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Biochar and covering as optimisation strategies for cattle manure composting: Trade-offs in gaseous emissions and safety

Winnie Ntinyari[1], Sven Sommer[2], Collins Oduor[1], Matthew Odipo[3], Elizabeth Cook[1], Peter Opala[3], Caroline Wambui[3], Lutz Merbold[4], Sonja Leitner[5]

[1] *International Livestock Research Institute (ILRI), Mazingira Centre, Kenya*
[2] *Aarhus University, Dept. of Biological and Chemical Engineering - Process and Materials Engineering, Denmark*
[3] *Maseno University, Department of Crop & Soil Sciences, Kenya*
[4] *Agroscope, Research Division Agroecology and Environment, Switzerland*
[5] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics (OPATS), Germany*

Abstract

Composting of livestock manure improves nutrient circularity and reduces health risks in smallholder farming systems of sub-Saharan Africa. Since composting requires regular turning and mixing of the manure for better aeration, this can lead to nutrient losses through greenhouse gas (GHG) and ammonia (NH_3) emissions. Given the importance of manure for farm productivity, developing optimised composting approaches and evaluating emissions, nutrient transformations, and compost safety is needed. A three-month outdoor composting experiment was conducted using cattle manure mixed with straw (4:1 w/w) and simulating conditions during solid manure storage in heaps. We evaluated five treatments: (i) unturned control (UC), (ii) turned (T), (iii) turned plus cover (TCov), (iv) turned plus 10 % biochar (TB), and (v) turned plus 10 % biochar plus cover (TBCoV). Mixtures of 200 kg were stored in 600 L plastic containers (n=3) that were equipped for gas measurements. Turning occurred three times during the thermophilic phase. Bacterial counts for Escherichia coli, coliforms, Enterococci and *Salmonella* were evaluated over the composting period.

Temperatures within the heap increased above the sanitisation threshold (50°C) in all composting treatments, and the biochar treatments had the longest thermophilic phase of 16 days. The UC treatment recorded the highest N O emissions, whereas emissions were reduced in TB and TBCoV by 61–77 %. Turning triggered high NH_3 emissions which were not reduced by covering or biochar addition, resulting in higher total NH_3 losses in the turned compost treatments. Changes in mineral N (NH and NO) indicated that nitrification and denitrification dominated at different composting stages, while declining NH :NO ratios suggested progressive compost stabilisation during maturation. Composting treatments had CH emissions during the thermophilic phase, indicating that anaerobic conditions developed inside the heap. Compared to the control, composting with biochar addition and covering reduced cumulative CH_4 emissions by 51–77 %. All composting strategies showed significant reductions in the four indicator pathogen species with temperature the main driver for pathogen reduction. We conclude that covering and biochar addition during

Contact Address: Winnie Ntinyari, International Livestock Research Institute (ILRI), Mazingira Centre, Nairobi, Kenya, e-mail: w.ntinyari@cgiar.org

cattle manure composting are promising low-cost interventions to reduce CH and N O emissions, but not NH losses, while producing a sanitary and safe organic fertiliser for sustainable crop production.

Keywords: Ammonia, crop-livestock integration, methane, nitrous oxide, nutrient circularity