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Influence of sewage sludge and organic composts on different soils under incubation periods: II. Heavy metals (Pb, Cd and Ni) releases.

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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 Pb, Cd and Ni from two different soils during incubation period up to 15 months.
The obtained results can be summarized in the following:
-Heavy metals (Pb, Cd and Ni) gradually increased with increasing the incubation period up to the end of 15 months.
-Heavy metals (Pb, Cd and Ni) 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 Pb, Cd and Ni 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 levels of the studied heavy metals could be arranged according to their concentrations in the decreasing order of: Pb > Ni > Cd.
-It has been found that the incubation of SS and organic composts to agricultural land increased the release of heavy metals (Pb, Cd and Ni) 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 in soil is very important because its direct effects on plant production and human nutrition [1]. The pollution of heavy metals restricted to the upper layer (surface layer) only, the heavy metals originating from various organic waste sources accumulate in the surface. The organic matter content in the uppermost layer is higher than in the lower layer [2].

The importance of heavy metals as environmental pollutants is well know and well documented in literature. **Underwood** [3] reported that the most toxic elements to plants when present in excess are Cd, Cu, Pb and Zn but damage may be caused by As, B, Cr, Hg, Mn, Mo, Ni and Se. Once metals are mobilized, they are available for uptake by several organisms, including plants. Each plant species requires a certain level of several heavy metals, which is usually higher than what is found in the surrounding environment.

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.

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 [4]**.** 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 [5]**.**

Toxic heavy metals, in particular Cd, Cu, Zn, Ni and Pb are frequently present in high concentration in sewage sludge [6] **.** According to the 1997 guidelines **WRC,** [7] 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.

Agricultural soils can have a wide range of Pb content, depending on parent material and anthropogenic inputs. **Noufal** [8] found that Pb ranged from 10.0 to 38.0 ppm and DTPA Pb ranged from 0.20 to 3.04 ppm with no pattern of distribution. He added that there was no significant correlation occurred between total Pb and soil parameters; however a significant positive correlation occurred between DTPA-Pb and $CaCO_3$.

Cadmium contents of nonpolluted soils are largely dependent on the rocks from which the soil parent material was derived and on the process of weathering to which the soil-forming materials have been subjected. **Noufal** [8] found that total Cd ranged from 0.35 to 4.99 mg/kg soil, DTPA extractable Cd varied from 0.01 to 0.09 mg/kg soil and both forms decreased with profile depth. Significant negative correlation occurred between total Cd and DTPA-Cd and pH, and highly significant positive correlation occurred with organic matter. The soil content of Ni is extremely variable, **Rashad et al.,**[9] found that the normal level of total Ni in alluvial soil of Nile Delta ranged between 21.0-44.0 ppm (average 32.0 ppm), and from 0.38 to 1.04 ppm (average 0.66 ppm) for available form. **Aboulroos et al.,**[10] recorded 0.3-1.02 ppm (average 0.64 ppm) for available Ni in these soils.

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)		
										Pb	Cd	Ni	Pb	Cd	Ni
Abou-Rawash	**96.20**	**1.82**	**1.98**	**Sandy**	**7.92**	**0.19**	**0.40**	**0.26**	**0.03**	**5.30**	**0.54**	**0.80**	**0.27**	**0.015**	**0.026**
El-Nobaria	**89.86**	**5.58**	**4.56**	**Sandy**	**8.32**	**0.24**	**9.20**	**0.13**	**0.01**	**7.07**	**0.52**	**0.84**	**0.44**	**0.009**	**0.055**

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	Pb	Cd	Ni	Pb	Cd	Ni
Sewage sludge	**6.22**	**1.04**	**46.48**	**16.85**	**1.61**	**0.32**	**7.82**	**72.6**	**16.89**	**17.6**	**0.80**	**0.24**	**0.18**
Banana compost	**6.90**	**2.70**	**24.1**	**17.9**	**0.78**	**0.47**	**2.16**	**33.9**	**0.50**	**10.8**	**0.48**	**0.16**	**0.30**
Cotton compost	**6.77**	**2.37**	**31.8**	**20.8**	**0.89**	**0.38**	**1.40**	**53.2**	**0.33**	**15.2**	**0.56**	**0.14**	**0.24**

The composts were prepared from banana and cotton wastes as reported by **Abdel –Moez and Wanas [11].** 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., [12].** 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 heavy metals (Pb, Cd and Ni) 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).

Preparation of incubation experiment pots:

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 Pb, Cd and Ni by **Lindsay and Norvell [13].**

Statistical analysis:

The obtained results were subjected to analysis of variance according to **Snedecor and Cochran[14]** 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 heavy metals (Pb, Cd and Ni) from Abou-Rawash and El-Nobaria soils during incubation period of 15 months. It is observed from data in Tables (3, 4 and 5) that the heavy metals (Pb, Cd and Ni) gradually increased with increasing the incubation period up to the end of 15 months. The heavy metals (Pb, Cd and Ni) under all the incubated organic waste treatments were remarkably higher than those obtained by control treatment.

Extractable Pb, Cd and Ni gradually increased with increasing the incubation period up to the end of 15 months. The heavy metals (Pb, Cd and Ni) 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.

Data show that incubation of different rates of SS alone or in combination with BC and CC significantly increased heavy metals (Pb, Cd and Ni) from Abou-Rawash and El-Nobaria soils at all the incubation periods of 0, 3, 6, 12 and 15 months (at end) as compared with untreated control. The levels of the studied heavy metals could be arranged according to their concentrations in the decreasing order of: Pb > Ni > Cd. In corporation of SS with application rate of 44 t fed.$^{-1}$ (SS_{44}) in both soils of Abou-Rawash and El-Nobaria soils, significantly increased the heavy metals (Pb, Cd and Ni) at all the incubation periods of 0, 3, 6, 12 and 15 months as compared when the other two rates of SS (SS_{11}& SS_{22}) were incorporated in both used soils.

The incorporation of the $SS_{44}BC_{22}$ or $SS_{44}CC_{22}$ treatments in both soils at the different incubation periods significantly increased all the heavy metals 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 obtained results show that heavy metals (Pb, Cd and Ni) significantly increased by increasing the application rates of sewage sludge from 11 to 44 t/fed. Under all the application rates and incubation periods, data show that incubation of BC treatments with the different rates of SS (11, 22 and 44 t/fed.) in Abou-Rawash and El-Nobaria soils significantly increased the heavy metals (Pb, Cd and Ni) as compared with CC treatments. These results show the beter effect of BC on extractable heavy metals in both soils than using CC treatments with SS. The extractable heavy metals at the end of the experiment (after 15 month) in Abou-Rawash and El-Nobaria soils ranged from 8 1.47 - 3.67 and from 1.90 - 3.86 ppm for Pb, from 0.05 - 0.098 and from 0.050 - 0.119 ppm for Cd and from 0.335 - 0.775 and from 0.501 - 0.940 ppm for Ni respectively. These results stood in agreement with those obtained by **Wong et al.,[15], Badawy, El-Motium[16]** and **Nedaeinia et al.,[17]** 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.

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

(DTPA) Available Pb (ppm)										Organic treatments
El-Nobaria					Abou-Rawash					
Incubation period (months)										
15	12	6	3	0	15	12	6	3	0	
0.47	0.45	0.45	0.44	0.42	0.32	0.29	0.28	0.27	0.25	Control
2.07	1.59	1.19	0.73	0.70	1.86	1.65	0.86	0.69	0.57	SS_{11}
1.96	1.65	1.14	0.95	0.91	1.47	1.25	0.89	0.64	0.47	$SS_{11}+BC_{22}$
1.90	1.56	0.93	0.85	0.79	1.84	1.56	1.04	0.68	0.48	$SS_{11}+CC_{22}$
2.85	2.57	1.95	1.03	0.99	2.99	2.71	1.08	0.81	0.63	SS_{22}
2.85	2.36	1.54	1.31	1.26	1.70	1.45	1.14	0.83	0.61	$SS_{22}+BC_{22}$
2.67	2.34	1.47	1.25	1.20	2.08	1.71	1.15	0.84	0.62	$SS_{22}+CC_{22}$
3.86	3.54	2.50	1.93	1.86	3.67	3.23	1.59	0.98	0.82	SS_{44}
3.36	3.07	1.93	1.41	1.36	3.29	3.04	1.71	1.13	0.95	$SS_{44+}BC_{11}$
3.58	2.97	1.81	1.69	1.64	2.61	2.39	1.69	1.11	0.95	$SS_{44+}BC_{22}$
3.66	3.46	2.09	1.63	1.59	3.45	3.18	1.86	1.26	1.06	$SS_{44+}BC_{44}$
2.84	2.31	1.80	1.60	1.56	2.94	2.64	1.30	1.16	1.03	$SS_{44+}CC_{11}$
3.41	3.13	1.92	1.77	1.70	2.29	1.94	1.49	1.07	1.01	$SS_{44+}CC_{22}$
3.25	2.88	1.99	1.82	1.75	3.12	2.89	1.56	1.26	1.12	$SS_{44+}CC_{44}$
0.23	0.26	0.12	0.11	0.07	0.13	0.23	0.16	0.09	0.09	L.S.D 5%
0.32	0.35	0.17	0.15	0.09	0.18	0.34	0.22	0.12	0.12	1%

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

(DTPA) Available Cd (ppm)										Organic treatments
El-Nobaria					Abou-Rawash					
Incubation period (months)										
15	12	6	3	0	15	12	6	3	0	
0.011	0.010	0.009	0.009	0.009	0.018	0.017	0.016	0.015	0.014	Control
0.050	0.038	0.033	0.018	0.016	0.050	0.026	0.023	0.018	0.016	SS_{11}
0.067	0.054	0.045	0.033	0.031	0.067	0.043	0.031	0.027	0.025	$SS_{11}+BC_{22}$
0.060	0.044	0.037	0.032	0.030	0.064	0.044	0.027	0.022	0.019	$SS_{11}+CC_{22}$
0.070	0.046	0.038	0.028	0.025	0.061	0.042	0.031	0.022	0.021	SS_{22}
0.078	0.065	0.057	0.044	0.040	0.080	0.066	0.035	0.031	0.028	$SS_{22}+BC_{22}$
0.069	0.057	0.049	0.042	0.040	0.075	0.059	0.037	0.029	0.026	$SS_{22}+CC_{22}$
0.090	0.066	0.062	0.041	0.039	0.070	0.057	0.037	0.033	0.030	SS_{44}
0.100	0.063	0.056	0.048	0.045	0.068	0.059	0.049	0.033	0.030	$SS_{44+}BC_{11}$
0.092	0.077	0.068	0.057	0.054	0.098	0.082	0.043	0.034	0.031	$SS_{44+}BC_{22}$
0.119	0.079	0.068	0.059	0.056	0.087	0.071	0.050	0.042	0.038	$SS_{44+}BC_{44}$
0.082	0.057	0.050	0.043	0.040	0.076	0.060	0.053	0.045	0.042	$SS_{44+}CC_{11}$
0.084	0.066	0.058	0.049	0.047	0.089	0.069	0.046	0.034	0.030	$SS_{44+}CC_{22}$
0.102	0.072	0.062	0.054	0.051	0.084	0.064	0.057	0.049	0.045	$SS_{44+}CC_{44}$
0.006	0.005	0.005	0.004	0.005	0.007	0.008	0.004	0.003	0.003	L.S.D 5%
0.010	0.006	0.007	0.006	0.007	0.009	0.011	0.005	0.004	0.004	1%

Table (5): Influence of sewage sludge and organic composts of banana and cotton on release of DTPA-extractable Ni from Abou - Rawash and El – Nobaria soils under incubation periods.

(DTPA) Available Ni (ppm)										Organic treatments
El-Nobaria					Abou-Rawash					
Incubation period (months)										
15	12	6	3	0	15	12	6	3	0	
0.060	0.058	0.057	0.055	0.050	0.039	0.034	0.029	0.027	0.025	Control
0.501	0.347	0.243	0.143	0.131	0.336	0.249	0.221	0.117	0.122	SS_{11}
0.800	0.575	0.270	0.118	0.110	0.393	0.274	0.224	0.137	0.128	$SS_{11}+BC_{22}$
0.678	0.374	0.187	0.096	0.072	0.335	0.239	0.163	0.103	0.089	$SS_{11}+CC_{22}$
0.641	0.498	0.429	0.207	0.178	0.560	0.344	0.247	0.206	0.170	SS_{22}
0.825	0.729	0.369	0.224	0.208	0.549	0.359	0.275	0.187	0.164	$SS_{22}+BC_{22}$
0.781	0.561	0.269	0.168	0.160	0.439	0.284	0.241	0.145	0.126	$SS_{22}+CC_{22}$
0.800	0.637	0.573	0.345	0.328	0.774	0.454	0.290	0.258	0.225	SS_{44}
0.741	0.692	0.341	0.190	0.173	0.554	0.452	0.401	0.199	0.168	$SS_{44+}BC_{11}$
0.851	0.700	0.430	0.261	0.237	0.642	0.458	0.374	0.229	0.202	SS_{44+} BC_{22}
0.940	0.801	0.582	0.346	0.337	0.775	0.571	0.431	0.219	0.193	SS_{44+} BC_{44}
0.600	0.559	0.260	0.167	0.150	0.493	0.300	0.252	0.161	0.138	SS_{44+} CC_{11}
0.701	0.545	0.367	0.213	0.192	0.581	0.406	0.350	0.186	0.154	SS_{44+} CC_{22}
0.734	0.654	0.431	0.234	0.211	0.684	0.484	0.407	0.186	0.158	SS_{44+} CC_{44}
0.133	0.098	0.034	0.022	0.009	0.060	0.030	0.023	0.025	0.010	L.S.D 5%
0.179	0.132	0.045	0.030	0.012	0.085	0.040	0.031	0.033	0.014	1%

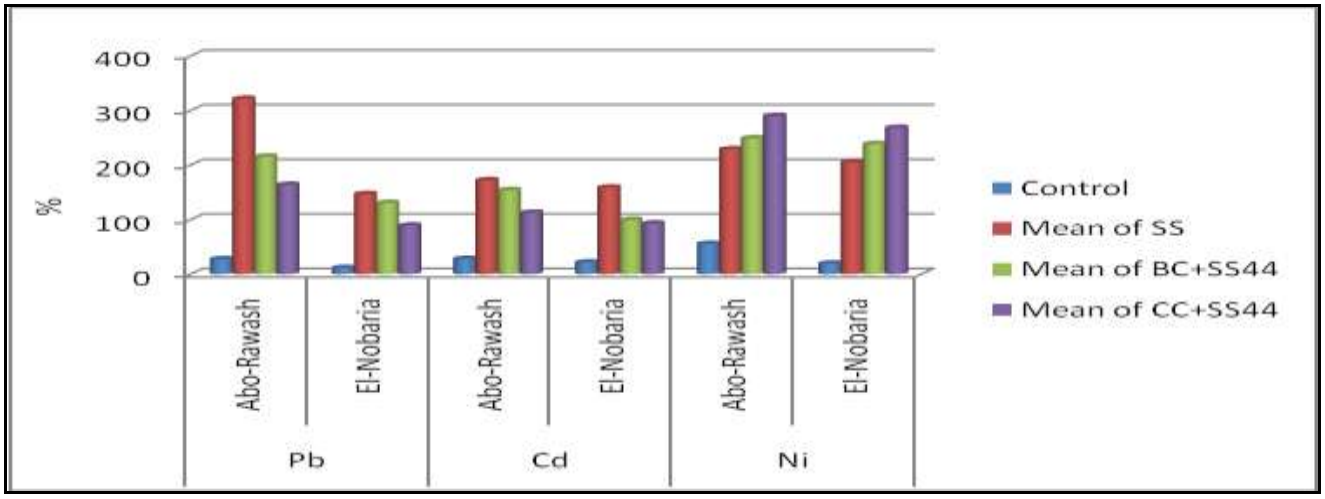

Fig. (1): Release percentage of heavy metals (Pb, Cd and Ni) from Abou-Rawash sandy soil and El - Nobaria calcareous soil at the end of experiment (after 15 months) as affected by different waste treatments.

Data in figure (1) show that the release percentages of extractable heavy metals differed from soil to other and from metal to another, they took the following order in Abou-Rawash soil Pb > Ni > Cu > Cd > Zn, Ni > Pb > Cu > Cd > Zn and Ni > Cu > Pb > Cd > Zn as affected with incorporation of mean SS, mean BC+SS44 and mean CC+SS44 treatments respectively. While in El-Nobaria soil were Ni > Cd, Pb, Cu, Zn, Ni > Pb > Cd > Cu >Zn and Ni > Cu > Cd > Pb > Zn as affected with mentioned treatments.

It has been found that the incubation of SS and organic composts to agricultural land increased the release of DTPA- extractable of heavy metals in Abou-Rawash sandy soil than those in El-Nobaria sandy calcareous soil. this results are harmony with **Nedaeinia et al.,[17].**

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 (Pb, Cd and Ni) 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.

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