MANAGEMENT SEWAGE SLUDGE THERMAL DRYING AMENDED SOIL

Mª. M. Delgado, M. A. Porcel, R. Miralles, E. Mª. Beltrán, L. Beringola, J. Valero
Department Environment, INIA Apdo 8111. 28080 Madrid. Spain. delgado@inia.es

ABSTRACT

Studies were conducted to determine using of an organic residue (sewage sludge treated) during two years (2002-2003), to study effects of sewage thermal drying on crop yield and chemical properties of soil under field condition. Productivity studies showed the great growth is obtained in mixed II treatment (10000 kg/ha sewage sludge thermal drying plus 350 kg/ha urea) with 20% more than mineral fertilization and followed mixed I (8000 kg/ha sewage sludge thermal drying plus 350 kg/ha urea) with 10% more than mineral fertilization also. No toxic effects arising from the heavy metals in the plant were observed. Moreover heavy metals concentration's in soil are below Spanish and European legal limits.

INTRODUCTION

Increasing sewage sludge production (Directive 91/271/CE) and use restrictions due the landfill directive (99/32/EC) give priority to the application of sewage sludge to the soil. The chemical composition of sewage sludges is of great importance when developing recommendations for the rates of sludge applications on agricultural land (Beltrán et al. 1999). At the present time, recommendations for sludge applications rates on land are based on the fertilizer value (N, P and K) and on the concentrations of trace metals present in sludge (Delgado et al. 1999). The metals of primary concern are Zn, Cu, Pb, Ni and Cd which, when applied to soils in excessive amounts, may reduce plant yields or impair the quality of food or fiber produced (Parr et al.1989).

The purpose of present study was to determinate the effect of sewage sludge thermal drying on crop yield and chemical properties of soil under field condition.

MATERIALS AND METHODS

The study was conducted during two years (2002-2003), at a cultivation area located in the province of Madrid, Spain. Maize (*Zea mays* L. Variety Juanita) was grown in soil amended with a sewage sludge thermal drying from one treatment plant of waste water in Madrid. Three different treatments were applied (in march bottom dressing and may cover dressing) to soil surface: mineral treatment (control) (Barrantes et al. 1992, Dominguez 1997), mixed I treatment and mixed II treatment (sewage sludge thermal drying plus urea). The characteristics of treatments used has been:

- **Mineral treatment (Control)**
  Basal dressing: 800 kg/ha of N-P-K (15-15-15)
  Top dressing: 350 kg/ha urea (46%)
- **Mixed I treatment**
  Basal dressing: 8000 kg/ha sewage sludge thermal drying
  Top dressing : 350 kg/ha urea (46%)
- **Mixed II treatment**
  Basal dressing: 10000 kg/ha sewage sludge thermal drying

Top dressing : 350 kg/ha urea (46%)

Table 1 shows the chemical composition of sewage sludge thermal drying used in the trials (dry weight), the pH was obtained with the glass electrode, using a soil water suspension of 1:2.5 (w/v), electric conductivity was determined in conductivimeter (soil/water ratio, 1:5.0) 25ºC, oxidable carbon by Walkely Black method (APHA, AWWA, WPCF 1992), total Kjeldahl nitrogen by Kjeldahl method (Hesse 1971) and P, K, Ca, Fe, Mg and heavy metal Cu, Pb, Cr Zn, Ni and Cd concentrations were determined by atomic absorption spectroscopy (AAS) after mineralisation with HNO_3 + $HCLO_4$ solution (Sims and Kline 1991). Harvested plants were oven dried at 65ºC, weighed for dry matter yield, ground and stored for analysis. The production and metal uptake of grain maize were analyzed after annual treatment.

Soil samples were brought from the field at depth 0-30 and 30-60 cm were taken from 30 sites (10 samples mineral treatment, 10 samples mixed I treatment and 10 samples mixed II treatment) for each depth, in winter of 2002 and 2003. For analyzing soil samples, they were air-dried, passed through a 2 mm sieve and stored at 4 ºC

***Table 1**. Chemical analysis of sewage sludge thermal drying used (2002 and 2003)*

CHARACTERISTICS	SEWAGE SLUDGE COMPOST*
Humidity (%)	18.25
pH (H_2O)	7.5
E.C. (dS/m.)	5.2
Organic Matter (%)	36.0
Oxidable Carbon (%)	12.1
Total Kjeldahl Nitrogen (%)	2.9
Phosphorus –P (%)	3.0
Potassium –K (%)	0.4
Calcium –Ca (%)	7.1
Iron –Fe (%)	1.7
Magnesium –Mg (%)	0.9
Copper –Cu (mg/kg)	293.5
Lead –Pb (mg/kg)	194.0
Chromium –Cr (mg/kg)	279.5
Zinc –Zn (mg/kg)	1205.5
Nickel –Ni (mg/kg)	55.0
Cadmium –Cd (mg/kg)	3.5

** Mean of two years.*

RESULTS AND DISCUSSION

Production results showed that in mixed II treatment (10.000 kg/ha sewage sludge thermal drying + 350 kg/ha urea) average grain yield was 14804 kg/ha, a 27 % increase with respect to mineral treatment in mixed I grain yield that was 12367kg/ha, a 12% increase with respect to the mineral (Table 2) (Hernandez et al. 1991).

***Table 2**. Yield maize grain in different treatments during 2002 to 2003 (kg/ha)*

	MINERAL	MIXTO I	MIXTO II
2002	12102	13419	15056
2003	9570	11315	14552
AVERAGE PRODUCTION	10836	12367	14804

In the Table 3 and Table 4 shows analytical characteristics of maize grain and maize stem, and no toxic effects arising from the heavy metals in the plant were observed.

***Table 3**. Analytical characteristics of maize grain in 2002 and 2003.*

Amended	Zn*	Cu*	Cr*	Pb*	Cd*	Ni*	P(%)	K(%)	Ca(%)
Mineral	8.56	1.04	0.63	0.005	0.005	0,092	0.21	0.27	0.002
Mixed I	11.83	1.64	0.87	0.005	0.005	0.105	0.24	0.30	0.004
Mixed II	11.50	1.77	1.43	0.005	0.005	0.090	0.21	0.31	0.004

***Table 4**. Analytical characteristics of maize stem 2002 and 2003.*

Amended	Zn*	Cu*	Cr*	Pb*	Cd*	Ni*	P(%)	K(%)	Ca(%)
Mineral	6.67	3.74	0.01	0.10	0.01	0,09	0.07	1.50	0.32
Mixed I	16.90	4.47	1.13	0.12	0.01	0.02	0.13	1.89	0.45
Mixed II	21.33	5.98	1.17	0.12	0.01	0..09	0.15	1.98	0.48

Also, the purpose of present study was to determinate the effect of sewage sludge thermal drying on several soil parameters (pH, E.C., organic matter, N, P, K and heavy metals). Although the annual application of the rate mixed II resulted in an important accumulation of heavy metals in the soil, never was over Spanish and European limits (Wagner, 1993).

In Table 5 within each heavy metal, the means followed by the same letter are not significantly different ($p>0.05$), based on analysis of variance (ANOVA) multiple range tests. There are not significant differences for the heavy metals lead, cadmium and chromium in anything for profile the annual application of the rate mixed II resulted in an important accumulation of heavy metals in the soil, never was over Spanish and European limits

***Table 5**. Heavy metals in soil profile (mg/kg.) in 2002 and 2003.*

Amended	MINERAL	MIXED I	MIXED II
		Cu	
0-30	6.50^{a}	9.20^{b}	15.70^{c}
30-60	3.30^{a}	3.35^{a}	6.30^{b}
		Zn	
0-30	30.60^{a}	54.00^{b}	60.60^{c}
30-60	20.70^{a}	26.20^{b}	39.20^{c}
		Ni	
0-30	8.40^{a}	8.60^{b}	10.30^{c}
30-60	7.60^{a}	6.85^{a}	8.90^{b}

Each value is represent the mean of 10 samples.

CONCLUSIONS

- Productivity studies showed the great growth is obtained in mixed II treatment (10000 kg/ha sewage sludge thermal drying plus 350 kg/ha urea) with 20% more than mineral fertilization and followed mixed I (8000 kg/ha sewage sludge thermal drying plus 350 kg/ha urea) with 10% more than mineral fertilization.
- Heavy metals concentration's in soil are below Spanish and European legal limits.
- Analytical characteristics of maize grain and maize stem, and no toxic effects arising from the heavy metals in the plant were observed.

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