LIFECYCLE OF METALS IN COMPOSTING OF MSW

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ABSTRACT

Although there are not still specific European regulations on biological management of solid wastes, the 1999 guideline about rubbish dumps stipulates a progressive reduction in the accumulation of organic matter in them.

When facing this problem, one of the possible options, which is probably the most recommended one in countries with a progressive impoverishment of organic matter in their soils, is the composting process.

Thus, in this work the composting process, in turned windrow, of the organic fraction of the municipal solid waste, selectively collected, was analysed for three years.

The composting process and the refined compost obtained were characterized. The results on the evolution of the pH, conductivity, C/N ratio, P, organic matter and other important variables were presented and discussed. Total metals content in compost was analysed and showed.

Suitable compost for agricultural use was obtained. This compost was used in wheat and garlic farming. No incidence of metals on fruit and soil was detected. Crops were found to be similar to those observed for a control test. However, requirements in metal contents are increasing in EU rules. Therefore, this Municipal Solid Waste (MSW) Compost made in Cordoba (Spain) will not be accepted for an agricultural use.

Keywords: *Compost; Municipal Solid Waste (MSW); Metals; Agricultural.*

INTRODUCTION

Compost production must be seen as an integrated part of all waste treatment and disposal options such as anaerobic digestion, sludge recycling, incineration or final disposal in safe landfill sites. The 1999/31/EC directive stipulates several targets for the reduction of biodegradable municipal waste in landfill. The targets are:

- reduction of 75% (by weight) of total biodegradable municipal solid waste produced in 1995 by 2006;
- reduction of 50% by 2009;
- and reduction of 35% by 2016.

Among the most important beneficial effects of the use of well defined compost as soil improvers or organic fertiliser are (Amlinger, 2003):

- The need of organic matter specifically on lands where the level of organic matter is low (<2-3%) and, thus, the soil is endangered for erosion, desertification or degradation of other essential soil functions (water retention, transformation, buffer, filter).
- The fertilizing properties of composts show a considerable secondary resource of plant nutrients. In addition, this gives the chance of substituting the traditional mineral fertilisers.
- Compost as alternative to peat products.
- Compost as carbon sink; and, therefore, as a contribution to the reduction of the greenhouse effect.

But safety measures or limit values must consider the requirements of a beneficial soil management with compost.

So, the 2nd working document on Biological Treatment of Biowaste, from 2001, intended to make a clear distinction between “compost”, derived only from separated sources of organic waste, and “stabilised biowaste”. Whereas compost may be marketed as high quality product for all areas of food production and private gardening, the stabilised biowaste is considered as one option along the lines of the provisions of the 1999 Landfill Directive (a pre-treatment of the waste to reduction of its biodegradability).

However, proposed requirements in metal contents for compost are very limiting. In this work, metals content in fresh biodegradable municipal solid waste, in compost, and in treated soil, have been analysed.

MATERIALS AND METHODS

The composting process, in turned windrow, of the organic fraction of the municipal solid waste, selectively collected, have been analysed for three years. The pile of composts, with 20 tonnes weight, were periodically turned and watered during 140 days to ensure its stability (Chica et al., 2003). Finally, refined compost (in 15 mm trommel screen and densimetric table) is obtained every year and disposed for its agricultural use in one annual plot experiment.

An overall 500 g of sample was collected from different parts of the pile and was subsequently used for chemical characterizations.

In a saturated paste extract, pH was determined using a CRISON pH-meter and electrical conductivity (EC) was determined using a CRISON conductimeter. On dry matter, dried at 60ºC during 72 hours, Nitrogen content was measured using the Kjeldahl-N method; organic matter was determined using the COD method; phosphorus was measured by spectrophotometry using a BECKMAN DU 640 spectrophotometer; and finally, metals content (HCl digestion) was determined by flame photometry with a PERKIN ELMER AA-300 atomic absorption spectrophotometer.

The chemical characteristics of the fresh MSW and refined composts obtained after 1, 2 and 3 years are shown in Table 1.

***Table 1**. Chemical characteristics of the fresh MSW and refined Composts.*

	pH	EC (dSm^{-1})	O.M. (%)	$N_{Kjeldahl}$ (%)	C/N	P (%P_2O_5)
MSW fresh	6.1	8.0	58	2.4	14.1	0.3
Compost 1st year	8.3	19.7	39	2.9	7.7	0.2
Compost 2nd year	8.4	13.2	36	2.6	8.1	0.3
Compost 3rd year	8.1	11.4	33	2.7	7.1	0.2

Three plot experiments were conducted from November to June alternating wheat farming with garlic farming during these three years. They were conducted in 32 blocks (4x10m sided). The experiment was a factorial combination of three types of fertilizer applications (supplying 180 kg/ha of nitrogen), a reference treatment (CONTROL, without N) and 8 annual replications (4 wheat-garlic-wheat and 4 garlic-wheat-garlic).

The three types of fertilizer applications were: 100% mineral Nitrogen (N-MINERAL); 100% MSW Compost (COMPOST); and 50% of N as mineral Nitrogen plus 50% as MSW Compost (50C–50M).

RESULTS AND DISCUSSION

Table 2 shows the metal contents obtained in fresh MSW and in refined compost compared with proposed limits at several normative. Every MSW Compost produced satisfy the Spanish law metal limits. However, the Cd, Cu and Zn contents were very high and made impossible to consider these composts like ecologic products. Moreover, if the 2nd draft of European document on Biological Treatment of Biowaste is approved, the product of this Biodegradable MSW composting will be considered as "stabilised biowaste" and will not be accepted for an agricultural use.

***Table 2**. Metals content in MSW compost and proposed limits for different regulations.*

	Cd (mg/Kg)	Cu (mg/Kg)	Cr (mg/Kg)	Ni (mg/Kg)	Pb (mg/Kg)	Zn (mg/Kg)
Fresh MSW	4	47	104	98	120	90
Compost 1st year	4	276	30	50	165	415
Compost 2nd year	3	252	57	57	120	579
Compost 3rd year	2	373	84	64	144	603
Spanish Law 05/28/1998	10	450	400	120	300	1100
Ecolabel 2001/688/CE	1.5	75	140	50	140	300
B.T.B. 2draft Compost – 1	0.7	100	100	50	100	200
B.T.B. 2draft Compost – 2	1.5	150	150	75	150	400
B.T.B. 2draft Stabilised BW	5	600	600	150	500	1500

As total matter in composting piles decreases by fermentation and evaporation processes, a general increase in metals content was expected. However, only Zn and Cu contents were really increased. Probably, the other metals were partially rejected in refining processes.

***Table 3**. Metals content in soil (0-15 cm).*

	Cd (mg/Kg)	Cu (mg/Kg)	Cr (mg/Kg)	Ni (mg/Kg)	Pb (mg/Kg)	Zn (mg/Kg)
BEFORE EXP.	0.8	14	31	54	34	26
CONTROL	1.0	22	25	19	39	32
N-MINERAL	1.3	20	29	20	39	28
50C–50M	1.5	24	21	22	36	32
COMPOST	1.5	25	32	20	42	33

Metals content in soil before the first experiment and at the end of three years were analysed and showed in Table 3. As can be seen, there was a slight enrichment in most of metals content, but there were no significant differences between the different treatments studied.

Crops of wheat and garlic (Table 4) were different year after year for weather reasons. For every year, N-MINERAL and 50C-50M treatments gave similar results and the highest productions. However, COMPOST (100%) treatment gave productions slightly better than those obtained for CONTROL, probably by their high EC (Castillo et al., 2004).

Table 4. *Wheat and garlic crops obtained.*

	WHEAT (kg/ha)			GARLIC (kg/ha)		
	Year 1	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**
N-MINERAL	4.450	4.860	1.340	2.290	8.130	15.240
50C–50M	3.930	5.080	1.960	2.130	7.470	14.010
COMPOST	3.040	4.500	1.980	1.820	6.590	12.350
CONTROL	2.710	4.340	1.150	1.620	5.600	10.490

On the other hand, there were not differences in metal contents among the treatments in wheat grain and garlic bulb obtained. Only Cu, Cr and Zn contents in the poorest crop of wheat (3^{rd} year) were higher than 10 mg/kg. Also, there were 2,3 mg/kg of Cd and more of 10 mg/kg of rest of metals in the poorest crop of garlic (1^{st} year).

CONCLUSIONS

Municipal Solid Waste Compost made in Cordoba (low industrial Spanish city) satisfies the Spanish law metal limits. However, if requirements in metal contents increased in EU rules, this Compost would not be accepted for an agricultural use.

Zn and Cu contents were significantly increased in composting process and no rejected in final refining process.

Crops obtained with the combined 50C-50M were similar, or even in some cases better than those obtained with mineral Nitrogen. The MSW Compost used as only amendment gave less favourable performance.

No incidence of metals on wheat grain and garlic bulb was detected.

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