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Bioaccumulation of heavy metals during composting and vermicomposting processes of sewage sludge

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Abstract

Using of sewage sludge as an organic fertilizer is restricted by international standards because it contains heavy elements in addition to, pathogenic microorganisms. Therefore, this study aimed to use technology of both composting and vermicomposting to remove heavy elements from sewage sludge by using bio-accelerator (*Trichoderma harzianum*, *Trichoderma viride* and *Phanerochaete chrysosporium,*) and vermi worms (*Eisenia fetida*) individually or combined together. The results showed that the use of bio-accelerator and *Eisenia fetida* worms together had a significantly positive effect on reducting the concentration of heavy metals to the safe limit compared to the Egyptian code during the 12-week experiment period, where it decreased the available concentration of heavy metals (Lead, Nickel and Cadmium) from 6.429, 4.448 and 0.197 in the initial experiment to 0.213, 0.142 and 0.065 mg /kg in the final experiment, respectively. Also, total concentrations of heavy metals were reduced to 313.95, 210.40 and 10.85 for Pb, Ni and Cd (mg/ kg) initially; meanwhile, the final concentrations did not exceed either the Egyptian code limits or worldwide Standards. In addition, to improve quality (NPK) of organic fertilizers and safety represented the highest percentage of removal 72, 67 and 62% for Cd, Ni and Pb respectively. So, this technique for sewage sludge treatment is considered promising for production of quality organic fertilizer and safe environmentally.

Keywords: compost, vermicompost, *Trichoderma harzianum*, *Trichoderma viride, Phanerochaete chrysosporium, Eisenia fetida*, heavy metals.

1. Introduction

The rapid growth of human populations causes a variety of problems around the world, particularly in developing countries (1). Organic wastes such as agricultural residues, organic industrial wastes and sewage sludge contain hazardous substances particularly heavy metals. Although sewage sludge is a source of organic matter and plant nutrients such as nitrogen, phosphorus and potassium, however, it also contains different toxic heavy metals such as cadmium (Cd), nickel (Ni), chromium (Cr), lead (Pb), mercury (Hg), and selenium (Se). The main risks of heavy metals are non-biodegradable compared with the other organic pollutants (2).

Argun *et al.* (3) reported that composting is defined as biodegradable stabilized and mineralized humus transformation process by bacteria, micro- and higher-level organisms of decomposable organic constituents (agricultural, urban commercial etc. wastes) in solid wastes. The evaluations of the composting process, compost maturity and stability were based on physical and chemical parameters of organic material content, reflecting the metabolic activity of micro-organisms involved in the composting process (4).

YAO *et al.* (5) stated that the fulvic acid (FA) and humic acid (HA)) especially humic acid, decreased the release of Pb, Cu and Cd, reducible and oxidable Pb, Cu and Cd, so, humic and fulvic are promising tools for immobilize heavy metals and prevent it from absorption.

Nurul *et al.* (6) suggested that the combination culture of microorganisms have a vital role for biodegradation of rice straw and faster of composting process. Also, these groups of microorganisms have ability of to enhance final product so, using combination culture decrease period of process and used to manage agriculture waste.

Vermicomposting process is a type of composting that certain species of earthworms are used to enhance the organic waste conversion to higher quality of final product. Vermicomposting

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technology is considered an appropriate treatment of the sewage sludge, besides it is one of the most important fields of environmental protection, where it can be considered as one of the most environmentally sustainable solutions; it provides valuable humus as well as decreasing the heavy metals content and numbers of pathogens bacteria (7). *Eisenia fetida* is an epigeic species that feeds on organic materials in the soil humic zone. It is a small worm measures 7.5 cm length and reddish brown in color. Earthworm population is affected by many factors as pH, temperature, moisture, aeration and type of worm food (8). During their feeding activities, it can accumulate heavy metals in their tissues; they can affect either availability or total heavy metal concentrations and hence reduce their involvement in food chain (9).

Turgay *et al.* (10) found that Earthworms can affect either available or total metal concentrations in soil in that they have capability to accumulate heavy metals in their tissues and hence reduce their involvement in soil food chain. During their feeding activities, earthworms can change either available or total metal concentrations in soil in that they are capable to accumulate heavy metals in their tissues.

Suleiman *et al*. (11) confirmed that the stabilized sludge has metal levels below the standard limits in 60 days from the initiation of vermicomposting process. Earthworms mineralize the nitrogen and phosphorus in sludge to make them bio-available to plants as nutrients. Meanwhile, mineralization of organic matter in sewage sludge by earthworms leads to a significant decrease in total organic carbon content and C/N ratio. Most nutrients recommended for plants are accessible in vermicompost, as well as considerable levels of humic substances (12). The aim of this study is to investigate tracking the pathway of heavy metals during the sewage sludge composting and vermicomposting process.

Materials and Methods

1- Waste materials

Sewage sludge was brought from El-Gabal El Asfar station for wastewater treatments, Cairo Governorate, Egypt.

Rice straw was collected from Moshtohor, Qalubia Governorate, air dried and chopped into small pieces (2-5 cm length). The chemical and physical properties of sewage sludge and rice straw were performed by Agric. Microbiological. Dept., Soils, Water and Environmental Res. Inst. (SWERI), Agriculture Research Center (ARC), Giza, Egypt.

2- Bio-accelerators

Pure strains culture of *Trichoderma harzianum* NRRL13019, *Trichoderma viride* NRRL3635 were used as cellulose decomposer. *Phanerochaete chrysosporium* NRRL 6359 were used as lignin decomposer. Strains were kindly provided by Microbiology. Dept., SWERI, ARC, Giza, Egypt. The medium was used to propagate the fungal strains in order to prepare the fungal inoculants (bio-accelerator), and the medium content was glucose (20g/L), potato infusion (1L) and pH was 5.6±0.2 (13).

3- Earthworm

Eisenia fetida was kindly provided by the Central Laboratory for Organic Agriculture, ARC, Giza, Egypt.

Experimental design:

Three experiments were carried out at the Organic Agriculture Central Laboratory, ARC.

First experiment (bio-accelerator group). Compost depended on the mixture of sewage sludge, rice straw and bio-accelerator. The statistical analysis was split split plot where the main plot was bio-accelerator and sub plot involved five treatments T1: Sewage sludge 100%, T2: Sewage sludge 75% mixed with rice straw 25%, T3: Sewage sludge 50% + rice straw 50%, T4: Sewage sludge 25% + rice straw 75% and T5: Rice straw only by rate 100%. Treatments were arranged in piles, each pile weighed about 200Kg out of the components of each one. The dimension of pile was 1m width, 1.5m length and 1m height. Fungal inoculant (*Trichoderma harzianum, viride* and *Phanerochaete chrysosporium*) were employed in a ratio of 1:1:1, as a biodegradable agent; the mixture was added to the piles at a rate of 10 L (10^9 cfu/100ml) per ton of raw materials, before starting the composting process. The process was continued up to 12 weeks. The physical and chemical analyses of compost and vermicompost samples were determined at zero time and monthly.

The main motives for not adjusting the C/N ratio at the beginning of the mixtures are that earthworms would be affected by the excessive accumulation of heavy metals according to (14).

Second experiment of vermicompost (earthworm group). The same aforementioned arrangement and same design of mixtures in compost process was followed with the addition of earthworm (*Eisenia fetida*) as main plot and sub plot were the treatments and denoted as T6 to T10.

Third experiment of pretreated vermicompost (bio-accelerator with earthworm). The same syllabus, experiment was run where it included five treatments by the same previous arrangement as compost experiment where the treatments included T11 to T15 represented sub plot, meanwhile, the main plot was mix between bio-accelerator with earthworm. This experiment a part of its considering pretreat vermicompost for different mixtures of sewage sludge with rice straw by addition bio-accelerators before counting other part by earthworm addition. After the addition of bio-accelerators, the temperature was continued to rise as result of biodegradation organic matter to reach thermophilic stage after which this temperature period was appropriate for biodegradation reach to 30 ^{0}C. It's worthy to mention that, the thermal stabilization must be secured before addition of earthworm into the raw materials, because high temperature is lethal for it. Therefore, *Eisenia fetida* was introduced into each set of the plastic bin, containing the pre-composted material.

The chemical analysis of compost and vermicompost samples included organic matter (OM), organic carbon (OC), carbon / nitrogen ratio (C/N) ratio, total nitrogen (TN), total phosphorus (TP), total potassium (TK), available and total concentration of heavy metals (Pb, Ni and Cd).

Methods:

Chemical determinations:

1.Organic matter: was determined according to (15).

2. Organic carbon was calculated according to (16).

3.Total nitrogen: was determined by (17).

4.Total phosphorus and Potassium: were determined according to (17).

5. Heavy metals: heavy metals (Cd, Ni and Pb) were digested and measured according to (18).

Statistical analysis:

Generally a split-split plot design was method of statistical analysis for three experiments. The main plot was differ for each experiment and the treatments were arranged in a randomized complete block design with three replications for each parameter. The treatment means were compared using least significant difference (L.S.D.) test as given by (19).

Results and Discussion

In a preliminary step, the analysis of raw materials used in formation of the piles was crucial to know the limits of heavy metals in each raw material. Data in Table (1) showed that the total heavy metals in raw sewage sludge was obtained 321.7, 222.25 and 12.50 mg/ Kg for lead, Nickel and cadmium, individually. Meanwhile, rice straw was the lowest in heavy metals content as well as NPK elements (benefit for soil and plants) also, contents of rice straw from organic matter (92.50%) was more than sewage sludge (53.10%) .

These trends are consistent with those of Connor *et al.* (20) who found that the contents of sewage sludge form heavy metal was more than the limits of worldwide standards particularly sewage sludge produced from mix with industrial wastewater.

Table (1): Chemical and physical characteristics of raw materials.

Characteristics	Rice straw	Sewage sludge
pH (1:10)	6.88	8.13
EC (1:10) dS/m	2.13	5.58
Bulk density kg/m^3	105	510
Moisture content %	10.00	46.00
Organic matter (OM %)	92.50	53.10
Organic carbon (OC %)	53.65	30.80
Total nitrogen (TN %)	0.50	2.00
NH^+_4-N, (mg/kg**)**	18	458
NO^-_3 -N, (mg/kg)	9	142
C/N ratio	107.3:1	15:1
Ash (%)	7.50	46.90
Total phosphorus (TP %)	0.36	1.36
Total potassium (TK %)	0.59	1.61
Total Lead (mg/kg)	13.00	321.70
Total Nickel (mg/kg)	8.30	222.25
Total Cadmium (mg/kg)	0.40	12.50

All mixtures treated with bio-accelerator (T1 –T5) represented composting process; meanwhile, the mixtures treated by earthworms (T6-T10) represented vermicomposting; but mixtures that were treated with both (bio-accelerator and earthworms) represented pretreated vermicomposting process which was produced after pretreatment stage. In this context, the result in Table (2) revealed that the treatments which were treated with both bio-accelerator and earthworms were superior in increasing the percentages of nitrogen, phosphorous and potassium in the final products compared with the same mixtures in the initial stage. Also, the treatment (T12) contents (75% sewage sludge +25% rice straw) resulted in an increase in the percentages of NPK from the initial stage (1.5, 1.4 and 1.52%) to a final product (2.62, 1.88 and 2.13). Conspicuously, the final product was much higher than the same mixture either compost (T3) or vermicompost (T7), individually. The lowest increase of NPK in final product was with mixture contents of 100% rice straw with compost, vermicompost and pretreated vermicompost.

Moreover, results exhibited that the percentages of organic matter decreased in the final products for all mixtures either treated with bio-accelerator or earthworms or both of them. This could be attributed to their efficient decomposition of organic matter. So, organic matter in final product in all mixtures was lower than initial ones.

Table (2): Properties of the initial raw materials and final product of the different organic fertilizers.

Treatments		T N (%)	T P (%)	T K (%)	O M (%)	O C (%)	C/N Ratio	Pb (mg/kg)	Ni (mg/kg)	Cd (mg/kg)
Bio-Accelerator*										
Initial	**T1**	1.68	1.41	1.66	52.66	30.54	18.18	6.434	4.445	0.195
	T2	1.43	1.35	1.42	67.23	38.99	27.27	4.857	3.860	0.142
	T3	1.11	1.12	1.36	72.52	42.06	37.89	2.380	2.970	0.065
	T4	0.80	0.77	1.20	85.18	49.40	61.76	0.874	0.830	0.023
	T5	0.52	0.4	0.79	97.22	56.39	108.4	0.260	0.166	0.008
Final	**T1**	2.52	1.82	2.05	39.88	23.13	9.18	2.360	2.219	0.105
	T2	2.13	1.73	1.83	47.30	27.43	12.88	1.068	0.790	0.026
	T3	2.04	1.52	1.69	51.05	29.61	14.51	0.511	0.500	0.007
	T4	1.31	1.22	1.53	66.23	38.41	29.32	0.320	0.271	0.006
	T5	0.91	0.79	1.19	80.09	46.45	51.05	0.085	0.059	0.002
Earthworm**										
Initial	**T6**	1.63	1.39	1.72	57.72	33.48	20.54	6.414	4.443	0.195
	T7	1.4	1.29	1.45	69.21	40.14	28.67	4.872	3.910	0.140
	T8	1.09	1.1	1.39	73.15	42.43	38.92	2.411	2.970	0.067
	T9	0.8	0.69	1.22	84.13	48.8	60.99	0.890	0.842	0.029
	T10	0.59	0.45	0.81	96.83	56.16	95.19	0.276	0.173	0.009
Final	**T6**	2.68	1.89	2.18	43.52	25.24	9.42	0.260	0.179	0.095
	T7	2.58	1.77	2.05	47.33	27.45	10.64	0.023	0.009	0.000
	T8	2.33	1.55	1.78	50.93	29.54	12.68	0.000	0.000	0.000
	T9	2.24	1.28	1.57	61.77	35.83	15.99	0.000	0.000	0.000
	T10	1.16	1.1	1.17	71.24	41.32	35.62	0.000	0.000	0.000
Bio-accelerator + earthworm										
Initial	**T11**	1.72	1.54	1.8	56.13	32.56	18.93	6.429	4.448	0.197
	T12	1.5	1,40	1.52	67.43	39.11	26.07	4.837	3.881	0.139
	T13	1.19	1.23	1.43	72.1	41.82	35.14	2.391	2.787	0.065
	T14	0.87	0.92	1.25	83.72	48.56	55.81	0.823	0.794	0.023
	T15	0.62	0.45	1.07	96.11	55.74	89.91	0.255	0.164	0.008
Final	**T11**	2.75	2.08	2.35	41.67	24.17	8.79	0.213	0.142	0.065
	T12	2.62	1.88	2.13	45.55	26.42	10.08	0.019	0.007	0.000
	T13	2.46	1.65	1.88	49.21	28.54	11.60	0.000	0.000	0.000
	T14	2.35	1.38	1.67	60.12	34.87	14.84	0.000	0.000	0.000
	T15	1.36	1.06	1.37	68.17	39.54	29.07	0.000	0.000	0.000
LSD 0.05	**Main Plot*** × Sub plot******							0.543	0.381	0.052
	Sub plot × Sub sub plot*****							0.067	0.487	0.054
	Main plot × Sub sub plot							0.082	0.596	0.066
	Main Plot × Sub plot × Sub sub plot							0.117	0.843	0.093

** Bio-accelerator: Trichoderma harzianum, viride and Phanerochaete chrysosporium.*
*** Earthworm: Eaisenia fetida. *** Main plot: Bio-accelerator, Earthworm and the interaction among them. **** Sub plot: Initial row and final product. ***** Sub sub plot: Treatments.*

The same behavior was noticed with organic carbon because the organic carbon content is almost one-half organic matter. In spite of C/N ratio which decreased to suitable ranges in some treatments, the best treatments were associated with the bio-accelerator + earthworm (T12); their values ranged in initial piles from 67.43, 39.11 and 26.07 to reach in final piles as 45.55, 26.42 and 10.08, respectively. It has been soundly to mention that the pile contents of rice straw comprised the lowest maturity, where C/N ratio did not reach to the low value of 20: 1. This result was in line with (21), who reported that carbon/nitrogen ratio has been used as an indication of the potential of compost maturity where, C/N ratio less than 20:1 is a good indicator of compost maturity. Also, this behavior means that the role of bio-accelerator is to pre-decompose the organic materials which in turn helped the earthworms to decompose the organic matter faster and improved the characteristics of the final product by increasing the N P K percentages (22).

Similar trend was observed in the available concentrations of Pb, Ni and Cd, where heavy metals were decreased during the composting process synchronous with decreasing the percentage of sewage sludge in all mixtures where, the mixture contents 100% sewage sludge (T1) recorded in initial process 6.434, 4.445 and 0.195 to reach in final process 2.360, 2.219 and 0.105 mg/Kg Pb, Ni and Cd, respectively. While the treatment contents of 25% sewage sludge with 75% rice straw (T4) were initially 0.874, 0.830 and 0.023 and reached in finally to 0.320, 0.271 and 0.006 mg/ kg. This could be ascribed to the sewage sludge source of Pb, Ni and Cd. Heavy metals possessed the lowest values in mixture T5 (100% rice straw only) and reached in final product to 0.085, 0.059 and 0.002 mg/Kg. Obviously, it has been surprising to get this result, that earthworms in mixtures enhanced the increase percentages of significant reduction of heavy metals either individually or combined with bio-accelerator; where, all heavy metals under study were not appear in the final products from T8 to T10 in vermicompost and T13 to T15 in pretreated vermicompost. This behavior may be due to the earthworms had mechanism of hyper accumulation of heavy metals.

Therefore, the obtained results exhibited that the composting process had slightly improved characteristics of the final products, as well as the vermicompost produced from earthworms only. This trend may be attributed to the substantial role of mixing bio-accelerator with earthworms in producing an environmentally safe organic compost (23). In this concern, Ananthanarayanan *et al.* (14) found that the earthworm under stress of excess of heavy metals can synthesis the metallothionein protein which can effectively bind with various metal ions and enhance the metal detoxification.

It is also worthily to detect that the total and available heavy metals concentration that were permanently determined during experiments exhibited total concentration of heavy metals were more than available concentration; also, initial was higher than that in the final products as shown in Figures (1and 2).

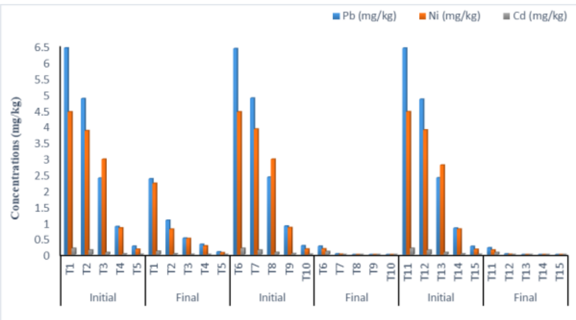


Fig. (1) Available concentrations of heavy metals in different mixtures.

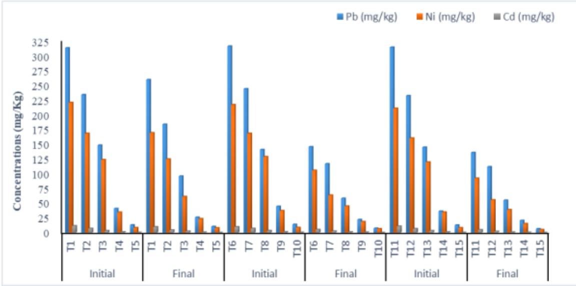


Fig. (2) Total concentration of heavy metals in different mixtures.

A verification of the aforementioned result, the data in Table (3) clearly revealed that the total concentration of heavy metals in both final product and in tissue of earthworm was logically in raw materials were greater than final products. In vermicomposting process by using earthworms only, lead was the highest heavy metals in raw materials (151.63 mg/kg) then it decreased in the final products (83.47 mg/kg) and mixture contents 100 sewage sludge (T6) possessed the highest content of heavy metals either in the initial of process (180.7 mg/kg) or final product (85.33 mg/kg). The lead contraction was always more than the other metals in the initial (315.7 mg/kg) or final (145.3 mg/kg) processes. Also, lead was the dominant concentration in tissue of earthworms in final product (28.66 mg/kg) and that through mixture 100% sewage sludge (67.45 mg/kg). On contrary, the lowest concentration of Pb in tissue was recorded in T10 (3.43 mg/kg) followed by T9 (11.29 mg/kg).

Meanwhile, the combined of *Eisenia fetida* and bio-accelerators treatment resulted in Pb reduction from the initial process (147.85 mg/Kg) to the final one (65.8 mg/Kg) and the highest rate of Pb in tissue was 39.24 mg/Kg. In addition, the maximum Pb values in tissue was obtained with the mixture contents 100% sludge (T11); (89.28 mg/Kg); meanwhile, the lowest Cd heavy metal concentration in earthworm tissue grown in mixture content of rice straw was only (0.02 mg/Kg).

During vermicomposting process earthworms have the ability to consume the sewage sludge and convert it into safe and high quality fertilizer where earthworms have a vital role in accumulating the heavy metals and passing through their intestines, causing a reduction in their potentiality risk and producing safe vermicompost. Consequently, removal percentages of heavy metals reached to maximum values (67, 62 and 59 %) in Cd, Ni and Pb respectively. In mixture T8, earthworms had the ability to accumulate heavy metal inside their intestines, where Cd reached to 0.61, Ni to 0.68 and Pb to 0.54 mg/ Kg during different mixtures as shown in Table (4). These results are in harmony with (11) where, they reported that the vermicomposting process involves the stabilization of organic matter through earthworm consumption that converts the waste into high quality.

Table (3): Total concentrations of heavy metals in vermicompost and earthworm tissues.

		Treatments	Vermicompost Pb	Vermicompost Ni	Vermicompost Cd	Mean	Tissue Pb	Tissue Ni	Tissue Cd	Mean
Earthworm**	Initial	**T6**	315.70	216.65	9.75	180.7	0.21	0.11	0.02	103.30
		T7	243.60	168.00	7.00	139.53	0.23	0.17	0.01	79.79
		T8	140.55	128.50	3.35	90.8	0.20	0.10	0.01	51.93
		T9	44.50	37.10	1.45	27.68	0.17	0.15	0.01	15.87
		T10	13.80	8.65	0.45	7.63	0.23	0.11	0.01	4.41
	Mean		151.63	111.78	4.40		0.21	0.13	0.01	
	Final	**T6**	145.30	105.45	5.25	85.33	74.31	54.33	2.20	67.45
		T7	116.50	63.45	2.45	60.80	52.87	42.96	1.04	48.58
		T8	58.05	44.85	1.10	34.67	29.41	22.97	0.67	27.39
		T9	22.10	18.55	0.70	13.78	11.89	11.74	0.29	11.29
		T10	7.25	6.45	0.20	4.63	3.28	2.17	0.02	3.43
	Mean		83.47	58.42	2.35		28.66	22.38	0.70	
Bio-accelerator* + Earthworm	Initial	**T11**	313.95	210.40	10.85	178.4	0.21	0.14	0.02	0.12
		T12	231.85	160.05	6.60	132.83	0.21	0.11	0.02	0.11
		T13	144.55	119.35	3.25	89.05	0.20	0.11	0.01	0.11
		T14	36.15	34.70	1.15	24.0	0.19	0.12	0.01	0.11
		T15	12.75	8.20	0.40	7.12	0.21	0.10	0.01	0.11
	Mean		147.85	106.54	4.45		0.21	0.12	0.01	
	Final	**T11**	135.65	92.10	4.85	77.53	89.28	61.21	2.77	51.08
		T12	111.55	55.35	2.05	56.32	54.67	50.80	1.13	35.53
		T13	54.80	38.88	0.90	31.53	32.29	24.79	0.77	19.28
		T14	20.55	15.15	0.55	12.08	15.72	12.69	0.31	9.57
		T15	6.45	5.10	0.17	3.91	4.26	3.16	0.02	2.48
	Mean		65.8	41.32	1.70		39.24	30.53	1.00	
LSD 0.05	**Main plot*** × Sub plot******		9.99	2.21	1.42		2.80	0.87	0.21	
	Sub plot × Sub sub plot*******		14.14	2.95	1.02		1.62	1.40	0.53	
	Main plot × Sub sub plot		14.14	2.95	1.02		1.62	1.40	0.53	
	Main Plot × Sub plot × Sub sub plot		20.00	4.17	1.44		2.30	1.98	0.75	

** Bio-accelerator: Trichoderma harzianum, viride and Phanerochaete chrysosporium.*

*** Earthworm: Eaisenia fetida. *** Main plot: Bio-accelerator, Earthworm and the interaction between them. **** Sub plot: Initial row and final product. ***** Sub sub plot: Treatments.*

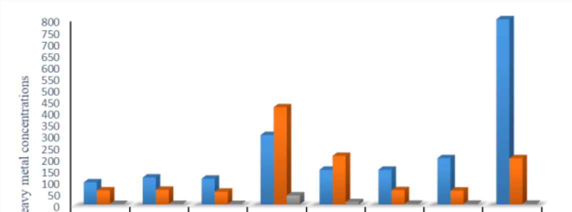
On the other hand, the joint biodegradation of both earthworms and bio- accelerates together achieved the highest removal percentage, where Cd recorded 72%, Ni 67% and Pb 62% in mixture 50% sewage sludge with 50% rice straw (T13) and also, it obtained the maximum accumulation of Ni (0.92 mg/Kg), Cd (0.86 mg/Kg) and Pb (0.77 mg/Kg) in the different treatments (Table 4).

Table (4): The removal percentages and bio-accumulation content in both types of vermicompost

	Treatments	Removal (%) Pb	Removal (%) Ni	Removal (%) Cd	Bio-accumulation (mg/kg) Pb	Bio-accumulation (mg/kg) Ni	Bio-accumulation (mg/kg) Cd
Earthworm	**T6**	54	51	46	0.51	0.51	0.42
	T7	52	62	65	0.45	0.68	0.42
	T8	59	62	67	0.51	0.51	0.61
	T9	50	53	52	0.54	0.63	0.41
	T10	47	25	55.5	0.45	0.34	0.075
Bio-accelerator + Earthworm	**T11**	57	56	55	0.66	0.66	0.57
	T12	52	65	68	0.50	0.92	0.55
	T13	62	67	72	0.60	0.64	0.86
	T14	43	56	52	0.77	0.84	0.56
	T15	49	37	57.5	0.66	0.62	0.11

These results agreed with those of (25); She found that the mutual reaction of both earthworms and aerobic microbes accelerates the biodegradation of organic wastes. Besides, after passing through the intestines, there are many useful microorganisms in the coprolite have capability to removal of heavy metals risks and reducing environment pollution. Also, she stated that the earthworms take excessive elements by covering them with layers of polypeptide, which confirmed by past research the polypeptide tracking from the tissue of earthworms until they reached the vermicompost or soil to estimate the heavy metals associated with field soil and vermicasts.

From the aforementioned findings, during composing, vermicomposting and pretreated vermicomposting processes, bio-accelerator, earthworms either alone or both together can dramatically remove the heavy metals from sewage sludge and different mixtures whereas, their values declined to about standards limits of either Egyptian code or worldwide ones as shown in Fig. (3). Similar results were reported by (25) and (26), where they found that the use of compost and vermicompost for home composters earthworms in the reduction of heavy metals (Cd, Pb, Cu, Zn, Ni and Cr) and their concentrations did not exceed the limits of heavy metals especially of standards of compost.



	(T3)	(T7)	(T12)	Egyptian Code*	USA Washington.	Canada	Australia	France
Pb	95.55	116.5	111.55	300	150	150	200	800
Ni	61	63.45	55.35	420	210	62	60	200
Cd	2.35	2.45	2.05	39	10	3	3	3

Fig. (3). Heavy metals content in some final treatments compared with both Egyptian and global standards (mg/kg).

Conclusions:

The succeed in reducing the concentration of some heavy metals such as lead, nickel and cadmium in final product during composting process, in order to produce a good fertilizer for agriculture enriched with the necessary elements needed by the plants is of a substantial importance. Also, it could be advised to use the pretreated vermicomposting technics by earthworms to recycle the sewage sludge before being used in the agricultural purpose due to its high content of pollutants especially heavy metals, where earthworms are capable of producing an environmentally improved and safe fertilizer product.

Obviously, authors can recommended the use of this technique (pretreated vermicomposting) for treating sewage sludge which is a promising mean to remove inflate of heave metals and protect the environment.

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