Evaluating manure impact methodologies within Life Cycle Assessments (LCA) of livestock systems and products

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Abstract

The environmental impact of livestock production is of critical concern, with manure management being a significant contributor to greenhouse gas (GHG) emissions, accounting for approximately 10% of total agricultural GHG emissions globally. Manure supports soil fertility, however its management causes GHG, in particular methane (CH_4) and nitrous oxide (N_2O). Life Cycle Assessment (LCA) is a key tool for quantifying these impacts in livestock systems. However, the lack of methodological harmonization in manure-related emissions assessments poses challenges for comparability and accuracy across LCA studies. Within this study, we undertook a harmonisation approach to assess LCA methods assessing manure emissions in livestock systems and production chains focused on: i) Assessing current LCA methodologies; ii) identifying key emission drivers, iii) supporting sustainable livestock systems, iv) providing recommendations for LCA practitioners.

An initial pool of 29,151 papers were collected. After screening, 263 papers remained, with 48 focused on manure emissions in LCA. The LCA method harmonization used criteria selected through expert panel and workshop: transparency, completeness, fairness and acceptance, robustness, and applicability, leakage inclusion for anaerobic digestion, accuracy in GHG emissions from manure storage and treatment, and accuracy in GHG emissions from animal housing.

While Intergovernmental panel climate on climate (IPCC) Tier 1 approaches dominate due to their simplicity, Tier 2 and Tier 3 methodologies provide greater accuracy by incorporating detailed system-specific parameters. However, the higher data requirements of these advanced methods limit their broad applicability. Further, inconsistencies in system boundary definitions, emission factor selection, and nitrogen dynamics modelling further complicate direct comparisons between LCA studies. As innovations are developed to reduce emissions, future LCA improvements could balance accuracy and applicability by refining emission factors and process models while integrating advancements in observation and crop-livestock assessments.

Keywords: Life Cycle Assessment, manure management, greenhouse gas emissions, methodological harmonization, livestock sustainability