BIOLOGICAL EFFECT OF THE ADDITION OF THERMALLY DRIED AND COMPOSTED SEWAGE SLUDGES TO RESIDUAL SOILS FROM A LIMESTONE QUARRY

Graciela Marando[1], Patricia Jiménez[1], Manuel Bonmatí[1], Marta Ginovart[2]

[1] Department of Agri-Food Engineering and Biotechnology. Technical University of Catalonia. Barcelona. Spain, manuel.bonmati@upc.edu.

[2] Department of Applied Mathematics III. Technical University of Catalonia. Barcelona. Spain.

UNIVERSITAT POLITÈCNICA DE CATALUNYA

The Third International Conference

Enzymes in the Environment: Activity, Ecology & Applications

INTRODUCTION

Residual materials coming from limestone quarries extraction are often used in the working reclamation process. Application of sewage sludge to residual materials facilitates the establishment of a vegetation cover. Besides protecting the soil from erosion, this can stimulate C and N cycling, thereby reducing pollution by runoff and leaching (Albadejo et al., 2000). Studies of enzyme activities provide information on the biochemical processes occurring in soil. There is growing evidence that soil biological parameters may be potential and sensitive indicators of soil ecological stress or restoration.

The aim of this work was to assess the effects of six different sewage sludges one year after application, on β-glucosidase and β-galactosidase activity, soluble organic matter, total and extractable carbohydrates, soil respiration and soil microbial biomass of residual soils from a limestone quarry.

MATERIAL AND METHODS

Residual soils: Both residual soils consisted in waste material generated from the working of a limestone quarry situated in Begues (Central Catalonia). The Mining Soil (MNS) was a mixture generated during the extraction process of the working, containing a 38% of fine earth; pH 8,5;lime 39,3%; C 0,47%; N 0,06%; sand 42,5%; silt 37%; clay 20,4%. The Milling Soil (MLS) was generated during the milling process of the stony material and contained 14% of fine earth; pH 8,9; lime 63,6%; C 0,27%; N 0,05%; sand 54,8; silt 22,6%; clay 22,4%.

Sludges: The main characteristics of the six sewage sludges are shown in Table 1. After dewatered, three of the sludges were thermally dried (TSS) and the other three were composted (CSS).

Experimental design: Each sludge was mixed with each waste with a level of organic carbon content in the less than 2 mm fraction of the final mixture of 1% as weight basis in dry matter. Applied amendments, given in dry weight basis, oscillated between 0,07% and 1,41% (sludge/mixture). Each type of mixture, and the control soils with no sludge added (150 kg each), were then placed (four replications) in polyethylene lysimeters. Containers were sawn (30 g m^{-2}) with a mixture of *gramineous* and *leguminosae*. Mixtures and control soils were left in the open for 13 months. **Sampling:** it was performed (20 cm-deep) after harvesting. Samples were air dried for 2 days, sieved (< 2mm) and stored at room temperate The main characteristics of the mixtures and control are shown in Table 2.

Analytical measurements: Extracted C (EC) was obtained by extraction with 0,5 M K_2SO_4 in the proportion of ¼ (w/v) and quantified (TOC SHIMADZU V-CSN); total carbohydrates (TCH) as reported by Cheshire and Mundie (1966); extractable (soluble in 0.5 M K_2SO_4) carbohydrates (ECH) by Badalucco *et al.,* (1992); microbial biomass (MB) by the fumigation-extraction method (Vance et al., 1987), basal respiration (BR) and cumulated CO2 as reported by Hernández and García (2003). β-glucosidase and β-galactosidase activities were measured according to Eivazi and Tabatabai (1988). The ratios of the mentioned parameters with respect to C were calculated. All determinations were performed in triplicate and all values reported are averages of the three determinations expressed on a dry weight bases. To find out which of the assayed parameters were more sensitive to the action of the six sewage sludge types on the two soils, the calculated means of each parameter were transformed to the 0-1 interval in order to make them comparable.

Statistical analysis: For each soil, the influence of two fixed main factors (sludge type and soil type) and one random factor (container) on the studied parameters were considered. General Linear Models (GLM) were used to evaluate the influence of the different factors on the measured variables. Data were analyzed using the Statistics Analysis System software, and the GLM procedure was performed using variance tests (SAS 1990). Separation of means was made according to the Tukey-Kramer procedure (at the level of α=0.05).

Table 1: Characteristics of sewage sludge

SLUDGE	ORIGIN	SYMBOL	DIGESTION	CE	pH	%Dry Matter	%OM	%Stable Organic matter	$\%P_2O_5$	$\%K_2O$	% N	%Stable N	NH_4^+ (ppm)	NO_3^- (ppm)
Composted	Manresa	CMN	anaerobic	3,9	7,1	95,5	55,5	40,6	9,9	0,3	2,3	0,9	2,5	-
	Vilaseca	CV	aerobic	8,5	6,9	91,6	58,3	35,8	13,3	0,6	3,0	1,0	3,5	-
	Blanes	CBL	anaerobic	7,6	6,5	98,0	56,6	29,0	16,0	0,2	3,2	0,8	5,7	-
Thermally dried	Sabadell	TS	anaerobic	0,9	7,3	96,9	62,2	39,5	13,3	0,2	3,9	1,0	0,4	-
	Mataró	TMT	anaerobic	5,8	6,2	85,9	74,0	40,4	7,5	0,3	3,5	0,7	2,5	-
	Besos	TBE	Physic- chemical	1,4	6,1	93,2	72,3	8,6	9,1	0,1	2,2	0,7	0,1	-

Table 2: Chemical characteristics of control and mixtures

Sewage sludge	Origin	pH	CE dS m^{-1}	% OM	% N	C/N	P mg kg^{-1}
			Milling	*Soil*			
Control		8,4	0,23	1,2	0,08	8,7	28
Thermaly dry	Sabadell	8,6	0,29	1,1	0,08	7,9	31
	Mataró	8,6	0,23	1,1	0,11	5,8	48
	Besós	8,5	0,28	1,3	0,09	8,4	54
Composted	Blanes	8,5	0,21	1,5	0,12	7,3	76
	Manresa	8,5	0,20	1,6	0,12	7,7	78
	Vilaseca	8,6	0,24	1,2	0,10	6,9	64
			Mining	*Soil*			
Control		8,5	0,22	1 ,0	0,07	8,2	6
Thermaly dry	Sabadell	8,2	0,22	1,6	0,12	7,7	55
	Mataró	8,3	0,18	1,9	0,13	8,5	72
	Besós	8,6	0,21	0,5	0,05	5.8	10
Composted	Blanes	8,3	0.24	1,7	0,14	8,2	71
	Manresa	8,4	0,26	1,8	0,12	7,0	73
	Vilaseca	8,3	0,37	2,1	0,16	7,6	83

RESULTS

Statistical results

Parameters with no interaction sludge-soil

β-Glucosidase activity: $\bar{X}$ Besós(*) treated soils= 1,04 µmol PNP g^{-1} h^{-1}= 2 x $\bar{X}$ (rest of mixtures)

TCH: $\bar{X}$ MNS-sludge mixtures= 1,51 mg g^{-1}= 1,5 x $\bar{X}$ MLS-sludge mixtures

EC: $\bar{X}$ MNS-sludge mixtures= 188 mg kg^{-1}= 1,2 x $\bar{X}$ MLS-sludge mixtures

(*) Besós sludge was the one with the lowest stable organic matter content

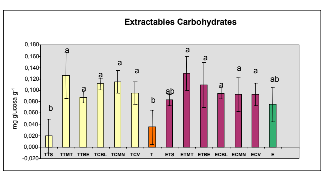
Parameters with interaction sludge-soil

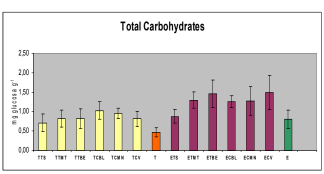
MBC and ECH: complex patterns, but mixtures with Mataró sludge were among those having the higher values and mixtures with Sabadell sludge were among those having the lowest values

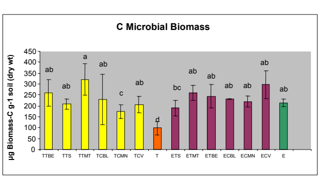
Ratios of the mentioned parameters with respect to C: The most remarkable: MBC/C Was higher in thermally dried sludges than in composted sludges

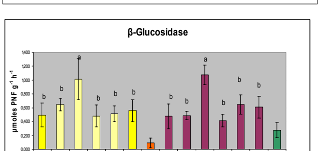
Table: ANOVA Summary. F-ratios

	MB	BR	EC	TCH	ECH	β-Galactosidase	β-Glucosidase
	F value Pr>F	F value Pr>F	F value Pr>F	F value Pr>F	F value Pr>F	F value Pr>F	F value Pr>F
Residual Soils (RS)	0.81 ns	1.66 ns	14.96 ***	30.42 ***	1.03 ns	1.26 ns	0.00 ns
Sewage Sludge (SS)	4.69 ***	0.99 ns	1.07 ns	2.22 ns	7.76 ***	0.96 ns	13.80 ***
RS * SS	3.04 *	1.70 ns	0.88 ns	1.28 ns	3.04 *	3.24 *	0.79 ns

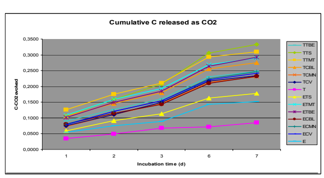


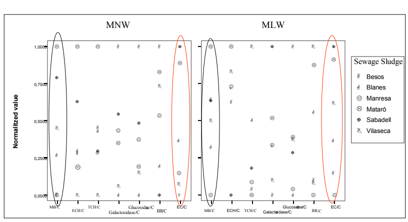






ECH, TCH, MB carbon, β-glucosidase activity, in residual soil-sludge mixtures. Overall mean values. Values not followed by the same letter show significant differences (p<0.05).





CONCLUSIONS

Differences in the sludges origin didn't allow to find absolute parameters distinguishing differences among the two post treatments (thermally drying or composting) of the sludges. The only exception was Cumulated CO2

MBC/C and Cumulated CO2 were higher in thermally dried sludge treated soils than in composted sludge treated soils: they were the most sensitive parameters in the detection of the effect of organic matter stabilization by composting post treatment over the sludges added to soils

β-Glucosidase was the most sensitive parameter in the detection of the decomposable organic matter content of the sludges present in the mixtures

MNS residual soil was able to retain more organic matter (TCH and EC) than MLS residual soil

The normalized values of the assayed parameters show that EC/C was the index better detecting differences among the six sludges in their effects over the soils.

REFERENCES

Albaladejo J., Castillo V. and Díaz E. 2000 Soil loss and runoff on semiarid lands as amended with urban solid refuse, *Land Degrad. Dev.* **11**, pp. 363–373.

Badalucco, L.., Gelsomino, A.., Dell'orco, S., Grego. S. and Nannipieri P. 1992. Biochemical characterization of soil organic compounds extracted by 0.5 M K_2SO_4 before and after chloroform fumigation. Soil Biology and Biochemistry, 24, 569-578.

Cheshire M.V. y Mundie C.M. 1966. The hydrolytic extraction of carbohydrates from soil by sulphuric acid. Journal of Soil Science, 17, 372-381.

Eivazi, F. and Tabatabai, M.A. 1988. Glucosidases and galactosidases in soils. Soil Biology & Biochemistry 20, 601-606.

Hernández, T. and García, C. 2003. Estimación de la respiración microbiana del suelo. En: Técnicas de Análisis de Parámetros Bioquímicos en Suelos. García, C., Gil, F., Hernández, T., Trasar, C. (Eds). Ediciones Mundiprensa. Madrid.

Vance, E.D., Brookes, P.C., Jenkinson, D.S. 1987. An extraction method for measuring soil microbial biomass C. Soil Biology and Biochemistry 19: 703-707.

This research was supported by the Ministerio de Medio Ambiente of Spanish Government and the ACA of the Autonomous Government of Catalonia