Circular economy in municipal organic waste management: process evaluation and quality of the composts obtained in a decentralized composting plant

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Introduction

The management of the municipal organic wastes in the circular economy framework together with the current European Union requirements to manage bio-waste separately, have led to new decentralized composting models adapted to the characteristics of each area. The decentralized composting allows to increase the reuse and recycling of the organic fraction from the selective collection of municipal solid waste (OFMSW), with the final purpose of reducing the consumption of natural resources and to protect the environmental and human health (Storino et al., 2018). Thus, an example of this type of composting model is the decentralized composting plant placed at the municipality of Lumbier (Navarre, Spain), where the organic fraction of the municipal solid waste collected separately from the area belonging to the Sangüesa Municipal Association (Navarre, Spain) is managed by composting. The main aim of this work was to study and compare two cycles of the composting processes developed at the decentralized composting plant mentioned by monitoring the composting process and to assess the quality, agronomic value and final characteristics of the end-products obtained.

Material and methods

Two trapezoidal composting piles (pile 1 and pile 2) were developed at the facilities of the decentralized composting plant placed at the Bordablanca farm-JoseneaBio (Lumbier, Navarre, Spain), belonging to the Government of Navarre. For the composting mixtures, the organic fraction of municipal solid waste separately collected (OFMSW), generated in the area covered by the Sangüesa Municipal Association (Navarre, Spain), was mixed with the pruning waste (PW) produced by the maintenance activities in parks and gardens. The main characteristics of these organic wastes are summarized in Table 1.

Table 1: Characteristics of the initial materials used in the composting processes expressed on a dry weight basis.

	OFMSW1	OFMSW2	PW1	PW2
Moisture (%)	83.2	81.2	38.4	4.7
pH	5.7	5.2	6.5	7.6
EC (dS m^{-1})	8.7	9.2	0.9	1.1
OM (%)	78.6	80.3	93.6	42.2
TOC (%)	43.3	42.8	47.0	25.2
TN (%)	3.0	2.3	0.4	0.9
TOC/TN ratio	14.4	18.6	117.5	28.0
P (g kg^{-1})	6.7	3.0	0.4	1.6
K (g kg^{-1})	16.2	12.9	2.5	8.8
Zn (mg kg^{-1})	42.8	19.0	20.4	58.7
Cr (mg kg^{-1})	16.9	6.3	34.5	62.1
Cd (mg kg^{-1})	0.1	0.1	0.1	0.4
Ni (mg kg^{-1})	7.0	1.7	6.5	14.3
Pb (mg kg^{-1})	2.1	0.9	1.2	19.9

EC: electrical conductivity; OM: organic matter; TOC: total organic carbon; TN: total nitrogen.

The initial dimensions of the formed piles in terms of length/width/height were 44 x 2.5 x 0.7 and 40 x 2.5 x 0.8 m, for pile 1 and pile 2, respectively. A weekly turning during the first month and on days 60, 120 and 180 with irrigation were carried out to maintain suitable conditions for a correct composting process. Temperature was monitored in both piles to evaluate the development of the process. The bio-oxidative phase had a total duration of 150 days, considering their end when the difference between the average temperature of the pile and the ambient temperature was less than 10 ºC. Then, the temperature control finished and the composts were left to mature approximately 2-3 months. Throughout the processes, four samplings were conducted in the piles (initial, thermophilic phase, end of bio-oxidative phase and maturation) and the samples of the mixtures were characterized, together with the initial wastes used (OFMSW and pruning waste). The physico-chemical, chemical and biological parameters of all the samples were determined according to the methods described by Bustamante et al. (2012) and Vico et al. (2018). In addition, the self-heating test was performed in the mature composting samples (Brinton et al., 1995).

Results and discussion

Both piles showed a rapid temperature increase during the first days of the process, reaching temperature values above 60°C, which were maintained more than a week. Thus, both piles complied with the requirements of EU Regulation 2019/1009 which guarantees the sanitisation of the composting mass. The pH and electrical conductivity showed a decrease during the composting process in both mixtures, probably due to the abundant irrigation or rainfall during outdoor treatment (Paredes et al., 2001). The organic matter concentration decreased in both composting processes, as did the TOC/TN ratio, with final values below 20, the maximum value established by Moreno et al. (2015) for mature compost. All composts showed adequate maturity and stability, with an absence of phytotoxicity (GI>50%), as well as a higher amount of humic acid compounds versus fulvic acids (Cha/Chf>1.6) and grade V according to the self-heating test (Brinton et al. 1995). Furthermore, in general, the mature composts studied did not imply any environmental or health risks, showing low concentrations of heavy metals values for this type of compost, as well as absence of *Salmonella sp*. However, the *E.coli* values for pile 2 were slightly higher than the maximum allowed by Spanish legislation (BOE, 2013).

Conclusions

The decentralized composting system for the management of the separately collected organic fraction of municipal waste is a sustainable model that completes the circular economy cycle and provides environmental benefits by avoiding less sustainable practices. The mixtures studied, in general, made it possible to obtain high quality, mature, stable final composts with good agronomic characteristics that guarantee their use in agriculture, reducing the consumption of mineral fertilisers. However, the control of the process and the characterisation of the final compost is essential to avoid the use of materials that could pose a risk to the human health and the environment.

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