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Influence of sewage sludge and organic composts on different soils under incubation periods: I. Zinc and copper releases

Hala Kandil

Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt

Abstract : This incubation experiment was conducted to evaluated the effect of different rates of sewage sludge (11, 22 and 44 ton fed^{-1}) alone or in combination with three rates of banana Compost (BC) and/or cotton compost (CC) on release of extractable Zn and Cu from two different soils during incubation period up to 15 months.

The obtained results can be summarized in the following:

- Extractable Zn and Cu gradually increased with increasing the incubation period up to the end of 15 months.
- The DTPA-extractable Zn and Cu under all the incubated organic manure treatments were remarkably higher than those obtained by control treatment. These results are true for Abou-Rawash sandy soil and El-Nobaria sandy calcareous soil as well as the incubation periods.
- The incorporation of the $SS_{44}BC_{22}$ or $SS_{44}CC_{22}$ treatments in both soils at the different incubation periods significantly increased Zn and Cu under study when they compared with $SS_{22}BC_{22}$ or $SS_{22}CC_{22}$ treatments as well as $SS_{11}BC_{22}$ or $SS_{11}CC_{22}$ respectively.
- The extractable heavy metals at the end of the experiment (after 15 month) in Abou-Rawash and El-Nobaria soils ranged from 8.07 - 13.78, and from 8.50 - 11.68 ppm for extractable Zn, from 1.70 - 4.51, and from 1.92 - 4.60 ppm for Cu, respectively.
- It has been found that the incubation of SS and organic composts to agricultural land increased the release of DTPA- extractable of Zn and Cu in Abou-Rawash sandy soil than those in El-Nobaria sandy calcareous soil.

Key words : Sewage sludge- Banana compost- cotton compost- Zinc- Copper- Heavy metals.

Introduction

Heavy metals released in to environment, among others by sewage sludge, pose a serious problem. While accumulating in living organisms they circulate in the trophic chain and moreover, their dangerous concentrations persist in ecosystems for a long time [1]. Currently remediation methods for heavy metals remove from soil and sludge are expensive and disruptive. Recently, efforts have been directed toward finding remediation strategies that are less expensive and less damaging to soil properties than current approaches.

Organic materials such as crop residues, farmyard manure, town refuse, rice straw, cotton stalks, water hyacinth compost, etc.; are available in abundance and reach tremendous amounts day after day. In rural areas of Egypt most of the crop residues are used for energy production through direct burning. Obviously, this means the loss of a great proportion of the organic matter needed to be composed to keep soil productivity.

Application of organic and compost to the newly reclaimed lands maintain ecological balance and develops biological processes to their optimum case. In addition to preservation of soil structure, earthworm and microorganisms. Addition of composts improve soil chemical and physical properties. It increases the water holding capacity and improve the soil structure and aggregates. Chemical properties include, decrease soil pH, increase cation exchange capacity (CEC) and enhance the availability of the most nutrient which important for plant growth and agricultural production. The intensive use of compost for increasing agricultural production, maintaining and enhancing soil fertility and decreasing pollution hazards is of vital importance especially in the newly reclaimed soil.

Generally, organic composts increase the absorptive power of the soil to nitrates. These absorbed ions are released slowly for the benefit of crop during the entire growth period and thus, there is a high possibility for increasing the concentration and uptake of these nutrients by plants[2]**.** Moreover, organic materials are degraded in soil by chemo-heterotrophic microorganisms and consequently the nutrients become available in soil. The extent of availability of such nutrients depends on the type of organic materials and microorganisms [3] **.**

Toxic heavy metals, in particular Cd, Cu, Zn, Ni and Pb are frequently present in high concentration in sewage sludge [4] **.** According to the 1997 guidelines **WRC** [5], the current standards for the unrestricted use of sludge on agricultural soils, cannot be attained within a reasonable frame work of affordability and applied technology.

Zinc content of the soils depends on the nature of the parent rocks, organic matter, texture, and pH. **El-Sokkary and Lag** [6] gave a range for large number of Egyptian soils of 3-195 ppm for total Zn with an average value of 78 ppm. **Aboulroos et al.,**[7] reported that the mean values of 98, 22 and 28 ppm for total Zn for alluvial, desertic sandy and calcareous soils of Egypt, respectively. They also found that the highest value was for the finer texture and the highest the organic matter content. Available Zn in the soil sample varied from 0.53 mg/kg to 1.3 mg/kg with mean value of 0.62 mg/kg. on the basis of critical limit [8]**.** The extractable Zn in soil represents only small fraction of total Zn. **Sillanpaa** [9] found that the average DTPA extractable Zn for 200 soil samples from Egypt was 1.17 ppm, with a range of 0.29 to 9.18 ppm. This DTPA extractable Zn represents an average only 1.5% of the total Zn in the soils of Egypt. **Aboulroos et al.,**[7] found that values of DTPA extractable-Zn in the studied soils varied widely from 0.42 to 4.38 ppm with an average of 1.79±0.09 ppm. They added that a range of 1.56 to 2.64 ppm DTPA extractable Zn could be used as background level of extractable Zn for the non polluted soils of Egypt.

Copper is bound strongly to clay minerals and organic matter in soils. Applied or deposits Cu persists in soils because it is strongly fixed by organic matter, oxides of Fe, Al, and clay minerals [10]**.** In this concern, **Thomas** [1] found that the bulk of soil Cu is found in organic fraction, particularly in coarse textured soils. **Aboulroos and Abdel-Wahid** [11] found that organic matter contributes by about 44%, silt by 30% and clay by 14% of the total Cu content in some soils of Egypt. Available Cu content in the soil sample varied from 2.4 mg/kg to 3.5 mg/kg with mean value of 3.2 mg/kg. Copper availability is dependent on soil charactaristics. It increases with increase organic matter but decrease with increase in pH and $CaCO_3$ content of soil [8]**.**

Aboulroos et al.,[7] studied the background levels of some heavy metals in soils of Egypt. They found that the values of DTPA extractable Cu in surface soil samples ranged from 1.05 to 4.86 ppm with an average of 3.39±0.08 ppm, soils from El-Menufia and Kafr El-Sheikh governorates possessed the highest level of extractable Cu which is significantly higher than the overall average.

Materials and Methods

Two different surface soil samples (0-30 cm) were collected, two unpolluted soils collected from Abou-Rawash (sandy) and El-Nobaria (sandy calcareous).

Soil samples were air dried, crushed, sieved through a 2mm sieve and thoroughly mixed before use. Some physical and chemical characteristics of the used soils were determined by standard procedures and are presented in Table (1).

Table (1): Some physical and chemical properties of the experimental soils.

Soil	% Sand	% Silt	% Clay	Soil texture	pH 1:2.5	E.C dS/m	% $CaCO_3$	% O.M	% N	Total heavy metals (ppm)		Available heavy metals (ppm)	
										Zn	Cu	Zn	Cu
Abou-Rawash	96.20	1.82	1.98	Sandy	7.92	0.19	0.40	0.26	0.03	14.04	5.45	2.71	0.36
El-Nobaria	89.86	5.58	4.56	Sandy	8.32	0.24	9.20	0.13	0.01	14.30	5.85	2.43	0.32

Sewage sludge was collected from Abou-Rawash station where sewage water has been disposed. Five samples were collected from different locations of different drying beds, and then mixed to form a composite sample. The solid sewage sludge was air dried, ground to pass through 2 mm sieve and stored in a container until the experiments start. The chemical analysis of the used sludge are presented in Table (2).

Table (2): Some properties of the organic composts used in the experiment.

Organic compost	pH 1:25	E.C dS/m	% O.M	C/N Ratio	Total %			Total heavy metals (ppm)		Available heavy metals (ppm)	
					N	P	K	Zn	Cu	Zn	Cu
Sewage sludge	6.22	1.04	46.48	16.85	1.61	0.32	7.82	516.3	186.6	8.04	3.10
Banana compost	6.90	2.70	24.1	17.9	0.78	0.47	2.16	263.6	44.9	3.08	0.58
Cotton compost	6.77	2.37	31.8	20.8	0.89	0.38	1.40	168.5	34.5	2.22	0.74

The composts were prepared from banana and cotton wastes as reported by **Abdel –Moez and Wanas** [12]**.** Banana and cotton wastes were shredded into 1-2 cm and packed in a plastic pots (50, 30 and 60 cm in upper, lower and high diameter, respectively) and supplemented with inorganic amendments (rock phosphate and elemental sulfur) which were added at 3% and 1% on weight basis, respectively and thoroughly mixed, some biofertilizers such as cellulose decomposes, yeast strain belonging to Candida Sp. at the rate of 5ml /kg wastes were added after the 1stturning 15 days from the beginning, this strain was kindly supported by Gomaa, A.M. Department of Agricultural Microbiology, NRC. The organic materials were composted for 2 months as described by **Datazell et. al.,** [13]**.** Chicken manure was added after the second turning (30 days from the beginning) at the ratio of 1: 3 Chickens to the organic materials, to enrich the wastes and the moisture was maintained at 60%. Some chemical analyses are presented in Table (2).

To study the release of Zn and Cu from the two different soils as affected by organic manure treatments and incubation periods; incubation experiments were conducted in the greenhouse at the National Research Center. Sandy and sandy calcareous soils were selected from Abou-Rawash and El-Nobaria regions, respectively for these studies.

The organic manure treatments in the incubation experiment were in three rates (11 , 22 and 44 t fed^{-1}) from sewage sludge, banana and cotton composts with three replicates, the incubation experiment 14 treatments of organic manure with three replicates were used. The organic treatments in this experiment were as follows:

1- Control. 2- SS_{11}. 3- SS_{11}+BC_{22}. 4-SS_{11}+CC_{22}. 5- SS_{22}.
6- SS_{22}+BC_{22}. 7- SS_{22}+CC_{22}. 8-SS_{44}. 9- SS_{44}+BC_{11}. 10- SS_{44}+BC_{22}.
11- SS_{44}+BC_{44}. 12- SS_{44}+CC_{11}. 13-SS_{44}+CC_{22}. 14- SS_{44}+CC_{44}.
(where SS : sewage sludge , BC : banana compost, CC : cotton compost).

Two kg samples of each of the two chosen soils from Abou-Rawash and El-Nobaria were packed in pots with a diameter of 20 cm and high of about 30 cm. The organic manure treatments as mentioned before were mixed thoroughly with the soil samples.

Three replicates for each treatment were run. Pots were kept at the greenhouse of National Research Centre (NRC) for the incubation period of 15 months. The moisture content was maintained at 70% of the water holding capacities of the used soils. After the period of storage at the normal conditions, soil samples of the different treatments from the incubation experiment were taken at 0 time (start) and after 3, 6, 12 and 15 months for the extraction of available (Zn and Cu) by **Lindsay and Norvell** [14]**.**

Statistical analysis:

The obtained results were subjected to analysis of variance according to **Snedecor and Cochran** [15] and the treatments were compared by using the L.S.D test at 0.05 and 0.01 levels of probability.

Results and Discussion:-

This incubation experiment was conducted to evaluate the effect of different rates of sewage sludge alone or in combination with three rates of banana compost and cotton compost on the release of DTPA-extractable Zn and Cu from Abou-Rawash and El-Nobaria soils during incubation period of 15 months.

It is observed from data in Tables (3 and 4) that the DTPA- extractable Zn and Cu gradually increased with increasing the incubation period up to the end of 15 months. The DTPA- extractable Zn and Cu under all the incubated organic waste treatments were remarkably higher than those obtained by control treatment.

These results are true for Abou-Rawash and El-Nobaria soils. The obtained results could be explained on the basis of variable decomposition rate with variable rate of heavy metals release from the applied organic wastes during the incubation periods. In this concern **Saha et al.,** [3] reported that organic materials are degraded in soil by chemoheterophic microorganisms and consequently the nutrients became available in soil. They added that the extent of availability of such nutrients depends on the type of organic materials and microorganisms. Data also show that the highest values of DTPA-extractable Zn and Cu were obtained after incubation period of 15 months in both soils. These results may indicate that a long period of decomposition was necessary for such rate of application of hardly decay materials as recommended by **Badran and Badr** [16.]

Table (3): Influence of sewage sludge and organic composts of banana and cotton on release of DTPA - extractable Zn from Abou-Rawash and El-Nobaria soils under incubation periods.

(DTPA) Available Zn (ppm)										Organic treatments
El-Nobaria					Abou-Rawash					
Incubation period (months)										
15	12	6	3	0	15	12	6	3	0	
3.20	3.04	2.58	2.43	2.39	4.00	3.47	2.78	2.71	2.70	Control
8.50	7.69	6.60	4.20	4.14	8.07	6.45	5.59	5.30	4.00	SS_{11}
10.26	8.99	6.80	5.29	5.13	9.77	9.47	6.40	6.11	6.07	SS_{11}+BC_{22}
8.58	7.72	6.47	4.89	4.76	9.61	9.42	6.20	5.64	5.48	SS_{11}+CC_{22}
9.68	8.63	7.13	5.96	5.80	9.55	8.65	6.52	5.71	5.48	SS_{22}
10.69	9.63	7.31	6.13	5.94	11.93	11.37	6.73	6.48	6.38	SS_{22}+BC_{22}
9.68	8.90	6.98	5.67	5.48	12.43	11.19	6.59	6.20	6.00	SS_{22}+CC_{22}
10.15	9.78	7.41	6.60	6.46	10.98	10.13	6.97	6.82	5.82	SS_{44}
10.75	9.38	6.99	6.10	5.89	11.92	9.79	6.79	6.49	6.38	$SS_{44+}BC_{11}$
11.68	9.53	7.83	6.65	6.47	13.78	13.53	8.50	7.09	6.96	SS_{44+} BC_{22}
10.10	8.97	6.80	6.40	6.26	12.80	12.50	7.50	6.52	6.46	SS_{44+} BC_{44}
9.99	9.27	6.78	6.28	6.02	10.30	9.70	6.49	6.10	5.96	SS_{44+} CC_{11}
10.36	9.22	7.13	6.39	6.24	12.04	11.87	7.20	6.80	6.65	SS_{44+} CC_{22}
9.85	9.18	7.03	6.56	6.43	11.17	10.86	6.82	6.22	6.12	SS_{44+} CC_{44}
0.37	0.26	0.30	0.40	0.24	0.61	0.58	0.27	0.28	0.30	L.S.D 5 %
0.49	0.37	0.43	0.53	0.33	0.82	0.78	0.36	0.37	0.41	1%

Table (4): Influence of sewage sludge and organic composts of banana and cotton on release of DTPA - extractable from Abou-Rawash and El-Nobaria soils under different incubation periods.

(DTPA) Available Cu (ppm)										Organic treatments
El-Nobaria					Abou-Rawash					
Incubation period (months)										
15	**12**	**6**	**3**	**0**	**15**	**12**	**6**	**3**	**0**	
0.42	0.39	0.36	0.32	0.30	0.51	0.45	0.40	0.36	0.34	Control
2.31	1.73	1.12	0.71	0.65	1.70	1.36	0.85	0.77	0.72	SS_{11}
2.17	1.64	1.30	0.75	0.66	2.63	1.87	1.02	0.99	0.86	SS_{11}+BC_{22}
1.92	1.15	0.94	0.77	0.72	2.09	1.66	0.81	0.71	0.68	SS_{11}+CC_{22}
2.91	2.16	1.85	1.22	1.16	2.90	2.27	1.14	0.94	0.84	SS_{22}
2.46	2.25	1.98	1.76	1.72	3.23	2.45	1.30	1.20	1.14	SS_{22}+BC_{22}
2.63	2.08	1.40	0.95	0.88	2.87	2.06	1.19	1.16	1.10	SS_{22}+CC_{22}
4.60	4.16	3.15	2.67	2.35	3.67	3.36	1.53	1.48	1.20	SS_{44}
3.54	3.04	2.40	1.72	1.66	3.70	3.42	2.24	1.82	1.52	$SS_{44+}$$BC_{11}$
3.20	2.63	2.26	1.96	1.90	3.72	3.43	1.62	1.46	1.34	SS_{44+} BC_{22}
3.89	3.33	2.42	2.15	2.06	4.51	4.12	2.30	1.86	1.54	SS_{44+} BC_{44}
2.89	2.42	1.85	1.65	1.58	4.14	4.02	2.40	1.69	1.50	SS_{44+} CC_{11}
3.76	3.11	2.15	1.58	1.49	3.31	2.71	1.73	1.39	1.26	SS_{44+} CC_{22}
3.51	2.84	2.17	1.91	1.82	4.05	3.59	1.82	1.45	1.28	SS_{44+} CC_{44}
0.25	0.24	0.19	0.18	0.11	0.36	0.17	0.19	0.18	0.12	L.S.D 5%
0.34	0.32	0.26	0.24	0.15	0.95	0.22	0.25	0.24	0.17	1%

Data reveal that incubation of different rates of sewage sludge alone or in combination with banana and cotton composts (BC & CC) significantly increased DTPA extractable Zn and Cu from Abou-Rawash and El-Nobaria soils at all the incubation periods as compared with untreated control. These results are in close agreement with the findings of **Samaras et al.,** [17] who stated that addition of sewage sludge and city waste compost to sandy soil decreased its soil pH and increased strongly the availability forms (DTPA-extractable form) of Zn and Cu.

It is clear from results obtained in Tables (3 and 4) that application of sewage sludge with the rate of 44 t/fed in both soils of significantly increased DTPA- extractable Zn and Cu at all the incubation periods. as compared with the other two rates of SS_{11} and SS_{22}. Data also reveal that treatments of SS_{44} BC_{22} or SS_{44} CC_{22} in both soils at the different incubation periods significantly increased all the heavy metals under study when compared with the treatments SS_{22} BC_{22} or SS_{22} CC_{22}as well as SS_{11} BC_{22} or SS_{11} CC_{22}, respectively. Also, addition the rate of SS_{22} BC_{22} or SS_{22} CC_{22} took the same trend when compared with the treatments SS_{11} BC_{22} or SS_{11} CC_{22}, respectively. The previous results show that DTPA- extractable Zn significantly increased by increasing the application rates of sewage sludge from 11 to 44 t/fed. These results stood in agreement with those obtained by **Wong et al.,** [18] and **Badawy and El-Motium** [19] who reported that DTPA- extractable heavy metals (Zn, Cu, Pb and Cd) increased according to the levels of sludge amendment for both limed and unlimed soil. Also, they reported that amounts of DTPA- extractable Zn, Cu, Cd and Ni increased linearly with the rate of sludge application.

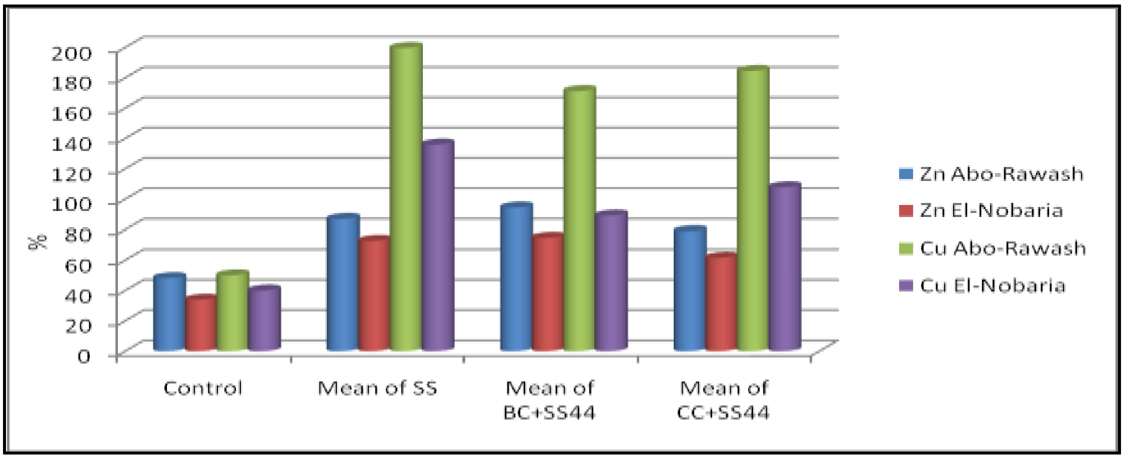

Fig. (1): Release percentage of DTPA-extractable Zn and Cu from Abou-Rawash sandy soil and El - Nobaria calcareous soil at the end of experiment (after 15 months) as affected by different waste treatments.

Data in Figure (1) show that the release of extractable Zn and Cu differed from soil to other and from metal to another, Generally, it has been found that the incubation of sewage sludge and organic waste composts to agricultural land increased the release of DTPA– extractable of studied heavy metals (Zn and Cu) in Abou-Rawash sandy soil than those in El-Nobaria calcareous soil. These increases were affected by soil types, organic waste source, incubation periods and the concerned element and this results agreement with **Nedaeinia et al.,[20].**

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