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 municipal organic waste in the framework of the circular economy together with the current European Union requirements to manage bio-waste separately, have given rise to new models of decentralized composting adapted to the characteristics of each area, which increase the reuse and recycling of the organic fraction from the selective collection of municipal solid waste (OFMSW), with the ultimate aim of reducing the consumption of natural resources and protecting environmental and human health.

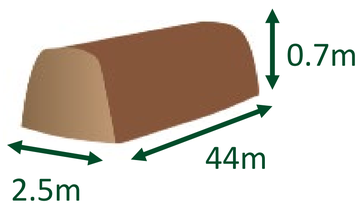
An example of this type of composting model is the decentralized composting plant placed at the municipality of Lumbier (Navarre, Spain), where the OFMSW is managed by composting. The aim of this work was to study and compare two cycles of the composting processes developed at the decentralized composting plant mentioned by monitoring the composting process and to assess the quality, agronomic value and characteristics of the end-products obtained.

Material & methods

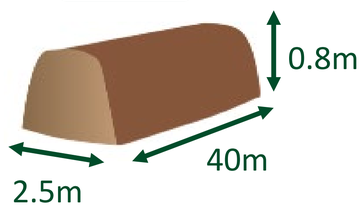
Characteristics of the initial materials

	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	28.0
P (%)	6.7	3.0	0.4	1.6
K (%)	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

Pile 1



Pile 2



Process control

Turning

- Weekly (month 1)
- Day 60
- Day 120
- Day 180

The duration of the bio-oxidative phase of the process was **150 days** for the 3 piles

Mature time
2-3 months

Samples
M1 Initial **M3** End of Bio-oxidative
M2 Thermophilic phase **M4** Maturity

Parameters
- Physico-chemical • Biological
- Chemical • Self-heating test

Results & Discussion

Thermal process characteristics

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 **sanitization** of the composting mass.

Evolution of physico-chemical and chemical parameters

Composting phases	Moisture %	BD (kg l^{-1})	pH	EC (dS m^{-1})	Na (g kg^{-1})	OM %	TOC/TN	TN %	K_2O %	P_2O_5 %
Pile 1: 50% OFMSW1 + 50% PW1										
M1	62.0	0.635	6.9	4.3	3.8	65.4	18.8	2.1	1.4	1.8
M2	53.0	0.351	7.6	2.9	2.7	60.1	18.3	1.6	1.1	1.1
M3	49.8	0.514	8.4	2.7	3.1	48.6	12.1	2.4	1.5	1.8
M4	47.2	0.622	8.1	2.5	3.5	41.5	11.9	2.1	1.6	1.7
Pile 2: 50% OFMSW2 + 50% PW2										
M1	53.7	0,492	5.8	7.0	3.8	67.1	18.4	2,0	1.5	1.3
M2	45.9	0.440	7.9	3.1	3.0	54.5	16.3	1.8	1.5	1.2
M3	43.9	0.401	8.3	2.4	3.0	52.7	13.6	2.0	1.3	1.5
M4	46.8	0.512	8.0	2.0	2.3	44.8	10.3	2.6	1.3	2.1

pH and **EC decrease** during the composting process in both mixtures, probably due to the abundant irrigation or rainfall during outdoor treatment. The **OM** concentration **decreased** too, as did the **TOC/TN ratio**, with final values below 20 (maximum value established for mature compost).

Maturity and stability parameters

	Germination Index %	Humic Acids %	Fulvic Acids %	Thermal stability degree (Brinton et al., 1995)
Pile 1	107	4.7	1.6	V, Stable
Pile 2	119	4.2	1.8	V, Stable

All composts showed **adequate maturity and stability** with absence of phytotoxicity, Cha/Chf>1.6 and degree of thermal stability V.

Environmental and health risks

	Cd (mg kg^{-1})	Ni (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Cr (mg kg^{-1})	Pb (mg kg^{-1})	*Salmonella/25g*	*E. coli* (NMP/g)
Pile 1	2	16	22	98	53	14	Absence	< 3
Pile 2	0.4	12	21	138	41	16	Absence	3600

No environmental or health risk, low concentrations of heavy metals and absence of *Salmonella sp*. The *E.coli* values for pile 2 were slightly higher than the maximum allowed by Spanish legislation.

Conclusions & Acknowledgements

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 made it possible to **obtain high quality, mature, stable final composts** with good agronomic characteristics that guarantee. The control of the process and the **characterization 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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