ARTICLE IN PRESS

Waste Management xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

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

Combining woody biomass for combustion with green waste composting: Effect of removal of woody biomass on compost quality

Bart Vandecasteele [a,*], Christophe Boogaerts [b], Elke Vandaele [b]

[a] Institute for Agricultural and Fisheries Research (ILVO), Plant Sciences Unit, Burg. van Gansberghelaan109, B-9820 Merelbeke, Belgium
[b] Vlaco vzw, Flemish Compost and Anaerobic Digestion Organization, Stationsstraat 110, B-2800 Mechelen, Belgium

ARTICLE INFO

Article history:
Received 20 March 2016
Revised 6 September 2016
Accepted 11 September 2016
Available online xxxx

Keywords:
Bioresource
Biomass valorization
Yard waste
Garden waste
Materials recycling

ABSTRACT

The question was tackled on how the green waste compost industry can optimally apply the available biomass resources for producing both bioenergy by combustion of the woody fraction, and high quality soil improvers as renewable sources of carbon and nutrients. Compost trials with removal of woody biomass before or after composting were run at 9 compost facilities during 3 seasons to include seasonal variability of feedstock. The project focused on the changes in feedstock and the effect on the end product characteristics (both compost and recovered woody biomass) of this woody biomass removal. The season of collection during the year clearly affected the biochemical and chemical characteristics of feedstock, woody biomass and compost. On one hand the effect of removal of the woody fraction before composting did not significantly affect compost quality when compared to the scenario where the woody biomass was sieved from the compost at the end of the composting process. On the other hand, quality of the woody biomass was not strongly affected by extraction before or after composting. The holocellulose:lignin ratio was used in this study as an indicator for (a) the decomposition potential of the feedstock mixture and (b) to assess the stability of the composts at the end of the process. Higher microbial activity in green waste composts (indicated by higher oxygen consumption) and thus a lower compost stability resulted in higher N immobilization in the compost. Removal of woody biomass from the green waste before composting did not negatively affect the compost quality when more intensive composting was applied. The effect of removal of the woody fraction on the characteristics of the green waste feedstock and the extracted woody biomass is depending on the season of collection.

1. Introduction

Biomass streams, e.g. natural biomass (Van Meerbeek et al., 2015), landscaping waste (Hensgen et al., 2011), garden trimmings (Shi et al., 2013) and public areas waste and compost (Raclavska et al., 2011), are applied as feedstock in the transition to a circular economy. Green waste can be used as feedstock for composting or co-composting (Francou et al., 2008; Ribeiro et al., 2007), or for energy production (Kranert et al., 2010; Shi et al., 2013). Using these resources for energy production should however be balanced with the need to recover carbon (C) and nutrients such as nitrogen (N), phosphorus (P) and potassium (K) from the green waste (Kranert et al., 2010). In fact, land application of compost, as means to recycle nutrients and C, has been found to have positive effects on chemical, physical and biological characteristics of agricultural soils (D'Hose et al., 2014, 2016; Willekens et al., 2014) leading to improved productivity.

The physical and chemical composition of garden waste, and green waste in general, are subject to high seasonal variability (Boldrin and Christensen, 2010), which affects also the composition of the organic fraction of municipal solid waste in suburban and rural areas (Hanc et al., 2011). Accordingly, the optimal balance between using green waste for composting or generating energy can vary seasonally. The mass reduction as a result of the organic matter (OM) decomposition during composting is related to the biochemical composition of the feedstock mixture (Komilis et al., 2003). Paradelo et al. (2013) reported that categorizing OM into cellulose, hemicellulose and lignin enabled a better monitoring of the degradation of the OM during waste decomposition, with higher stability of the compost being correlated with lower holocellulose (hemicellulose + cellulose) levels. Results of Hutchinson and Griffin (2008) also indicate that fiber analyses can be used to establish relative differences in compost stability, as these

* Corresponding author.
E-mail address: bart.vandecasteele@ilvo.vlaanderen.be (B. Vandecasteele).

http://dx.doi.org/10.1016/j.wasman.2016.09.012
0956-053X/

parameters measure the availability of the remaining C substrate for microbial activity in the compost.

Lack of available N might be a limiting factor for OM mineralization. N limitation can occur when composting feedstock mixtures rich in lignocellulosic materials and/or materials with high C/N ratios. This was reported by Eiland et al. (2001) for mixtures of miscanthus straw and pig slurry with initial C/N ratios of 47–54, by Paradelo et al. (2013) for winery waste and by Doublet et al. (2011) in a comparison of several bulking agents for sewage sludge composting. The promotion of biomass use for green energy production (EU 2020 targets) through subsidies (green certificates) has created a diversion of biomass (especially woody biomass) toward the energy sector and thus affects the potential for composting (Viaene et al., 2016). This may result in shortage of woody biomass as a crucial element in composting, as it is both a carbon source and creates the aerobic conditions during composting. However, if the green waste feedstock has a high proportion of woody material (with high C/N ratio), part of the woody material could be recovered as woody biomass. Haynes et al. (2015) concluded that the nutrient content, N mineralization potential and decomposition rate of green waste differ greatly among particle size fractions. The coarser fraction of green waste had higher C/N ratios and lower mineral N concentrations than the finer fractions, but when N was added as urea, the increase in C mineralization was higher for the coarse fraction than for the finer fractions, while the opposite was reported for N mineralization (Haynes et al., 2015). These results of Haynes et al. (2015) indicate that N was the limiting element for decomposition of the coarse fraction of green waste characterized by a higher C/N ratio as the decomposition rate was increased after adding more N. A higher amount of coarse green waste may thus result in N shortage during composting. The above mentioned studies indicate the need to balance the C/N ratio in green waste potentially by diverting the lignocellulosic and/or the coarser fraction from the green waste. However, strongly reducing the proportion of woody material in the compost feedstock could have negative effects: it may inhibit aeration and thus the composting process, first and second, it may reduce the quality of the compost and thus decrease the inherent value as a source of C and nutrients, thus pushing the composting facilities for modifications in the composting type and process (Zhang and Sun, 2014).

In this study, 9 composting facilities were monitored to assess the effect of partial removal of woody biomass in the feedstock on the composting process and the final compost quality. The amount of wood in the feedstock was measured and the results of regular composting (with woody biomass recuperation at the end of the process) were compared to those of an experimental batch where woody biomass was already partially removed from feedstock. This set-up was repeated three times during 1 year to account for the seasonal effect on feedstock composition. For a total of 48 full-scale compost experiments, a wide range of characteristics of the green waste feedstock, recovered woody biomass and compost were assessed, i.e., chemical and biochemical composition of all fractions, stones, impurities and gross calorific value for the woody biomass, and oxygen uptake rate and potential N immobilization for the compost. To the best of our knowledge this is the first study to assess the effects of woody biomass removal on compost quality at full scale (48 full-scale compost trials). The tested hypothesis is that (a) removal of woody biomass from the green waste before composting negatively affects the compost quality and (b) the effect of removal of the woody fraction on the characteristics of the green waste feedstock, the compost and the extracted woody biomass is depending on the season of collection.

2. Materials and methods

2.1. Trials at composting facilities

2.1.1. Definitions

The terminology used in this study is (Fig. 1):

- "Regular composts" indicate the composts where the woody biomass was screened out of the compost after composting, while "experimental composts" indicate the treatment where the woody biomass was screened from the green waste before composting.
- "Green waste": the starting material (yard and garden waste, landscaping trimmings and pruning) at the beginning of the process which is used unsorted (non-sieved) for the regular set-up (i.e., the regular feedstock) or sorted (i.e., after sieving) for removing the woody biomass in the experimental set-up (i.e., experimental feedstock).
- (regular/experimental) "Feedstock": material at the start of the composting process.
- (regular/experimental) "Compost": end product of the composting of green waste after the coarse fraction, i.e., the residual woody biomass was removed with a sieve.

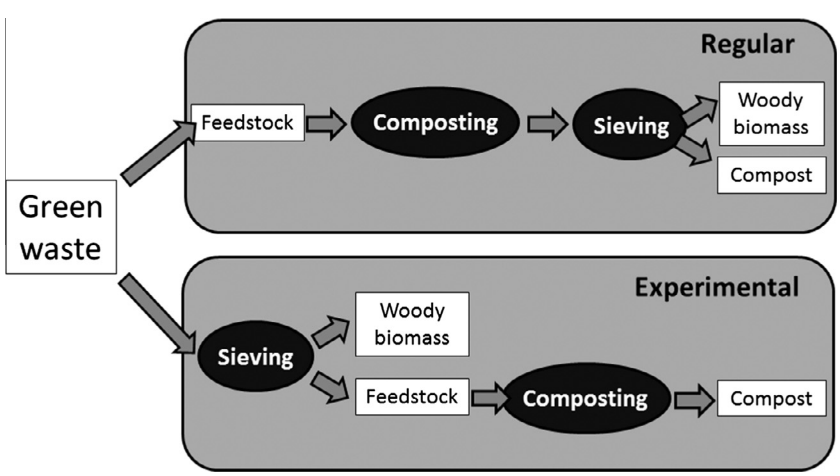

Fig. 1. Schematic overview of the set-up of the compost trials when woody biomass was removed before (experimental scenario) or after (regular scenario) composting. Both experiments at one facility started from the same green waste. "Regular composts" indicate the composts where the woody biomass was screened out of the compost after composting, while "experimental composts" indicate the treatment where the woody biomass was screened from the feedstock before composting.