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Contents of Lead and Cadmium in Barley Plants as Directly Affected by some Organic Manure Applications in a Sandy Soil

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THE PRESENT works was carried out as a pot experiment to study the effect of some organic manure (compost, biogas and sewage sludge) in addition to untreated soil as a control. Five ascending rates 0.5, 1, 2, 3, or 4 % on the content of Pb and Cd in sandy soil and the grown barley plant.

The obtained results showed that, AB-DTPA extractable Pb and Cd increased significantly due to application of organic manure and the increases progressed with increasing the rate of application. The average values of available Pb and Cd in the soil ranged from 0.15 to 7.55 and 0.02 to 0.37 mg kg^{-1} respectively.

The soil treated with sewage sludge and biogas manure gave relatively higher significantly of the AB-DTPA extractable Pb and Cd than that treated with the compost or manure. The highest concentrations of Pb and Cd ware less than the maximum concentration permissible for arable lands 40 and 1.0 mg kg^{-1} for Pb and Cd, respectively. High extractable Pb in the treatment of 2 % application of sewage sludge with significant difference over the lower concentration.

On the other hand, results showed that dry matter weight (gm pot^{-1}), weight of 100 grains and height of barley plants as affected by application of compost , biogas or sewage sludge manure to a sandy soil were significantly increased over control due to supplying with organic matter. Also, data indicated that biogas was the mast effective on 100 grains of barley plants followed by sewage sludge in height and dry matter yield and then compost. However, the difference in grain yield obtained due to application of biogas manure or sludge applications was insignificant. The highest rate of organic manure 4.0% showed a insignificant decrease in dry weight, of 100 grains and plant height compared with the rate of 3.0 %, which is considered as the optimum rate for producing the highest dry matter yield.

Data also revealed that the concentration of Pb and Cd in barley straw and grains progressively and consistently increased by increasing the rate application of compost, biogas and sewage sludge manure and the straw exhibited more accumulation than grains. On the other hand, Pb and Cd contents of straw and grains were increased by sewage sludge manure, flowed by biogas manure and then compost.

From the above mentioned results, it can be concluded that accumulation of heavy metals Pb and Cd in barley plants, due to treatments, decreased in the order sewage sludge > biogas > compost. Therefore, it is necessary to use sewage sludge at a proper rate to avoid this pollution. The compost and biogas manure are simple and effective means to produce energy and clean organic manure for cropping edible plants. Soils treated with sewage sludge may be more suitable for woody trees which may be economically of great concern.

Keyewords: Organic manure (Compost, Biogas and Sewage sludge), Sandy soil, Barley plant, Lead (Pb) , Cadmium (Cd).

Treating the soil with municipal organic wastes is a potentially valuable resource of essential macro and micro nutrients to plant, and it may also serves a good natural soil conditioner due to its high consisting compounds of nutrients and organic matter. Newly reclaimed desert lands are very poor soils in their physical, chemical and biological properties and consequently its fertility which may be improved by addition of organic wastes. However, repeating these applications may cause hazard of some side effects on both the growing plants or grazing animals and consequently human health.

Mahmoud *et al.* (1982) showed that application of biogas manure increased contents of mineral Pb and Cd in the barley grains.

According to Achtnich (1980), Pb and Cd present in sewage sludge are toxic to plants, since they interfere with the work of some enzymes and may cause lethargy effect on the embryos and metabolic process. Also, they may delay seed germination and growth steps. Also, Schossig (1983) showed that compost applied at 156 or 312 ton dry matter / ha to the upper 35 cm soil surface resulted in good increase in yields of winter rye in the first year, and winter rape in the second year, nevertheless, soil contained much increases in Cd and Pb. Otabbong *et al.* (1997) showed the effects of sewage sludge application on NH_4 NO_3 extracted Pb and Cd as well as metal uptake by barley in a sandy loam soil. They concluded that soil metals immediately determined after mixing the soil with sewage sludge were markedly decreased their Pb levels, and substantial amounts of residual Cd were stayed in the soils, regardless the significant of metal uptake in straw and roots ($P = 0.05$) enhanced by sewage sludge applications.

Mineev *et al.* (2003) in a crop rotation system of barley studied the effect of applications of 15 and up to 120 ton sewage sludge / ha where cadmium and lead contents in the used sewage sludge were 80 and 120 mg kg^{-1}. The authors conclude that prolonged application of sewage sludge led to the accumulation of heavy metals at levels above limits of permissible concentrations both in and below the plough-layer.

The aim of this work is to study the effected of different rates of organic manures (compost, Biogas, and sewage sludge) added to sandy soil on the content of Pb and Cd in barley plants.

Material and Methods

A pot experiment was set up under green house condition using sandy soil collected from desert soil (about 25 km from Cairo a long the Cairo Suez road). The particle size distribution was 85.42, 7.50, 2.75 and 4.33 % for the factions coars sand, fine sand, silt and clay, respectively giving a sandy textural class according to Piper (1950). The organic wastes used in the current work were compost (rice straw and farmyard manure at ratio 1:3, respectively was incorporated 6 weeks before sowing barley). Biogos manure obtained from Moshtohor Biogas Research Station and sewage sludge taken from El Gabal El Asfar Sludge station. Chemical analyses of the tested manure (compost, biogas and, sewage sludge) as will as the investigated soil are given in Table 1 according to Brummer & Wasner. (1987) Earthenware pots of 8 kg soil capacity were filled up with the soil. Four replicates for each treatment were used and arranged in a complete randomization design after mixing soil thoroughly with one of the rates 0.0, 0.5,1.0, 2.0, 3.0 and 4.0 % (dry basis) of each of the tested manures (compost, Biogas and sewage sludge). Ten grains of barley (*Hodiwn vulgar,* Giza 124) were sown in pots on 15/11/2003. The seedlings were thinned to only 5 plants per pot. Each pot received 1.5 g superphosphate, 1.5 g ammonium sulphate and 2gm potassium sulphate before sowing. After 150 days from planting, plants were cut one cm above the soil surface. plant material divided into straw and grains, the plants were oven dried at 70° and dry weighed. Dry grains and straw were ground and prepared for chemical analysis to determine the content of Pb and Cd by wet digestion method (Jackson, 1967).

Available amounts of Pb and Cd in the soil samples were extracted using diethyl en tryamin, penta acetic acid in (1, N) ammonium bicarbonate solution (AB DTPA) according to Soltanpur & Schwab (1977). Contents of Pb and Cd in barley plants were determined using an atomic absorption spectro photometer (Perkin Elemer, 2380).

TABLE 1. Chemical analysis for the tested manures and the investigated soil.

Fractions	Compost	Biogas	Sewage sludge	Soil
Ec mmhos/cm/25°	5.0	3.6	4.8	2.0
pH(1 : 2.5)	7.2	7.1	6.6	7.2
Organic matter	49.9	57.5	44.5	0.22
O.C %	30.36	30.87	34.41	-
Total N%	1.5	1.7	3.0	-
C/N ratio	20.29	19.3	11.47	-
Available Pb (mg kg^{-1})	3.58	4.34	5.42	0.6
Available Cd (mg kg^{-1})	1.2	1.4	1.55	0.02

Result and discussion

Soil heavy metals Pb and Cd

Data illustrated graphically in Fig. 1 showed that AB-DTPA extractable Pb increased due to application of organic manure and the increases progressed with the rate of application. The average values of available Pb rangedfrom 0.15 to 2.58, 2.75 and 7.55 mg kg^{-1} in the sandy soil treated with 4 % of compost, biogas and sewage sludge manures, respectively. The soil treated with sewage sludge gave the highest of the AB-DTPA extractable Pb. Results are in agreement with Touchton & Boswell (1975) and El-Sebaey (2002) who found that the amounts of extractable Pb, generally increased with sewage sludge addition rate. Gaynor & Halstead (1976) found that sewage sludge application increased DTPA extractable Pb 2 to 3 times, than that untreated.

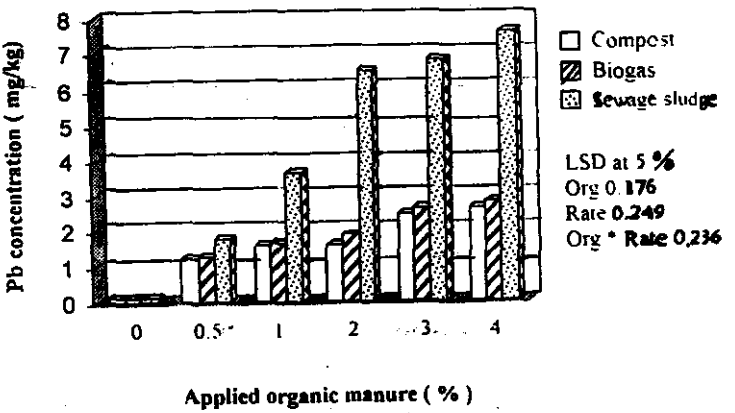

Fig. 1. AB-DTPA extractable Pb in the sandy soil as affected by the organic manure applications.

The highest concentration of available Pb in the investigated soil was less than 40 mg kg^{-1} which reported as a maximum permissible limit for arable lands, according to National Academy of Science (1972). Concentration of Pb in AB-DTPA extraction was markedly increased due to the addition of organic manures (Fig. 1). Lead concentration tended to be highest due to the addition of sewage sludge, moderate under biogas and lowest under compost addition. The increases were progressive with increasing addition rates of organic manures up to the level of 4.0 %. High significant in Pb extractable was 2 % application of sewage sludge. These results are in agreement with the finding of El-Nennah *et al.* (1982) and khalil (1990) who showed that contents of Pb in surface layer were significantly in positive correlated with organic matter content ($r = 0.914^{**}$), and silt + clay content ($r = 0.825^{**}$).

Data illustrated in Fig. 2 revealed that AB-DTPA extractable Cd from sandy soil treated with compost; biogas or sewage sludge manure rates up to 4.0 % were in the range of 0.02 0.37 mg kg^{-1} under barley plants. These results indicated that sewage sludge was the most effective organic waste in enriching

soil with heavy metals compared to the compost or the biogas manures (the latter showed the lowest effect). Such trend of result may be attributed to the high content of metal and rapid decomposition of sewage sludge compared to compost or biogas and consequently the mineraliszation process of the different heavy metals is expected to be highest with soil treated with sewage sludge and lowest with compost. Also, the higher contents of Cd in sludge compared to compost or biogas monure may account for the abovementioed trend which is confirmed by the results of Anderson & Nilson (1973), who indicated that application of sewage sludge to soil often resulted in significant increases in toxic metal concentration of the soil.

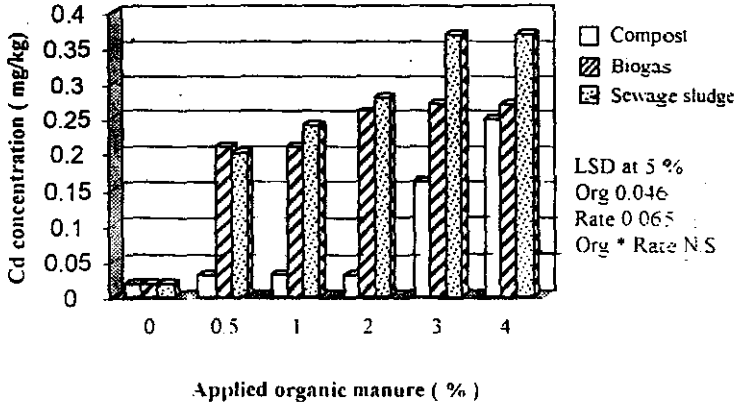

Fig. 2. AB-DTPA extractable Cd in sandy soil as affected by the organic manures applications.

Application of organic manures (Fig. 2) showed a significant increase in available Cd concentration in soil, the highest concentration resulted from sewage sludge or biogas application such increases progressed and was more obvious with increasing the application rate of organic manure up to 3.0 %, then a slight insignificant decrease or increase was occurred under the highest addition rate of organic manure (4.0 %) as compared with the addition rote of 3.0 %. Touchton & Boswell (1975); Williams *et al.* (1980) and Abdel -Naim *et al.* (1998) showed that the metal levels determined immediately after mixing the soils with sewage sludge were markedly increased. Otabbong *et al.* (1997) and El-Sebay (2002) showed that the values of available Cd in me rhizosphere of corn or faba bean plants were significantly increased by increasing sewage sludge application.

The highest Cd concentration was less than 1.0 $mgkg^{-1}$ which is considered the maximum concentration permissible for arable lands according to National Academy of Science (1972).

Dry matter yield of barley plants

Data presented in Table 2 showed that dry matter weight (g pot^{-1}), weight of 100 grains (g) and plant height (cm) of barley plants as affected by application

of compost, biogas or sewage sludge manure to the sandy soil were increased over control. The increases were of the highest progressive with increasing the addition rate of organic manure as compared with no addition treatment. The positive effect of these organic manure on barley dry weight, weight of 100 grains and plant height was probably attributed to their ability to increase microbial activity adding complexing agents to the soil and affecting the redox status of soil and consequently changing the nutrients status that have oxidation-reduction potential, *e.g.*, Fe, Mn, Zn, and Cu (Reisenauer, 1988).

The present finding was in agreement with that reported by Eskandar (2002) who found that sludge, biogas and city compost could serve as good organic fertilizers to maximize crop productivity.

As shown in Table 2, it is clear that the highest rate of organic manure (4.0 %) showed a insignificant decrease in Dry weight, weight of 100 grains and plant height as compared with the rate of 3.0 %, which is considered the optimum rate for producing the highest dry matter yield, the inhibited growth of barley plants caused by the higher rates of compost, boigas and sewage sludge may be due to its higher content of heavy metals Cd and Pb or related to some interaction between these elements and other elements in growth media. El-Sokkery *et al* . (1988) reported that the influence of sewage sludge on crop yield has been found to be variable and dependent on its elemental composition and application rate.

Rabie *et al.* (1997) found that seed yield of faba bean grown on a soil received 2.5 % sludge was significantly increased. While slightly increase was observed under the addition rate of 5.0 %, then declined progressively to reach values below the control at level of 10.0 %.

Contents of Pb and Cd in barley planets

Concentration of Pb in both grain and straw of barley plants were markedly increased due to the addition of organic manure (Fig.3 and 4), Lead concentration tended to be the highest the value by addition of sewage sludge, moderate under biogas and lowest values resulted from compost addition. The increases were progressive with increasing addition rates of organic manures up to the highest level of 4.0 %. The strow exhibited more accumulation than grains. Mohamed (1991) found that application of dried sewage sludge to calcareaus and non-calcareaus soils increased the concentration and uptake of Pb by alfalfa plants, compared to control.

High significant increase in Pb concentration was observed for both grains and straw of barley plants grown on the soil amended with organic manure compared to that grown without organic manure. A similar trend was occurred concerning effect of the applied rate of organic manure, increasing rate of the applied manure caused an increase in Pb concentration, however these increases were significant for grains and straw. Otabbong *et al.*(1997) and lur *et al.* (1995) pointed out to the effect of sewage sludge application on soil NH_4NO_3-extractable Pb arid Cd as well as their uptake by barley plants they reported that soil metal levels determined immediately after mixing the soils with sewage sludge were markedly increased. However, metal uptake in straw and roots was significantly ($P = 0.8$) enhanced by sewage application.

TABLE 2. Effect of some organic manurs on the dry matter yield of barley plant.

Treatment Rate R (%)	Type of organic manure (OM)											
	Compost	Biogas	Sewage sludge	Mean	Compost	Biogas	Sewage sludge	Mean	Compost	Biogas	Sewage sludge	Mean
	Dry weight (g / pot)				Weight of 100 grains (g)				Plant height (cm)			
0.0	5.65	5.65	5.65	5.65	2.08	2.08	2.08	2.08	35.30	35.30	35.30	35.3
0.5	8.45	9.24	9.82	9.17	2.56	3.07	3.17	2.93	44.30	50.10	50.60	48.33
1.0	10.25	10.99	11.10	10.78	2.98	3.39	3.23	3.20	44.60	53.30	52.20	50.03
2.0	10.70	10.37	11.60	10.89	3.40	3.19	3.28	3.29	51.50	54.00	53.60	53.03
3.0	11.06	12.56	13.56	12.48	3.50	3.66	3.84	3.66	54.60	53.60	58.50	55.56
4.0	10.13	11.18	11.10	10.80	3.44	3.38	3.41	3.41	50.10	51.60	52.50	51.4
Mean	9.38	10.03	10.47	9.96	2.99	3.12	3.16	3.09	46.73	49.65	50.75	48.94
LSD at 5 %	OM = 0.156 R = 0.11 OM * R = 0.148				OM = 0.163 R = N.S OM * R = N.S				OM = 0.253 R = 0.179 OM * R = 0.240			

Note : 0.0 is no addition of organic manure.

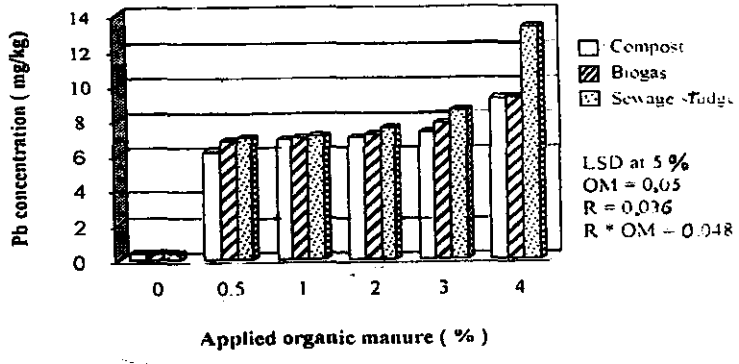

Fig. 3. Concentration of heavy metal Pb in barley straw as affected by the organic manure applications.

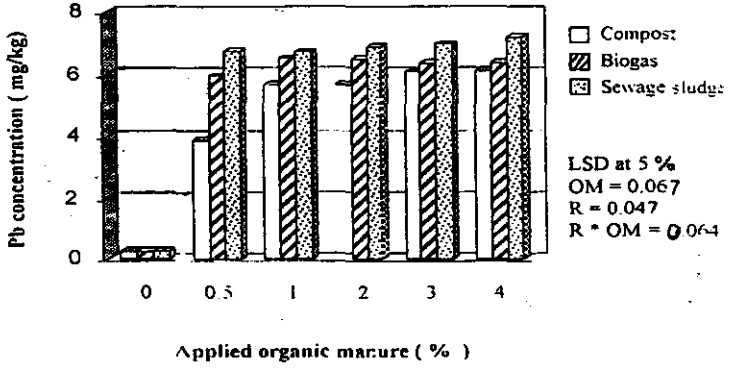

Fig. 4 . Concentration of heavy metal Pb in barley grains as affected by the organic manure applications.

Compared to the soil not received organic manure, all organic manure treatments increased markedly Cd concentration and its content in both straw and grains with significant difference (Fig. 5 and 6). What ever the find of manure Chaney *et al.* (1975) showed that Cd and Pb concentration in barley increased significantly with increasing rates of sewage sludge application.

Data showed that Cd concentration of barley straw gave the same trend of Cd concentration grains plants were significant, such increases progressed and more obvious with increasing the application rate of organic manure. Chang *et al.* (1982), on barley grown a sandy loam soil treated with 100 tons sludge/ha,

showed that the Cd content of grains was increased to 0.38 mg kg^{-1},relative to the control which was less than 0. 04mg kg^{-1}.

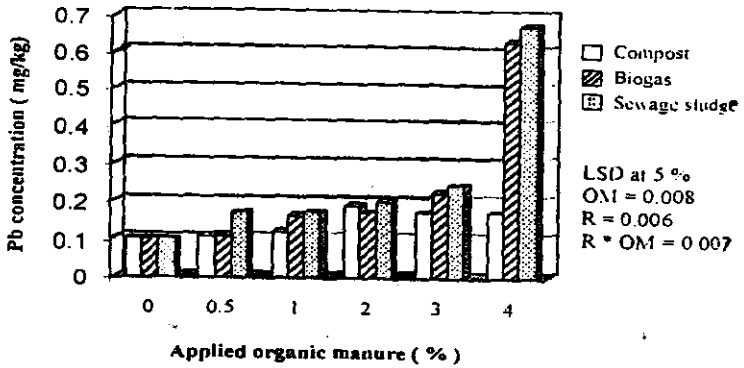

Fig. 5. Concentration of heavy metal Cd in barley straw as affected by the organic manure applications.

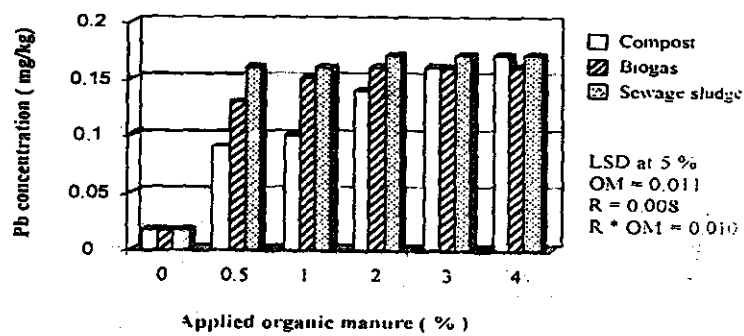

Fig. 6. Concentration of heavy metal Cd in barley grain as affected by the organic manure applications.

On the other hand, the average values of Pb and Cd concentration in barley straw and grains varied according to type of the applied organic waste. The sewage sludge resulted in the highest Pb and Cd concentrations in plant whereas compost and biogas were of least effect. All the studied organic wastes resulted significant higher uptake values than the untreated soil. These results in harmony with those of Mineev *et al.* (2003).

According to the safety limits of Pb (13.5 mg Kg^{-1}) pointed by Chapman (1968), barley straw and grains contained lower Pb concentrations than that

limits where were not more than 13.20 and 7.18 mg kg^{-1}, respectively. Regarding to the safety limit of Cd (1.0 mg kg^{-1}) in barley straw and grains, respectively which were also in normal range.

From the above mentioned results, it can be concluded that under this investigation conciliation there were accumulation of heavy metals Pb and Cd in barley plants due to compost, biogas and sewage sludge treatments, coefficients decreased in the order sewage sludge > biogas > compost. However, the levels were within the permissible limits and below the toxic concentration as previously recorded. Therefore it is necessary to use sewage sludge at a proper rate to avoid this pollution. On the other hand, the compost and biogas manure are simple and effective means to produce energy and used as clean organic manure. Also these manure would be free from pathogenic bacteria generally, cropping edible plants grown on soil treated with sewage sludge should be avoided, where, planting of woody trees may be economically of great concern.

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محتوي الرصاص والكادميوم فى نباتات الشعير النامية فى تربة رملية مضاف إليها بعض الأسمدة العضوية

محمود محمد السباعي ، محمد السعيد مطر و محمود كامل ناصف
معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية –القاهرة– مصر.

نفذ هذا البحث فى أصص وذلك لدراسة محتوى نبات الشعير من الرصاص والكادميوم وأيضاً التربة بعد إضافة بعض الأسمدة العضوية إليها الكمبوست (سماد بلدي + قش الأرز) ومخلفات البيوجاز من مركز البحوث الزراعية بمشتهر ومخلفات المجاري من الجبل الأصفر بإستخدام المعدلات صفر، ٠,٥، ٠,١، ٠,٢، ٠,٣، ٠,٤ ٪ من وزن الأصيص (على أساس الوزن الجاف لهذه الإضافة) فى تربة رملية أخذت من طريق مصر السويس (ك ٢٥ من القاهرة).

أظهرت النتائج أن تركيز الرصاص والكادميوم فى مستخلص الـ AB-DTPA يزيد زيادة معنوية بزيادة معدل أستخدام المادة العضوية بالمقارنة بالكنترول وكانت زيادة الرصاص فى التربة ٠,١٥ إلى ٧,٥٥ ملليجرام لكل كيلو جرام والكادميوم ٠,٠٢ إلى ٠,٣٧ ملليجرام لكل كيلو جرام باستخدام معدل ٤٪ من مخلفات المجاري الجافة إلا أن هذين التركيزين فى مدى الحدود المسموح بها وكانت أعلى زيادة معنوية عند ٢٪ بإستخدام مخلفات المجاري. وكان وزن المادة الجافة ووزن ١٠٠ حبه من نبات الشعير أكثر معنوية مع البيوجاز بالمقارنة بمخلفات المجاري وكان إرتفاع النباتات أكثر معنوية مع مخلفات المجاري. ولم يكن الفرق بين معدلي ٣، ٤٪ معنوياً وهذا يدل على أن أمثل استخدام للأسمدة العضوية كان عند ٣٪. وزاد تركيز الرصاص والكادميوم فى السيقان أكثر من حبوب الشعير وكانت الزيادة على النحو التالي مخلفات المجاري > مخلفات البيوجاز > الكمبوست وكان الزيادة داخل الحدود المسموح. وقد أشارت النتائج أن استعمال مخلفات المجاري يؤدي إلى تلوث التربة على فترة زمنية قصيرة بينما البيوجاز والكمبوست يؤديان إلى توفير سماد عضوي نظيف نتيجة استعمال قش الأرز فى الكمبوست ادى إلى نقص الرصاص والكادميوم ولذلك ننصح بتجنب استخدام مخلفات المجاري فى زراعة النباتات التي تؤكل ويزرع بدلاً منها أشجار تستخدم فى الصناعة.