Decentralized composting models for organic waste management I: two examples of community composting in the Valencian Community (Spain)

C. Álvarez[1], M.D. Pérez-Murcia[1], C. Gómez[1], A. García-Rández[1], E. Agulló[1], E. Martínez-Sabater[1], I. Irigoyen[2], M. López[3], J. Andreu-Rodríguez[1], C. Paredes[1], A. Pérez-Espinosa[1], R. Moral[1], M.A. Bustamante[1]

[1] Centro de Investigación e Innovación Agroalimentaria y Agroambiental (CIAGRO-UMH), Universidad Miguel Hernández, EPS-Orihuela, Ctra. Beniel Km 3.2, 03312 Orihuela, Alicante.
[2] Department of Agricultural Production, Public University of Navarre (UPNA-NUP), Pamplona, Spain
[3] Universitat Politècnica de Catalunya (UPC), Campus del Baix Llobregat, Edifici D4, C. Esteve Terradas, 8 08860, Castelldefels, Spain
Presenting author email: marian.bustamante@umh.es

Introduction

The progressive implementation of the circular economy in the productive cycle is producing a conceptual change on the models for organic waste management, where waste is now becoming to be considered as a resource. Thus, new scenarios have emerged in which the management by composting of different organic waste fractions, such as those from household waste stream, garden and park waste and remains from fresh product markets (bio-waste) is conducted in a more local manner using decentralized models, such as community composting (Mihai *et al.*, 2020). However, the control of the process and of the final product is not standardized yet in these new composting models, which is essential to guarantee the agronomic value, quality and especially the hygienic conditions of the compost obtained. Thus, when the composting process is not properly managed can induce the proliferation and dispersion of potentially pathogenic microorganisms, such as *Salmonella* and/or *Listeria*. Therefore, the main aim of this work was to study and monitor two examples of community composting of the selectively collected organic fraction of the municipal solid waste generated in two concrete small municipalities located in the Valencian Community (Spain), to guarantee the effectiveness of the composting process to obtain a sanitized compost.

Material and methods

Two composting piles were prepared using the organic fraction from the selective collection of municipal solid waste (OFMW) coming from the municipalities of Carrícola and Fontanars dels Aforins (Valencia, Spain), both with a population of approximately of 100 and 1000 inhabitants, respectively. The composting heaps were prepared at the community composting islands of the Consorcio de Residuos COR-V5 of the municipalities of Fontanars (pile 1) and Carrícola (pile 2), respectively. For the preparation the composting heaps, the corresponding OFMW and the pruning waste (PW) produced during the maintenance activities of the public green areas of each municipality were mixed. In particular, in the case of pile 2, the pruning waste (PW2) also contained donkey manure. The main characteristics of these organic wastes are summarized in Table 1.

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

	OFMW1	OFMW2	UPW1	UPW2
Dry weight (%)	31.6	27.9	78.2	80.6
pH	6.5	7.7	8.9	6.4
Electrical conductivity (dS/m)	5.52	3.34	3.25	6.54
Organic matter (%)	68.7	62.2	77.7	73.9
Total organic carbon (%)	38.9	35.0	41.1	41.5
Total nitrogen (%)	2.39	1.35	1.00	2.47
TOC/TN	16.3	25.9	41.0	16.8
P (g/kg)	0.62	0.63	0.16	0.38
Fe (mg/kg)	357	1828	1307	736
Cu (mg/kg)	11.3	24.9	7.58	14.1
Mn (mg/kg)	32.6	127	53.5	49.0
Zn (mg/kg)	39.7	39.1	24.9	35.4
Cd (mg/kg)	0.63	0.11	0.07	0.08
Cr (mg/kg)	11.1	30.6	24.1	36.4

OFMW1: organic fraction of municipal solid waste from Fontanars; OFMW2: organic fraction of municipal solid waste from Carrícola; PW1: urban pruning waste from Fontanars; PW2: urban pruning waste + donkey manure from Carrícola; TOC: total organic carbon; TN: total nitrogen.

The percentages of the initial materials used to prepare the composting piles, on a fresh weight basis, were the following:
Pile 1: 84.2 % OFMW1 + 15.8 % UPW1
Pile 2: 82.7 % OFMW2 + 17.3 % UPW2

The composting heaps (about 12000 kg for pile 1 and 3500 for pile 2) were composted in trapezoidal piles by the turned windrow composting system, with mechanical turnings every month until the end of the bio-oxidative phase. The bio-oxidative ended when the temperature values in the mixtures decreased to ambient temperature and a difference between the pile temperature and the ambient temperature was ≤ 10ºC during at least 10 consecutive days after a whirl. This phase had a duration of approximately 90 days in both piles. Then, composts were left to mature during a month, approximately. Throughout the composting process, the moisture of the piles was maintained at levels not lower than 40%. The piles were sampled in four occasions (initial phase, thermophilic phase, end of the bio-oxidative stage and maturity phase of composting) and processed following the methodology described by Bustamante *et al*. (2012). In the initial wastes and the composting samples, pH, electrical conductivity (EC), dry matter, organic matter (OM), total organic C (TOC) and total N (TN) were determined according to the methods used by Bustamante *et al.* (2012). In addition, in these samples, after HNO_3/$HClO_4$ digestion, microelements, P and heavy metals were measured by ICP-OES. The germination index (GI) was calculated using seeds of *Lepidium sativum* L. and different microbial pathogen groups (*Salmonella*, *Listeria monocytogenes* and faecal Coliforms (*E. coli*)) were investigated in the mature composts (Morales *et al*., 2016).

Results and discussion
The thermal profiles in both composting heaps showed a suitable evolution of this parameter, which showed values higher than 60ºC for more than two weeks, reaching maximum temperature values of 76ºC at least two days. This behaviour in both piles fulfils the European requirements on compost sanitation (EU Regulation 2019/1009), since these temperature ranges guarantee the maximum pathogen reduction (Storino *et al*., 2016). This trend was also observed in a study of community composting of the organic fraction of municipal waste in a case study in Galicia (Spain) (Villar-Comesaña *et al*., 2017). Regarding the physico-chemical and chemical parameters, the pH and the electrical conductivity values increased in both mixtures, whereas organic matter levels decreased, principally during the thermophilic phase, when the highest temperature values were reached and the total nitrogen concentrations increased in both composting mixtures during the process, showing pile 2 the highest contents of total nitrogen at the end of the composting process. Both composts showed a suitable maturity degree with absence of phytotoxicity, as well as verified the criteria concerning the limit values for pathogenic microorganisms established by the European legislations (EU Regulation 2019/1009).

Conclusions
The decentralized composting of the organic fraction from the selective collection of municipal solid waste with urban pruning waste, conducted in the municipalities of Carrícola and Fontanars (Valencia, Spain), allowed to obtain a high-quality product, with suitable characteristics, such as adequate maturity degree and nutrient content, absence of phytotoxicity and a good sanitary quality, with levels of human pathogens in the composts below the maximum limit for the use of composts as fertilisers. In addition, this waste management model provides environmental benefits in the circular economy framework, increasing the environmental awareness of citizens and reducing the impacts derived from the landfill and/or incineration of these organic wastes.

Acknowledgements
This research has been financed in the framework of the research project NEOCOMP (ref. PID2020-113228RB-I00) funded by MCIN/ AEI /10.13039/501100011033. The authors also wish to thank the Consorcio de Residuos V5-COR for its participation in this study.

References
Bustamante, M.A., Alburquerque, J.A., Restrepo, A.P., de la Fuente, C., Paredes, C., Moral, R., Bernal, M.P., 2012. Co-composting of the solid fraction of anaerobic digestates, to obtain added-value materials for use in agriculture. Biomass Bioenergy 43, 26–35.
Mihai, F.C., Plana, R., et al., 2020. Bioremediation of organic contaminants based on biowaste composting practices. In Handbook of Bioremediation (pp. 701-714). Academic Press.
Storino, F., Arizmendiarrieta, J.S., Irigoyen, I., Muro, J., Aparicio-Tejo, P.M., 2016. Meat waste as feedstock for home composting: Effects on the process and quality of compost. Waste Management 56, 53-62.
Villar-Comesaña, I., Alves, D., Mato, S., Romero, X.M., Varela, B., 2017. Decentralized composting of organic waste in a European rural region: a case study in Allariz (Galicia, Spain). IntechOpen 4, 53–79.