FARMING PRACTICE
MANURE PROCESSING TECHNIQUES

IMPACT: GLOBAL WARMING POTENTIAL (LCA)

Reference 16

Miranda, ND; Tuomisto, HL; McCulloch, MD 2015 Meta-Analysis of Greenhouse Gas Emissions from Anaerobic Digestion Processes in Dairy Farms Environ. Sci. Technol. 49, 5211–5219 10.1021/acs.est.5b00018

Background and objective

Farms with livestock have particularly high emissions due to enteric fermentation and fugitive greenhouse gases (GHGs) from stored and land-applied manure. Therefore, the development of methodologies to estimate the carbon footprint reduction of various farming technologies is of great relevance. In particular, dairy farming has been reported to contribute 4% of global anthropogenic GHG emissions.(2) Anaerobic digestion (AD) is a technology that holds the potential to mitigate these emissions. This meta-analysis quantifies the changes in greenhouse gas (GHG) emissions from dairy farms, caused by anaerobically digesting (AD) cattle manure. As this is a novel quantifiable synthesis of the literature, a database of GHG emissions from dairy farms is created. Each case in the database consists of a baseline (reference with no AD system) and an AD scenario.

Search strategy and selection criteria

The database is developed by a systematic selection of articles to ensure reproducibility. Selected articles meet the following criteria: (i) peer-reviewed scientific publication in the field of study; (ii) primary source; and (iii) inclusion of numerical data of GHG emissions for dairy farms with and without an AD process. The first criteria is established to obtain high-quality results in the academic literature. The second criteria is applied to avoid duplicates and, consequently, review articles are excluded. The third criteria is introduced to ensure that numerical results are relevant for this meta-analysis. The ISI Web of Knowledge database(27) is used because it mainly contains peer-reviewed journals. To search for articles on this platform, all publication years and types are selected and the language is set to English. The papers selected include quantitative results that allow the evaluation of changes in GHG emissions from baseline(s) to AD scenario(s). Where articles reported more than two scenarios, multiple cases are entered into the database. A case is defined as the emissions from different activities (operation units) from baseline and related AD scenarios, determined under the same conditions (e.g., a study of the effect of storage temperature over GHG emissions from untreated and digested slurry would consider each temperature as a case). Cases may include multiple or single operation units. In order to identify sources of variation of the cases, additional variables are recorded in the database.

Data and analysis

Nonparametric statistics is applied, first, to assess the overall effect of AD on emission and, second, to examine the relation between some emissions. To evaluate the significance of the changes in GHG emissions (from baseline to AD scenarios), the Wilcoxon Signed Rank test(36, 37) is used. It is applied over the median values of RC distributions and zero (value of Relative changes if no difference between scenarios exists). Significant differences between these values (Wilcoxon P-value <0.05) indicate evident changes in the emissions when AD is implemented. This test is also utilized to assess the significant difference between two distributions of Relative changes for digestate vs raw slurry.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
30	Dairy farms slurry manures	Anaerobic digestion of manure only.	Raw slurry	Metric: The selected articles report emissions of different GHGs per functional unit [f.u.] (GHGi, i = CH_4, N_2O, or CO_2). To standardize the emissions, these are expressed as carbon dioxide equivalents (CO_2e).; Effect size: Relative difference between treatment and control	56.25

Results

- In the database, 24 cases report emissions from stored untreated and digested slurries. Relative changes for this operation unit show a significant decrease in total GHG emissions (median = −81.9%, Wilcoxon's P = 0.01).
- It is found that CO_2 and N_2O emissions are not usually reported for storage and have large interquartile ranges (CO_2 = 208.0% and N_2O = 61.2%). Consequently, nonsignificant changes in emissions between raw and digested slurry (Wilcoxon's Ps CO_2 = 0.584 and N_2O = 1.000) are obtained for those GHGs.
- Results indicate that GHG emissions from digestate after field application are significantly less (median = −36.0%, Wilcoxon's P = 2.61 × 10−3) than from untreated slurry.
- The median of 1.4% indicates that this percentage of the baseline emissions is increased due to leaks from the digester. This change in emissions is significantly different to the baseline emissions (Wilcoxon's P = 0.014), which implies that there are sufficient cases to conclude that fugitive emissions from digesters alone increase the carbon footprint of the dairy activities.
- The offset of fossil fuels with biogas usa as fuel significantly reduces the emissions with respect to the baseline scenarios (median = −11.0% and Wilcox's P = 7.63 × 10−6).

Factors influencing effect sizes

- No factors influencing effect sizes to report

Conclusion

The median reductions in emissions from the baseline scenarios, according to operation units, are −43.2% (n.s.) for storage, −6.3% for field application of slurries, −11.0% for offset of energy from fossil fuel, and +0.4% (n.s.) for offset of inorganic fertilizers. The leaks from digesters are found to significantly increase the emissions from baseline scenarios (median = +1.4%).