

CHARACTERIZATION OF MUNICIPAL SOLID WASTE COMPOSTS PRODUCED IN SPAIN

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1 INTRODUCTION

Composting is clearly reported as one of the most effective technique to transform organic wastes into an interesting resource, useful to improve soil characteristics and playing a potential role in reducing greenhouse gases, due to its high content in stable organic matter (Favoino and Hogg, 2008). However, its agronomical properties are dependent on several factors, which pollutant contents becomes the most restrictive for its use.

Organic wastes produced in Spain correspond mainly to farming wastes, municipal solid waste organic fraction, sewage sludge and organic wastes from agrifood industry. Organic fraction of municipal solid waste is commonly managed in Spain by biological treatments, generally composting, to fulfil the requirements set by the EU Landfill Directive (1999/31/EC) and, as a result, this compost becomes a possible product to be used in agriculture.

In Spain, municipal solid waste is regulated by Law 10/1998 on waste, which obliges municipalities of more than 5000 inhabitants to collect waste separately, but without special mention of organic fraction. On the other hand, Catalonia (NE Spain) has a specific regulation for waste since 1993 (Law 6/93 regulating waste) focusing on waste generation with special concern on separate source collection of organic fraction. This law has been recently modified (Law 9/2008), forcing all municipalities to collect waste separately, including those of less than 5000 inhabitants. Thus, in Spain, it is possible to find (a) composting plants processing organic fraction from source sorted municipal solid waste (mainly in Catalonia), and (b) other facilities that treat organic fraction from municipal solid waste collected on mass, and recovered by mechanical separation at the beginning of the process.

In order to avoid soil contamination by pollutants application from composted organic wastes, several Members States of the EU have adopted specific regulations to establish limitations for some of pollutant contents. Spain is one of these countries, and its legislation has been focused mainly on heavy metals. However, some other parameters are also important to be considered before an agronomic use of composted organic waste. Unfortunately, no requirements are set in the Spanish law to assess the quality of compost organic matter, and only a threshold value, requested as a minimum content, is stated for the total organic matter of the product. This Spanish law, RD 824/2005 concerning fertilizers products, also provides requirements for the following parameters: moisture content, C/N ratio, percentage of impurities and particle size (Table 1).

In this paper, the fulfilment of the requirements states by RD 824/2005 are evaluated for composts obtained from several municipal solid waste composting facilities of Spain.

TABLE 1 Requirements established by RD 824/2005

Heavy metals ¹ (mg kg ⁻¹ dry basis)	Requirements			Other parameters (wet basis)	Requirements
	Class A	Class B	Class C		
Cd	0.7	2	3	Moisture content	30-40%
Cu	70	300	400	C/N	<20
Ni	25	90	100	% Total organic matter	>35
Pb	45	150	200	% Impurities	<3
Zn	200	500	1000	Particle size	90% particles Ø < 25mm
Cr	70	250	300		

¹ RD 824/2005 states three classes of compost (A, B and C) based on heavy metal content. Class A is the most demanding, but from the point of view of the compost commercialization, the legislation does not differentiate between compost from class A and B. Class C cannot be applied to agricultural soils in doses greater than 5 tonnes of dry matter per year. Composts that do not achieve one of these three classes cannot be commercialized and have to be landfilled (or incinerated).

2 MATERIALS AND METHODS

A total of 58 municipal solid waste composting facilities located in Spain were sampled in 2003-2007: 22 facilities of source sorted collected organic fraction of municipal solid waste (SC) and 36 facilities of mechanical-sorted organic fraction of municipal solid waste (MS). The compost obtained from these installations were analysed, 63 composts from MS and 115 from SC. Composting facilities that treat SC add municipal yard trimmings, which improve aeration and provide a carbonaceous source that balance the initial composition (López et al., 2010a). In contrast plants that treat MS do not add yard trimmings because non compostable materials are considered as a bulking agent.

The evaluated parameters were (a) moisture content, (b) impurities, (c) total organic matter, (d) C/N, (e) particle size and (f) heavy metals. Moisture content was measured drying samples at 105 °C to a constant weight. Impurities were determined by removing them by hand from a total of over 600 g of dry sample. Total amount of impurities was weighed to calculate the percentage on dry basis. Total organic matter (TOM, % dry basis) and organic nitrogen (org-N, % dry basis) analyses were conducted on dry, impurities free and milled samples. Milling was performed using a planetary zirconium oxide ball mill (Retsch PM100) to avoid mineral contamination. TOM was determined by the loss on ignition after it was heated for 4 h in a muffle furnace (Carbolite CWF 11/13) at 560 °C. Total organic carbon content was estimated by dividing TOM by 2 (Zucconi and de Bertoldi, 1987, Saña et al., 1989) to calculate C/N ratio. Org-N was determined by specific ion electrode (ThermoOrion 720A as a potentiometer and ThermoOrion 95_12 as an electrode) after Kjeldahl digestion (Selecta Block Digest 20). Heavy metal contents were determined by atomic absorption spectrometry (Zn, Cu, Ni, Cr, Pb and Cd) after dissolution of ashes (ignition at 470°C) in 3N HNO₃ (Saña et al. 1989).

For each parameter, differences between SC and MS samples were examined by t-test using Satterthwaite's approximation.

3 RESULTS AND DISCUSSION

3.1 Moisture

No significant differences were detected between moisture content of SC and MS (Table 2). Most of the compost samples did not comply with the legislation requirements regarding humidity, although they showed on average near the threshold (minimum content 30% and maximum content 40%). Considering together SC and MS samples, only 26% were within the thresholds and 65% were below. As we reported in Huerta-Pujol et al. (2010), the actual composting process leads the compost matrix to low moisture content, due to self-heating of mass, but also to low watering developed. On the other hand, the post-processing equipment works better with low moisture content (Krauss et al., 1987) and preferably under 30% (Diaz et al., 2007).

3.2 Impurities and particle size

SC compost showed significant lower content in impurities than MS compost (3,83%±0,46 for SC and 9,18%±1,46 for MS on dry basis). RD 824/2005 does not allow more than 3% of impurities with a size over 2mm (Table 1). This percentage is expressed in "mass" and therefore wet. Our impurities assessments were performed on dry matter according to the U.S. Composting Council (1997). Thus, in order to adjust our values to the proposed legislation, a correction of the moisture content of compost was done to express the impurities in wet basis and determine the degree of compliance towards this parameter. In this case 42 samples from MS compost and 67 samples from SC compost were analyzed. The results showed that 67% of the MS compost did not comply with the legislation, while 64% of the SC did it, just the reverse ratio. However, and considering that SC composting facilities treat organic fraction from source sorted collection, 64% is still a low proportion of samples. This indicates that more efforts are needed to improve the quality of SC organic matter by improving source sorted collection. On the other hand, mechanical devices used by MS composting facilities cannot avoid the presence of impurities in the compost obtained (López et al. 2010b).

The law also stipulates that 90% of the particles will pass through a mesh of 25 mm and no problem was detected to fulfil with this point.

3.3 Organic matter and C/N ratio

MS compost showed lower total organic matter and organic nitrogen contents than SC compost. On the other hand, SC compost presented a lower C/N ratio (Table 2).

TABLE 2 Characteristics of MS and SC composts. (p: significance of difference between MS and SC)

	H	TOM	orgN	C/N	Zn	Cu	Ni	Cr	Pb	Cd
	%	% dry basis								
	mg·Kg ⁻¹ dry basis									
MS compost samples (n=63)										
Mean	26,45	49,77	1,56	16,24	565	246	72	88	160	0,98
SE	1,23	1,15	0,04	0,41	37,94	14,02	5,76	9,49	14,43	0,07
SC compost samples (n=115)										
Mean	27,00	57,23	2,10	14,05	201	88	17	18	52	0,35
SE	0,87	0,82	0,04	0,28	8,71	5,07	1,35	1,62	4,03	0,02
p	0.7147	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

RD 824/2005 sets a 35% on wet basis of total organic matter content as a minimum requirement, which represents at least 50% of organic matter on dry sample, assuming the minimum threshold of 30% humidity. Only few of studied compost presented values in organic matter under the 50% on dry basis. Actually, 21% of the SC compost and 46% of MS compost did not achieve this threshold. It is worth noting that very stable compost will result in a lower organic matter than those ones which has suffered an incomplete process. Moreover, as we reported in López et al. (2010b), MS composting starts from a matrix poorer in organic matter and, if the process were developed correctly, could easily low the 50% set as minimum requirement.

Regarding C/N ratio, RD 824/2005 establishes that the compost have to present a value under 20. Most of the studied compost met this requirement (97% of SC and 86% of MS).

3.4 Heavy metal content

In general, MS compost showed higher values of heavy metal contents than SC (Table 2). Both types of composts were mainly included in class B (52% of the total samples), whereas only 19% remained within the class A. SC compost showed 30% of samples in class A, while none of MS samples were included in this class. SC compost showed 66% of samples in class B, 3% in class C and only 2% should be landfilled. On the other hand, MS composts mainly belonged to class C (32%), a few of them achieved class B (27%) and most of them (41%) should be landfilled (Figure 1). Therefore, SC composts showed less than 6% of samples with restrictions on use.

It is important to know the status of fulfilment of the compost currently produced, but it is also interesting to see which heavy metals are more restrictive for legislative fulfilment in order to establish some kind of preventive measure. In Figure 2, we show the percentage of samples in each class for each metal. For both SC and MS, copper, lead and zinc were the more restrictive. The most significant difference between MS and SC is in the proportion in class C and landfilling destination (Figure 2).

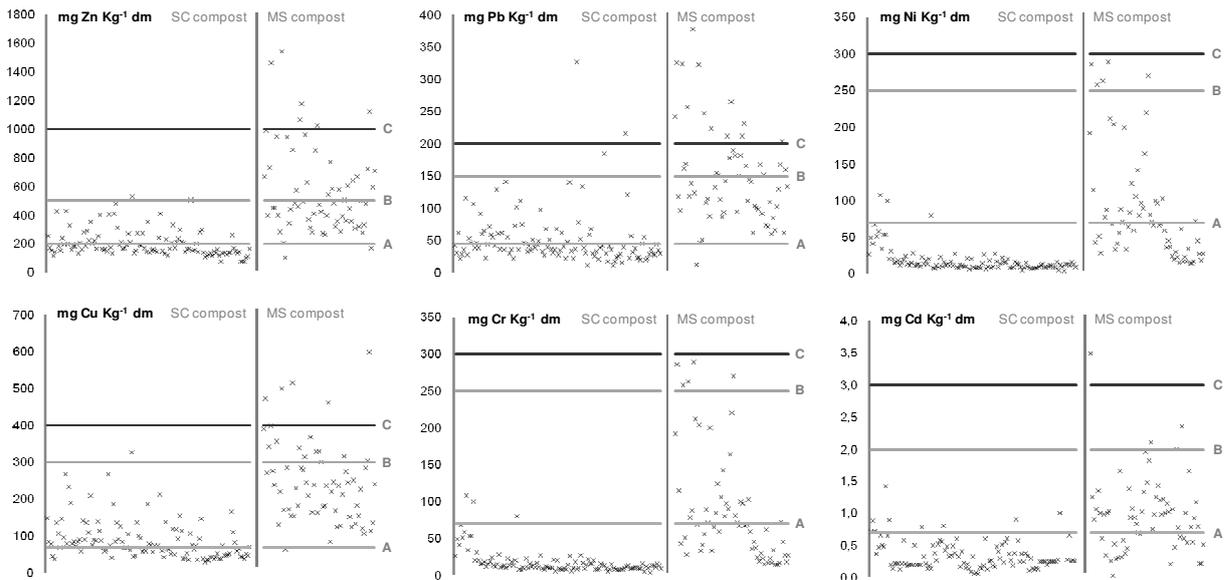


FIGURE 1 Heavy metal content in SC and MS composts, according to RD 824/2005

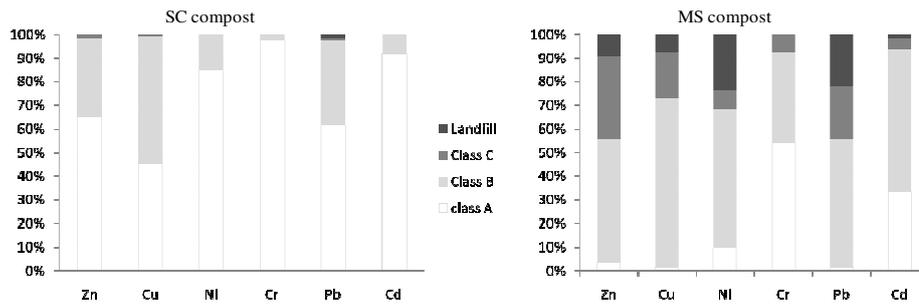


FIGURE 2 Heavy metal classification achieved by each studied element for SC and MS compost

4 CONCLUSIONS

The results show that more efforts should be done to enhance and improve the source sorted collection of municipal solid waste organic fraction to increase compost quality. In general, quality of the composts obtained from the SC was higher than those ones obtained from MS, according to the classification established by RD 824/2005. Most of SC composts were included in class B (66%), 30% in class A and only 2% should be landfilled. In contrast, 41% of MS composts should be landfilled and none of them were included in class A. In both cases (SC and MS) zinc, copper and lead were the most restrictive heavy metals to fulfil the current Spanish legislation.

It is important to highlight the low moisture content in both SC and MS composts. This fact could affect the fulfilment of the law and also could influence some aspects related to the compost application on land. Moreover, it could denote an improper development of composting process.

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