



Contents lists available at ScienceDirect

## Waste Management

journal homepage: [www.elsevier.com/locate/wasman](http://www.elsevier.com/locate/wasman)

## Nitrification during extended co-composting of extreme mixtures of green waste and solid fraction of cattle slurry to obtain growing media

Rafaela Cáceres<sup>a,\*</sup>, Narcís Coromina<sup>a</sup>, Krystyna Malińska<sup>b</sup>, F. Xavier Martínez-Farré<sup>c</sup>, Marga López<sup>c</sup>, Montserrat Soliva<sup>c</sup>, Oriol Marfà<sup>a</sup>

<sup>a</sup>IRTA, Research and Technology, Food and Agriculture, GIRO Unit, Carretera de Cabrils km 2, 08348 Cabrils, Catalonia, Spain

<sup>b</sup>Institute of Environmental Engineering, Czestochowa University of Technology, Brzeźnicka 60a, 42-200 Czestochowa, Poland

<sup>c</sup>Universitat Politècnica de Catalunya (UPC), ASQUAS Research Group, Campus del Baix Llobregat, c/Esteve Terradas, 8, 08860 Castelldefels, Catalonia, Spain

## ARTICLE INFO

## Article history:

Received 25 April 2016

Revised 6 August 2016

Accepted 17 August 2016

Available online xxxx

## Keywords:

Separated cattle slurry

Green waste

Nitrification

Natural acidification

Growing medium

Physicochemical properties

## ABSTRACT

Next generation of waste management systems should apply product-oriented bioconversion processes that produce composts or biofertilisers of desired quality that can be sold in high priced markets such as horticulture.

Natural acidification linked to nitrification can be promoted during composting. If nitrification is enhanced, suitable compost in terms of pH can be obtained for use in horticultural substrates. Green waste compost (GW) represents a potential suitable product for use in growing medium mixtures. However its low N provides very limited slow-release nitrogen fertilization for suitable plant growth; and GW should be composted with a complementary N-rich raw material such as the solid fraction of cattle slurry (SFCS). Therefore, it is important to determine how very different or extreme proportions of the two materials in the mixture can limit or otherwise affect the nitrification process.

The objectives of this work were two-fold: (a) To assess the changes in chemical and physicochemical parameters during the prolonged composting of extreme mixtures of green waste (GW) and separated cattle slurry (SFCS) and the feasibility of using the composts as growing media. (b) To check for nitrification during composting in two different extreme mixtures of GW and SFCS and to describe the conditions under which this process can be maintained and its consequences.

The physical and physicochemical properties of both composts obtained indicated that they were appropriate for use as ingredients in horticultural substrates.

The nitrification process occurred in both mixtures in the medium-late thermophilic stage of the composting process. In particular, its feasibility has been demonstrated in the mixtures with a low N content. Nitrification led to the inversion of each mixture's initial pH.

© 2016 Published by Elsevier Ltd.

### 1. Introduction

It has been stated that the next generation of waste management systems should apply product-oriented bioconversion processes that produce composts or biofertilisers of desired quality that can be sold in high priced markets such as horticulture (Polo et al., 2006; Cáceres et al., 2015b). These systems should aim at the recycling of plant nutrients and organic matter, use or save renewable energy, keep a good economy and prevent polluting emissions to the environment (Veeken et al., 2004).

Composting, the process of turning organic wastes into stable products under aerobic conditions through decomposition by

microorganisms, is one of the most favored options to deal with organic waste (Kulcu et al., 2008). Organic matter is transformed during composting as a result of complex interactions among chemical, physical and biological processes (López-González et al., 2013). Although composting is a widely used process, there are still gaps in our understanding due to the high variety of feedstock materials and composting conditions (Himanen and Hänninen, 2011), particularly when the process is managed to obtain a targeted product. According to the literature, approximately 5.7 Mt of green waste (GW) compost is produced each year in EU countries (Himanen and Hänninen, 2011).

Composted GW can be used as an ingredient of growing media (Benito et al., 2005). However, this feedstock has been shown to have low N content due to the prominent presence of pruning

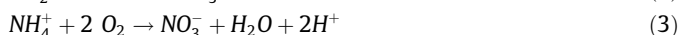
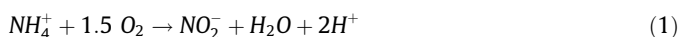
\* Corresponding author.

E-mail address: [rafaela.caceres@irta.cat](mailto:rafaela.caceres@irta.cat) (R. Cáceres).

debris. Therefore, in order to avoid N starvation in crops, the GW should be composted with a complementary N-rich raw material such as the solid fraction of cattle slurry (SFCS). Statistics show that more than 1.5 Gt of animal manure is produced in the EU-27 Member States every year, mostly from cattle and pig production (Bustamante et al., 2012).

The characteristics of the final compost depend on the raw material and composting system used (Cáceres et al., 2006; Bustamante et al., 2009; Malińska and Zabochnicka-Świątek, 2013). Several different process conditions can lead to a substantial loss of nitrogen as gaseous  $\text{NH}_3$ , including an initial low C/N ratio, alkaline pH and maintaining a high oxygenation ratio during the composting process (Zeng et al., 2011; Raviv et al., 2005). Lignified GW normally causes an acidic reaction and a high C/N ratio (Cáceres et al., 2015a; López et al., 2010a; Raviv et al., 2005), which means that GW and SFCS can be co-composted together because of their complementary characteristics.

Nitrification, which has been described as the transformation of  $\text{NH}_3$  to  $\text{NO}_3^-$  via  $\text{NO}_2^-$  by ammonia-oxidizing organisms (Eqs. (1) and (2)), can be regarded as the gatekeeper of nitrogen turnover during the composting process (Zeng et al., 2011). The recent discovery of a completely nitrifying bacterium from the genus *Nitrospira* showed that the complete nitrification process (*Comammox*) (Eq. (3)) actually exists in nature (Daims et al., 2015). Recent studies have also demonstrated the importance of maintain aerobic conditions in the entire profile of the manure composting matrix (Wang et al., 2015).



Natural acidification linked to nitrification during the composting process (Eqs. (1) or (3)) can be promoted under certain environmental conditions, mainly during the cooling and curing stage of the process (Cáceres et al., 2006; Nolan et al., 2011). If nitrification is enhanced, suitable compost in terms of pH can be obtained for use in horticultural substrates.

As stated above, GW compost represents a potential suitable product for use in growing medium mixtures because of the low salt content and moderate pH and the high stability of mature compost. However, its low  $\text{N}_{\text{org}}$  provides very limited slow-release nitrogen fertilization for suitable plant growth. Other authors have stated that nitrification intensity in certain composting matrices is limited when N-poor feedstocks are used and that low amounts of N are available because N is protected within lignocellulosic structures (López-Cano et al., 2016). Manure is an appropriate feedstock that can be added to GW as a source of N (Cáceres et al., 2006; Bustamante et al., 2009). However, it is important to determine how very different or extreme proportions of the two raw materials in the mixture can limit or otherwise affect the nitrification process.

The nitrification rate is a function of the initial concentration of total  $\text{NH}_4^+\text{-N}$  in waste (De Guardia et al., 2010), among other factors. Previous research has also demonstrated that a certain amount of  $\text{NH}_4^+\text{-N}$  should be present at the end of the thermophilic stage so that the nitrification process can continue (Sánchez-Monedero et al., 2001). Along the same lines, the addition of biochar should retain  $\text{NH}_4^+\text{-N}$  to favor this process (López-Cano et al., 2016). Moreover, recent studies on the microorganisms responsible for microbial oxidation have revealed that ammonia-oxidizing archaea (AOA) could play an important role in nitrification processes in agricultural waste composting (Zeng et al., 2011).

The purposes of the study were:

- To assess the changes in chemical and physicochemical parameters during the prolonged composting of extreme mixtures of green waste and separated cattle slurry and the feasibility of using the composts as growing media.
- To check for nitrification during composting in two different extreme mixtures of GW and SFCS and to describe the conditions under which this process can be maintained and its consequences.

## 2. Material and methods

### 2.1. Material

Shredded green waste feedstock (GW) was obtained from a composting plant in Cabrils (Barcelona, Spain). The solid fraction of cattle slurry (SFCS) was obtained from a livestock farm in Sant Joan les Fonts (Girona, Spain). Mixtures with 25% and 75% (volume/volume) of each feedstock were tested, resulting in two composting piles: GW25 (25% GW and 75% SFCS, v/v) and GW75 (75% GW and 25% SFCS) (Cáceres et al., 2015a). The main characteristics of these mixtures were described before (Cáceres et al., 2015a).

### 2.2. Composting method

An experimental composting system with volume of 6 m<sup>3</sup> was set up indoors inside a macro-tunnel in Cabrils (Catalonia-Spain) (latitude 41°25'N, longitude 2°23'E and altitude 85 m).

At the early stage of the composting process (45 days), a static method was used; air was blown (800–2000 L h<sup>-1</sup>) through a fan from the bottom of the pile up. Henceforth, aeration in two piles was provided by turnings using a front-end loader and this favored the homogenization of the material.

The pile temperature was monitored by inserting temperature probes (Pt-100) into two different locations in the composting matrix (Cáceres et al., 2015a). According to Cáceres et al. (2015a), the parameter DH was calculated. Ambient temperature was also measured every 10 min on a daily basis using a Testo data logger (model 177-H1, Testo, Lenzkirch, Germany).

Materials were moistened whenever its gravimetric moisture content was below 55 g g<sup>-1</sup>·100 (fresh weight basis) (Cáceres et al., 2006). Parameters related to field management of the process were described in detail by Cáceres et al., 2015a.

The experiment was conducted for 27 weeks.

### 2.3. Laboratory methods

Sampling of the material in decomposition was carried out in three locations of the piles (right, center and left sides). The samples were taken weekly in the first two months and fortnightly after this period of time.

The organic fraction of the samples was analyzed on dry and ground samples. The organic matter (OM) content of the composting samples was analyzed by loss on ignition at 470 °C for 5 h (Cáceres et al., 2015a). Organic N was measured using a specific  $\text{NH}_3$  electrode after a Kjeldahl digestion. The  $\text{C}/\text{N}_{\text{org}}$  ratio was calculated using the equation  $\text{C}/\text{N}_{\text{org}} = 0.58 \cdot \text{OM}(\%) / \text{N}_{\text{org}}$  (Jolanun and Towparyoon, 2010).

Electrical conductivity (EC) and pH were measured in a 1:5 water soluble extract (weight:weight, w:w) obtained after mechanically shaking the fresh sample in water suspension. The pH was determined with a specific probe (Ross Ultra® Triode of pH/ATC, Thermo Scientific Orion, Nijkert, Netherlands) plugged to an Expandible Ion Analyzer (Orion Dual Star pH/ISE Bechtol, Thermo Scientific Orion, Nijkert, Netherlands). The EC was mea-

Download English Version:

<https://daneshyari.com/en/article/5757081>

Download Persian Version:

<https://daneshyari.com/article/5757081>

[Daneshyari.com](https://daneshyari.com)