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USING MUNICIPAL WASTES AS SOIL AMENDMENT FOR URBAN TREES: (II). ANALYSIS OF SOIL AND SEEDLING LEAVES AND ROOTS

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ABSTRACT

An experiment was conducted at the Nursery of the Department of Timber trees, Antoniades gardens, East of Alexandria to evaluate the influence of various municipal wastes on the soil analysis as well as, the leaves and roots uptake of macro, micro-elements and heavy metals of seedlings of three urban tree species. The amendment treatments consisted of: control, dried raw sludge (DRS), solid garbage compost (SGC) and a (Mixture) of both amendments. One-year-old seedlings of Delonix regia Jacaranda mimosifolia and Ailanthus altissima were used in this experiment through two successive seasons. Each tree seedling was transplanted into large volume tin filled with 20 Kg of soil and was irrigated to its field capacity. Generally, dry bulk density (Db) of amended soils with municipal wastes was notably lower than control without significant differences for the three tree species. Also, the mixture treatment had the highest values of soil EC, pH, N, P and K followed by DRS then SGC. The leaves of both Delonix and Jacaranda seedlings were highly significant in uptake of macro, micro-elements and heavy metals when grew in mixture followed by DRS then SGC treatments whereas, uptake of the abovementioned elements by Ailanthus leaves increased in respect with control but were similar significantly when planted in the three municipal treatments. The roots of Delonix exhibited higher uptake of macro and micro-elements when grew through the SGC amended soil. On the other hand, the uptake efficiency of all elements were higher even as Jacaranda roots penetrated in mixture treatment also, when Ailanthus roots grew through DRS amended soil.

INTRODUCTION

Soil compaction resulted from sidewalk and roadway construction can influence the growth of urban trees by negatively affecting root establishment and reducing the subsequent uptake of water and nutrients (Grabosky and Bassuk 1995). Application of composted organic wastes slowly release significant amounts of nitrogen and phosphorus. In addition to supplying plant nutrients, organic compost has been shown to increase the level of soil organic matter, enhance root development and increase the water-holding capacity of soil. On the other hand, applying organic materials promote biological activity in the soil, as well as a favorable nutrient exchange capacity, water balance, organic matter content and soil structure (Zibilske 1987; Muse 1993 and Eghball 2001). Compost also inoculates the soil with vast numbers of beneficial microbes (bacteria, fungi etc.) and the habitat that the microbes need to live. These microbes are able to extract nutrients from the mineral part of the soil and eventually pass the nutrients on to plants (Johnson 1996).

Sewage sludge amended soils demonstrate a higher rate of organic matter decomposition. This can be explained by an increase of microbial biomass and an increase in microbial mineralization activities for several months following the biosolid application (Harrison *et al*., 1996). Therefore, Pichtel *et al*., (1994) confirmed that the sewage sludge amendments generally maintained the highest soil K and P concentrations.

A long-term field experiment was conducted by Giusquiani *et al*., (1995) to determine the effect of the additions of urban waste compost on the physical and chemical properties in a calcareous soil. In the amended plots total and humified organic C, Pb, Cu, and Zn showed a significant increase compared with nonamended plots. Also, barley plants were cultivated by Moreno *et al*., (1996) in a calcareous soil amended, at different rates, with sewage-sludge composts containing different heavy-metal contents and the transference of these heavy metals to the plant was studied. Cadmium and Zn were easily absorbed by barley plants, increasing their concentration with respect to the control in plants grown in the soil amended with compost containing high amounts of these metals. However, Ni was retained by organic matter and was not transferred to plants. Plants grown in amended soils showed higher N and P contents than control plants. The concentrations of Cd and Zn in plants were positively correlated with Cd and Zn contents in the soils. After cultivation, amended soils showed a better nutritional state than control soil (higher N-NO_3^- and total and available P than the control). Consequently, Jackson *et al.* (2003), incorporated compost into their soil fertility program, and reported that the use of compost increased soil quality. The application of compost increased soil microbial, total soil nitrogen and reduced surface bulk density.

Preplanting application of biosolids at rates of 13 and 26 Mg dry solids ha^{-1} having total N equivalents of 445 and 893 kg ha^{-1} and total P equivalents of 128 and 256 kg ha^{-1} on a Sitka spruce (*Picea sitchensis*) plantation resulted in a significant increase in foliar and soil Zn concentrations seven years after planting (Dutch and Wolstenholme 1994). As well as, no

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changes were detected in Zn, Cr, Pb, Ni, or foliar P concentrations, but increases in foliar N were detected following application of biosolids having a total N equivalent of 1,160 kg ha^{-1} in red pine (*Pinus resinosa*) and white pine (*Pinus strobus*) plantations in Michigan (Brockway 1983). Foliar levels of Ni and Cd, in Douglas-fir and grand fir growing on a sandy outwash soil amended with sewage sludge were found significantly elevated, but not toxic (Harrison and Henry 1994).

This study was conducted to evaluate the influence of various municipal wastes on the soil analysis as well as, the leaves and roots uptake of macro, micro-elements and heavy metals of *Delonix regia Jacaranda mimosifolia* and *Ailanthus altissima* tree seedlings.

MATERIALS AND METHODS

Treatments and plant material

This experiment was conducted from March, 2003 to November, 2005 at the Nursery of the Department of Timber trees, Antoniades gardens, East of Alexandria. The amended treatments consisted of four treatments: (1) control, (2) dried raw sludge (DRS) with 20 Mg ha^{-1} dry wt. basis according to Hasselgren, (1999) (3) solid garbage compost (SGC) with 126 Mg ha^{-1} according to Eriksen *et al.*, (1999) and (4) DRS (20 Mg ha^{-1}) + SGC (126 Mg ha^{-1}). The dried raw sludge brought from Ameryiah Municipal Sewage Treatment Plant, while the solid garbage compost came from the ONYX Company, Alexandria. Each amendment was thoroughly mixed totally with the soil, in one application, on 26 April, 2003 to ensure further incorporation and a uniform planting media.

One-year-old seedlings of three tropical deciduous tree species were chosen for this study as urban trees that were: (1) *Delonix regia* Hook.) Raf. family: Fabaceae, (flame tree), (2) *Jacaranda mimosifolia* D. Don family: Bignoniaceae, (jacaranda) and (3) *Ailanthus altissima* (Mill.) Swingle (family: Simaroubaceae, (tree of heaven- Chinese sumac). Each tree seedling was transplanted into large volume tin (20X20X40 cm) filled with 20 Kg of soil (with 5.0 % $CaCO_3$, 1.2 dS m^{-1} EC, organic matter 0.2 % and pH, 8.0), as an experimental unit, and was irrigated to its field capacity. Then the three seedling cultivations were continued through two successive seasons (2003/2004 and 2004/2005). Experimental design was a complete randomized using 4 amended treatments with 5 replications for 3 tree species. Data were analyzed by analysis of variance ANOVA using CoStat software and means were separated by Duncan's Multiple Range Test at the probability 5% level of significance.

Measurements

Physical and chemical analysis:

Soil properties as well were analyzed before and after planting transplants for:

1. Soil bulk density (Db) was determined by core method as described by Black and Hartge (1986). The core method was carried out by pressing a stainless steel cylinder of known volume and the mass was obtained by drying at 105 °C.
2. Salinity: Soil water extract 1:1 was obtained according to Richards (1954) and EC was measured using digital EC meter.
3. pH was measured using 1:2.5 soil water extract and pH was measured by digital pH meter in soil suspension and adjusted at 25 °C.
4. Available N, P, and K measured according to Page (1982).
5. DTPA-extractable trace elements: Ni, Pb, Cd, Cr, Zn and Mn were extracted by DTPA according to Lindsay and Norvell (1978). The concentrations of trace elements were measured by Atomic Absorption spectrophotometer (perkin Elmer). Another parameters were measured are the elemental compositions of both leaves and roots affected by amended treatments and its comparison with control. Half gram of oven dried leaves and roots was wet digested with H_2SO_4 and H_2O_2 (Evenhuis and Dewaard, 1980). N, P, K and trace elements were determined as above.

RESULTS AND DISCUSSIONS

1- Soil analysis

Bulk density (Db)

Generally, dry bulk density (Db) of amended soils with municipal wastes was notably lower than control without significant differences for the three tree species (Table 1). The soil of tree of heaven seedlings which amended by dry raw sludge (DRS) had the lowest value of bulk density (Db) in respect with other treatments that recorded 1.40, 1.34 and 1.35 g cm^{-3} for tree of heaven, jacaranda and flame tree species, respectively. This result is probably due to the presence of organic matter in the media hence, is compatible with Jackson *et al.* (2003) that the application of compost reduced surface bulk density.

Table (1): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on bulk density (Db) of the soil under the three tree species.

Treatment	Bulk density (g cm^{-3})		
	Tree of heaven	**Jacaranda**	**Flame tree**
Control	1.48a	1.42a	1.45a
DRS	1.40a	1.34a	1.35a
SGC	1.41a	1.36a	1.35a
Mixture	1.45a	1.36a	1.37a

Means followed by a similar letter within a column are not significantly different at the probability 0.05 by Duncan's Multiple Range Test.

Chemical composition

Tables (2 and 3) declared the effects of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on the chemical composition of the soil under the three tree species. Generally, mixture treatment had the highest values of EC, pH, N, P and K followed by DRS then SGC. The soil amended by mixture had the higher electrical conductivity value (42.9%) followed by DRS and SGC that recorded 28.6 and 7.1% more than control, respectively. This result may due to that the mixture treatment of both garbage compost and sludge which is the richer in the aforementioned nutrients. The data in Table (2) reflected that planting the tree seedlings under all treatments reduced the EC value of its soil after two successive seasons otherwise, the pH value of the various amended soils had not affected either by amendment source or by tree planting. Initial pH of control, DRS, SGC and mixture soils were 8.0, 7.3, 8.1 and 8.2, respectively, and 8.0, 8.0, 8.1 and 8.2 for the soils of the three tree species, after two successive seasons. This could be explained that the pH modifying is very difficult as a result of the high buffering capacity of the soil. Also, the mixture treatment maintained the highest available soil N, P, and K concentrations (200.0, 337.5 and 257.1%, respectively) more than control while the DRS and SGC amendments recorded 100.0, 175.0 and 126.2%, and 70.0, 150.0 and 95.2%, respectively in respect with control. Increasing soil nitrogen with using different amendment sources was compatible with Moreno *et al.*, (1996); El-Naim and El-Houseini (2002) and Jackson *et al.* (2003) on the other hand, Pell and Nyberg (1989) and Pichtel *et al.*, 1994) stated that soil phosphorous and potassium levels were increased with effluent application.

The elemental content of N, P, K and Fe under all amended soils were decreased after cultivation at the end of this study comparing with initial cultivation data as a result of depletion by planted seedlings for its growth requirement wherever, they increased under control soil after the two successive seasons which may be explained that these three species are deciduous trees consequently, are shedding their leaves in autumn through winter hence are decomposition in the soil and release their mineral contents. Although the N, P, K and Fe content of control soil was increased however, this increase still less than the content of the amended soils after the same period that reflect the economical value of the used municipal wastes. Likewise, the Zn and Mn contents under all amended soils were minimized after cultivation in compare with initial cultivation data. These results are in parallel with Giusquiani *et al.*, (1995) that the additions of urban waste compost significantly increased the soil zinc (Z) and lead (Pb) contents. The results in Table (3) indicated that the heavy metals content of Pb, Ni, Cd and Cr for SGC were in general lower than the average heavy metals reported for DRS and below the critical concentrations in soil regulated by Kabata and Pendias, (1992). Wherever seedlings of tree of heaven were the most in depletion the macro-elements (N, P and K) however, were the most efficiency in terminated the heavy metals (Pb, Ni, Cd and Cr) followed by jacaranda then flame tree seedlings (Tables 2 and 3). Therefore, tree of heaven species could be planted as phytoremediator in polluted areas with these heavy metals.

Table (2): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on electrical conductivity (EC), pH and macro-elements contents in the soil under the three tree species.

Treatment	Before cultivation					After cultivation														
						Tree of heaven					Jacaranda					Flame tree				
	EC	pH	DTPA extractable elements (ppm)			EC	pH	DTPA extractable elements (ppm)			EC	pH	DTPA extractable elements (ppm)			EC	pH	DTPA extractable elements (ppm)		
			N	P	K			N	P	K			N	P	K			N	P	K
Control	1.4	8.0	50	8.0	420	1.2	8.0	65	13.2	550	1.2	8.0	60	12	580	1.2	8.0	65	13	585
DRS	1.8	7.3	100	22	950	1.5	8.0	80	17	720	1.5	8.0	95	21	800	1.5	8.0	95	22	830
SGC	1.5	8.1	85	20	820	1.2	8.1	72	17	800	1.2	8.1	75	19	810	1.2	8.1	78	19	815
Mixture	2.0	8.2	150	35	1500	1.3	8.2	110	30	1230	1.3	8.2	120	31	1300	1.3	8.2	125	32	1350

Table (3): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on micro-elements and heavy metal contents in the soil under the three tree species.

Treatment	Before cultivation							After cultivation																				
								Tree of heaven							Jacaranda							Flame tree						
								DTPA extractable elements (ppm)																				
	Fe	Mn	Zn	Pb	Ni	Cd	Cr	Fe	Mn	Zn	Pb	Ni	Cd	Cr	Fe	Mn	Zn	Pb	Ni	Cd	Cr	Fe	Mn	Zn	Pb	Ni	Cd	Cr
Control	15.1	2.9	1.0	0.5	0.2	1.4	0.01	16.8	2.7	1.0	0.5	0.2	1.3	0.01	17	2.8	1.1	0.5	0.2	1.4	0.01	18	2.8	1.0	0.5	0.2	1.4	0.01
DRS	20.0	5.5	3.0	6.0	5.0	2.0	0.08	18.0	3.2	2.9	5.3	4.2	1.8	0.06	19	3.8	3.0	5.9	4.3	1.9	0.06	20	4.0	3.0	5.9	4.6	1.9	0.07
SGC	21.0	4.0	2.0	5.1	4.1	1.5	0.05	20.0	3.0	1.5	4.8	3.2	1.3	0.04	20	3.5	1.7	5.0	3.5	1.4	0.04	20	3.7	1.8	5.0	3.8	1.4	0.05
Mixture	25.0	6.0	3.9	6.6	4.5	2.3	0.1	25.0	4.0	3.2	5.8	4.3	1.8	0.08	26	4.5	3.5	6.0	4.4	1.9	0.08	26	4.0	3.7	6.3	4.5	2.1	0.09

2- Uptake of macro, micro elements and heavy metals

2-1 Delonix regia

Uptake of macro-elements

Figure (1-a) showed that after two successive seasons leaves of flame tree seedlings planted in the soil amended by mixture had significantly the highest N, P and K content of 2.6, 4.2 and 2.8-fold, respectively followed by DRS which had 2.4, 2.6 and 2.4-fold, respectively than control. On the other hand, the leaves of the seedlings grew in soil amended by solid garbage compost (SGC) uptake the lowest N, P and K content (1.7, 1.6, 1.6-fold, respectively than control). Moreover, the roots penetrated through the soil amended by SGC accumulated the maximum content of N and K (13.64 and 8.49 g), respectively followed by these planted in mixture treatment that uptake 10.41 and 6.56 g, respectively afterward, the roots grown in DRS amended soil which had 9.41 and 5.52 g, respectively. Whereas, the higher significant uptake of P was detected in the roots grew through mixture amended soil (0.72 g) followed by those grew in both SGC and DRS soils (0.53 and 0.45g, respectively) that had the same significant level (Fig. 1-b). This result could be attributed to the higher growth of the roots biomass, total length and total area in SGC amended soil which absorbed high quantity of these elements (data presented in another study). Where SGC and DRS amendments were not differed significantly according to P uptake via the roots of flame tree seedlings, however the double quantity of these amendments in mixture treatment increased P uptake.

Uptake of micro-elements

Figure (1-a) illustrated that micro-elements had similar trend as macro-elements content where the leaves of flame tree seedlings planted in the soil amended by mixture uptake the maximum significant Fe, Zn and Mn content (3.4, 3.5 and 3.1-fold, respectively) followed by the leaves of the seedlings grown in DRS treatment that uptake the moderate content of these elements (2.9, 3.1 and 2.3-fold, respectively) then the leaves grown in SGC which uptake the minimum content of Fe, Zn and Mn (1.8, 1.9 and 1.7-fold), respectively in comparing with control. Additionally, micro-elements content of the roots had somewhat the same trend of macro-elements that occurred for those grew in SGC amended soil (Fig. 1-b), which uptake170.52, 30.3 and 9.85 mg, respectively followed by the roots grew in mixture then that planted in DRS. These results are in agreement with this of Dutch and Wolstenholme (1994) on a Sitka spruce (*Picea sitchensis*) plantation.

Uptake of heavy metals

Figure (1-a) demonstrated that different amendment treatments had as well, the same trend as macro and micro-elements regarding the heavy metals content of flame tree leaves except for (Cd). The leaves of the seedlings grew in mixture, DRS and SGC soil had 5.0, 3.6 and 1.7-fold, respectively of lead (Pb) content with respect to control. Also, they had 5.4, 3.8 and 1.8-fold, respectively of nickel (Ni).On the other hand, leaves of the seedlings grew in both mixture and DRS amended soil were similar significantly and uptake 3.5 and 3.1-fold, respectively of cadmium (Cd) with respect to control followed by SGC that had the same level of significance with control. Furthermore, the roots of flame tree seedlings had maximum significant uptake of (Pb) and (Ni) when grew in the soil amended by mixture treatment. Fig. (1-b) revealed that (Ni) was not differed significantly when uptake by the roots of flame tree seedlings in either DRS or SGC amended soils. Otherwise, (Cd) reached its maximum content in the roots planted in (SGC) treatment although was not different significantly with mixture treatment. The obtained data are in agreement with Moreno *et al.*, (1996) that nitrogen, phosphorus, cadmium and Zn were easily absorbed by barley plants, increasing their concentration with respect to the control in plants grown in the soil amended with compost containing high amounts of these metals.

2-2 Jacaranda mimosifolia

Uptake of macro-elements

There was evidence that municipal wastes increased the uptake of macro-elements in the leaves of jacaranda seedlings after two successive seasons from amending (Fig. 2-a). The leaves of the seedling grew in mixture and DRS amended soils significantly, had the highest N and K uptake that were 3.5 and 3.7 and 3.3 and 3.7 times than control, respectively. Regarding P uptake, the mixture treatment recorded the maximum uptake by seedling leaves followed by DRS treatment then SGC that uptake 5.1, 3.2 and 1.7 times than control. In general, macro-elements uptake by roots had been shown to increase with the addition of municipal wastes as amended soil with an exception for P uptake. Fig. (2-b) showed a 1.9-fold increase in N and K after mixture application than control as well as, 1.6 and 1.4-fold after SGC application. These results agrees with the findings of the positive effects associated with sludge- compost application on nitrogen that reported by Brockway (1983) on red pine and white pine plantations. Also, non changing in P uptake by roots was confirmed by Brockway (1983) and Ferrier *et al.* (1996) who applied biosolids slurry at rates of 3.3 and 4.8 dry Mg ha^{-1} supplying N equivalents of 190 and 290 kg ha^{-1}, respectively, on Scots pine plantation resulted in increases in foliar N but no change in foliar P after one year.

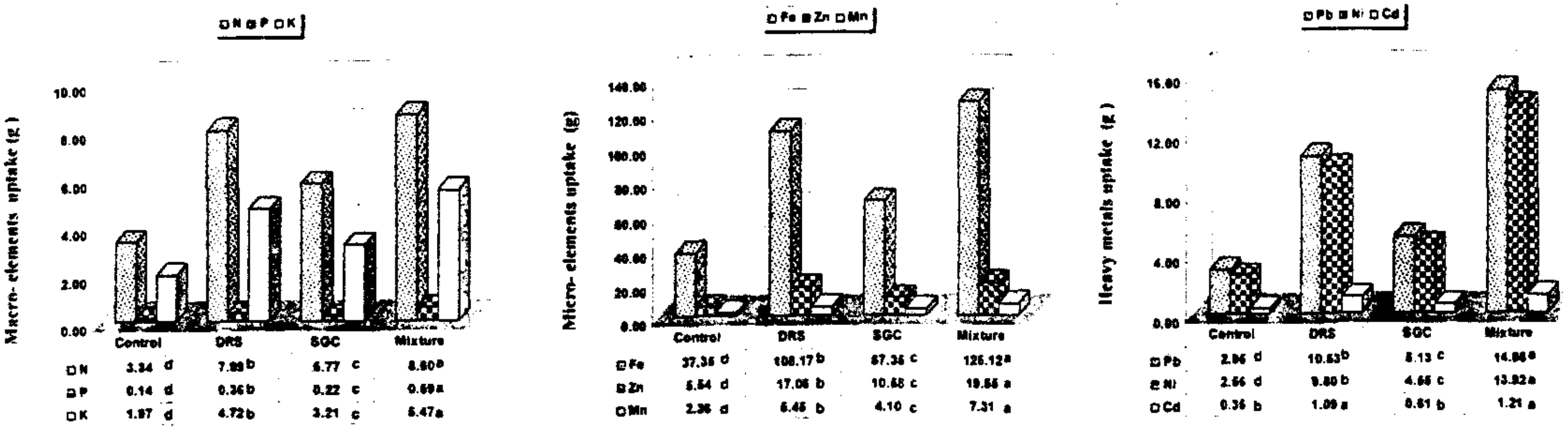


Fig. (1-a): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on leaves chemical composition of flame tree.

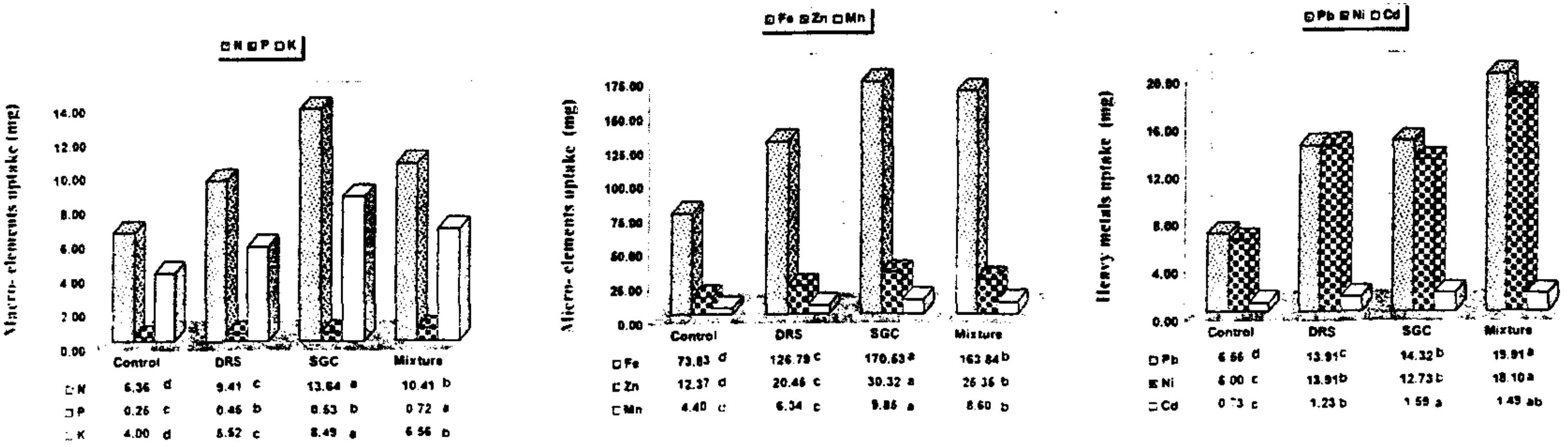
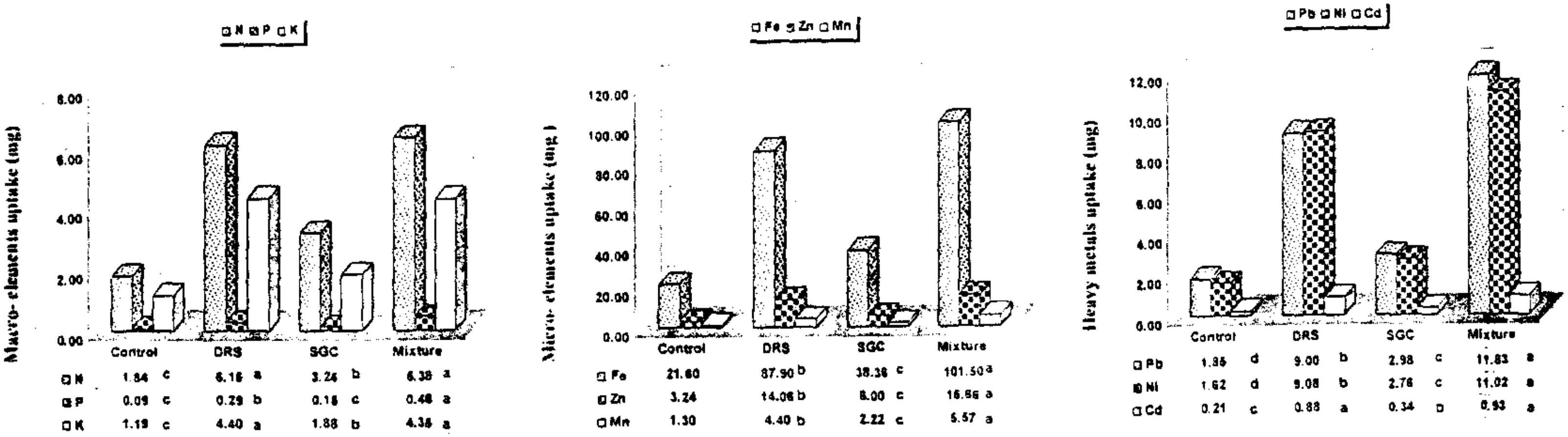


Fig. (1-b): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on roots chemical composition of flame tree.

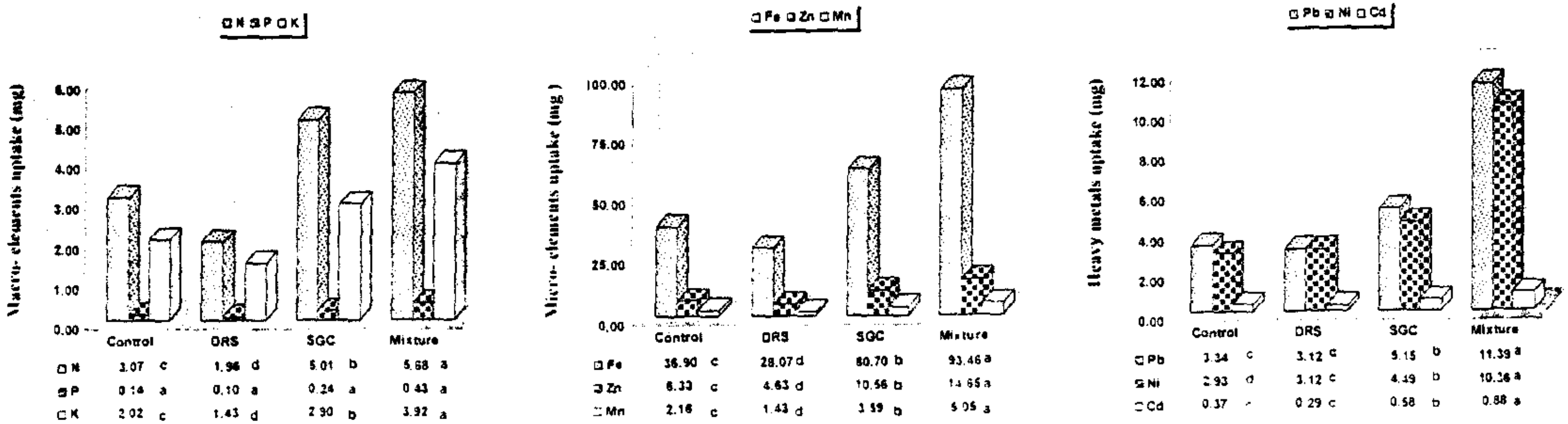


	Control		DRS		SGC		Mixture	
N	1.84	c	6.16	a	3.24	b	6.38	a
P	0.09	c	0.29	b	0.16	c	0.48	a
K	1.19	c	4.40	a	1.88	b	4.38	a

	Control		DRS		SGC		Mixture	
Fe	21.60		87.90	b	38.36	c	101.50	a
Zn	3.24		14.06	b	6.00	c	16.66	a
Mn	1.30		4.40	b	2.22	c	5.57	a

	Control		DRS		SGC		Mixture	
Pb	1.86	d	9.00	b	2.98	c	11.83	a
Ni	1.62	d	9.08	b	2.76	c	11.02	a
Cd	0.21	c	0.88	a	0.34	b	0.93	a

Fig. (2-a): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on leaves chemical composition of jacaranda.

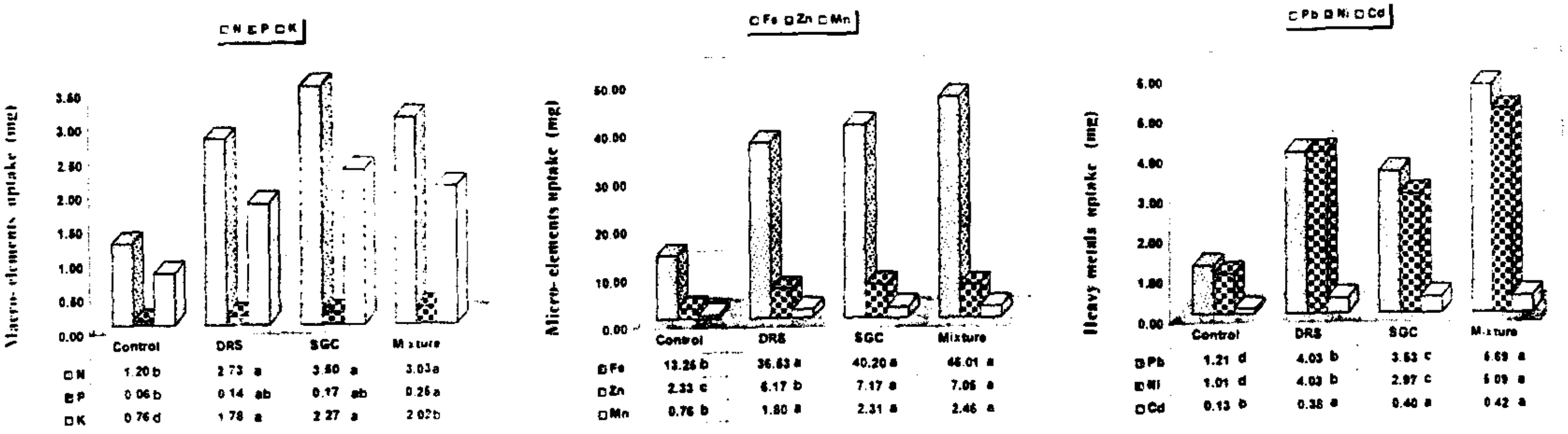


	Control		DRS		SGC		Mixture	
N	3.07	c	1.96	d	5.01	b	5.68	a
P	0.14	a	0.10	a	0.24	a	0.43	a
K	2.02	c	1.43	d	2.90	b	3.92	a

	Control		DRS		SGC		Mixture	
Fe	36.90	c	28.07	d	60.70	b	93.46	a
Zn	6.33	c	4.63	d	10.56	b	14.65	a
Mn	2.16	c	1.43	d	3.59	b	5.05	a

	Control		DRS		SGC		Mixture	
Pb	3.34	c	3.12	c	5.15	b	11.39	a
Ni	2.93	d	3.12	c	4.49	b	10.36	a
Cd	0.37	[illegible]	0.29	c	0.58	b	0.88	a

Fig. (2-b): Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on roots chemical composition of jacaranda.

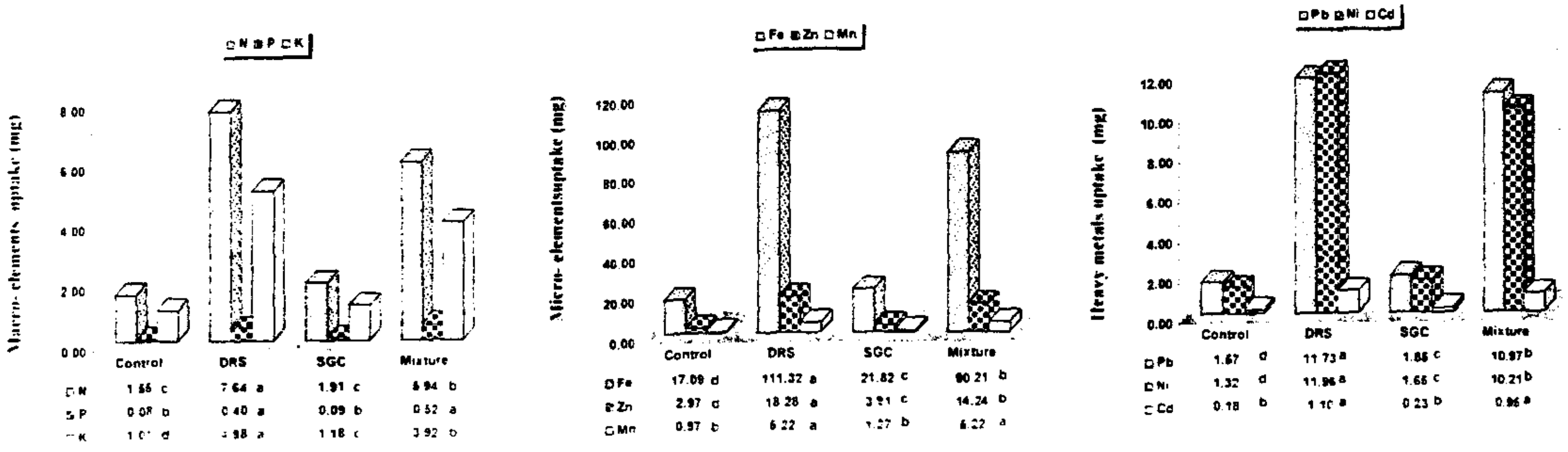


	Control	DRS	SGC	Mixture
□N	1.20 b	2.73 a	3.50 a	3.03a
▨P	0.06 b	0.14 ab	0.17 ab	0.26 a
□K	0.76 d	1.78 a	2.27 a	2.02b

	Control	DRS	SGC	Mixture
□Fe	13.26 b	36.63 a	40.20 a	46.01 a
▨Zn	2.33 c	6.17 b	7.17 a	7.06 a
□Mn	0.76 b	1.80 a	2.31 a	2.46 a

	Control	DRS	SGC	Mixture
□Pb	1.21 d	4.03 b	3.63 c	5.69 a
▨Ni	1.01 d	4.03 b	2.97 c	5.09 a
□Cd	0.13 b	0.38 a	0.40 a	0.42 a

Fig. (3-a):Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on leaves chemical composition of tree of heaven.



	Control	DRS	SGC	Mixture
□N	1.56 c	7.64 a	1.91 c	6.94 b
▨P	0.08 b	0.40 a	0.09 b	0.52 a
□K	1.0[illegible] d	[illegible].98 a	1.18 c	3.92 b

	Control	DRS	SGC	Mixture
□Fe	17.08 d	111.32 a	21.82 c	90.21 b
▨Zn	2.97 d	18.28 a	3.[illegible]1 c	14.24 b
□Mn	0.97 b	6.22 a	1.27 b	6.22 a

	Control	DRS	SGC	Mixture
□Pb	1.67 d	11.73 a	1.86 c	10.97 b
▨Ni	1.32 d	11.96 a	1.65 c	10.21 b
□Cd	0.18 b	1.10 a	0.23 b	0.96 a

Fig. (3-b):Effect of dried raw sludge (DRS), solid garbage compost (SGC) and their mixture on roots chemical composition of tree of heaven.

Uptake of micro-elements

Figure (2-a) illustrated that micro-elements content of jacaranda leaves had the same behavior of macro-elements where those seedlings grown in *mixture* followed by DRS amended soils significantly had the maximum uptake of Fe, Zn and Mn after two successive seasons then the leaves of the seedlings grown in SGC amended soil. In addition, Fig. (2-b) demonstrated that the roots grew through the soil amended by mixture had the highest significant uptake of Fe, Zn and Mn (93.46, 14.65 and 5.05 mg, respectively) followed by SGC which uptake 60.70, 10.56, 3.59 mg, respectively of the abovementioned micro-elements. It was noticeable that micro-elements uptake by roots penetrated through DRS amended soil were lower than those grew in control treatment. These results are in harmony with this of Dutch and Wolstenholme (1994) on a Sitka spruce (*Picea sitchensis*) plantation.

Uptake of heavy metals

The presented data in Figure (2-a) showed that jacaranda leaves had similar trend of aforementioned macro and micro-elements for heavy mental content. The leaves of the seedlings which grew in mixture treatment uptake 11.83, 11.02 and 0.93 mg followed by the leaves of those grew in DRS treatment which uptake 9.00, 9.08 and 0.88 mg, of Pb, Ni and Cd, respectively also, it is noticeable that there was no significant difference between Cd uptake by seedlings leaves planted in both mixture and DRS amended soil. Regardless the superior uptake of jacaranda roots which had grown in mixture amended soils, so the roots that penetrated in SGC amended soil had highly significant content of Pb, Ni and Cd that were 1.7, 1.4 and 2-times more than the roots content grew in DRS amended soil (Fig. 2-b). These finding were similar to that of Harrison and Henry (1994) in Douglas-fir and grand fir growing on a sandy outwash soil amended with sewage sludge that foliar levels of Ni and Cd, were found significantly elevated, but not toxic.

Generally, while the concentration of measured metals in the roots of jacaranda seedlings which grew in dried raw sludge (DRS) were significantly higher than those grew in solid garbage compost (SGC) (the data not illustrated) but the uptake of these metals had an opposite behavior where they recorded high values in SGC more than DRS that could be attributed to the restricted growth and distribution of jacaranda roots in DRS that reflected in its uptake of these metals from the soil.

2-3 Ailanthus altissima

Uptake of macro-elements

There was indication that municipal wastes inadequately increased the uptake of macro-elements in the leaves of tree of heaven seedlings after two successive seasons from amending (Fig. 3-a). There was a significant increase in N uptake by the leaves when amended by the various municipal wastes comparing to control, but there were no differences among them. The significant uptake of K after two seasons was detected in seedlings leaves when planted in SGC amended soil which recorded 3.0-fold followed by mixture then DRS that recorded 2.7 and 2.3-fold, respectively than control. Otherwise a significant increase in P uptake (4.2-fold in compare with control) was occurred when the seedlings planted in mixture amended soil where the other amendments were not differed significantly. In general, macro-elements content of roots had been shown to increase with the addition of municipal wastes as amended soil (Fig. 3-b). The Figure also illustrated that roots of tree of heaven seedlings planted in DRS amended soil had higher uptake of N, P and K more than that of control whereas the N uptake was increased in the roots of DRS treatment than control but this increase was not significant. Likewise the P uptake by roots grew in mixture and DRS was similar significantly as well as, SGC and control had the same level of significance. This result agrees with the findings of the positive effects associated with sludge- compost application on nitrogen and phosphorus that reported by Moreno *et al.*, (1996). Otherwise, non significant increase in P uptake by leaves of the seedlings amended by municipal wastes was compatible with the finding of Ferrier *et al.*, (1996) on Scots pine plantation after one year.

Uptake of micro-elements

Figure (3-a) illustrated that the Fe and Mn uptake significantly increased than control by the leaves of the seedlings amended by various municipal waste treatments without significant differences among them. On the other hand, Zn uptake was the higher by both SGC and mixture treatments without non significant differences between them, followed by DRS treatment. Additionally, Fig. (3-b) demonstrated that the roots grew through the soil amended by DRS had the highest significant uptake of Fe and Zn (111.32 and 18.28 mg, respectively) followed by mixture then SGC which uptake 90.21 and 14.24 mg and 21.82 and 3.91 mg, respectively of the abovementioned micro-elements. Whereas, Mn uptake by roots was similar significantly after grew through DRS and mixture also, SGC had the same level of significance with control.

Uptake of heavy metals

The higher accumulation of Pb and Ni in the leaves (5.69 and 5.09 mg, respectively) were observed in the seedlings grew in mixture amended soil conversely, the lower accumulation (3.53 and 2.97 mg, respectively) occurred in SGC whereas, the leaves grew in DRS amended soil had moderate values of these heavy metals (4.03 and 4.03 mg, respectively) comparing with control (Fig. 3-a). Otherwise, leaves of tree of heaven seedlings increased their Cd uptake significantly when amended by the different municipal wastes than control but there were non significant differences among these amendments. Generally, heavy metals content of tree of heaven roots had similar trend of its leaves uptake where the roots of the seedlings that grew in DRS amended soil were the richest in Pb, Ni and Cd content (7.5, 9.1 and 6.1-fold, respectively) followed by the seedling roots that penetrated through mixture treatment (7.0, 7.7 and 5.3-fold, respectively) whereas, roots grew in SGC amended soil had the lowest content of these metals (1.2, 1.3 and 1.3-fold, respectively) in respect with control (Fig. 3-b).

While uptake of tree of heaven roots that grew in DRS amended soil were the higher than mixture, on the contrary the concentration of the measured elements were the best in the roots grew through mixture than DRS amended soil (data not presented) so, this may be related to the minimum distribution of the roots in mixture treatment as a result to its content of SGC that may limit the penetration of the roots.

RECOMMENDATION

This study highlights the significance of municipal wastes in improving and sustaining physical and chemical composition of the soil for continuous growth of urban trees. Also, it is recommended to apply this study on both sandy and calcareous soil of planted trees in newly reclaimed areas.

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الملخص العربى

استخدام مخلفات المدن كمحسن لتربة أشجار الشوارع :

(٢) تحليل التربة والأوراق والجذور

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أجريت هذه التجربة خلال الفترة من مارس ٢٠٠٣ وحتى نوفمبر ٢٠٠٥ في مشتل قسم الأشجار الخشبية- معهد بحوث البساتين بحدائق أنطونيادس، بشرق الأسكندرية. اشتملت التجربة على أربع معاملات كمحسنات للتربة: الكنترول، الحمأة الخام المجففة، القمامة المتحللة وخليط من الحمأة والقمامة. زرعت شتلات عمر علم واحد من أشجار البونسيانا والجاكرندا وشجرة السماء لمدة فصلين نمو متعاقبين. تم زراعة كل شتلة فى صفيحة معدنية كبيرة الحجم مملوة بحوالى ٢٠ كجم من التربة الطينية المخلوطة بمحسنات التربة المذكورة، ورويت حتى سعتها الحقلية خلال موسمى النمو. صممت التجربة بالنظام العشوائى الكامل حيث احتوى على ٤ محسنات للتربة X ٥ مكررات وذلك لكل نوع شجرى

<u>ويمكن تلخيص أهم النتائج فيما يلى:</u>

- بشكل عام فإن الكثافة الحجمية للتربة المحسنة بمخلفات المدن كانت أقل من التربة الغير محسنة ولكن دون وجود فروق معنوية ما بين أنواع المحسنات المستخدمة.
- معاملة (الخليط) حققت أعلى قيمة بالنسبة لدرجة التوصيل الكهربائى، قيمة الحموضة والقلوية، وكل من النيتروجين والفوسفور والبوتاسيوم المتاح بالتربة، يليها معاملة (الحمأة الخام المجففة) ثم (القمامة المتحللة).
- أوراق شتلات البونسيانا والجاكرندا كانت الأعلى معنوياً فى امتصاص المعادن الكبرى والصغرى والثقيلة عند زراعتها فى تربة محسنة بمعاملة (الخليط) يليها تلك المحسنة بـ(الحمأة الخام المجففة) ثم (القمامة المتحللة)، بينما امتصاص تلك العناصر المذكورة آنفاً بواسطة أوراق شتلات شجرة السماء زادت مقارنة بالكنترول ولكن دون وجود فروق معنوية ما بين أنواع المحسنات المستخدمة.
- جذور شتلات البونسيانا أظهرت أعلى امتصاص للعناصر الكبرى والصغرى عند زراعتها فى تربة محسنة بـ (القمامة المتحللة)، من جهة أخرى فإن كفاءة امتصاص الجذور لجميع العناصر المقدرة كان أعلى ما يمكن عند انتشار الجذور فى تربة محسنة بـ (الخليط)، كذلك عند نمو جذور شتلات شجرة السماء فى تربة محسنة بـ(القمامة الخام المجففة).
- بينما شتلات شجرة السماء كانت الأعلى فى استنزاف العناصر الغذائية الكبرى من التربة إلا أنها كانت الأكثر كفاءة فى تخليص التربة من العناصر الثقيلة الملوثة تليها الجاكرندا ثم البونسيانا الأقل كفاءة. أى كانت تقوم بدور المنظف الحيوى وبالتالى تلعب دور مهم فى تنقية التربة الملوثة.

<u>التوصية :</u>

تلقى هذه الدراسة الضوء على أهمية مخلفات المدن فى تحسين المكونات الطبيعية والكيماوية للتربة الطينية لأشجار المدن بغرض استمرار نموها، لذلك نوصى بتطبيق هذه الدراسة على كل من التربة الرملية والجيرية للأشجار المنزرعة بالمناطق حديثة الاستصلاح.