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Background and objective

The establishment of sustainable soil waste management practices implies minimizing their environmental losses associated with climate change (greenhouse gases: GHGs) and ecosystems acidification (ammonia: NH₃). Although a number of management strategies for solid waste management have been investigated to quantify nitrogen (N) and carbon (C) losses in relation to varied environmental and operational conditions, their overall effect is still uncertain. The authors have analyzed the current scientific information through a systematic review. The authors quantified the response of GHG emissions, NH₃ emissions, and total N losses to different solid waste management strategies (conventional solid storage, turned composting, forced aerated composting, covering, compaction, addition/substitution of bulking agents and the use of additives).

Search strategy and selection criteria

The authors gathered the available peer-reviewed literature published before November 2013 concerning gaseous emissions during composting and/or storage of organic solid waste. Articles were searched on the ISI Web of Knowledge and Google Scholar database by combining specific keywords related to treatment. First, studies describing data of CH₄, N₂O, or NH₃ fluxes (at least one of them) over a reported measurement period were collected. We decided to analyze gaseous losses in terms of cumulative emissions, as a proportion of initial carbon (C) or N content in the waste material (%CH₄-C, %NH₃-N, %N₂O-N). Thus, to harmonize the data included in our dataset, in some cases, it was necessary to transform the reported data into values referred to an element mass basis. Those studies not describing results as cumulative emissions or not reporting enough details to perform this conversion were excluded from the analysis. Additionally, we decided to include articles which expressed results just in terms of total N losses, based on a N mass balance, because this approach can add valuable information with regard to the general influence of different treatments and conditions in the overall N conservation through solid waste management. This parameter involves the already mentioned N gaseous emissions (NH₃, N₂O) but also any other kind of N losses via gas or liquid, such as dinitrogen (N₂) or nitrate.

Data and analysis

The only criterion used for weighting was the number of aggregated independent treatments contained in our composite datasets. Weighted mean effect sizes of each category were calculated, with bias-corrected 95% confidence intervals (CIs) generated by a bootstrapping procedure (10 000 iterations), using metawin software. Mean effects of treatments were considered different from the control at the 0.05 significance level when the 95% confidence interval did not overlap zero.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
76	Solid manure (dairy cows, swine, poultry, green waste)	Solid manure Solid manure improved composting techniques (turning, forced aeration, compaction, covering, bulking agents, additives)	Solid manure conventional storage (heaps)	Metric: CH ₄ , N ₂ O emissions; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	68.75

Results

- Mechanical turning and forced aeration with a ventilation device (e.g., centrifugal blower) are both efficient composting methods that involve active aeration, thereby ensuring the O₂ supply to the microorganisms and promoting microbial breakdown of organic materials. This is consistent with the results displayed in this meta-analysis, which indicates a statistically significant effect of these composting methods on increasing CO₂-C emissions in comparison with conventional static storage. Periodical turning is the only composting method that reduces CH₄ emissions in comparison with conventional static storage of solid waste. although statistical significance could not be found within the confidence level (95%) of the study, periodical turning showed a tendency toward decreasing N₂O emissions.
- Improving the porosity and physical structure of the pile can be achieved by either increasing the ratio of bedding material with respect to manure (e.g., straw) or through the use of a different bulking agent with a high content of recalcitrant compounds (e.g., wood chips). According to our results, this strategy is an efficient way to reduce both CH₄ and N₂O emissions during solid waste management. In contrast, it did not significantly affect CO₂ emissions.

Factors influencing effect sizes

- Moisture content : Raw materials with high initial moisture, close to 80%, tend to promote CH₄ emissions.
- Bulk density : The authors examined the relationship between the bulk density of the pile vs. N₂O and NH₃ losses, finding a positive relationship with N₂O emissions and negative with NH₃ emissions, which stresses the risk of pollution swapping when trying to mitigate N₂O emissions by manipulating solid waste density.

Conclusion

Turning have shown potential for reducing GHGs emissions, whereas no clear effects were detected for forced aerated system.