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LCA applied to residual organic fertilizing materials - An overview of substitution methodological options and quantitative substitution rates

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Life Cycle Assessment and Other Assessment Tools for Waste Management and Resource Optimization
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Multifunctionality of residual organic fertilizing materials in LCA

Often solved by system expansion by subtraction

« to treat a waste » = **Anaerobic digestion/composting + digestate/compost spreading** − Production and spreading of mineral fertilizers

Anaerobic digestion/composting + digestate/compost spreading
- « to treat a waste »
- « to fertilize »

Production and spreading of mineral fertilizers
- « to fertilize »

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Different substitution ways

→ Literature study of LCA methodological options to deal with substitution of residual organic fertilizing materials

Methodology

LCA case studies of residual organic fertilizing materials (digestate, compost) including land spreading

Queries

digestate
mineral fertilizer
LCA
substitution
allocation

Details on methodological choices and quantitative rates to substitute residual organic fertilizing materials with mineral fertilizers

- What are the methodological choices to substitute residual organic fertilizing materials with mineral fertilizers ?
- What are the quantitative rates used?
- Which are the mineral fertilizers substituted?

Methodological substitution choices

Different ways to consider substitution

Substitution way	Articles
No substitution / Not clear	3
Agronomical sense (to fulfill the plant requirements)	5
LCA sense (production of mineral fertilizers is potentially avoided)	34

Substitution rates: reduction by [50-75%] of the use of mineral fertilizers for 3 articles

Basis for the substitution	Articles
Fertilizing potential* *amount of N, P and K (g/kg) contained in the organic material	24
Plant nutrient availability** **availability of nutrients to be taken up and used by agricultural crops	7
Other	3

Methodological substitution choices

Substitution way	Articles
No substitution / Not clear	3
Agronomical sense	5
LCA sense (the fertilizing function is subtracted)	34

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Substitution based on the fertilizing potential, which is counted up via

8 The fertilizing potential of the digestate/compost

ex: g of NH_4^+/kg of digestate

→ Generally, articles provide very few information on the substitution method used. A 100% N/P/K substitution rate is implicitly used

10 A substitution rate applied to the fertilizing potential of the digestate/compost

ex: 40% of N_{tot} digestate content

→ The N substitution rate reflects a percentage of available NH_4^+-N/N_{tot} content

→ [20-75%] substitution rates for N

→ 100% rates are often assumed for P and K

→ Can be weighted by the effective mineral fertilizer replacement rate (1 article)

5 The N/P/K fertilizer replacement value (N/P/K FRV)

Substitution is based on the use of a fertilizer replacement value (from national regulations for 4 articles). N: [15-75%]; P and K: 100%

1 The C/N ratio (N content is calculated based on the C/N ratio)

Methodological substitution choices

Substitution way	Articles
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Substitution based on the plant nutrient availability

- Nutrient consideration
  - N always substituted
  - P and K respectively substituted in 6 and 4 of the 7 papers
- Substitution rates
  - Available N: [45-90%] of N_{tot} (available as NH_4^+-N)
  - Available P: [50-100%] of P_{tot} or P as P_2O_5
  - Available K: [80-100%] of K_{tot} or K as K_2O

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Other LCA sense substitution ways

- Organic product amount
- Limiting element

Application of the substitution

- Consideration of mineral fertilizers
  - Production: all papers
  - Emissions: 7 papers

- Substituted mineral fertilizers (number of articles)

N mineral fertilizers	P mineral fertilizers	K mineral fertilizers
Ammonium nitrate (8) Urea (4) Not precised (4) Calcium ammonium nitrate (3) Ammonium sulphate (1) Diammonium phosphate (1)	**Triple Superphosphate (6)** **Superphosphate (6)** Not precised (5) Diammonium phosphate (3)	**Potassium chloride (7)** Potassium sulphate (4) Not precised (4)

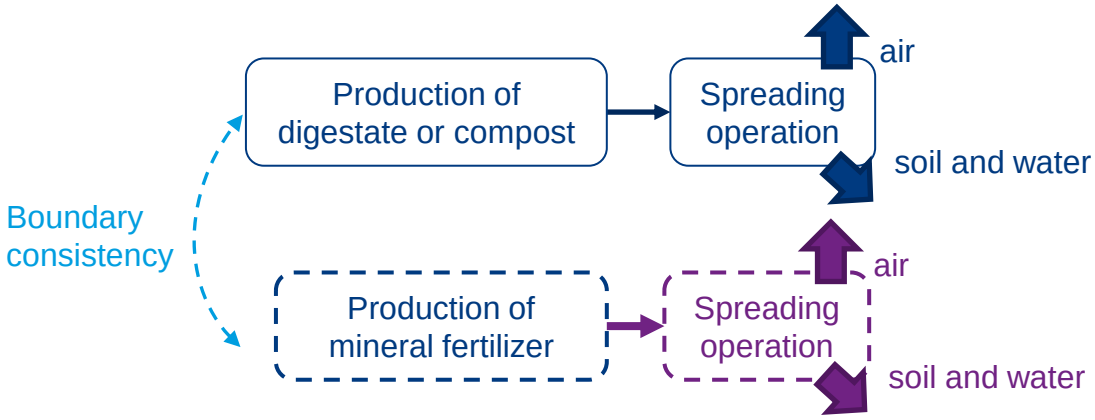
- Impact on results of the substitution
  - Insignificant in most of the case studies
  - When significant, impacts on climate change, acidification and eutrophication are pointed out (due to N_2O, NH_3, nitrate, phosphate)

Conclusion

- Different methodological approaches, which require different information
- No consensus on the substitution methodological approach
- Substitution based on the fertilizing potential in the most frequent
- Substitution in an attributive perspective → avoided mineral fertilizer production
- Consequential perspective → cast doubt on the effective avoided production

Outlook

From literature of methodological choices to inventory data



Thanks for your attention

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