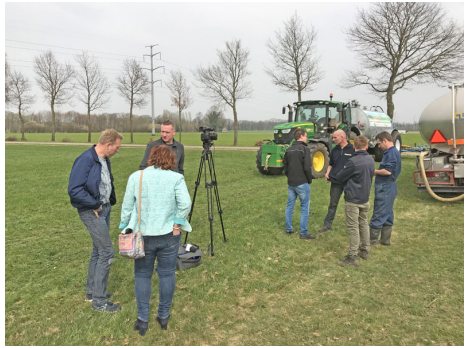
Mineral concentrate Groot Zevert Vergisting

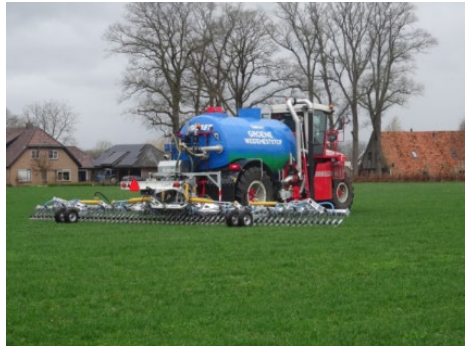
Ammoniumsulphate GMB Zutphen

Liquid Urea-ammonium nitrate

Regular mineral fertiliser

Regular Blends





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Kunstmestvrije Achterhoek

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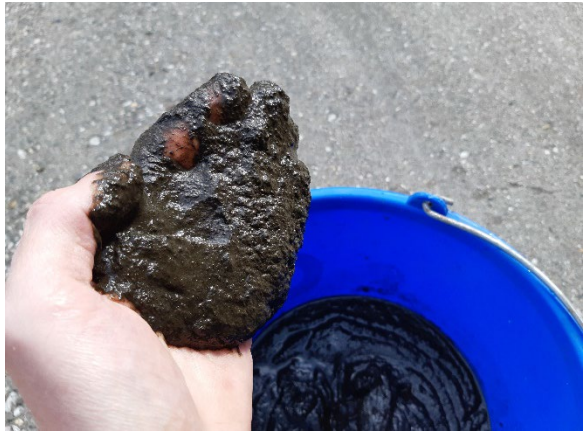
Application options P recovered fertiliser

Direct application in P demanding regions (however still not possible on dairy farms with derogation Nitrates Directive)

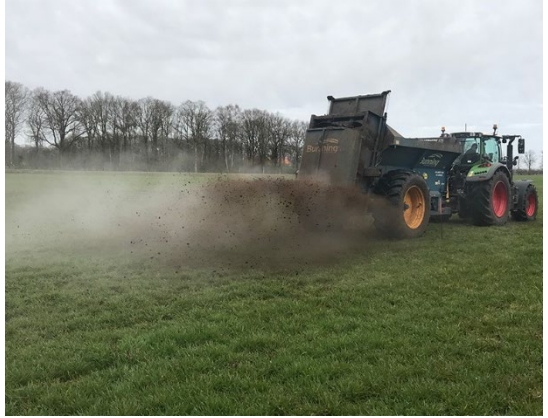


Export: Ca~P (before drying)

Extra costs for drying Ca~P (only profitable with residual heat of the biogas plant)

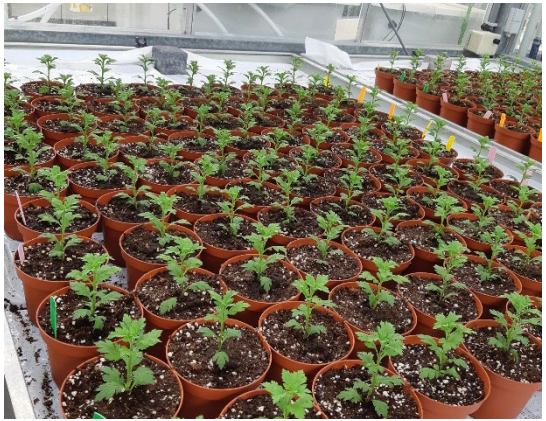
Can be sold to fertiliser industry in solid forms.

Application Nutrient poor soil conditioner (after nutrient recovery)



Soil conditioner € 0-5/ton

Ratio Organic matter and P_2O_5 comparable to compost.



Resource potting industry € 20/m³

Replaces fossil peat. Very high demand.

However, origin animal manure does not fit within current certification.

Casing soil € 20/m³

Replaces fossil peat. High demand.

Origin animal manure no obstacle.

Product seems to fit.

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Demonstration plant Benas (D)

Location:	Ottersberg (Northern Germany) and biogas plant built in 2006
Feedstock:	fresh crop of silage maize (82%) and poultry manure (18%)
Agriculture:	Silage maize production (energy crops)
Nutrient recovery:	NH_3-stripping from digestate into $(NH_4)_2SO_4$ coupled with $CaCO_3$ production due to use of gypsum in stead of sulphuric acid
Philosophy:	- High NH_3 concentrations (poultry manure) can reduce biogas production - Maximize effectivity of fertilisation on 3 500 ha ***own*** agricultural land

o Liquid digestate as fertiliser and solid digestate as soil improver

o $(NH_4)_2SO_4$ as substitute for mineral fertilisers

o option for fibre production (to be used outside agriculture)

(Agronomic aspects not tested in this case).

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Demonstration plant Benas (D)

Biofibres, resource of paper and packaging.

Paper and cardboard; mulch paper also used to cover soil in vineyards (erosion protection).

Fibre cast products can be used as transport protection, transport packaging as well as in horticulture.

Saving costs (Plant / land owner)

Saved costs:	€/y
Use of $(NH_4)_2SO_4$	244 000
Use of $CaCO_3$	63 000
Income from fibers	82 000
Total	389 000

Calcium carbonate

Ammonium sulphate

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Conclusions

- Nutrient recovery technologies for processing digestate have developed strongly from pilot scale to large-scale applications at centralised biogas plants (high-tech systems). But the market strategy of the plants highly differ.
- Biobased nitrogen fertilisers produced from the liquid fraction of digestate can compete with synthetic mineral nitrogen fertilisers from an agronomic (and environmental) point of view.
- Biobased P-products recovered from the solid fraction of digestate can be used as raw material for the fertiliser industry or in P demanding areas. The remaining nutrient poor organic matter is an excellent soil improver or a replacement for highly peat demanding industries.
- However, there are still high risks regarding investments in nutrient recovery technologies and the market is not yet developed for biobased and tailor-made fertilisers (acceptance by farmers). The plants are willing, but new incentives are needed to stimulate a broad implementation of a circular economy for nutrients.

Thank you for your attention!

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