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Cao Y, Wang X, Bai Z, Chadwick D, Misselbrook T, Sommer SG, Qin W, Ma L 2019 Mitigation of ammonia, nitrous oxide and methane emissions during solid waste composting with different additives: A meta-analysis *Journal of Cleaner Production* 10.1016/j.jclepro.2019.06.288

Background and objective

Composting of solid waste can be associated with a loss of the agronomic value (nutrient loss), as well as a source of environmental impact through the emission of the greenhouse gases (GHG) nitrous oxide (N₂O) and methane (CH₄) and volatilization of ammonia (NH₃). Additives have been considered as a useful option to mitigate these environmental emissions, but the wider effects of using different additives on multiple gas emissions is still uncertain. The objectives of this study were: (i) to quantify and compare the mitigation effect of different additives on multiple gases; (ii) to assess the importance of feedstock properties (moisture content, C/N ratio and pH) on mitigation effect; (iii) to investigate the relationship between additive application dosage and mitigation effect; (iv) to explore optimal options to reduce TN loss and NH₃, N₂O and CH₄ emissions. Here the results concerning the impact of additives during composting on TN losses are reported.

Search strategy and selection criteria

Peer-reviewed literature, theses and conference papers from 1994 to 11th February 2018 were collected, using the electronic databases: Web of Science, Google Scholar and the China National Knowledge Infrastructure. In this literature search, the following specific keywords were combined: composting, additives (amendments), nitrogen loss, ammonia, nitrous oxide, methane or greenhouse gas emissions. To be included in this meta-analysis, studies needed to meet the following criteria: (i) the study should include control treatments; (ii) the study described the mitigation efficiency of at least one of TN, NH₃, N₂O and CH₄ for each treatment; (iii) aerobic composting process was ensured by forced aeration and/or turning; and (iv), the composting process was complete, as indicated by the compost temperature remaining stable at the ambient temperature.

Data and analysis

Mean effect sizes and bias-corrected 95% confidence intervals were generated by running a bootstrapping procedure with 5000 iterations using Metawin 2.1.4 software. The effects of 3 variables on mean effect were explored: additive type, application dosage and feedstock properties.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
105	Livestock manure, food waste, sewage sludge and/or green waste	Additives (chemical additives, e.g. phosphate, magnesium salts, superphosphate, gypsum etc.; physical additives, e.g. biochar, zeolite, bentonite, etc.; microbial additives, e.g. nitrite-oxidizing bacteria (NOB), NTB (ammonifiers, nitrobacteria, azotobacter) agent, etc.)	No additive	Metric: TN losses, in terms of cumulative TN losses as a proportion of the TN of the initial composting material; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	62.5

Results

- According to this meta-analysis, the use of additives can significantly reduce TN loss (46.4%, on average), compared with the control.
- There was a range in mitigation efficiencies depending on the additive type. Application of chemical additives was more efficient at reducing TN loss (52.0%), compared with other additives. The effectiveness of chemical additives on TN loss can vary according to additive properties. Specifically, phosphate and magnesium salts had the greatest mitigation potential, reducing TN loss by 68.0%, followed by superphosphate. Acids were very effective in reducing TN loss during composting (37.1%).
- The application of physical additives was also an effective option to reduce TN loss, with respective average reductions of 43.5%, with biochar and zeolite giving significant reductions.
- The present meta-analysis showed that the application of microbial additives were less effective than chemical or physical additives in reducing TN loss, with average reduction of 10.2%.
- There was significant linear correlation between application dosage of phosphate and magnesium salt and the mitigation efficiency for TN loss between 0 and 20%, with TN loss decreasing by 4.7% for every 1% increase in the application of phosphate and magnesium salt. The magnitude of the mitigation of TN loss increased as the dosage rate of superphosphate increased over the range of 0–20%, with decreases in TN losses of 3.2% for every 1% increase in superphosphate application. Chemical additives at low moisture content were more effective in mitigating TN loss (57.8%) than these at high moisture content (40.9%). At low C/N ratios (≤ 20), chemical additives resulted in a greater mitigation of TN loss compared to physical additives, although at high C/N ratios (>20 to ≤ 30) there was a tendency for the opposite effect.

Factors influencing effect sizes

- Additive type : The present meta-analysis showed that the application of microbial additives were less effective than chemical or physical additives in reducing TN loss.
- Additive properties : Among chemical additives, phosphate and magnesium salts had the greatest mitigation potential;
- Application dosage : Higher impact of chemical and physical additive on TN losses for higher dosage;
- Initial moisture content : Low moisture content increased effectiveness of chemical additives
- Initial C/N ratio : Low C/N ratios stimulated the effectiveness of chemical additives to reduce TN loss; high C/N ratios stimulated the effectiveness of physical additives to reduce TN loss;

Conclusion

This first global meta-analysis establishes that the use of additives can significantly reduce the TN loss during composting.