CHANGES THROUGHOUT STORAGE, IN THE PHYSICO-CHEMICAL CHARACTERISTICS OF A MIXTURE CONTAINING WOOD ASH, SEWAGE SLUDGE AND MEAT FLOUR

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ABSTRACT

A mixture containing 12% sewage sludge, 80% wood ash and 8% meat flour was incubated for different periods of time to determine any changes in its characteristics. We thus attempted to simulate the conditions under which the mixtures would be stored before being spread on land.

We placed samples of 60 g of mixture in PET containers of 500 cm^3, at room temperature, and incubated replicate samples for two, four and six weeks. Physicochemical characteristics of the samples were determined at the end of the incubation periods.

Electrical conductivity, Total Kjeldahl Nitrogen and pH levels decreased with increasing incubation time, as did levels of Fe, Al and heavy metals. However, the levels of available P, Ca and Mg increased with time. The spreading of the mixture on acid soils is potentially useful because of its high nutrient content and low heavy metal content.

INTRODUCTION

Timber industries that combine with bioenergy production plants generate wood ash as a by-product. The ash is considered as non toxic waste in Galicia (NW Spain), where more than forty thousand tons are produced every year (Solla-Gullón, 2003).

Analysis of the chemical composition of the ash shows that it is an excellent source of nutrients and that it is alkaline, properties that make it potentially useful for correcting certain nutrient deficiencies in soils (Demeyer et al., 2001) and as a soil amendment. However, there are problems associated with the handling of this by-product because of its density and size distribution. On the other hand, generation of sewage sludge is also increasing and data from the Ministerio de Medio Ambiente (2000) indicate that 53% of the sewage sludge produced in Spain is recycled on agricultural land, and the benefits of application of the waste product to land are already known (Metcalf and Eddy, 1998; Wong et al., 2001). However, there are also problems associated with the handling of the sludge, which must also be stabilized before being applied on soils.

The use of meat flour has been prohibited in the preparation of animal foodstuff as a precautionary measure aimed at preventing the spread of bovine spongiform encephalopathy (BSE). More than four hundred thousand tons of meat flour are generated in Spain every year according to data from the Ministerio de Agricultura Pesca y Alimentación (2003), which constitutes a serious environmental problem. The precautionary measures have also affected the market for meat flour originating from non-ruminant animals, for which an alternative use must be found, e.g. for agronomic purposes, although certain handling problems must first be resolved.

In a previous study in which mixtures of different proportions of these materials were assessed, it was found that a mixture of 12% sewage sludge, 80% ash and 8% meat flour was the most manageable (Carrera, 2003). In the present study we investigated the changes in the mixture after different periods of storage, prior to its recycling for agronomic purposes.

MATERIAL AND METHODS

The wood ash was obtained from the INTASA factory (San Sadurniño, A Coruña, Spain). The sewage sludge was supplied by the waste management company Agroamb S.L., (Lugo, Spain) and originated from a sewage treatment plant, where it had undergone aerobic processing. Finally, the meat flour, also supplied by Agroamb S.L. originated from non-ruminant animals and therefore there was no risk of it containing prions.

We prepared a mixture of 12% sewage sludge, 80% wood ash and 8% meat flour, a combination considered to be optimal in terms of aggregate formation, consistency and odour, from a prior study of mixtures of different proportions of these materials (Carrera, 2003). Samples of the mixture were placed in polythene containers (500 cm^3), covered with filter paper to allow gas exchange, and maintained in the laboratory at ambient temperature (20ºC). Replicate samples were incubated for three different periods of time to simulate storage periods of 2, 4 and 6 weeks. At the end of these times the following analyses were carried out:

The pH_{H2O} was measured by potentiometric titration using a solid:liquid ratio of 1:2.5 (Guitián and Carballas, 1976). Electrical conductivity (EC) was measured by the electrometric method, using the same ratio of solid:liquid. Total carbon was measured following acid oxidation and titration (Guitián and Carballas, 1976). Total nitrogen was measured by the Kjeldahl method after acid extraction (catalysed) in a thermostatic block, with posterior distillation and titration (Tan, 1996). Phosphorus in the aqueous extract was determined by colorimetry with ascorbic acid following the steps described by Tan (1996). Phosphorus in the Melhich III extract was also determined by colorimetry with ascorbic acid (Tan, 1996). Soluble and Mehlich III-extractable Ca, Mg, Na, K, Fe, Al, Mn, Zn, Ni, Cu, Co, Cd, Cr and Pb were determined after the corresponding extraction (ratio 1:50, 1 h shaking and posterior filtration), by atomic absorption spectrophotometry (or atomic emission for Na and K) and ICP-OES, depending on the element. Finally, the moisture content was calculated from the wet weight of the fresh ash and the dry weight, obtained after drying the ash in an oven at 105ºC to constant weight.

RESULTS AND DISCUSSION

Because of the characteristics of the materials under study, i.e. the doughy consistency and unpleasant smell of the sewage sludge, the powdery consistency of the wood ash, and to a certain extent the meat flour, we had previously investigated the combination of the materials that was most suitable in terms of its manageability as a solid and its chemical composition. The optimal mixture was found to be that composed of 80% wood ash, 12% sewage sludge 8% meat

Table 1*. Physicochemical characteristics of the mixture after different incubation times. Contents are expressed in terms of dry weight.*

Parameter	1º incubation	2º incubation	3º incubation
EC. (µS cm^{-1})	1225	1095	703
pH (H_2O)	8.57	7.62	7.44
Moisture content (%)	34.28	6.68	5.94
Total carbon (%)	14.63	24.48	19.98
Total organic matter (%)	25.16	42.11	34.37
N total (%)	5.14	4.33	0.24
Ratio of C/N	2.85	5.65	83.25
P in aqueous extract (mg Kg^{-1})	276.51	258.27	276.85
P in Mehlich III extract (mg Kg^{-1})	501.15	369.74	441.54

flour (Carrera et. al., 2003). In the present study samples of this mixture were incubated for 2, 4 and 6 weeks. Measurement of the changes in different parameters over time (Table 1) showed that EC was always high, although it decreased over time. The pH also decreased over time. Total carbon had increased after 4 weeks, due to the formation of labile substances, then decreased, probably because of mineralization of organic compounds. Total nitrogen decreased over the incubation time, particularly in the last period of storage, possibly because of the volatization of part of the nitrogen. Both soluble and extractable P decreased before increasing again before the end of the experiment. The decrease in P coincided with an increase in soluble Ca (Fig. 1), therefore coprecipitation of the two elements may have occurred.

The changes in concentrations of different cations are shown in Fig. 1; K was present at the highest concentrations, followed by Ca, Na and Mg; the concentration of K decreased over time whereas there was a trend of increasing concentration followed by a slight decrease in concentration for the latter three cations. As regards the cations extractable with Mehlich III reagent (Fig. 2), Ca predominated followed by K and Mg. The same trends were seen as for the soluble form.

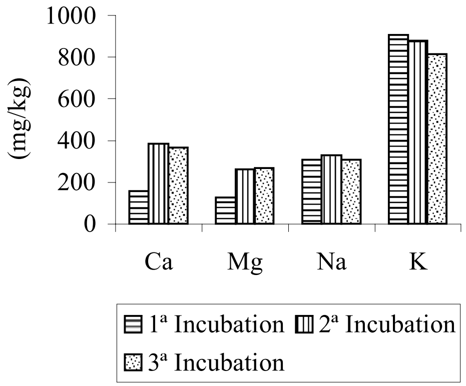

***Figure 1**. Concentration of different elements in aqueous extract.*

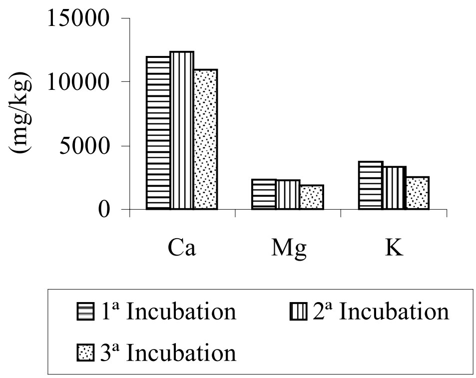

***Figure 2.** Concentration of different elements in Mehlich III extract.*

The ratio of Ca/Mg remained at around 5 throughout the storage time, which is a suitable proportion in terms of application to soils.

The concentrations of both soluble (aqueous extract) and bioavailable (Mehlich extract) forms of other elements are shown in Table 2. Both forms of Fe decreased after 4 weeks incubation, then increased by 6 weeks, although did not reach the levels present at 2 weeks. The concentration of soluble Al decreased with increasing storage time, but the bioavailable form first decreased at the start of the storage time but then had increased by six weeks. The soluble forms of Mn, Zn and Ni had increased in concentration at 4 weeks and had again decreased at 6 weeks. The soluble form of both Mn and Ni decreased in concentration throughout the experiment, whereas Zn first increased then decreased in concentration. The concentrations of both forms of the remaining metals (Cu, Co, Cd, Cr and Pb) decreased with increasing storage time, except for the bioavailable form of Cr, which had increased slightly at 6 weeks.

These variations in the concentrations of the different metals may be due to the interaction of the metals with organic substances, giving rise to products of different degrees of stability, which leads to the production of different amounts of soluble and/or bioavailable forms of the metals, depending on the conditions existing at each moment.

Table 2. *Concentration of different elements in the aqueous extract and in the Mehlich III extract.*

Elements	1º Incubation		2º Incubation		3º Incubation	
	Water	Mehlich	Water	Mehlich	Water	Mehlich
Fe (mg kg^{-1})	5.03	441.83	2.64	298.88	3.07	320.99
Al (mg kg^{-1})	5.55	1331.22	1.43	1122.86	0.67	1522.29
Mn (mg kg^{-1})	1.84	264.4	1.94	223.13	0.04	199.21
Zn (mg kg^{-1})	1.61	59.09	4.83	75.66	1.63	41.37
Ni (mg kg^{-1})	0.51	2.72	0.52	2.22	0.44	2.1
Cu (mg kg^{-1})	7.79	60.6	4.73	24.2	2.83	10.97
Co (mg kg^{-1})	0.,07	0.5	0.07	0.49	0.05	0.43
Cd (mg kg^{-1})	0.02	0.32	0.02	0.31	0.01	0.29
Cr (mg kg^{-1})	0.02	0.18	0.01	0.11	0.02	0.17
Pb (mg kg^{-1})	0.07	17.76	0.02	12.92	0.02	12.42

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