

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

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INTRODUCTION



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

Stringent fertilization levels

Need for sustainable resource management !

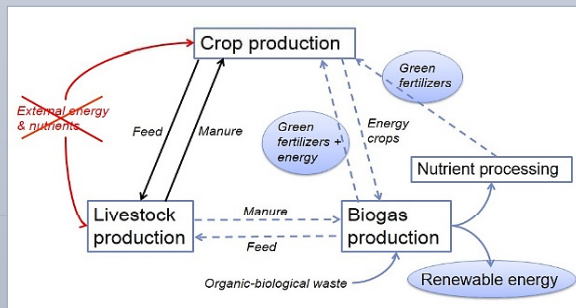


Increasing use of synthetic fertilizers

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



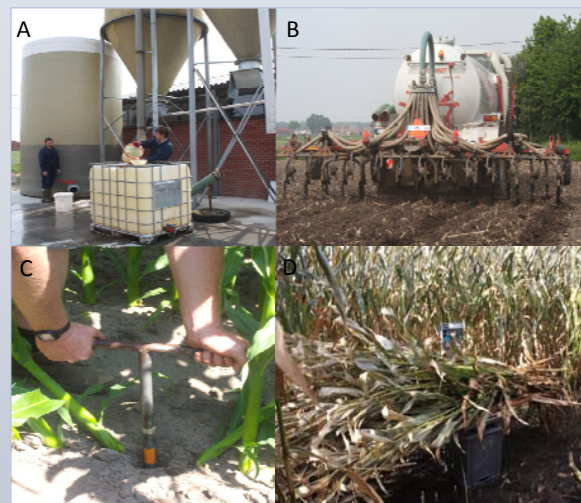
MATERIALS AND METHODS

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 ₂ O
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

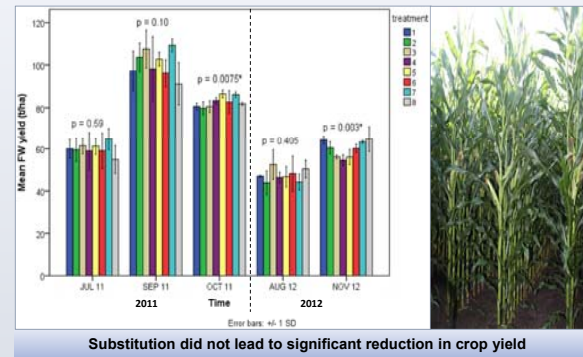
5. Biogas potential: Anaerobic digestion batch tests (37°C)

6. Economical and ecological evaluation (2011):

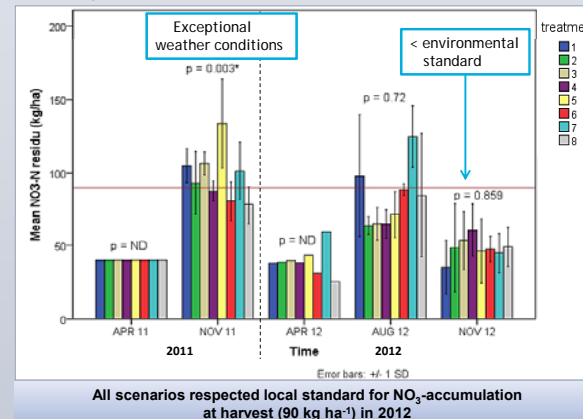
Vaneeckhaute et al. (2013). Biom. Bioenerg. 49, 239-48.

RESULTS (1)

• Fresh weight biomass yield



• NO₃-N residue in soil (0-90 cm)



• Nutrient balances

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

	Scenario 1				Scenario 2				Scenario 3			
kg ha ⁻¹ year ⁻¹	N-3	N-30	P ₂ O ₅	K ₂ O	N-3	N-30	P ₂ O ₅	K ₂ O	N-3	N-30	P ₂ O ₅	K ₂ O
Manure application	186	186	76	216	186	186	76	216	186	186	76	216
Deposition	30	30	9	8	30	30	9	8	30	30	9	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 ^a	-48 ^a
Leaching ^a	45	24			41	18			31	2		

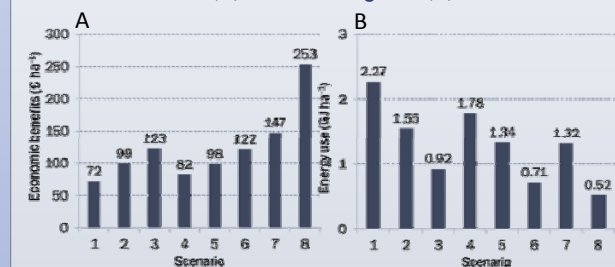
Substitution of synthetic N by air scrubber waste water (Sc 1 → 3) resulted in:
^a N-leaching ↓, while effect on denitrification, volatilization and organic matter breakdown was nihil
^b Negative surplus on soil P₂O₅-balance ⇒ soil P₂O₅-recovery ↑ and crop uptake ↑
^c K₂O-uptake by crops ↓ ⇒ K₂O-deficit on soil balance ↓ ⇒ synthetic K₂O required ↓

RESULTS (2)

• Soil quality

- No significant differences in EC, pH-H₂O, 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 NO₃-leaching and increase soil P₂O₅-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 FRONT-CRSNG)

ACKNOWLEDGEMENTS

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