EVALUATING THE DOSE EFFECT OF A DIFFERENTLY POST-TREATED DEWATERED SEWAGE SLUDGE OVER TWO DEGRADED SOILS COMING FROM WORKING QUARRIES

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Introduction

In Catalonia, the reclamation of quarries involving the use of sewage sludge has started recently and is becoming more and more frequent (Bonmatí et al. 2000). The application of dewatered sewage sludge to soils improves soil fertility because it increases nutrient content, structure and aggregate stability, biological activity and crop yields. The post-treatment of dewatered sludge by composting or thermal drying is required to avoid sanitary problems and operational drawbacks, and to remove unpleasant odours and the possible presence of organic pollutants. As far as we know, it is not known the effect of thermal dried or composted dewatered sludge on microbial and biochemical properties of soil. The aim of this study was to compare, under laboratory conditions, the effects of two different doses (one of them twice as high as the other) of thermically dried, composted or unpost-treated dehydrated sewage sludge on β-glucosidase activity, total and extractable carbohydrates, basal respiration and microbial biomass when applied to two soils from working quarries. Differences found in the dose effect, depending on the sludge type, would inform us about differences in the organic matter composition of the sludges.

Material and Methods

Experimental Design: A **dewatered sludge (DWS)** was **composted (CPS)** and **thermally dried (TDS)**. Each sludge was mixed with two diferent soils: a **clayey soil (CL)** and a **sandy soil (SA)** at two different rates of C: 2% (**low dose, L**) and 4% (**high dose, H**) on dry weight basis in the final mixture. Applied amendments were equivalent to 100 (L) and 200 (H) Mg ha^{-1}(dry weight basis). Each mixture, and the control soils, were then placed in containers (9 l) and incubated for nine months at 25º C; soil moisture was kept constant at 30% of the field capacity. Three containers were prepared for each treatment. Sampling was performed after **7, 67 and 267 days of incubation**.

Soils: CL soil was a mixture of A and Bw horizons of a soil developed over limestone and dolomite from a quarry located in Alcover (South Catalonia);pH 8.7; lime 25.4%; C 0.5%; N 0.038%; sand 31%; silt 30%; clay 39%. SA soil was the B horizon of a soil developed over limestone and sandstone from San Fost de Campcentelles (Central Catalonia); pH 8.8, lime 0.6%; C 0.25%;N 0.006%; sand 77%; silt 8%; clay 16%.

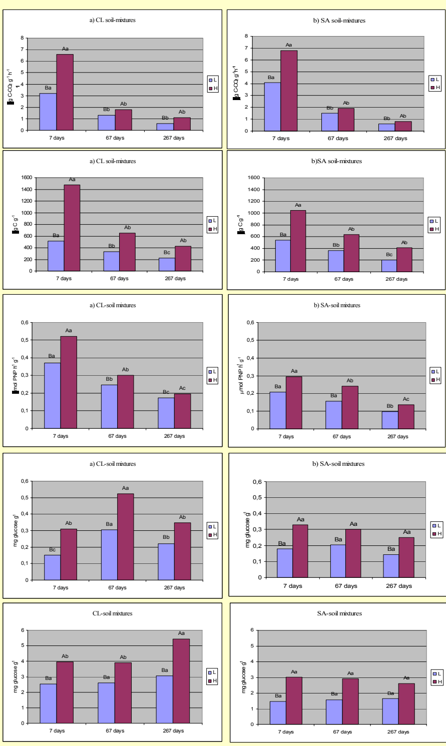
Sludges: DWS was from a waste water treatment plant with anaerobic digestion; moisture 79.7%; total organic matter 669 g kg^{-1} (d.m.); stable organic matter 39.5%; total N 46.6 g kg^{-1}(d.m); total P 18.9 g kg^{-1}(d.m.); pH 8.3; electrical conductivity 1.80 dS m^{-1}.

CPS was obtained by composting the dewatered sludge, with pine wood splinters as a bulking agent; moisture 33.5%; total organic matter 643 g kg^{-1} (d.m.); stable organic matter 46.2%; total N 33.6 g kg^{-1}(d.m); total P 15.5 g kg^{-1}(d.m.); pH 7.4; electrical conductivity 5.84 dS m^{-1}.

TDS was obtained by drying the dewatered sludge in a heated cylinder; moisture 15.3%; total organic matter 675 g kg^{-1} (d.m.); stable organic matter 37.0%; total N 44.5 g kg^{-1}(d.m); total P 17.8 g kg^{-1} (d.m.); pH 7.0; electrical conductivity 5.28 dS m^{-1}.

Analysis: Microbial biomass (MB) and soil basal respiration (BR) were immediately determined in fresh samples. Samples were air dried for two days and stored at room temperature for one year before the measurement of total (TCH) and extractable (ECH) carbohydrates and β-glucosidase activity.TCH was determined as reported by Cheshire and Mundie (1966) and ECH (soluble in 0.5 M K_2SO_4) by Badalucco et al. (1992). MB carbon was determined by the fumigation-extraction (Vance et al., 1987) and BR as the CO_2 produced after 20 days of incubation at 25º C (Anderson ,1982). The β-glucosidase activity was determined as reported by Tabatabai (1982) and Vuorinen (1993). Depending on the measured parameter, measurements in each container were not replicated or replicated three times.

Sludge mixtures (mean values)	Initial (7 days)	Final (267 days)
Basal respiration	H = 2.0 x L	H = 1.5 x L
Microbial biomass	H = 2.5 x L	H = 1.5 x L
β-glucosidase activity		
Extractable carbohydrates	H = 1.5 x L	
Total carbohydrates		



BR, MB carbon, β-glucosidase activity, ECH and TCH in CL and SA soil-sludge mixtures; low dose (L) high dose H . Overall mean values (including the three sludge types). Values not followed by the same capital letter/lower case show significant differences (p<0.05) between doses/sampling dates.

I. GLOBAL DOSE EFFECT

1.- General behaviour: H > L
For all the parameters the increase was significantly higher the larger the amount of sludge applied

2.- Microbial parametres were more sensitive to the dose effect than biochemical parametres.
The dose effect for microbial parameters was less stable

II. DOSE EFFECT FOR EACH SLUDGE TYPE

The general behaviour was always accomplished only in the case of DWS-treated soils

	soil-CPS sludge mixtures	soil-DWS sludge mixtures	soil-TDS sludge mixtures
Basal respiration	H = L	H > L	H > L
Microbial biomass	H = L	H > L	H > L
β-glucosidase activity	H > L	H > L	H = L
Extractable carbohydrates	H > L	H > L	H > L
Total carbohydrates	H > L	H > L	H > L

Table showing a summary of t-test results for low (L) and high (H) sludge doses of BR, MB, β -glucosidase activity, and ECH and TCH contents for each type of sludge in CL and SA soil-sludge mixtures at three times.

III. QUANTITATIVE VALUE OF THE DOSE EFFECT

	Basal respiration		Microbial biomass carbon		β-glucosidase activity		Extractable carbohydrates		Total carbohydrates	
Days of incubation	*7*	*267*	*7*	*267*	*7*	*267*	*7*	*267*	*7*	*267*
CL soil-CPS sludge mixtures	42Aa	ns	ns	ns	43Aa	ns	79Aa	90Aa	17Ba	38Ba
CL soil-DWS Sludge mixtures	143Aa	88Aa	129Ba	120Aa	47Aa	ns	77Aa	31Aa	78Aa	129Aa
CL soil-TDS sludge mixtures	98Aa	100Aa	316Aa	81Ab	ns	ns	132Aa	76Aa	72Aa	82Aa
SA soil-CPS sludge mixtures	ns	ns	ns	ns	115Aa	56Aa	106Aa	ns	113Aa	130Aa
SA soil-DWS sludge mixtures	141Aa	29Ab	67Aa	108Aa	78Aa	36Aa	90Aa	61Ba	94Aa	36Ba
SA soil-TDS sludge mixtures	ns	60Aa	131Aa	107Aa	ns	ns	69Ab	133Aa	115Aa	47Bb

Relative increment (%) caused by the dose increase in BR, MB, β -glucosidase activity, and contents of ECH and TCH in CL and SA soil-sludge mixtures. Initial and final values. CPS, composted sludge, DWS dehydrated sludge, TDS thermally dried sludge. Values not followed by the same capital letter/lower case show significant differences (p<0.05) between sludge type/sampling dates;

ns= no significant dose effect.

Initial dose effect
CL-TDS and SA-TDS sludge mixtures
Δ Microbial biomass carbon > Δ Basal respiration

Thermally drying of DWS probably caused the appearance of substances inhibiting microbial activity

Final dose effect
ECH content in SA sludge mixtures
Δ soil-TDS > Δ soil-DWS > Δ soil-CPS

Relative increment of ECH in SA-treated soils is the only dose effect which is able to distinguish among the three sludges

CONCLUSIONS

Differences found in the dose effect of the three sludge types over the soils allow us to establish some hypotheses about the organic matter characteristics of these sludges. The unpost-treated dehydrated sewage sludge is simultaneously supplying decomposable and enzymatically-active organic matter to the soils. Thermally drying causes a partial decomposition of the organic matter present in the dehydrated sludge and also a denaturizing effect on its enzyme activity, whereas the stabilization effect of the dewatered sludge organic matter and its enzyme activity by composting is confirmed.

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