EVALUATION OF A MIXTURE OF WOOD ASH, SEWAGE SLUDGE AND MEAT FLOUR

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ABSTRACT

Large quantities of several waste products such as sewage sludge, wood ash (a by-product of the timber industry) and meat flour from non-ruminant animals (waste that has lost its traditional market) are currently generated. In this study we evaluated mixtures comprised of these waste products in terms of their recycling value for agronomic purposes.

After preliminary studies, we concluded that a mixture of 12% sludge, 80% ash and 8% meat flour was the most appropriate for the present purpose. This mixture offers clear advantages over the individual wastes that it contains. The mixture is less odorous and is also more stable as an aggregated solid. The resultant product also has suitable properties for use as a fertilizer and soil conditioner.

INTRODUCTION

The spreading of sewage sludge on land is widespread as a method of its disposal as well as for the recovery of poor soils (Metcalf and Eddy, 1998). Korentaje (1991) states that the main benefits of the application of sludge are: an increase in nutrients for plants and improvement in the physical properties of the soil. However, waste sludge requires stabilization treatment before being suitable for reuse on agricultural land.

The use of meat flour of animal origin has been prohibited in the elaboration of animal foodstuff as a precautionary measure aimed to prevent the spread of bovine spongiform encephalopathy (BSE). More than four hundred thousand tons of meat flour is generated every year in Spain (Ministerio de Agricultura, Pesca y Alimentación, 2003), and this constitutes an important environmental problem. These measures have also affected the market for meat flours of non-ruminant origin, for which an alternative use must be found; one possible use is in agronomy, although some handling problems must first be resolved.

Ash is generated by the timber industry as a by-product. As an alternative to being dumped, it can be re-used as e.g. an amendment and fertilizer to correct nutrient deficiencies in forest soils (Etiégni and Campbell, 1991; Ohno and Erich, 1990). Wood ash have properties that make them suitable for use in fertilizing soils with deficiencies of certain nutrients (Demeyer et al., 2001; van Hees et al., 2003) and in amending acidic soils. However, the variability in its density and size make its handling difficult.

Disposal of these by-products involves considerable additional costs, as well as an environmental problem. Mixing together of the wastes, which would offer benefits in terms of stabilizing the sludge and improving the handling of the flour and ash, may be seen as part of a recycling strategy that favours the productive use of the waste and has environmental benefits.

MATERIAL AND METHODS

Wood ash was obtained from the INTASA factory (San Sadurniño, A Coruña, Spain). Before analysis the ash was homogenised. The pH_{H2O} was measured by potentiometric titration (Guitián and Carballas, 1976), using a solid:liquid ratio of 1:50, because of the peculiarities of the material. The same ratio was used when measuring the EC. Total carbon was measured after acid oxidation and titration (Guitián and Carballas, 1976). The total nitrogen was measured by the Kjeldahl method, after catalysed acid digestion in a thermostatic block, with posterior distillation and titration (Tan, 1996). The water-soluble phosphorus was determined by colorimetry with ascorbic acid, following the method described by Tan (1996). The concentrations of soluble Ca, Mg, Na and K were determined, after extraction in distilled water (ratio 1:50, with 1 h shaking and then filtration), by ICP-OES. The material was digested in nitric acid before determining the concentration of Zn, Cu, Cd, Cr, and Ni by ICP-OES and cold vapour mercury AA for Hg. Finally, to calculate the moisture content of the ash, a sample of the fresh ash was weighed and then dried in an oven at 105ºC to constant weight.

The meat flour was supplied by the waste management company Agroamb S.L. (Lugo, Spain). The flour originated from non-ruminant animals and there was no risk of it containing prions. The analyses carried out were identical to those carried out with the ash.

The sewage sludge was supplied by the same waste management company (Agroamb S.L.) and was originally obtained from a sewage treatment plant where it was subject to aerobic processing. Analyses were similar to those carried out with the ash, i.e. pH, electrical conductivity (ratio of 1:2.5), moisture content, contents of C, N and P. The determinations made after extraction with nitric acid were the same as for the ash, as described above.

Following the analyses, the sludge, ash and meat flour were mixed together, varying the proportions until obtaining suitable results in terms of consistency (formation of aggregates), odour and pH of the final product. Problems associated with the handling of the sludge were mainly due to its doughy consistency and the need for it to be stabilized; these problems were overcome by mixing the sludge with wood ash. The main difficulty with the application of the ash is caused by the low weight and density of the particles, which make it difficult to handle and easily blown away by the wind or washed away by rain. This difficulty is minimized by mixing the ash with a binding substance, such as sewage sludge (and in this case the meat flour, disposal of which was problematic because the traditional market had been lost). The same analyses carried out with each material were also applied to the mixture of sludge, meat four and wood ash.

RESULTS AND DISCUSSION

According to previous results obtained by our research team (Pousada et al., 2003) the proportions required for an optimal mixture (when using only sewage sludge and wood ash) were 30% sludge, 70 % ash. The inclusion of the new material, meat flour, involved a change in these proportions. In preliminary experiments, we combined the products to find out the maximum content of meat flour that could be mixed with the sludge, the resulting percentages were 33.2% sludge and 66.8% meat flour. The percentages correspond to the dry weights calculated from the moisture content of each material. Mixtures of different proportions of the three materials were then made:

- 15% sewage sludge + 70% wood ash + 15% meat flour: the resulting mixture was a uniform paste with no aggregates, probably because of the high moisture content of the sludge.
- 20% sewage sludge + 70% wood ash + 10% meat flour: this mixture was even more pasty than the first because of the higher proportion of sludge.
- 11.7% sewage sludge + 74.2% wood ash + 14.1% meat flour: the unpleasant odour associated with the sewage sludge began to be reduced and differentiated aggregates were obtained, but which were too small for the present purpose.

- 10.6% sewage sludge + 79.5% wood ash + 9.9% meat flour: the odour was reduced and larger sized aggregates were formed.
- 12.2% sewage sludge + 63.3% wood ash + 24.5% meat flour: this mixture had similar characteristics to the former but the meat flour did not bind completely with the sludge.
- 14% sewage sludge + 80.4% wood ash + 5.6% meat flour: the odour was considerably less in this mixture and larger aggregates were formed than in the previous mixtures. These proportions appeared to be close to optimal. Three more mixtures of the following proportions were prepared:
- 10% sewage sludge + 85% wood ash + 5% meat flour: the high content of ash in this mixture prevented the formation of good-sized aggregates and the mixture was too loosely bound for the present purpose.
- 17% sewage sludge + 75% wood ash + 8% meat flour: in this mixture the aggregates formed were too large to be useful in terms of storage and possible application on the ground.
- 12% sewage sludge + 80% wood ash + 8% meat flour: in this case the odour was reduced and the consistency and aggregate formation were the most suitable of all the mixtures tested. This mixture was therefore considered as optimal and was subject to a detailed characterization.

The physicochemical characteristics of the by-products used (wood ash, sludge and meat flour) and also of the optimal mixture, are shown in Table 1.

***Table 1**. Physicochemical characteristics of the ash, sludge and flour used and the mixture of the three composed of 12% sludge, 80% ash and 8% meat flour. Percentage contents are expressed in terms of the dry weights.*

Parameter	Wood ash	Sewage Sludge	Meat flour	Mixture
Moisture content (%)	2.37	85. 24	31.9	-
pH (H_2O)	9. 89	8.51	8.21	8.42
EC (µS cm^{-1})	272	1496	1288	1421
P in aqueous extract (mg kg^{-1})	11.48	1288.32	1145.35	239.02
P in Mehlich extract (mg kg^{-1})	565.49	4383.73	6872.98	489.60
Total carbon (%)	0.70	33.91	39.19	19.74
Total N Kjeldahl (%)	0.20	10.02	22.93	2.87
C/N ratio	3.48	3.39	1.71	6.88

(-) = no data available.

The wood ash had a low moisture content, high pH and a low nitrogen content, as most of this element was volatized during combustion, and also a low carbon content, showing that the ash was highly combusted. The concentrations of heavy metals (Table 2) were relatively low.

The sludge had a high moisture content, was alkaline and showed high EC. The contents of nitrogen and carbon were high, as was that of phosphorus. The concentrations of heavy metals (Table 2) were lower than those permitted by Spanish legislation (Ministerio de Agricultura, Pesca y Alimentación, 1990).

The meat flour was alkaline, showed high electrical conductivity and high concentrations of nitrogen, carbon and phosphorus, both in soluble and potentially available forms. The concentrations of heavy metals (Table 2) were even lower than in the ash and sludge.

The mixture was alkaline and had a higher pH than that of the mixture composed of 30% sludge and 70% ash (Pousada et al., 2003), and showed high EC. The concentration of water-soluble phosphorus and that extractable with Mehlich III reagent were high although lower than in the sewage sludge or meat flour separately. The concentrations of carbon and nitrogen, both were higher than in the wood ash and lower than in the sludge and meat flour. The nitrogen content was higher than that of the mixture of ash and sewage sludge (Pousada et al., 2003), which

***Table 2**. Heavy metal contents of the different waste products.*

Element	Wood ash	Sewage Sludge	Meat flour
Zn (mg kg^{-1})	157.64	516.25	154.82
Ni (mg kg^{-1})	39.30	30.78	2.13
Cu (mg kg^{-1})	51.07	284.91	12.85
Cd (mg kg^{-1})	1.63	1.13	1.24
Cr (mg kg^{-1})	28.84	30.58	0.84
Pb (mg kg^{-1})	15.53	195.52	0.22
Hg (mg kg^{-1})	0.05	0.04	0.69

reflects the benefit of the addition of the meat flour.

Analysis of the contents of the soluble form of different elements (Table 3) shows that the predominant element in the wood ash was Ca, followed by Mg and thereafter by Na and K. Potassium was the least abundant element in the wood ash in contrast to the findings of other authors (Demeyer et al., 2001; Pousada et al., 2003) who report it to predominate. In both the sewage sludge and the meat flour, K was the predominant element, followed by Na, then Ca and Mg in lower quantities. The mixture contained high concentrations of the four elements: K, Na, Ca and Mg, which were present in more equal proportions than in each waste material considered separately.

***Table 3**. Concentration of different elements in the aqueous extract.*

Elements	Ash	Sludge	Meat flour	Mixture
Ca (mg kg^{-1})	571.67	33.48	33.34	284.53
Mg (mg kg^{-1})	308	26,6	2,27	235,69
Na (mg kg^{-1})	40.13	2314.52	1003.3	578.34
K (mg kg^{-1})	33.6	3011.02	1305.22	752.37

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REFERENCES

Demeyer, A., Voundi Nkana, J.C., Verloo, M.G. 2001. Characteristics of wood ash and influence on soil properties and nutrient uptake: an overview. Biores. Technol., 77: 287-295.

Etiégni, L., Campbell, A. G. 1991. Physical and chemical characteristics of wood ash. Biores. Technol., 37: 173-178.

Guitián, F., Carballas, T. 1976. Técnicas de análisis de suelos. Editorial Pico Sacro. Santiago de Compostela (S).

Metcalf and Eddy., 1998. Ingeniería de aguas residuales. Tratamiento, vertido y reutilización. McGraw-Hill, Madrid (S).

Ministerio de Agricultura, Pesca y Alimentación 1990. Real Decreto 1310/1990, de 29 de Octubre. BOE del 1 de Noviembre de 1990. Madrid.

Ohno, T., Erich, M. S. 1990. Effect of wood ash application on soil pH and soil test nutrient levels. Agric. Ecosyst. Environ., 32: 223-239.

Pousada, Mª.Y., Núñez, A., Seoane, S. 2003. Evaluación de la mezcla de lodos residuales con cenizas de combustión de madereras como enmienda de suelos ácidos. In: Bienes, R., Marqués, M.J. (eds.): *I Simposio Nacional sobre control de la erosión y degradación del suelo*, Madrid. (S), 2003, pp. 299-302.

Tan, K.H. 1996. Soil sampling, preparation and analysis. Marcel Deker, Inc. New York (US).

van Hees, P.A.W., Nyberg, L., Holmström, S.J.M., Lundström, U.S. 2003. Pools and fluxes of cations, anions and DOC in two forest soils treated with lime and ash. Water, Air, Soil Pollut., 3: 145-165.