Bioresource Technology 218 (2016) 335–343

Contents lists available at ScienceDirect

Bioresource Technology

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

Improving green waste composting by addition of sugarcane bagasse and exhausted grape marc

Lu Zhang, Xiangyang Sun *

College of Forestry, Beijing Forestry University, Beijing 100083, PR China

HIGHLIGHTS

- Sugarcane bagasse (SCB) and exhausted grape marc (EGM) were added to compost.
- SCB and/or EGM enhanced the two-stage composting of green waste.
- Physico-chemical and microbiological properties explained the rapid decomposition.
- Temperature, water retention, microorganisms, enzymes, and nutrients were optimized.
- Combination of 15% SCB and 20% EGM reduced the two-stage composting time to 21 days.

ARTICLE INFO

Article history:
Received 5 May 2016
Received in revised form 21 June 2016
Accepted 24 June 2016
Available online 27 June 2016

Keywords:
Exhausted grape marc
Green waste
Sugarcane bagasse
Two-stage composting

ABSTRACT

The composting of lignocellulosic waste into compost is a potential way of sustainably disposing of a waste while generating a useful product. The current study determined whether the addition of sugarcane bagasse (SCB) (at 0, 15, and 25%) and/or exhausted grape marc (EGM) (at 0, 10, and 20%) improved the two-stage composting of green waste (GW). The combined addition of SCB and EGM improved composting conditions and the quality of the compost product in terms of temperature, water-holding capacity, particle-size distribution, coarseness index, pH, electrical conductivity, water-extractable organic carbon and nitrogen, microbial numbers, enzymatic activities, polysaccharide and lignin content, nutrient content, respiration, and phytotoxicity. The optimal two-stage composting and the best quality compost were obtained with the combined addition of 15% SCB and 20% EGM. With the optimized two-stage composting method, the compost matured in only 21 days rather than in the 90–270 days required for traditional composting.

1. Introduction

With the rapid development of urban green space in China, urban green waste (GW), i.e., park and garden litter and trimmings, has dramatically increased. In Beijing, for example, the amount of GW produced has increased by about 50,000–100,000 tons per year (Zhang and Sun, 2014a; Zhang et al., 2013). Traditional GW disposal has involved incineration or deposition in landfills, which reduce the efficiency of land use and cause environmental problems such as water contamination and odour pollution (Bustamante et al., 2013; Gabhane et al., 2012). As an alternative, composting technology has been considered an effective method for transforming the organic matter into a potentially safe, stable and sanitary product that can be used as a soil amendment, an organic fertilizer, or a substitute for peat in soilless culture (Chen et al., 2014). For biomasses that are high in lignocellulose, however, traditional composting is time consuming, produces odorous gases (i.e., NH_3 and H_2S), and generates a low quality compost product unsuitable for commercial use (Gabhane et al., 2012). Thus, reducing the time required for composting and increasing the quality of the compost product have become important goals in the use of composting for GW disposal.

Researchers previously described an innovative, two-stage composting technology that includes a primary composting (PC) and a secondary composting (SC) (Zhang et al., 2013). This new method results in two peaks in composting temperature (at 55–60 °C or even higher) and a longer thermophilic period. As a consequence, the production of a mature and stable compost requires only 30 days rather than the 90–270 days required for traditional composting (Zhang et al., 2013).

---

* Corresponding author at: College of Forestry, Beijing Forestry University, P.O. Box 111, Beijing 100083, PR China.

E-mail addresses: sunxy@bjfu.edu.cn, sunxy1211@163.com (X. Sun).

http://dx.doi.org/10.1016/j.biortech.2016.06.097
0960-8524/

Previous studies have indicated that the addition of various substances to the composting mass can accelerate the composting time and improve the quality of the compost product (Gabhane et al., 2012; Karak et al., 2013; Makan, 2015). One of these additives, sugarcane bagasse (SCB), is the fibrous residue left after the crushing and extraction of juice from sugar cane stalks during the manufacture of raw sugar (Mohee et al., 2015). In the composting of organic waste from livestock, SCB is commonly used as the structuring agent, whose main purpose is to correct the water content of the mixture by forming porous spaces in the composting mass. This increases the availability of oxygen and reduces the loss of static pressure in systems using forced aeration (Teixeira et al., 2015). The addition of sufficient SCB, which is acidic, can also enhance the nutrient transformation of organic wastes by controlling the pH (Cole et al., 2016). Moreover, SCB can be used as a carbon source to adjust the carbon:nitrogen (C:N) ratio and enhance the availability nutrients, including nitrogen (N), phosphorus (P), and potassium (K) (Kumar et al., 2010). Mohee et al. (2015) found that the use of SCB in the composting of municipal solid waste improved the compost quality and shortened the time required to achieve stabilization. Furthermore, the addition of SCB to municipal soil waste significantly increased the contents of organic matter (OM) and N in the compost product and greatly reduced N gaseous losses (Kumar et al., 2010; Mohee et al., 2015). However, the use of SCB in the two-stage composting of GW has not been studied.

With the development of a wine industry in China, the generation of exhausted grape marc (EGM), an abundant and low-value winery waste, has greatly increased (Torres-Climent et al., 2015). Addition of EGM can increase the composting temperature especially in the thermophilic phase and thereby ensure the effective destruction of pathogens and other undesirable organisms (Bustamante et al., 2013; Paradelo et al., 2013). Addition of EGM also tends to reduce the pH of the compost (perhaps because of the high water-soluble carbohydrate content of EGM) and may therefore help balance the pH during composting (Achmon et al., 2016). Winery and distillery wastes like EGM also tend to have low electrical conductivity (EC), high OM content, low heavy metal content, and significant contents of P and K that support microbial activity and reproduction during composting (Bustamante et al., 2011). Researchers have reported that the phytotoxicity of the compost product is reduced when animal manures are co-composted with winery and distillery wastes (Bustamante et al., 2011, 2013). Furthermore, EGM may reduce the rate and duration of NH_3 emission during composting, which could increase the N content in the compost product and reduce air pollution (Requejo et al., 2014). However, nothing is known about the effects of EGM on GW composting.

The overall goal of the present study was to optimize the two-stage composting of GW. The specific objectives were (i) to determine the optimal ratio of SCB and/or EGM in the two-stage composting of GW; (ii) to characterize the changes in the physical, chemical, biochemical, and microbial properties of GW during composting; and (iii) to evaluate the quality of the compost product.

2. Materials and methods

2.1. Composting materials

The GW that was used as the raw material for composting consisted mainly of the fallen leaves and branch cuttings of poplar (*Populus tomentosa* Carr.) produced by urban landscape maintenance in Beijing in the spring of 2015. The GW was mechanically shredded into 1 cm pieces (Zhang et al., 2013). SCB was obtained from Fujian Chengfa Agriculture Development Co. (China) and was air-dried and shredded into 3–6 cm pieces. EGM was obtained from Nanjing Nongaigou Farm Products Department (China). Bamboo vinegar was also added during the composting because it can reduce N volatilization and therefore increase the retention of N in the compost (Zhang et al., 2013). Bamboo vinegar, which is a light-yellow and transparent acidic liquid with a slightly smoky smell, was obtained from the Beijing Kaiyin Organic Fertilizer Production Co. (China). A microbial inoculum, which was a mixture of *Trichoderma* spp. inoculum (60%, v/v) and *Phanerochaete chrysosporium Burdsall* inoculum (40%, v/v), was prepared as described by Wei et al. (2007); it was added at the onset of composting to accelerate the degradation process. The main physico-chemical characteristics of the initial materials are listed in Table 1. The determination methods are described in Section 2.4.

2.2. Experimental design and composting process

A two-stage composting process was used in this study (Fig. 1). The amount of GW in each treatment was the same. Before the start of the process and based on a previous report (Zhang and Sun, 2014b), the C:N ratio of the GW was adjusted to 25–30 by the addition of urea, and the moisture content of the GW was adjusted to about 60% by water addition. Various quantities of SCB and/or EGM were then combined with the GW (Table 2) to produce a uniform mixture of composting mass. Finally, an equal amount of microbial inoculum was added to each composting mixture (5 ml of inoculum kg^{-1} dry GW) (Zhang et al., 2013). The nine combinations of GW, SCB, and EGM are hereafter referred to as nine treatments.

At the beginning of the PC (day 0), the nine treatments were added to composting reactors, which were non-covered cement containers (6 m long, 2 m wide, and 1.5 m high) with an automatic compost-turning and -watering system. Each treatment was represented by three replicate composting reactors, resulting in 27 composting reactors. The automatic system turned the mixture in each reactor for 40 min every day during the PC to ensure oxygen supply (Zhang and Sun, 2014a; Zhang et al., 2013). When the temperature of the mixture increased to 50–60 °C, 2 ml of bamboo vinegar (diluted in 2 L of water) per 100 kg of mixture (dry weight) was sprinkled onto the mixtures as they were being turned (Zhang et al., 2013). When the temperature dropped to 35–45 °C, the PC was considered complete. The temperatures in all treatments decreased to 35–45 °C by day 6. At that time, the mixtures were once again treated with the vinegar solution. On day 6, the mixture was removed from each composting reactor with an excavator and placed in open windrows (three windrows per reactor). The SC of all treatments began on day 6. Each windrow had a trapezoidal cross-section and was 2 m long, 1.5 m wide, and 1 m high. The windrows were turned over manually with a mini-excavator for 40 min every 3 days to ventilate the mixtures (Zhang and Sun, 2014b). Diluted bamboo vinegar was added during the SC as described for the PC. When the temperature of a windrow decreased to the ambient temperature, the whole composting process was considered complete.

Throughout the composting process, water was added to the mixtures whenever the water content dropped below 60%. The moisture content of the composting mixture was determined daily with an SK-100 moisture meter (Tokyo, Japan). The ambient temperature and the temperatures at a depth of 60 cm in the front, centre, and back of each composting mixture were measured daily with a self-made temperature sensor with a temperature dial and a 1 m long rod; this was done before the composting mixtures were turned and watered. The three readings per composting mixture were averaged.