

## LCA APPLIED TO RESIDUAL ORGANIC FERTILIZING MATERIALS – AN OVERVIEW OF EMISSION INVENTORY DATA AT THE SPREADING OPERATION

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LCA case studies applied to waste management options of organic products face several inventory completeness issues and among them, the spreading operation emissions. Indeed, organic products contain nutrient elements which turn into air, water and soil emissions after their spreading. LCA practitioners need to consider these quantitative data in order to carry out relevant assessments. Emission data obtained from experimental measurements, as they are specific to each residual organic fertilizing material and each pedoclimatic condition, cannot be used as generic data. Moreover, when the LCA case study is processed based on the primary function “to treat the waste”, the secondary function “to fertilize with organic fertilizers” can be solved by system expansion by subtracting the secondary functions. Thus, mineral fertilizers, also having spreading emissions, are often subtracted. This paper aims to present results of a literature review dealing with emission data at the spreading operation, both for residual organic fertilizing materials and mineral fertilizers. A set of 30 papers detailing emission data of organic wastes and mineral fertilizers during the spreading operation was selected from a corpus of 132 peer-reviewed papers<sup>1</sup> dealing with LCA case studies of residual organic fertilizing materials including land spreading. The selected papers were used to state how the N, P and trace metal element emissions at spreading operation were inventoried, as well as the consideration of C emission and sequestration.

Emissions are heterogeneously considered in the case studies. N<sub>2</sub>O, NH<sub>3</sub> and NO<sub>3</sub><sup>-</sup> are usually quantified whereas NO<sub>x</sub>, N<sub>2</sub> and PO<sub>4</sub><sup>3-</sup> are often left out of the system. Based on the literature review, it has not been possible to suggest emission values for each type of residual organic fertilizing material. Main conclusions are:

- N<sub>2</sub>O : their value ranges are quite consensual (0,17%-2% for direct emissions, 1% of N emitted as NH<sub>3</sub> and NO<sub>x</sub> and 0,75-2% of N emitted as NO<sub>3</sub><sup>-</sup> for indirect emissions<sup>2</sup>).
- As NH<sub>3</sub> emissions are very variable, a pedoclimatic model should be used. There is a high variability on nitrate models, which should be better investigated.
- NO<sub>3</sub><sup>-</sup> emissions into water have a great variability, either on the emission rate value or on the different forms N is expressed (leakages or run-off of total N, N-NH<sub>4</sub>...).
- NO<sub>x</sub> are expressed as a % of direct and/or indirect N<sub>2</sub>O emission produced during denitrification.
- N<sub>2</sub> is rarely considered, whereas it should be in order to equilibrate the N mass balance and check that no N is artificially created or lost.
- PO<sub>4</sub><sup>3-</sup> leakages are in a range value of 1,7% to 10% of P.
- For climate change, biogenic carbon is hardly ever considered. Trace metal concentration is barely considered and constitutes a subject to explore especially concerning toxicity and ecotoxicity impacts.

The spreading emissions of mineral fertilizers are not often considered. Emission rates are issued from the same sources as for organic products, and their values are very close.

The influence of the spreading emissions of the organic products and the substituted mineral fertilizers on the LCA results has been noticed several times. Over all, the impact of the spreading operation has been pointed out because of the NH<sub>3</sub> contribution to acidification and the NH<sub>3</sub> and nitrate contributions to eutrophication. The impact of the spreading operation on climate change due to N<sub>2</sub>O emissions, on eutrophication due to phosphate emissions, on particulate matter formation due to NO<sub>x</sub> emissions has also been detected. Those results tempt to pay particular attention to the inventory emissions.

The review led to an overview of the emission inventory data for residual organic fertilizing materials and mineral fertilizers at the spreading operation. A value range has been proposed for each P-based and N-based emission and when it was not possible, variability has been highlighted. The infrequent consideration of carbon fate and trace metals in LCA case studies has been pointed out. The impact of the inventory emissions on results has been assessed to be weighty and leads to recommendations for LCA practitioners in waste management.

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<sup>1</sup>The corpus was constituted using queries with the keyword groups: digestate, mineral fertilizer, LCA, substitution, allocation

<sup>2</sup> Direct N<sub>2</sub>O emissions are emitted during the nitrification and denitrification processes during the nitrogen cycle. Indirect N<sub>2</sub>O emissions are emitted from NH<sub>3</sub>, NO<sub>x</sub> and NO<sub>3</sub><sup>-</sup> emissions.