Nutrient recovery from biodigestion waste (water) streams and re-use as renewable fertilizers

Céline Vaneeckhaute[1,2],Greet Ghekiere[3], Evi Michels[1], Peter A. Vanrolleghem[2], Erik Meers[1], Filip M.G. Tack[1]

[1]Ghent University, Lab for Analytical and Applied Ecochemistry, Coupure Links 653, 9000 Ghent, Belgium
[2]Université Laval, model*EAU*, Département de génie civil et de génie des eaux, 1065, avenue de la Médecine, Québec G1V 0A6, QC, Canada
[3]Inagro, Provincial Research and Advice Center for Agriculture and Horticulture, Ieperseweg 87, B-8800 Beitem, Belgium

INTRODUCTION

Nutrient excesses in the environment from animal manure, digestate sludge, waste water, ashes, etc.

↓

Stringent fertilization levels

↕ **Need for sustainable resource management !**

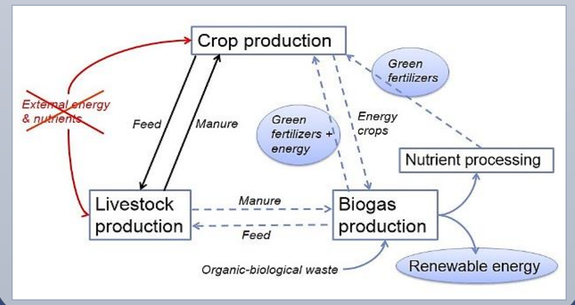
Increasing use of synthetic fertilizers

↓

Nutrient depletion (P, K)
quality ↓ ↔ price ↑

OBJECTIVES

- To evaluate the **fertilizer potential** and **identify potential bottlenecks** for agricultural re-use of recovered bio-digestion waste derivatives as substitute for synthetic fertilizers and/or as P-poor equivalent for animal manure
- To evaluate the **impact** of these renewable fertilizers **on soil quality and crop production**
- To assess an **economical and ecological evaluation** of the cradle-to-cradle use of these products in agriculture and to explore their marketing value



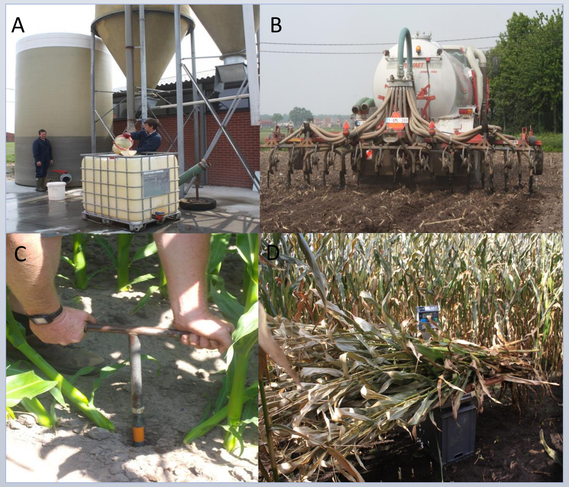
MATERIALS AND METHODS

1. Experimental set-up

Eight different scenarios for re-use of digestate and its derivatives as substitute for synthetic fertilizers and/or animal manure (Sc 1 = reference, n = 4)

Scenario	Synthetic start N	Animal manure	Synthetic N	Air scrubber water	Mixture digestate/ liquid fraction	Liquid fraction digestate	Synthetic K_2O
1	X	X	X	-	-	-	X
2	X	X	-	X	-	-	X
3	-	X	-	X	-	-	X
4	X	-	X	-	X	-	X
5	X	-	-	X	X	-	X
6	-	-	-	X	X	-	X
7	X	X	-	-	-	X	X
8	-	X	-	-	-	X	X

2. Product sampling (A), fertilization (B) and sampling of soil (C) and plants (D)



3. Physicochemical analysis

- Fertilizer value: total content and plant available contents of macro- and micronutrients in products, soils and plants
- Soil quality: pH, EC, organic carbon, sodium adsorption ratio, P and heavy metal accumulation

4. Nutrient balances: Calculations + modeling with NDICEA

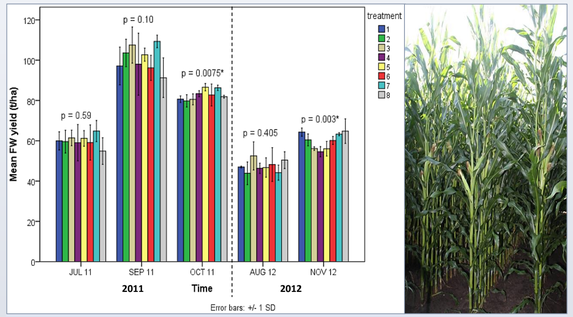
5. Biogas potential: Anaerobic digestion batch tests (37°C)

6. Economical and ecological evaluation (2011):

Vaneeckhaute et al. (2013). Biom. Bioenerg. 49, 239-48.

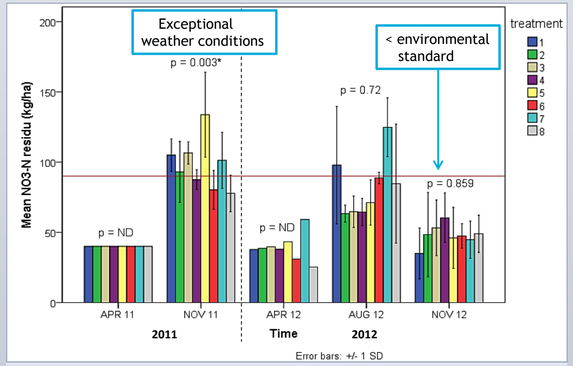
RESULTS (1)

- **Fresh weight biomass yield**



Substitution did not lead to significant reduction in crop yield

- **NO_3-N residue in soil (0-90 cm)**



All scenarios respected local standard for NO_3-accumulation at harvest (90 kg ha^{-1}) in 2012

- **Nutrient balances**

N-3 and N-30: simulation over 3 and 30 years

kg ha^{-1} year^{-1}	Scenario 1				Scenario 2				Scenario 3			
	N-3	N-30	P_2O_5	K_2O	N-3	N-30	P_2O_5	K_2O	N-3	N-30	P_2O_5	K_2O
Manure application	186	186	76	216	186	186	76	216	186	186	76	216
Deposition	30	30	3	8	30	30	3	8	30	30	3	8
Total application	216	216	79	224	216	216	79	224	216	216	79	224
Removal with products	228	228	77	301	240	240	76	292	251	251	82	271
Calculated surplus	-12	-12	1	-77	-24	-24	2	-69	-36	-36	-4[b]	-48[c]
Leaching[a]	45	24			41	18			31	2		

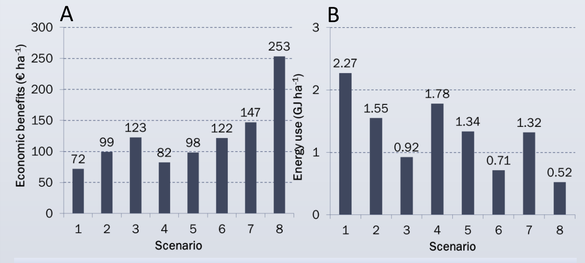
Substitution of synthetic N by air scrubber waste water (Sc 1 → 3) resulted in:

[a] N-leaching ↓, while effect on denitrification, volatilization and organic matter breakdown was nihil
[b] Negative surplus on soil P_2O_5-balance ⇒ soil P_2O_5-recovery ↑ and crop uptake ↑
[c] K_2O-uptake by crops ↓ ⇒ K_2O-deficit on soil balance ↓ ⇒ synthetic K_2O required ↓

RESULTS (2)

- **Soil quality**
  - No significant differences in EC, pH-H_2O, pH-KCl, sodium adsorption ratio, S-content, P and metal accumulation
  - Significantly more organic carbon added to soil when applying digestate or its liquid fraction (Sc 4-8)

- **Economical (A) and ecological (B) evaluation**



Sc 8 most beneficial: use of liquid fraction of digestate without synthetic fertilizer addition

CONCLUSIONS

Recycling of nutrients from biodigestion waste derivatives in agriculture can:

- create sustainable substitutes for synthetic fertilizers with high nutrient use efficiencies
- reduce NO_3-leaching and increase soil P_2O_5-recovery
- result in economical and ecological benefits

⇒ The use of these products should be stimulated in environmental legislation

⇒ Research has started on the modeling of physicochemical nutrient recovery systems for wastewater and sludge streams to sustainably produce these marketable fertilizers with high nutrient availability (BMP Innovation FRQNT-CRSNG)

ACKNOWLEDGEMENTS

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