

# Microbial Biomass and Activity in a Calcareous Soil Amended with Municipal Solid Waste Compost

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## ABSTRACT

The dynamics of soil health indicators such as microbial biomass, urease and acid phosphatase activities, in a calcareous soil amended with different doses of Borg Elarab municipal solid waste compost (MSWC) were studied over 120 days of incubation at 30° C at 60% of soil water holding capacity. The parameters were found to increase with the increase in doses of MSWC. Soil microbial biomass (MB) activity reached peak values at 30 days of incubation and then gradually decreased up to 120 days of incubation. Urease and acid phosphatase activities showed peak values at 60 and 90 days of incubation, respectively. The increase in soil enzyme activities with the fall in MB suggested that the release of enzymes was associated with lysis of microbial cells at the end of their life cycle. There was no indication of any detrimental effect on soil health indicators of application of MSWC to soil

**Keywords:** Microbial Biomass, Calcareous Soil, Municipal Solid Waste, Compost, Borg Elarab

## INTRODUCTION

The importance of manures, crop residues and other organic materials in maintaining soil health is widely recognized. The application of organic matter may increase crop yield through improvement of the physical, chemical and microbiological composition of the soil (EL-Kouny et al., 2004; 1999). Incorporation of lime sludge by plough less tillage (10-12 cm) resulted in significantly higher soil water content, better seedbed structure and greater crop germination rate., (Aleksandras et al., 2014). Liquid and solid manure applied in the top soil layers (0-7.6 cm), showed significant decreases (10%) in soil bulk density in the top layers where manure had been applied, (Arriaga and Lowery, 2003). The organic matter status of tropical soils is inherently low. The design of management practices is therefore of fundamental importance in improving soil health (Doran and Safley, 1997; Doran et al., 1994; Haris and Bezdicek, 1994). The generation and disposal of municipal solid waste are impotent global environment issues. Recent attention has been directed towards conservation and reclamation of

natural resources. Solid waste, ordinarily considered a nuisance, can be composted for recycling of waste materials. Investigations have ascertained both beneficial and adverse effects of municipal solid waste compost (MSWC). Unfavorable effects have been attributed to poor quality of compost related to maturity and stability (Jimenez and Garcia 1989). Another serious objection to MSWC relates to its content of heavy metals (Stratton et al., 1995), which depends on the source of raw materials from which the compost is derived. Heavy metals inhibit soil health indicators such as microbial biomass (Brookes and McGrath 1984) and activity (Tyler 1981). These microbial parameters are instrumental in nutrient cycling processes and could be used as indicators of soil health (Doran and Parkin, 1994). The effect of MSWC application to a calcareous soil, under laboratory conditions, on the dynamics of soil microbial biomass and microbial activities such as urease (UR) and phosphatase (AP) activities was the aim of this study.

## MATERIALS AND METHODS

Surface soil (0-10 cm depth) was collected from a potato field in the Borg Elarab area, Alexandria, Egypt. Air dried, screened (2mm) and preserved for analyses. MSWC was obtained from a composting facility set up by Borg Elarab Municipal Station. Solid waste was converted into compost by the aerobic fast fermentation process in windrows using microbial culture to enhance composting. The characteristics of the soil and MSWC, expressed on a moisture-free basis and analyzed by standard methods (Page et al., 1982 and EL-Kouny et al., 1999), are given in Table (1).

**Incubation study:** Each one kg of soil was well mixed thoroughly with the MSWC rate corresponding to 0, 2.5, 5, 10, and 20 t<sub>fed</sub><sup>-1</sup>; regarding that the composting application depth is 9 cm in the field (John et al, 2003) and then was placed in a plastic container of 14 cm height and 10 cm diameter, according to statistical design of treatments. Water was added to the soil /compost mixture to bring the moisture content to 60% water holding capacity.

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**Table 1. Physico- chemical characteristics of municipal solid waste compost and calcareous soil**

Parameter	Compost	Soil
Colour	Dark brown	-----
pH	7.5	7.8
EC (dsm <sup>-1</sup> )	2.5	0.93
WHC (%)	85	14
MO%	18.5	43.57
Soil texture	sandy clay loam	
Sand %	-----	64.85
Silt%	-----	12.05
Clay%	-----	23.10
Bulk density (g/cm <sup>3</sup> )	0.61	1.71
Organic C (%)	20	0.75
Total N (%)	1.2	0.2
C/N	16.67	ND
CEC [Cmol /kg <sup>-1</sup> ]	81	8.00
Total humus (%)	22	ND
Compost-C day <sup>-1</sup> at 22 °C		
Microbial biomass (mgkg <sup>-1</sup> )	1709	
Heavy metals (mgkg <sup>-1</sup> )		
Total Zink:	502	-----
Total Copper:	167	-----
Total Cadmium:	1.7	-----
Germination index	94	-----

ND= not determined

The plastic containers were then incubated in the dark for 120 days at 30°C. The moisture content was maintained throughout the incubation period by adding required amounts of sterile distilled water. The experiment had a factorial completely randomized design with 2 replicates. Factor A was 5 levels of MSWC; 0, 2.5, 5, 10, and 20 t fed<sup>-1</sup> added to the soil. Factor B was 7 levels of incubation periods; 10, 20, 30, 45, 60, 90, and 120 days. The treated soil was collected periodically and analyzed. Microbial biomass (MB) in soil was measured by fumigation- extraction method (Joergensen, 1995) and Alef (1995). Urease (UR) and phosphomonoesterase in soil were measured according to Tabatabai and Bremner (1972) and Tabatabai and Bremner (1969) respectively.

## RESULTS AND DISCUSSION

**Compost quality:** Stipulated norms for compost quality assessment by physical, physico-chemical, chemical, microbiological, Biochemical and biological methods are proposed (Epstein 1997, Mondini et al. 1997). The organic-C content, total N content and water holding capacity of the compost were optimal; however, a high electrical conductivity demanded attention. Based on properties such as colour, pH, CEC (cation exchange

capacity), total humus and microbial biomass, the compost could be graded as stable and mature. Biologically, the compost was not phytotoxic as determined by germination index test (Keeling et al. 1994). Total zinc, copper and cadmium contents of the compost were above critical level (Epstein, 1997), which require careful monitoring on application to soil.

**Microbial biomass:** The variations in soil MB between treatments and periods were statistically significant Table (2). A marked increase in soil M was found for each increase in dose of MSWC from 2.5 to 20 t fed<sup>-1</sup>. MB in the treated soil mixture, were significantly higher than the MB in the control. Elsokkary et al., (2011) reported increases in soil MB at 20 and 80 t fed<sup>-1</sup> MSWC application rates to soil. Such increase in soil MB was probably caused by the higher level of soluble organic-C in MSWC- enriched soils. In compost-treated soils, the soil MB reached peak values at 30 days of incubation and decreased gradually, with the lowest value at 120 days. However, in the control treatment the soil MB started declining from 10 days onwards. Availability of biogenic material for biomass stimulation (Jenkinson and Ladd 1981) induced the increase in soil MB of enriched soils. The initial

increase may also correspond to the growth of the zymogenous population associated with organic matter enriched (Jenkinson et al., 1987) and incorporation of exogenous microorganisms (Perucci 1992). The observed decline in soil MB after 30 days, consistent with the work carried out by Sparling (1985), may be associated with a nutrient shortage or the 'protective capacity' of the soil biomass. Excess biomass generated beyond that capacity is automatically killed or lysed, resulting in lower biomass.

**Enzyme activities:** Both the urease (UR) and acid phosphatase (AP) activities in the soil were increased significantly by the increase of MSWC dose as compared to the control treatment (Tables 3 and 4). The activity of UR in the soil increased up to 60 day and then declined at 120 day. In contrast, the acid phosphatase activity in the soil increased up to 90 day, irrespective of treatment, and then declined at 120 day. The dynamics of UR and AP activities in the soil did not follow the trend of MB.

**Table 2. Dynamics of Microbial biomass in calcareous soil amended with graded doses of municipal solid waste compost from Borg Elarab station**

Treatment (T)	Microbial biomass ( $\mu\text{g g}^{-1}$ soil)							
	Period (P) (days of incubation)							
	10	20	30	45	60	90	120	Mean
Control	72	53	35	26	23	18	18	35
2.5 t fed	92	101	106	92	93	56	52	85
5 t fed	120	123	137	114	108	72	69	106
10 t fed	136	160	174	149	121	93	79	130
20 t fed	153	198	205	176	148	121	109	159
Mean	115	127	131	111	99	72	65	

LSD ( $p < 0.05$ ) for T = 10.06; P = 11.90; P \* T = 26.64

**Table 3. Dynamics of urease activity in calcareous soil amended with graded doses of municipal solid waste compost from Borg Elarab station**

Treatment (T)	Urease activity ( $\mu\text{g}$ urea hydrolyzed $\text{g}^{-1}$ soil $\text{h}^{-1}$ at $37^\circ\text{C}$ )							
	Period (P) (days of incubation)							
	10	20	30	45	60	90	120	Mean
Control	19	22	28	32	37	23	13	25
2.5 t fed	29	33	38	40	49	36	15	34
5 t fed	33	36	40	49	58	42	24	40
10 t fed	37	47	51	55	61	48	32	47
20 t fed	43	51	56	66	74	62	37	56
Mean	32	38	43	48	56	42	24	

LSD ( $p < 0.05$ ) for T = 4.52; P = 5.35; P \* T = not significant

**Table 4. Dynamics of Acid phosphatase activity in calcareous soil amended with graded doses of municipal solid waste compost from Borg Elarab station**

Treatment (T)	Acid phosphatase activity ( $\mu\text{g}$ paranitrophenol released $\text{g}^{-1}$ soil $\text{h}^{-1}$ at $37^\circ\text{C}$ )							
	Period (P) (days of incubation)							
	10	20	30	45	60	90	120	Mean
Control	124	127	137	178	177	202	202	164
2.5 t fed	173	189	201	247	258	274	269	230
5 t fed	199	208	218	261	279	284	277	247
10 t fed	209	247	276	304	317	343	337	290
20 t fed	227	256	279	320	342	394	391	116
Mean	187	206	222	262	275	300	295	

LSD ( $p < 0.05$ ) for T = 4.83; P = 5.72; P \* T = 12.77.

The increase in soil enzyme activities followed the decrease of MB suggested that the release of the enzymes was linked to lysis of microbial cells at the end of their life cycle (Perucci, 1990).

Results showed that addition of MSWC in doses as high as 20t fed<sup>-1</sup> did not have a detrimental effect on soil health indicators such as MB and enzyme activities.

### CONCLUSION

In this current work, microbial biomass, urease and acid phosphatase activities, in a calcareous soil amended with different doses of Borg Elarab municipal solid waste compost (MSWC) were studied as dynamics of soil health indicators. MB in the treated soil mixtures, were significantly higher than the MB in the control. Both the urease (UR) and acid phosphatase (AP) activities in the soil were increased significantly by the increase of MSWC dose as compared to the control treatment. The dynamics of UR and AP activities in the soil did not follow the trends of MB. The increase in soil enzyme activities followed the decrease of MB suggested that the release of the enzymes was linked to lysis of microbial cells at the end of their life cycle. Results showed that addition of MSWC in doses as high as 20t fed<sup>-1</sup> did not have a detrimental effect on soil health indicators.

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