European Commission

FARMING PRACTICE
MANURE STORAGE TECHNIQUES

IMPACT: GHG EMISSIONS

Reference 6

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 (N_2O) and methane (CH_4) and volatilization of ammonia (NH_3). 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 NH_3, N_2O and CH_4 emissions. Here the results concerning the impact of additives during composting on N_2O and CH_4 emissions 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, NH_3, N_2O and CH_4 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: 1) N_2O emission; 2) CH_4 emission; 3) Total CO_2eq; 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 N_2O (44.6%) and CH_4 (68.5%) emissions and GWP (54.2%) of emissions, compared with the control. However, there was a range in mitigation efficiencies depending on the additive type. Microbial inocula resulted with non-significant effect on N_2O and lacked of evidence for CH_4 emissions.
- Physical additives resulted in greater mitigation of N_2O emission, with a mean reduction of 65.5%, with biochar and zeolite giving average reductions of 59.8 and 69.9%, respectively. Chemical additives had no effect on reducing N_2O emission during solid waste composting. Gypsum even increased N_2O emission by 56.8%. However, from this study N_2O emission was not promoted by the addition of acids during solid waste composting. The application of NOB has been shown to control N_2O accumulation, which may explain the significantly reduce N_2O emission by 54.2%.
- Compared with chemical additives (61.8%), physical additives resulted in greater mitigation of CH_4 emission, with a mean reduction of 72.5%. Specifically, biochar significantly reduced CH_4 emission, by 67.5%. For chemical additives, phosphate and magnesium salt, superphosphate and gypsum can significantly reduce CH_4 emission by 45.5, 51.0 and 89.7%, respectively.
- Both chemical and physical additives were effective in reducing the total GWP due to their impacts on reducing gaseous emissions from the composting process. A greater mitigation was observed for physical (67.2%) than chemical additives (28.6%). Biochar and zeolite gave significant reductions in the total GWP (62.8 and 70.2%, respectively), whereas no significant mitigation of GWP was found when phosphate and magnesium salt, superphosphate or gypsum was added.
- Physical additives at low moisture content were more effective in mitigating N_2O emissions (68.5%) than these (9.5%) at high moisture content.

Factors influencing effect sizes

- Initial moisture content : High moisture content suppressed the effectiveness of physical additives in mitigating N_2O emission
- Additive type : Chemical additives had no effect on reducing N_2O emission; physical additives resulted in greater mitigation of N_2O and CH_4 emissions;
- Additive properties : Gypsum even increased N_2O emission, while biochar and zeolite reduced N_2O emission; Biochar and zeolite gave significant reductions in the total GWP, no significant effect of phosphate and magnesium salt, superphosphate or gypsum.

Conclusion

This global meta-analysis establishes that the use of additives can significantly reduce N_2O and CH_4 emissions, and total GHG emissions expressed as GWP during composting.