Chemosphere 117 (2014) 14–19

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Technical Note

Effects of mixing and covering with mature compost on gaseous emissions during composting

Wen Hai Luo [a,b], Jin Yuan [a], Yi Ming Luo [c], Guo Xue Li [a,*], Long D. Nghiem [b], William E. Price [d]

[a] College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China
[b] School of Civil, Mining and Environmental Engineering, University of Wollongong, Wollongong, NSW 2522, Australia
[c] Beijing Monitoring Station for Animal Husbandry Environment, Beijing 102200, China
[d] School of Chemistry, University of Wollongong, Wollongong, NSW 2522, Australia

HIGHLIGHTS

- The addition of mature compost reduced CH_4 and N_2O emissions during composting.
- Covering with mature compost increased NH_3 emission during composting.
- Inoculating with *strain M5* in cover layer reduced CH_4 but increased N_2O emission.

ARTICLE INFO

Article history:
Received 18 February 2014
Received in revised form 12 May 2014
Accepted 13 May 2014

Handling Editor: O. Hao

Keywords:
Composting
Greenhouse gases
Mature compost
Pig manure
Inoculation

ABSTRACT

This study investigated effects of mature compost on gaseous emissions during composting using pig manure amended with corn stalks. Apart from a control treatment, three treatments were conducted with the addition of 5% (wet weight of raw materials) of mature compost: (a) mixing raw materials with mature compost at the beginning of composting; (b) covering raw materials with mature compost throughout the experimental period; and (c) covering raw materials with mature compost at the start of composting, but incorporating it into composting pile on day 6 of composting. Mature compost used for the last treatment was inoculated with 2% (wet weight) of raw materials of *strain M5* (a methanotrophic bacterium) solution. During 30-d of composting, three treatments with the addition of mature compost could reduce CH_4 emission by 53–64% and N_2O emission by 43–71%. However, covering with mature compost throughout the experimental period increased cumulative NH_3 emission by 61%, although it could reduce 34% NH_3 emission in the first 3 d. Inoculating *strain M5* in mature compost covered on the top of composting pile within first 6 d enhanced CH_4 oxidation, but simultaneously increased N_2O emission. In addition, mixing with mature compost could improve compost maturity. Given the operational convenience in practice, covering with mature compost and then incorporating it into composting pile is a suitable approach to mitigate gaseous emissions during composting.

1. Introduction

Composting is a promising technology for the treatment of livestock manures. During composting, organic materials are aerobically degraded by microorganisms, therefore significantly reducing the volume and mass of these organic wastes. Meanwhile, the pathogen-free, non-toxic and nutrient-rich end compost can be produced under certain conditions with sufficient composting time (Scheutz et al., 2011). However, considerable emissions of NH_3, CH_4 and N_2O could occur during composting, which not only reduce the reusable nutrients in final compost but also lead to secondary pollution such as greenhouse effect, degrading environmental benefits of composting.

During composting, 9.6–46% of initial TN loss of raw materials is in form of NH_3 emission (Fukumoto et al., 2003; Morand et al., 2005; Jiang et al., 2011). The N_2O emission may constitute of 0.2–6% of initial TN loss of raw materials (Beck-Friis et al., 2001; Szanto et al., 2007). While forced aeration composting system has been widely applied, CH_4 emission accounts for 0.8–14% of initial carbon loss of raw materials due to partial anaerobic conditions in composting piles (Hao et al., 2004; Yamulki, 2006; Szanto et al., 2007; Jiang et al., 2011). Both N_2O and CH_4 are major greenhouse gases (GHGs), whose global warming potential is 298

* Corresponding author. Tel.: +86 1062733498.
E-mail address: ligx@cau.edu.cn (G.X. Li).

http://dx.doi.org/10.1016/j.chemosphere.2014.05.043
0045-6535/© 2014 Published by Elsevier Ltd.

and 25 times higher than that of CO_2, respectively, based on a 100 years' time frame (IPCC, 2007). Therefore, it is necessary to mitigate these gaseous emissions to enhance environmental benefits of composting.

Biofiltration is an effective technique to mitigate gaseous emissions during composting. Filter materials, such as mature compost, can absorb gases that exhaust from composting piles. Diverse bacteria acclimated in filter materials can also contribute to the mitigation of gaseous emissions. Hong and Park (2005) reported that using a medium depth of 500 mm of mature compost amended with coconut peels could completely remove NH_3 emitted from manure composting. In addition, mature compost of different waste materials has also been widely applied as a low-cost biocover material to minimize CH_4 emission from landfill sites (Barlaz et al., 2004; Stern et al., 2007; Scheutz et al., 2009). The large surface area and permeable pore space of mature compost can yield suitable conditions for methanotrophs proliferation, thus effectively oxidizing CH_4 (Scheutz et al., 2011). Furthermore, mature compost with sufficient water-holding capacity can keep covering materials at high water content, reducing the gaseous permeability or diffusion coefficients in covering layer (Stern et al., 2007).

Mature compost is an economical bulking agent to optimize composting process. Mixing mature compost with raw materials can improve inter-particle voids in compositing pile, thus increasing air permeability (Iqbal et al., 2010). Because of the bulking property, mature compost could create a suitable environment for microbial growth in composting pile (Scheutz et al., 2009). Therefore, mature compost was also referred as to be an inoculating agent in many studies (Kato and Miura, 2008; Abichou et al., 2009). However, to our knowledge, the effects of direct addition of mature compost on gaseous emissions during composting have not yet been systematically studied. Therefore, this study aims to comprehensively investigate the effects of mature compost on the emission profiles of NH_3, N_2O and CH_4 during composting using a mixture of pig manure and corn stalks.

2. Materials and methods

2.1. Composting materials and setup

The raw material was a thorough mixture of pig manure and chopped corn stalks (<80 mm in length) at a ratio of 7:1 (wet weight). Pig manure was obtained from a pig farm (Shujiatuo Town, Beijing, China) where the "ganqingfen" system was used. The "ganqingfen" system is solid animal excreta manually collected in the stables before flushing urine with water (Schuchardt et al., 2011). Chopped corn stalks were used as structural materials, collected from Shangzhuang Experimental Station, China Agricultural University, Beijing. Mature compost, which used the same raw materials as this study, was collected from a pilot composting box. The characteristics of raw materials and mature compost are given in Table 1.

A series of 60 L composting vessels were used in this study to simulate the forced-draft aeration system (Fig. 1). The aeration rate was set at 0.48 L kg^{-1} DM^{-1} min^{-1}. A C-LGX program was used to intermittently interrupt the aeration for 5 min every 25 min, and automatically record temperature in the center and top of composting pile.

Table 1
Characteristics of raw materials and mature compost for composting.

Materials	TOC [a]	TKN [a]	NH_4^+—N	NO_2^-—N + NO_3^-—N	Moisture (%)	C/N
	(g kg^{-1}) [a]		(mg kg^{-1}) [a]			
Pig feces	363	28.4	4300	80	79.8	12.8
Corn stalks	414	9.6	–	–	4.8	43.2
Mature compost	290	26.9	2800	350	16.8	10.8

[a] TOC: total organic carbon; TKN: total Kjeldahl nitrogen; values were on dry matter basis.

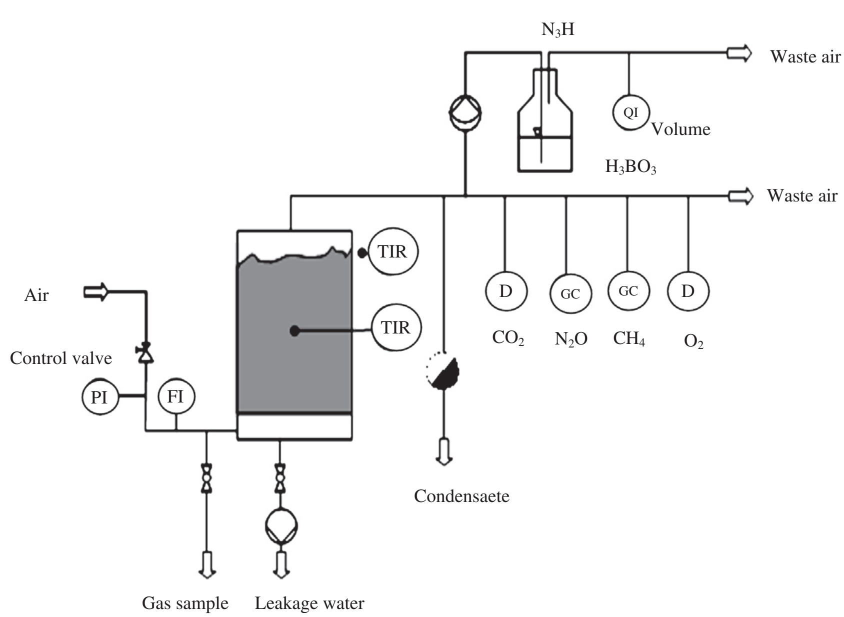

Fig. 1. Sketch map of a closed composting vessel. PI: pressure indicator; FI: flow indicator; TIR: temperature information recorder; QI: quantity indicator; GC: gas chromatograph; D: CO_2/O_2 detector.