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Lead and Cadmium Availability and Uptake by Rice Plant in Response to Different Biosolids and Inorganic Fertilizers

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Abstract: Problem statement: Contents of heavy metals in soil are very important because soil is the first link in the food chain. **Approach:** But, pay attention to importance the subject, we performed this project to investigate the lead (Pb) and Cadmium (Cd) availability and uptake by rice plant in response to different biosolids Municipal Solid Waste (MSW), Vermicompost (VC) and inorganic Fertilizers (CF) using split plot arrangement based on randomized complete block design with three replications in 2008. **Results:** The results showed that fertilizer and application periods treatments influenced Pb and Cd accumulation. The highest available Pb (4.89 ppm) and Cd (0.173 ppm) belong to 3 years application of 40 ton.ha^{-1} MSW +1/2 CF treatment. During 3 years application of 20 ton.ha^{-1} MSW+1/2 CF the most Pb accumulated in root. **Conclusion:** The maximum Pb uptake by shoot and grain happened in 40 ton.ha^{-1} MSW treatment. With application 40 ton.ha^{-1} VC +1/2 CF, the maximum Cd accumulated in root. During 3 years application of 40 ton.ha^{-1} MSW and 20 ton.ha^{-1} VC the highest Cd uptaked by shoot. While, the maximum Cd concentration in grain belong to 20 ton.ha^{-1} MSW +1/2CF and CF treatments when added to soil for 3 continuous years.

Key words: Biosolids, inorganic fertilizers, rice, cadmium, lead

INTRODUCTION

There are many sources of heavy metals in compost and particularly products derived from household municipal solid waste. For example, these include household dust, batteries, disposable household materials (e.g., bottle tops). They are also present in plastics, paints and inks, body care products and medicines and household pesticides (Piccolo and Stevenson, 1981). In relation to the application of composted residuals to soil, the main elements generally of concern include: Zn, Cu, Ni, Cd, Pb, Cr and Hg because they are potentially present in compost that their amounts may be greater than the background values in the receiving soil.

Nevertheless, the organic amendments prepared from different organic wastes (raw material), with different kind (composting or vermicomposting) and time of process, produce a final product which differs in its quality (Gaur and Singh, 1995). The maximum permissible values of heavy metal content vary widely among the different standards. Recommendations for safely use, are usually determined by a minimum admissible level of required substances or a maximum tolerable limit for unwanted ones (Hogg *et al*., 2002).

Jordao *et al*. (2005) had shown that the addition of the urban solid wastes compost resulted to increase the available Zn, Cu, Pb and Ni levels. These heavy metals may accumulate in soil with repeated fertilizer applications.

Increasing metal concentrations and changes in the distribution of metals in soil amended with compost in the long-term are generally reported to increase the concentrations of heavy metals in the tissues of plants growing in the soil (Gigliotti *et al*., 1996; Wei and Liu, 2005; Zheljazkov and Warman, 2004). Zheljazkov (2004) found that increases in plant tissue metals were not proportional to the total metal concentrations measured in soil amended with source-segregated MSW-compost.

Pichtel and Stevenson (1981) detected increased uptake and potentially phytotoxic concentrations of Zn, Cu and Ni in plant tissues of oats grown in a pot experiment amended with MSW (manually sorted) and sewage sludge composts. Due to the relatively low concentrations of Cd and Pb in inorganic fertilizers, Prochnow *et al*. (2001) have recommended their use without drawbacks regarding environmental contamination but (Rahaman *et al*., 2007) shown that inorganic fertilizers especially phosphate and urea

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fertilizers are a important source of heavy metals Cd and Pb for soil.

However, little information is available either on the uptake of heavy metals by plants in soils fertilized with different phosphate fertilizers or on the long term accumulation of such metals in paddy soils in north of Iran conditions. Cadmium concentration in maize amended with phosphate fertilizers was significantly affected not only by phosphorous sources but also by their localization in the soil (Prochnow *et al*., 2001). Meanwhile, to know the potential risk of heavy metals to plants, animals and human beings, it is necessary to evaluate their mobile or available fractions in soil and plants. Thus, the objective of this study was to investigate different biosolids and inorganic fertilizers role on Pb and Cd availability and uptake in paddy soil during 3 years application.

MATERIALS AND METHODS

This project was performed during 2006-2008 cropping season in research field of Sari Agricultural Sciences and Natural Resources University, Sari, Iran. This area located in north of Iran (34°33´N; 52°6´E and altitude 16 m). The experiment design in a split plot arrangement was a randomized complete block with three replications. Main-plot was fertilizer treatment with 10 levels comprise, 20 and 40 ton.ha^{-1} MSW (T1 and T2), 20 and 40 ton.ha^{-1} MSW+1/2 CF (T3 and T4), 20 and 40 ton.ha^{-1} VC (T5 and T6), 20 and 40 ton.ha^{-1} VC+1/2 CF (T7 and T8), CF (T9) that based on soil testing comprise 100 kg ha^{-1} urea, 150 kg ha^{-1} triple super phosphate and 100 kg ha^{-1} potassium sulphate and control or without any fertilizer treatment (T10). The sub-plots were three application periods of fertilizers: P1 = 2006, P2 = 2006+2007 and P3 = 2006+2007+2008. This investigation started in 30 plots with size of 3×12 m, since 2006. In 2007 in 2/3 of initial plots, (3×8 m) and in 2008 in 1/3 of initial plots, (3×4 m), fertilizer treatments added to soil (sum 90 plot). Prior to planting (in 2006), soil samples were taken to determine some physical and chemical properties of soil. The results of soil testing are presented in Table 1. In addition, some samples were taken from MSW and VC for determining it's chemical properties (Table 2).

Agricultural practices started in last of April with plowing the land and preparing the rice nursery. The motioned fertilizers with certain amounts added in plots and seedlings transplanted with 25×25 cm at May 10. After rice harvesting, soil samples were taken from paddy soil (0-30 cm) for determining total and available Lead (Pb) and Cadmium (Cd). Total Pb and Cd contents of soil were measured using Varian Spectra A A-10 Atomic Absorption Spectrometer (Baker and Amacher, 1982). Available Pb and Cd contents of soil measured by (Korboulowsky *et al*., 2002) method. At harvest time samples of root, shoot (stem + leaves) and grain of rice plant were selected and Pb and Cd contents in these parts were determined by dry ash method (Association of Official Analytical Chemists (AOAC), 1990). Statistical analysis of data was done using MSTATC and SPSS software and means were compared using Duncan's Multiple Range Tests ($p \leq 0.05$).

RESULTS AND DISCUSSION

Soil, municipal solid waste and vermicompost characteristics: The physicochemical parameters of the soil and biosolids (MSW and VC) are presented in Table 1 and 2, respectively. The pH of agricultural soil was 7.63, while the pH values of the MSW and VC samples were found 7.41 and 8.05 respectively. Several legislations (e.g., Italy, Belgium, Spain) suggest a range for pH value for this kind of organic amendments (6.0-8.5) to ensure compatibility with most plants (Hogg *et al*., 2002). At low pH (at 6.5 for instance), the mobility and leaching of heavy metals increases and their mobility and availability decreases as the pH approaches neutral or raises above pH 7. Electrical Conductivity (EC) is another parameter to be considered as an index for these products. Among the samples analyzed, MSW analyzed have shown EC values greater than 4 dS m^{-1} (9.07 dS m^{-1}) (Table 2). The considerable amount of total nitrogen, highlights the benefits of using MSW and VC as an agricultural fertilizer. The Organic Carbon (OC) is an important component, because it tends to either soluble form or insoluble complexes with the heavy metals, to migrate, or to be retained in the soil. The results showed that the OC content in soil was 1.6% while MSW and VC were 22.63 and 9.63%, respectively. After excess amendment the soil, the percent of OC will increase naturally. The soil have 31 cmol kg^{-1} CEC, 0.16 % nitrogen and silty clay texture, while samples of MSW and VC have 0.80 and 1.94% nitrogen, respectively. Municipal solid waste and vermicompost have 0.586 and 0.622% total phosphorus and 0.42 and 0.70% potassium, respectively (Table 1 and 2).

Investigation Pb and Cd (total and available) in soil: Fertilizer treatments, application periods and interaction effect of fertilizer × application periods significantly affect on Pb and Cd (total and available) concentration in soil (Table 3).

Table 1: Some physicochemical properties of studied soil (0-30 cm)

		Percent						dS m^{-1}		ppm		
Soil texture	Sand	Silt	Clay	OC	N	pH	CEC (cmol kg^{-1})	EC	Pb (T)	Pb(A)	Cd(T)	Cd(A)
Silty clay	7.3	44.7	48	1.6	0.16	7.63	31	1.84	31.47	2.61	1.18	0.07

T: Total, A: Available

Table 2: Some chemical properties of municipal solid waste (MSW) and Vermicompost (VC) applied in this research

Organic fertilizers	EC dS m^{-1}	OC (%)	N (%)	pH	Pb (T) ppm	Pb(A) ppm	Cd(T) ppm	Cd(A) ppm
MSW	9.07	22.63	0.80	7.41	306.05	25.47	2.63	0.19
VC	2.06	9.63	1.94	8.05	29.74	1.16	2.59	0.05

T: Total, A: Available

Table 3: Means comparison of Pb and Cd accumulation (ppm) in soil

	Pb		Cd	
Fertilizer treatments (A)	Total	Available	Total	Available
T1 = 20 ton.ha^{-1} MSW	39.770^{b}	4.002^{b}	1.8160^{c}	0.089^{cd}
T2 = 40 ton.ha^{-1} MSW	43.903^{a}	4.148^{ab}	2.0100^{bc}	0.106^{b}
T3 = 20 ton.ha^{-1} MSW+1/2 CF	38.988^{bc}	3.666^{c}	1.7510^{c}	0.098^{bc}
T4 = 40 ton.ha^{-1} MSW +1/2 CF	42.366^{a}	4.272^{a}	2.2100^{a}	0.128^{a}
T5 = 20 ton.ha^{-1} VC	33.383^{e}	2.844^{e}	2.0100^{bc}	0.079^{d}
T6 = 40 ton.ha^{-1} VC	37.332^{cd}	3.131^{d}	2.1280^{b}	0.095^{bc}
T7 = 20 ton.ha^{-1} VC +1/2 CF	33.141^{e}	2.772^{e}	1.8470^{c}	0.092^{cd}
T8 = 40 ton.ha^{-1} VC+ 1/2 CF	36.254^{d}	3.119^{d}	2.2460^{a}	0.107^{b}
T9 = CF	33.570^{e}	2.788^{e}	1.5800^{d}	0.088^{cd}
T10 = Control	31.527^{e}	2.648^{e}	1.2160^{e}	0.079^{d}
Application periods (B)				
P1 = 2006	3.036^{c}	33.872^{c}	1.5360^{c}	0.077^{c}
P2 = 2006+2007	3.289^{b}	36.797^{b}	1.8778^{b}	0.095^{b}
P3 = 2006+2007+2008	3.692^{a}	40.401^{a}	2.2500^{a}	0.116^{a}
ANOVA				
A	**	**	**	**
B	**	**	**	**
A×B	**	**	*	*
CV (%)	16.080	22.280	25.120	21.240

Means within the same column and each treatment followed by the same letter are not significantly different according to DMRT ($p \leq 0.05$); * and **: Significant in 5 and 1% probability levels, respectively (based on Duncan test)

The most concentration of Pb (total and available) in soil, was recorded under MSW treatments such as, highest total Pb concentration, 43.903 ppm, measured in T_2 treatment (40 ton.ha^{-1} MSW) and most available Pb (4.272 ppm) was happened under T_4 treatment (40 ton.ha^{-1} MSW +1/2 CF), as shown in Table 3.

The highest content of total Cd (2.246 ppm), measured under T_8 treatment (40 ton VC+ 1/2 CF), nevertheless, has not significant difference with T4 treatment (40 ton CO +1/2 CF). While, the maximum concentration of available Cd, concluded in T4 treatment (40 ton.ha^{-1} MSW +1/2 CF) (Table 3). Generally, in most treatments of MSW, accumulated total and available Pb and Cd in soil were greater than other treatments. An explanation for that could be relationship with it's source of initial material.

Madrid (Mortvedt, 1996) applied MSW at moderate rates on a sandy loam soil for three years. They found that heavy metal content in soil increased compared to the control treatment and their results indicated that metals accompanied by MSW were more available than native metals in soil. Jordao *et al*. (2005) with investigating heavy metals availability in soil treated with MSW showed that MSW could add heavy metals such as lead and cadmium in soil. The present results demonstrated that with increasing application periods of fertilizer treatments, Pb and Cd accumulation in soil increased regularly. For example, the increasing available Pb in P2 compared to P1 treatment was 8.64% and in P3 compared to P2 treatment was 9.79% (Table 3). In agreement to these results (Afyuni *et al*., 2007; Al-Najar *et al*., 2005; Mortvedt, 1996) found that heavy metals accumulation in soil were enhanced by increasing periods of application. In contrast (Korboulowsky *et al*., 2002) observed little effect of sewage sludge on heavy metals accumulation. Similarly, application of 32 ton.ha^{-1} of biowaste compost in soil for 5 years did not affected the total contents of Cd in soil, whereas the Pb contents were higher than the control (Bartl *et al*., 2002). Under 3 continuous years application of 40 ton.ha^{-1} MSW + 1/2 CF, most of total and available Pb (50.65 and 4.89 ppm respectively) and maximum concentration of available Cd (0.173) accumulated in soil (Table 4). By contrast, under 3 continuous years application of 40 ton.ha^{-1} VC, concluded maximum content of total Cd (2.71 ppm) (Table 4). Covelo (Covelo *et al*., 2004) observed that the amendment with humified organic matter may reduce the soluble fraction of lead in polluted agricultural soils, which was explained on the basis of chemical processes of adsorption involving the oxygenated functional groups such as the carboxylates which acted as ligands for Pb^{2+} to produce stable organometallic complexes (Piccolo and Stevenson, 1981). The molecular structure of vermicompost contains carboxylic acids responsible for the adsorption of heavy metals in a process that involve exchange of protons of weak organic acids for heavy metals ions dissolved in aqueous solutions (Carrasquero and Flores, 2004). Thus, organic acids in vermicompost has an important role in reducing the heavy metals availability for plants.

Investigation Pb and Cd uptake by rice plant: Aplication of MSW, VC and inorganic fertilizers in rice cultivation significantly affected on Pb and Cd uptake by rice plants except Pb in rice grains (Table 5). The accumulation and uptake of these metals by plants, due to application of SS and MSW has been reported by several investigators (Mortvedt; Semu and Singh, 1996; Wang *et al*., 2008). Application periods of fertilizer treatments markedly affected on Pb and Cd uptake by different plant organs.

Table 4: Means comparison interaction effects of fertilizer × application periods on Pb and Cd (ppm) in soil

	Pb-T			Pb-A			Cd-T			Cd-A		
Treatment	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
T1	33.57^{hij}	40.97^{bcd}	44.76^{b}	3.28^{f-i}	3.95^{cde}	4.78^{ab}	1.65^{g-l}	1.65^{g-l}	2.16^{b-f}	0.072^{hi}	0.094^{d-h}	0.101^{c-g}
T2	40.43^{cde}	41.34^{bcd}	49.94^{a}	3.63^{def}	4.13^{c}	4.68^{ab}	1.44^{j-m}	2.01^{d-g}	2.54^{ab}	0.079^{ghi}	0.108^{b-f}	0.130^{b}
T3	34.66^{f-j}	38.45^{def}	43.86^{bc}	3.22^{f-j}	3.43^{fgh}	4.36^{bc}	1.29^{klm}	1.95^{e-h}	2.18^{b-f}	0.079^{ghi}	0.086^{e-i}	0.129^{b}
T4	34.88^{f-j}	41.58^{bcd}	50.64^{a}	3.92^{cde}	4.01^{cd}	4.89^{a}	1.81^{f-j}	2.35^{a-d}	2.48^{abc}	0.087^{e-i}	0.124^{bc}	0.173^{a}
T5	31.31^{j}	33.19^{hij}	35.66^{f-i}	2.75^{jkl}	2.81^{jkl}	2.97^{h-l}	1.66^{g-k}	2.18^{b-f}	2.16^{b-f}	0.065^{i}	0.079^{ghi}	0.094^{d-h}
T6	32.97^{hij}	38.74^{def}	40.29^{cde}	2.76^{jkl}	3.11^{g-k}	3.53^{efg}	1.60^{h-l}	2.24^{b-e}	2.71^{a}	0.072^{hi}	0.101^{c-g}	0.111^{b-e}
T7	31.71^{ij}	31.95^{ij}	35.76^{f-i}	2.59^{l}	2.81^{jkl}	2.92^{i-l}	1.73^{g-j}	1.69^{g-j}	2.12^{c-f}	0.086^{e-i}	0.079^{ghi}	0.109^{b-f}
T8	34.09^{g-j}	36.67^{e-h}	38.00^{d-g}	2.78^{jkl}	3.21^{f-j}	3.36^{f-i}	1.87^{e-i}	2.19^{b-f}	2.69^{a}	0.094^{d-h}	0.111^{b-e}	0.116^{bcd}
T9	33.57^{hij}	33.57^{hij}	33.57^{hij}	2.79^{jkl}	2.79^{jkl}	2.79^{jkl}	1.27^{lm}	1.50^{i-l}	1.96^{e-h}	0.072^{hi}	0.084^{f-i}	0.108^{b-f}
T10	31.53^{ij}	31.53^{ij}	31.53^{ij}	2.65^{kl}	2.65^{kl}	2.65^{kl}	1.09^{m}	1.08^{m}	1.48^{jkl}	0.065^{i}	0.087^{e-i}	0.087^{e-i}

Means within the same column and each treatment followed by the same letter not significantly difference according to DMRT ($p \leq 0.05$). P1: 2006, P2: 2006+2007 and P3: 2006+2007+2008. T1: 20 ton.ha^{-1} MSW, T2: 40 ton.ha^{-1} MSW, T3: 20 ton.ha^{-1} MSW+1/2 CF, T4: 40 ton.ha^{-1} MSW +1/2 CF, T5: 20 ton.ha^{-1} VC, T6: 40 ton.ha^{-1} VC, T7: 20 ton.ha^{-1} VC +1/2 CF, T8: 40 ton.ha^{-1} VC+ 1/2 CF, T9: CF and T10: Control

Table 5: Means comparison Pb and Cd uptake in different parts of rice plant

	Pb (ppm)			Cd (ppm)		
Fertilizer treatments (A)	Root	Shoot	Grain	Root	Shoot	Grain
T1 = 20 ton.ha^{-1} MSW	413.667^{d}	101.655^{ab}	54.074^{b}	67.778^{ab}	24.539^{cd}	11.370^{a}
T2 = 40 ton.ha^{-1} MSW	458.519^{b}	122.931^{a}	63.704^{a}	67.407^{ab}	31.915^{a}	11.211^{a}
T3 = 20 ton MSW+1/2 CF	484.482^{a}	102.837^{ab}	60.001^{ab}	54.963^{c}	27.187^{bc}	11.352^{a}
T4 = 40 ton MSW +1/2 CF	472.704^{ab}	95.745^{b}	44.444^{c}	52.370^{c}	30.085^{ab}	11.370^{a}
T5 = 20 ton.ha^{-1} VC	3833.407^{e}	104.019^{ab}	59.259^{ab}	42.000^{d}	28.369^{abc}	11.178^{a}
T6 = 40 ton.ha^{-1} VC	383.110^{e}	104.019^{ab}	57.037^{ab}	52.148^{c}	25.752^{cd}	9.107^{b}
T7 = 20 ton.ha^{-1} VC +1/2 CF	427.259^{cd}	115.839^{ab}	57.778^{ab}	61.963^{b}	26.823^{bc}	10.574^{a}
T8 = 40 ton.ha^{-1} VC+ 1/2 CF	436.889^{c}	109.929^{ab}	58.519^{ab}	73.000^{a}	24.570^{cd}	10.600^{a}
T9 = CF	342.778^{f}	99.291^{b}	64.444^{a}	51.222^{c}	25.255^{cd}	11.611^{a}
T10 = Control	265.593^{g}	74.468^{c}	37.037^{d}	40.296^{d}	22.366^{d}	8.222^{b}
Application periods (B)						
P1 = 2006	364.711^{c}	89.007^{b}	45.111^{c}	44.067^{c}	21.103^{c}	8.177^{c}
P2 = 2006+2007	404.633^{b}	96.454^{b}	55.778^{b}	54.778^{b}	24.971^{b}	11.069^{b}
P3 = 2006+2007+2008	451.178^{a}	123.759^{a}	66.010^{a}	70.100^{a}	33.984^{a}	12.732^{a}
ANOVA						
(A)	**	*	ns	**	**	**
(B)	**	**	**	**	**	**
A×B	**	ns	ns	ns	**	**
CV (%)	19.070	28.560	28.70	19.760	27.420	24.780

Means within the same column and each treatment followed by the same letter not significantly difference according to DMRT ($p \leq 0.05$); * and **: Are significant in 5 and 1% levels respectively and ns is not significant (based on Duncan test)

Table 6: Means comparison interaction effects of fertilizer × application periods on Pb uptake (ppm)

	Root			Shoot			Grain		
Fertilizer treatments	P1	P2	P3	P1	P2	P3	P1	P2	P3
T1	372.2^{kl}	390.6^{jk}	478.2^{cd}	81.56^{f-i}	102.8^{b-i}	120.6^{a-f}	42.22^{g-j}	57.78^{c-f}	62.22^{cd}
T2	444.4^{efg}	454.4^{def}	476.7^{cd}	106.4^{b-i}	109.9^{b-h}	152.5^{a}	46.67^{fgh}	66.67^{a-d}	77.78^{a}
T3	377.8^{kl}	523.3^{b}	552.3^{a}	81.56^{f-i}	85.11^{e-i}	141.8^{ab}	57.78^{c-f}	53.33^{d-g}	68.89^{abc}
T4	392.0^{jk}	493.3^{c}	532.8^{ab}	78.01^{ghi}	85.11^{e-i}	124.1^{a-e}	33.33^{ij}	40.00^{hij}	60.00^{cde}
T5	374.6^{kl}	377.9^{kl}	397.8^{ijk}	92.20^{d-i}	88.65^{e-i}	131.2^{a-d}	46.67^{fgh}	60.00^{cde}	71.11^{abc}
T6	357.8^{lm}	369.8^{kl}	421.8^{ghi}	102.8^{b-i}	99.29^{c-i}	109.9^{b-h}	44.44^{ghi}	60.00^{cde}	66.67^{a-d}
T7	383.3^{kl}	416.2^{hij}	482.2^{cd}	92.20^{d-i}	117.0^{a-g}	138.3^{abc}	48.89^{e-h}	60.00^{cde}	64.44^{bcd}
T8	414.4^{hij}	428.4^{fgh}	467.8^{cde}	106.4^{b-i}	109.9^{b-h}	113.5^{a-g}	46.67^{fgh}	64.44^{bcd}	64.44^{bcd}
T9	307.2^{o}	341.1^{mn}	380.0^{kl}	81.56^{f-i}	95.75^{d-i}	120.6^{a-f}	53.33^{d-g}	64.44^{bcd}	75.56^{ab}
T10	223.3^{q}	251.2^{p}	322.2^{no}	67.38^{i}	70.92^{hi}	85.11^{e-i}	31.11^{j}	31.11^{j}	48.89^{e-h}

Means within the same column and each treatment followed by the same letter not significantly difference according to DMRT ($p \leq 0.05$). P1: 2006, P2: 2006+2007 and P3: 2006+2007+2008. T1: 20 ton.ha^{-1} MSW, T2: 40 ton.ha^{-1} MSW, T3: 20 ton.ha^{-1} MSW+1/2 CF, T4: 40 ton.ha^{-1} MSW +1/2 CF, T5: 20 ton.ha^{-1} VC, T6: 40 ton.ha^{-1} VC, T7: 20 ton.ha^{-1} VC +1/2 CF, T8: 40 ton.ha^{-1} VC+ 1/2 CF, T9: CF and T10: Control

Table 7: Means comparison interaction effects of fertilizer × application periods on Cd uptake (ppm)

Fertilizer treatments	Root P1	Root P2	Root P3	Shoot P1	Shoot P2	Shoot P3	Grain P1	Grain P2	Grain P3
T1	56.22^{efg}	61.11^{def}	86.00^{a}	20.43^{ef}	21.28^{ef}	31.92^{bc}	7.67^{gh}	12.89^{abc}	13.56^{ab}
T2	57.89^{ef}	63.44^{c-f}	80.89^{ab}	21.28^{ef}	31.92^{bc}	42.55^{a}	8.33^{fgh}	11.78^{a-d}	13.52^{ab}
T3	37.11^{ij}	55.56^{efg}	72.22^{bcd}	21.28^{ef}	28.37^{cd}	31.92^{bc}	7.83^{fgh}	12.11^{a-d}	14.11^{a}
T4	32.67^{j}	55.56^{efg}	68.89^{b-e}	21.18^{ef}	31.92^{bc}	37.16^{ab}	9.00^{e-h}	11.56^{a-e}	13.56^{ab}
T5	34.22^{j}	33.33^{j}	58.44^{def}	21.28^{ef}	21.28^{ef}	42.55^{a}	7.87^{gh}	12.11^{a-d}	13.56^{ab}
T6	41.44^{hij}	53.89^{fgh}	61.11^{def}	24.06^{def}	21.28^{ef}	31.92^{bc}	7.67^{gh}	8.00^{fgh}	11.56^{a-e}
T7	50.00^{f-i}	61.11^{def}	74.78^{abc}	23.73^{def}	24.82^{de}	31.92^{bc}	7.83^{fgh}	10.33^{c-f}	13.56^{ab}
T8	56.22^{efg}	80.56^{ab}	82.22^{ab}	16.97^{f}	24.82^{de}	31.92^{bc}	10.08^{d-g}	10.42^{c-f}	11.30^{b-e}
T9	42.78^{g-j}	50.00^{f-i}	60.89^{def}	21.31^{ef}	22.85^{def}	31.61^{bc}	7.39^{h}	13.33^{ab}	14.11^{a}
T10	32.11^{j}	33.22^{j}	55.56^{efg}	19.52^{ef}	21.18^{ef}	26.40^{cde}	8.00^{fgh}	8.17^{fgh}	8.50^{fgh}

Means within the same column and each treatment followed by the same letter not significantly difference according to DMRT ($p \leq 0.05$). P1: 2006, P2: 2006+2007 and P3: 2006+2007+2008. T1: 20 ton.ha^{-1} MSW, T2: 40 ton.ha^{-1} MSW, T3: 20 ton.ha^{-1} MSW+1/2 CF, T4: 40 ton.ha^{-1} MSW +1/2 CF, T5: 20 ton.ha^{-1} VC, T6: 40 ton.ha^{-1} VC, T7: 20 ton.ha^{-1} VC +1/2 CF, T8: 40 ton.ha^{-1} VC+ 1/2 CF, T9: CF and T10: Control

Table 8: Simple correlation between studied traits (n = 90)

	Concentration Pb-T	Concentration Pb-A	Concentration Cd-T	Concentration Cd-A	Uptake Pb-root	Uptake Pb-shoot	Uptake Pb-grain	Uptake Cd-root	Uptake Cd-shoot	Uptake Cd-grain
Pb-T conc.	1.00									
Pb-A	0.85**	1.00								
Cd-T	0.49**	0.46**	1.00							
Cd-A	0.65**	0.61**	0.62**	1.00						
Pb-root uptake	0.66**	0.66**	0.65**	0.63**	1.00					
Pb-shoot	0.39**	0.27*	0.40**	0.42**	0.46**	1.00				
Pb-grain	0.39**	0.21*	0.42**	0.32**	0.38**	0.36**	1.00			
Cd-root	0.53**	0.46**	0.56**	0.57**	0.63**	0.55**	0.44**	1.00		
Cd-shoot	0.48**	0.45**	0.57**	0.57**	0.53**	0.47**	0.43**	0.55**	1.00	
Cd-grain	0.42**	0.42**	0.53**	0.57**	0.56**	0.45**	0.49**	0.51**	0.60**	1

* and **: Are significant in 5 and 1% levels respectively (based on Duncan test)

The most concentration of Pb in root (552.3 ppm) was recorded under 20 ton.ha^{-1} MSW+ 1/2 CF treatment when, added to soil for 3 continuous years (Table 6). Application of 40 ton.ha^{-1} MSW accumulated maximum Pb in shoot (122.931 ppm) that had only significant difference with control treatment (Table 5).

Also, under 40 ton.ha^{-1} MSW (T2) and inorganic fertilizer (CF) treatments, maximum content of Pb was accumulated in grain that had about 74% enhancement compared to control treatment (Table 5).

Rahaman *et al*. (2007) stated that among the inorganic fertilizers, phosphate fertilizers are the greatest sources of heavy metals and then urea also may cause heavy metal contamination of soils and its uptake by plants. Other researchers also found increases in heavy metals, especially Cd up take by plants as a consequence of phosphate fertilizer applications (Mortvedt, 1987; Prochnow *et al*., 2001). Therefore, these results indicate that phosphate fertilizers can be an important source for Pb and Cd entry in the food chain. Maximum concentrated Cd in root (73.00 ppm) measured under T8 treatment (40 ton VC+ 1/2 CF) (Table 5). Using 20 ton.ha^{-1} VC during 3 continuous years, concentrated maximum Cd in shoot (42.55 ppm) and under 3 years application of 20 ton.ha^{-1} MSW + 1/2 CF and CF treatments measured the highest Cd uptake in grain (14.11 ppm) (Table 7).

In general, Pb and Cd accumulation in root was more than shoot and grain. With increasing application periods from one to 3 years, Pb and Cd uptake increased regularly, as well. Such as, for example, the increasing Pb uptake by grain in P3 treatment in compared to P2 treatment was 18.34% and in P2 treatment was 23.65% more than P1 treatment. The percent of Cd uptake by grain in P3 treatment was 15.02% more than P2 treatment. Also, in P2 treatment Cd uptake by grain, concluded 35.37% more than P1 treatment (Afyuni *et al*., 2007; Al-Najar *et al*., 2005; Bartl *et al*., 2002; Mortvedt, 1987) had shown that accumulation of most heavy metals in soil increase with repeated organic fertilizers application, as like as compost and sewage sludge, thereby increasing the risk of crop and food chain contamination. But (Jordao *et al*., 2005) found that total and available heavy metals concentration had not significantly response to application of sewage sludge compost in Vineyards (Table 5).

Increasing metal concentrations and changes in the distribution of metals in soil amended with compost in the long-term are generally reported to increase the concentrations of heavy metals in the tissues of plants cultivated in this soil (Gaur and Singh, 1995; Wang *et al*., 2008). Rahaman *et al*. (2007) had shown that inorganic fertilizers especially phosphate and urea fertilizers are an important source of Cd and Pb for soil. Cadmium concentration in maize amended with phosphate fertilizers was significantly affected not only by P sources but also by their localization in the soil (Pichtel and Anderson, 1997).

Investigation correlation relationships between Pb and Cd concentration in soil and rice: Results of the correlation studies revealed that there are strong relationship between total and available Pb and Cd concentrations in soil and their uptake by rice plant (Table 8). Application of MSW, VC and inorganic fertilizers in rice cultivation accumulated more, Pb and Cd accumulation in soil than other treatments. Observed higher correlation between Pb-T with Pb uptake. Correlation coefficient between total Pb with Pb uptake by grain concluded (r = 0.39**).

Correlation coefficient between available Pb with Pb concentration in grain was r = 0.21**. Correlation coefficients between Cd-A with Cd uptake was more than Cd-T (Table 8).

In agreement this result (Chen *et al*., 1996) had shown that the total concentrations of metals in soil are not good indicators of bioavailability, or good tools for potential risk assessment either, because of the different and complex distribution patterns of metals among various chemical species or solid phases.

CONCLUSION

The present research concludes that municipal Solid Waste Compost (MSW), Vermicompost (VC) and Inorganic Fertilizers (CF) could be affect on Pb and Cd concentration in soil and their subsequent uptake by rice plant. The highest available Pb and Cd in soil, occurred when 40 ton MSW+ 1/2 CF added to soil for 3 continuous years (about 84.5 and 98.8% enhancement compared to control treatment, respectively). Lead uptake by grain, increased to 59% in 3 continuous years application of 40 ton.ha^{-1} MSW and the most Pb content in root (71% enhanced compared to control) measured in 3 continuous years application of 20 ton.ha^{-1} MSW+1/2 CF. Meanwhile, increasing the Cd content in root concluded 54% in compared to control treatment in 3 continuous years application of 20 ton.ha^{-1} MSW also, the maximum Cd uptake by grain obtained in 3 continuous years application of CF and 20 ton.ha^{-1} MSW+ 1/2 CF (66% more than control treatment). Summary, influence of MSW treatments on Pb and Cd accumulation in soil and rice, was more than VC treatments. Using CF, concentrated highest Cd in grain (14.11 ppm) for 3 continuous years. With increasing the application periods from 1-3 years, Pb and Cd concentration increased in soil and crop tissues, as well. Meanwhile, Pb and Cd uptake in roots were more than in shoot and grain.

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