Environment Protection Engineering

Vol. 24 1998 No. 1–2

MAMDOUH F. ABDEL-SABOUR*, MASSOUD, A. MASSOUD*, MAGDY A. RIZK*

MUNICIPAL SOLID WASTE COMPOST QUALITY IN CAIRO CITY AND ITS EFFECT ON GROWING FOOD CROPS

Municipal solid waste (MSW) compost was, on occasion, collected from Shoubra compost plant, Cairo, during 1994–1995. Physical and chemical characteristics of the MSW compost were investigated and its heavy metal content was determined using instrumental neutron activation analysis (INAA) technique for total Fe, Co, Cr and Zn, while Mn, Cu, Cd, Pb and Ni concentrations were determined by means of atomic absorption spectrometry (AAS) technique. The effect of MSW compost application to sandy soil on two crops, namely corn (*Zea mays*) and sesame (*Sesamum indicum* L.), was studied in a field test. The sandy soil was amended with MSW compost at different rates (2, 6 and 8%). The accumulation of heavy metals in the growing crops was evaluated using atomic absorption which allows us to assess the environmental acceptability of MSW composts.

The results showed that the levels of the elements tested were always lower than the corresponding values recorded either in American or German MSW composts except for Cu and Cr whose concentrations were higher than the German levels by 2.5-fold. Application of MSW compost to sandy soil seems to stimulate the growth of the crops tested in this study which may suggest the possible use of such a compost as organic soil conditioner. The transfer factors (TF's) of different heavy metals were calculated. The data show that the mean values of TF's for corn were higher than those for sesame. The order of metal TF's for corn was as follows Co = Fe > Cd > Cu > Pb > Zn > Mn > Ni and that for sesame Co > Fe > Cd = Zn > Ni > Cu = Mn > Pb.

1. INTRODUCTION

There is a large amount of salvageable and compostable materials in refuse, about 68.5% on a weight basis. One of the major problems in refuse utilization is the separation of non-compostable from the compostable materials. The non-compostable material consists of 0.9% of metals, 1.6% of rags, 11.7% of glass and 9.8% of tin cans. Today, the share of plastics in municipal refuse has increased to 2–3% and they should be separated from the compostable material before composting. Rags, scrap metal and some of the cardboard and bottles should be separated and sold for

* Soil and Water Department, Nuclear Res. Center, Cairo, Egypt 13579.

recycling. Recent equipment development has greatly improved the separation of these materials.

All types of solid organic matter can be composted under varied conditions. Improper compost operations are extremely hazardous to health. Basically, production of compost results from the decomposition of organic matter by microorganisms under aerobic conditions which is relatively fast; however, anaerobic processes are comparatively slow and odoriferous.

In Egypt, reckoning 500–650 g and 220 g of municipal refuse per day per capita in large cities and in rural areas, respectively, we can obtain 14 million tons of garbage per year giving about 9 million tons of organic fertilizer equivalent to 18 million tons of yard manure. Three methods of solid waste disposal are appropriate under Egyptian conditions in terms of technology: thermal destruction, particularly for hospital solid wastes (sanitary controlled incineration), landfilling and composting. Composting is more economical and environmentally friendly method (POLPRASERT [16]). Municipal solid waste composting is used in order to reduce the volume and mass of municipal solid waste (MSW) and to produce a stable organic material that may be used as a soil amendment.

The objective of this study was to determine the physical and chemical properties as well as total content of heavy metals (Fe, Zn, Cu, Mn, Co, Ni, Cd and Pb) in Cairo MSW composts. The effect of MSW compost application to sandy soil on the growing crops was also evaluated.

2. MATERIALS AND METHODS

Representative samples of the municipal solid waste (MSW) compost, product of Shoubra MSW-composting plant, were, on occasion, collected from different locations along the windrows at approximately 50 cm depth during 1994–1995. Physical and chemical analyses of different compost samples were done to determine the total solids, moisture contents, organic matter, organic carbon, total nitrogen and pH according to the American Public Health Association (APHA) [3] standard methods. Air dried samples were ground and digested according to HESSE [10]. Heavy metal contents were determined using atomic absorption spectrometry. Prior to acid digestion, approximately 10 g of compost dried at 105 °C was randomly selected from each grab or compost sample and ground. Granular particles, including fragments of glass, metal and plastic, were excluded during the grinding process. Replicate subsamples (0.5 g each) were digested using the US-EPA method [17]. Moreover, 1 g of MSW samples was activated in a nuclear reactor by neutron flux 10^{-13} n/s for 48 h; after the cooling period a gamma spectrum for different elements was calculated and compared to the International Atomic Energy Agency (IAEA) reference sample SL-1 [12]. The content of different elements was calculated according to the following equation:

$$\frac{\text{peak net area (sample)}}{\text{peak net area (reference)}} = \frac{\text{concentration of element (sample)}}{\text{concentration of element (reference)}}$$

2.1. FIELD TEST

Cairo municipal solid waste (MSW) compost was applied to Inshas Sandy Loam Soil at Nuclear Research Center Farm. Table 1 indicates some physicochemical properties of the soil used. MSW compost was applied at the rate of 0, 2, 6, 8% and incorporated to soil to the depth of 30 cm in a completely randomized experimental design. Corn and sesame seeds were planted in 21 m^2 plots, each with three replications for each treatment under sprinkler irrigation system. Nitrogen was applied to improve the C/N ratio of the compost at three intervals (after planting, vegetation stage and before fruiting stage) as urea-N (46%) at the rate of 50 kg/Fad. (Faddan = 4200 m^2), plant shoot samples were collected after 1, 2 and 3 months. Grain and seeds' yields were harvested then, their dry weight was recorded. Plant samples were wet digested according to CHANEY [5]. Surface soil samples were collected at the same time of sampling, air dried, ground and extracted by DTPA method according to LINDSAY and NORVAL [13].

Table 1

Physical and chemical properties of Inshas sandy soil

Sand [%]	Fine sand [%]	Silt [%]	Clay [%]	Organic matter [%]	pH	$CaCO_3$ [%]	Total soluble salts [%]	CEC [meq/100 g of soil]
73.8	22.2	1.1	2.6	0.08	8.55	0.16	0.05	2.94

Elemental analyses of the digested and extracted solutions were carried out using G.B.C. atomic absorption spectrometry (AAS). The solutions were analyzed for Fe, Mn, Zn, Cd, Pb, Co and Ni using an air acetylene flame.

3. RESULTS AND DISCUSSION

The physical and chemical analyses of the composted municipal solid waste samples are shown in table 2. A comparison between our values and those published by Germans and Americans (FUNKE and BIDLINGMAIER [8]) is shown in table 2. The organic matter constitutes 39.5%, while C/N ratio is 18.1 which can prove that the compost has not been completely matured. HORTENSTINE [11] concludes that compost should be ripened before being applied to the soil, otherwise decomposition will continue at the expense of soil nitrogen.

Table 2

Physical and chemical analyses of the compost produced in Shoubra plant

Parameter	Shoubra plant compost	American standard*	German standard**
Total solids [%]	74.73	52	55
Moisture content [%]	25.28	39.3	35
Organic matter [%]	39.47	21.5	20
Organic carbon [%]	22.89	29.7	30.0–60
Total nitrogen [%]	1.26–1.6	1.97	3–5
C/N ratio	18.1	15.8	10–12
pH	7.2	7.0	6.9
Stones [%]	3.48	7.5	max 5
Plastic, glass, metal [%]	1.72	9.0	max 0.5
Phosphorus [%]	0.55	1.16	0.62
Electrical conductivity	0.95–1.1	0.85	0.60

* After C. HORTENSTINE [11].
** After U. FUNKE and W. BIDLINGMAIER [8].

Total nitrogen content in MSW compost samples was relatively low with an average of 1.45%. Most of this nitrogen was found in an organic form. The data indicate that total nitrogen present in MSW composts may not be easily available for plants and suggest that the compost should be enriched with nitrogen either by mixing it with wastes rich in nitrogen, e.g. chicken manure, or by inoculating it with nitrogen-fixing bacteria.

3.1. TOTAL CONTENT OF HEAVY METALS IN MSW COMPOST

Total Fe, Mn, Zn, Cu, Co, Ni, Cr, Cd and Pb contents in MSW composts determined by instrumental neutron activation analysis (INAA) method and atomic absorption spectrometry (AAS) are shown in table 3 with the reported means of MSW compost in the USA and Germany. The element levels tested by us were always lower than the corresponding values obtained in the USA and Germany, except for Fe, Cu and Cr which were higher than the German standards by 2.5-fold for Cu and Cr and 11-fold for Fe. The presence of heavy metals in MSW compost results from their presence in both naturally occurring materials (yard wastes, food wastes) and man-made materials (pigments, inks, metals, plastics). No toxicity was reported for the high levels of Fe since it always forms sparingly soluble compounds.

Copper toxicity to plants has been reported near copper deposits, smelters and excessive amounts of Cu-pesticides and fertilizers applied to strongly acidic soils

(GOUGH et al. [9])). However, when MSW or sludge composts with normal copper concentrations have been land-applied, even at very high rates, no evidence of copper phytotoxicity was observed (CHANEY and RYAN [6]).

Table 3

Total content of metals (μg/g) in MSW composts produced in Shoubra plant compared to American and German standards

Element	(1) Shoubra	(2) USA	(3) Germany
Fe*	41964	5330	3700
Mn**	362	–	–
Zn*	421	2500	400
Cu**	272	1000	100
Co*	10.3	50	40
Cd**	0.35	10	2.0
Cr*	259	1000	100
Ni**	43.6	200	50
Pb*	16.7	250	150

* INAA method of analysis.

** AAS method of analysis.

(1) Mean of 6 samples determined by means of instrumental neutron activation analysis (INAA) and atomic absorption spectrometry (AAS) methods.

(2) *New York State Class I Regulations* [14], subpast 365, New York State Department of Environment, Albany, New York.

(3) POLPRASERT C. [16], *Organic waste recycling*, John Wiley and Sons, Chichester, England, p. 357.

Table 4

DTPA- extractable metals (ppm) as affected by MSW application

Rate [%]	Elements [ppm]							
	Fe	Mn	Zn	Cu	Co	Ni	Cd	Pb
Control	8.4	2.2	29.5	0.78	0.32	0.39	0.14	1.32
2	9.5	2.5	3.63	0.97	0.37	0.60	0.18	2.32
6	12.8	3.2	3.65	1.08	0.40	0.83	0.18	2.32
8	11.0	3.6	4.97	1.34	0.44	0.82	0.15	2.27
Mean	11.1	2.9	3.8	1.04	0.38	0.75	0.16	2.1
	± 1.02	± 0.5	± 0.7	± 0.18	± 0.03	± 0.01	± 0.01	± 0.44

Several studies showed no accumulation of chromium in the tops of plants grown on soils enriched with organic wastes comprising high chromium concentration (CUNNINGHAM et al. [7]). The removal of many manufactured materials from the MSW stream could reduce the levels of heavy metals in MSW composts. Recycling through source separation, or separation at a composting facility can reduce the level of heavy metals in composts (POLPRASERT [16]).

Knowledge of elemental concentration of the compost, however, does not allow for a prediction of its bioavailability. So the determination of the available elements associated with MSW compost is necessary for assessing the environmental acceptability of MSW composts. Table 4 shows the DTPA-extractable metals (ppm) as affected by MSW application to sandy soil at increasing rates. It is clear that the available fraction of the metals tested is relatively low compared to the total.

3.2. EFFECT OF MSW COMPOST APPLICATION ON DRY MATTER AND SEED YIELD

The dry matter and grain yield of the two plant species grown on amended soil were significantly increased due to addition of MSW compost (tables 5 and 6), similar results were obtained by ABDEL-SABOUR [1]. The stimulation effects of the treatments tested can be attributed to the adequate supply of nutrients and the improvement in soil hydro-physical properties which may affect soil water retentivity (ABDEL-SABOUR et al. [2]). This finding proves that MSW compost may by utilized on agricultural land as a source of nutrients for crop production and as organic amendment for the improvement of soil physical properties (ABDEL-SABOUR et al. [2]).

Table 5

Effect of applied MSW-compost on dry matter yield and grain in corn and sesame plants

Treatment [%]	Corn dry matter yield [g/plant]		Sesame dry matter yield [g/plant]		Grain dry matter yield [kg/ha]	
	Vegetation	Flowering	Vegetation	Flowering	Corn	Sesame
Control	13.6	26.73	24.2	45.3	1,533	468
2	37.33	109.00	38.3	60.5	3,333	659
6	58.96	130.67	55.7	65.7	2,634	746
8	78.43	156.70	54.7	102.2	4,395	868
L.S.D. (5%)*						
Rate	5.35	4.6	4.4	1.5	135	68

* Least significant difference at 5%.

3.3. CONCENTRATION OF HEAVY METALS IN CORN AND SESAME SHOOTS AND SEEDS

Application of MSW compost significantly increased the concentration of heavy metals in shoots and seeds of the two plant species (tables 6, 7). The results for corn and sesame varied in their metal levels, depending on the plant species and plant part; for instance, corn shoots accumulated more Fe, Cu, Co and

Pb; however, sesame shoots showed higher Zn, Ni and Cd concentrations. In the case of corn grains, the concentrations of Co, Ni and Cd were always higher than in sesame which accumulated more Fe, Mn, Zn, Cu and Pb. This metal accumulation may be attributed to plant affinity to nutrients and other available elements which compete and interfere with each other. In the meantime, no phytotoxicity symptoms were observed which might suggest that both corn and sesame could tolerate the increasing levels of heavy metals in the treatments tested. It is clear from tables 6 and 7 that the concentrations of metals in shoots or seeds never exceed their permissible levels in foodstuffs. This finding confirms the results of O'CONNOR et al. [15]. Understanding the chemistry of organic composts will better explain the low potential for phytotoxicity and phytoavailability of metals. According to CHANEY [5] the phytotoxicity of a compost caused by heavy metals is revealed at low pH of soil and such concentrations of these metals that are toxic to plants. He reported that in the case of a good quality of sludge, phytotoxicity has not been observed in the field even at low pH (e.g., 5.5). It seems that after the metals are released from the MSW compost, they subsequently interact with the minerals and constituents of soil and are occluded in oxides or precipitate as hydroxides, leading to a reduction in metal activity and therefore their toxicity. It is highly contaminated compost that causes toxic effects, not the ordinary MSW compost. Due to the presence of high levels of humic materials and hydrous iron oxides in compost and the presence of other elements with element being evaluated, the bioavailability of other elements is quite low (CHANEY [5]).

Table 6

Concentrations of heavy metals in corn and sesame shoots as affected by MSW compost addition (μg/g)

Treatment	Fe	Mn	Zn	Cu	Co	Ni	Cd	Pb
Corn								
Control	370	30.0	34.4	19.8	3.5	6.2	3.9	70.0
2	328	37.2	36.4	18.5	4.4	6.5	4.4	71.7
6	414	28.4	59.7	23.0	5.6	6.7	3.9	76.5
8	342	37.2	50.0	27.0	5.9	6.5	4.0	75.0
Sesame								
Control	120	41.1	30.4	6.7	2.5	10.6	3.9	10.8
2	110	49.9	53.7	13.1	3.8	21.7	5.2	12.5
6	111	53.1	56.3	14.3	5.3	19.7	4.2	13.4
8	113	58.2	62.5	16.3	3.3	12.2	4.3	14.1
L.S.D. (5%)*								
Rate	42.3	4.3	5.4	2.33	0.78	0.93	0.32	3.5

* Least significant difference at 5%.

Table 7

Concentrations of heavy metals in corn and sesame grains as affected by MSW compost addition (μg/g)

Treatment	Fe	Mn	Zn	Cu	Co	Ni	Cd	Pb
Corn								
Control	37.9	25.5	37.2	3.35	10.2	25.7	3.65	Nd
2	66.4	26.7	57.9	11.85	13.9	20.2	5.00	ND
6	88.7	27.2	46.9	13.00	14.7	26.2	5.10	ND
8	89.7	28.9	44.0	12.50	15.0	29.7	5.50	ND
Sesame								
Control	20.4	35.1	49.9	15.00	6.5	20.7	3.30	1.90
2	16.1	20.4	56.2	14.40	12.1	15.9	3.10	2.25
6	10.7	34.7	57.9	14.30	13.6	25.7	2.75	2.75
8	14.3	33.0	58.5	14.6	13.9	29.9	4.75	2.83
L.S.D. (5%)*								
Rate	12.9	2.84	4.98	2.15	1.67	2.87	1.45	1.87

* Least significant difference at 5%.

3.4. COEFFICIENT OF HEAVY METALS TRANSFER FOR CORN AND SESAME

Concentrations of the heavy metals in the plants and in the corresponding soil (DTPA) extracts (table 4) proved that the soil-to-plant transfer factors (TFs) could be calculated according to formula similar to that suggested by BUNZLE and KRACKE [4]. In the present paper, the TF values were calculated for net concentration of element in plant as related to the net concentration of the same element in soil solution (DTPA extract).

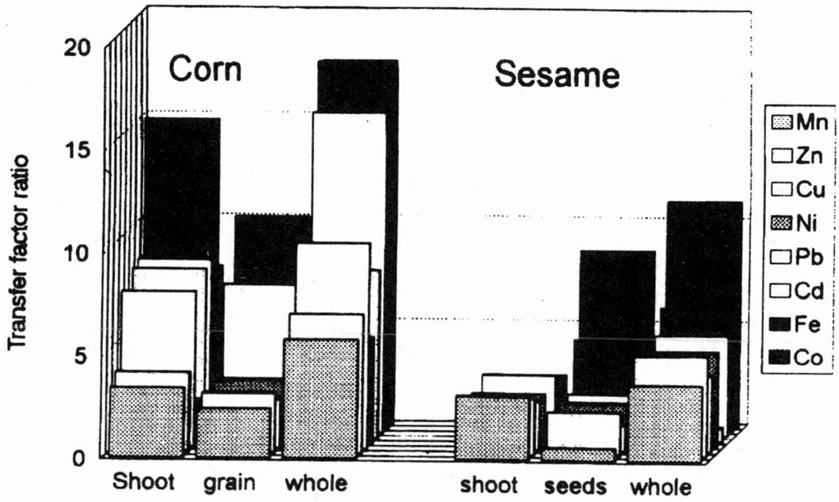
$$TF_{\chi} = \frac{\text{total plant uptake treated with } \chi - \text{total plant uptake (control)}}{\text{DTPA extract of } \chi - \text{DTPA extract (control)}}$$

where χ is heavy element.

TF_{χ} is used to describe the transfer of the metal tested to the plant parts (shoots, grains and seeds).

The differences observed in transfer factors for different heavy metals were found to be affected by plant species, plant parts and rate of MSW application.

The data in tables 8 and 9 show that for most elements tested the mean values of TF's for corn shoots and grains are higher than those for sesame shoots and seeds. This may indicate that sesame accumulates smaller amounts of heavy metals from Cairo-MSW compost than corn plants. The mean values of TF's for corn plant (see the figure; shoots + grains) can be arranged in the following descending order:



Average values of transfer factor for the heavy metals tested in corn and sesame crops

Co = >Fe > Cd > Cu >Pb > Zn >Mn > Ni.

The corresponding order for sesame plants is as follows:

Co > Fe > Cd = Zn > Ni > Cu = Mn > Pb.

Table 8

Transfer coefficient for corn and sesame shoots as affected by MSW compost addition

Treatment	Fe	Mn	Zn	Cu	Co	Ni	Cd	Pb
Corn								
2	17.50	3.86	4.49	7.82	7.74	2.57	9.40	5.95
6	10.05	3.52	3.83	8.27	7.96	1.61	10.02	8.13
8	16.81	2.80	3.43	6.71	6.98	1.98	5.60	10.4
Mean	14.8	3.39	3.92	7.6	7.56	2.05	8.40	8.16
Sesame								
2	1.11	3.87	2.75	2.53	2.34	3.95	3.5	0.27
6	1.42	2.57	3.30	2.1	2.96	1.84	2.50	0.39
8	2.35	2.86	2.48	2.43	1.89	1.79	2.6	1.00
Mean	1.63	3.10	2.84	2.35	2.40	2.53	2.87	0.55

Table 9

Transfer coefficient for corn grains and sesame seeds
as affected by MSW compost addition

Treatment	Fe	Mn	Zn	Cu	Co	Ni	Cd	Pb
Corn								
2	2.90	3.49	4.20	3.80	12.90	2.79	5.80	ND
6	2.85	2.39	3.16	1.60	8.50	2.17	6.13	ND
8	2.72	1.29	1.42	1.87	8.80	4.45	9.75	ND
Sesame								
2	4.95	0.18	2.66	1.82	10.6	1.05	1.80	0.07
6	4.48	0.96	2.29	1.29	8.44	2.15	1.45	0.11
8	3.70	0.72	1.20	0.85	6.32	3.18	2.88	0.14

ABDEL-SABOUR [1] found similar arrangement for TF's of the elements tested when Cairo sewage sludge was applied to the soil for the same plants studied. For corn and sesame those arrangements can be presented as follows: Fe > Co > Cd > Ni > Pb > Mn > Zn > Cu. The present investigation and those of sewage sludge (ABDEL-SABOUR [1]) prove that Fe, Co and Cd have the highest potential for the transfer from soil to the growing crops.

4. CONCLUSIONS

The results obtained showed that the levels of the elements tested were always lower than the corresponding values recorded either in American or German MSW composts except for Cu and Cr which were 2.5-fold higher than the German levels. MSW compost application to sandy soil seems to stimulate the growth of the crops tested in this study which may suggest the possible use of such a compost as organic soil conditioner. The transfer factors (TF's) of different heavy metals were calculated, and the data show that the mean values of TF's for corn were higher than for sesame. The values of TF's for corn and for sesame can be arranged in the following descending orders: Co = Fe > Cd > Cu > Pb > Zn > Mn > Ni and Co > Fe > Cd = Zn > Ni > Cu = Mn > Pb, respectively. Application of MSW composts should be regulated on the basis of their total and available elemental content as determined by acid digestion or by a non-destructive analytical technique. In addition, further research is necessary for better understanding the leachability and bioavailability of elements from MSW compost amended agricultural soils in the long term.

REFERENCES

[1] ABDEL-SABOUR M.F., *Fate of heavy metals in sewage sludge amended sandy soil*, Egyptian Soil Sci. J., 1997, 37, 123–138.

[2] ABDEL-SABOUR M.F., ODGEN C.B., EL-GENDY R.W., *Conditioning effects of organic waste composts on hydrophysical properties of Inshas sand soil*, Egyptian Soil Sci. J., 1997, 37, 1–11.

[3] American Public Health Association (APHA), *Standard methods*, 14th ed., Washington, D.C., 1979.

[4] BUNZL K., KRACE W., *The science of the total environment*, 1987, 63, 111-124.

[5] CHANEY R.L., *Land application of composted MSW: Puplic health, safety and environmental issues*, [in:] Proc. of Nat. Conf. of the Solid Waste Composting Council, 1992, Alexandria, VA 22314, pp. 61–83.

[6] CHANEY R.L., RYAN J.A., *Heavy metals and toxic organic pollutans in MSW-composts,* [in:] *Sci. and Engineering of Composting*, H. Hoitink and H.M. Keener (eds.), The Ohio State Univ., 1992, 423–449.

[7] CUNNINGHAM J.D., KEENEY D.R., RYAN J.A., *Phytotoxicity and metal uptake from soil treated with metal-amended sewage sludge*, J. Environ. Qual. 1975, 4, 455–460.

[8] FUNKE U., BIDLINGMAIER W., *Compost quality and marketing*, London and New York, Elsevier Applied Sci., 1987, pp. 341–344.

[9] GOUGH L.P., SHACKLETTE H., CASE A.A., *Element concentrations toxic to plants, animals and man*, U.S. Geol. Surv. Bull., 1979, 1466, 80.

[10] HESSE P.R., *A textbook of soil chemical analysis*, Murray, London, 1971.

[11] HORTENSTINE C.C., *Municipal refuse compost as a soil amendment and nutrient source for sorghum*, J. Environ. Qual., 1972, 2, 345–345.

[12] IAEA 1992. Intercomparison Runs Reference Materials. Analytical Quality Control Services, Standard Reference Material Lake Sediments SL-1 IAEA, Vienna, Austria.

[13] LINDSAY W.L., NOVELL W.A., *Development of DTPA soil test for zinc, iron, manganese and copper*, Soil Sci. Am. J., 1978, 42, 421–428.

[14] *New York State Class I Regulations*, New York State Department of Environ., Albany, 1995, New York, p. 365.

[15] O'CONNOR G.A., CHANEY R.L., RYAN J.A., *Bioavailability to plants of sludge borne toxic organic*, Reviews of Environ. Contam. and Toxicology, Vol. 121, 1991, pp. 129–155, Springer-Verlag, New York Inc.

[16] POLPRASERT C., *Organic waste recycling*, Chichester, England, John Wiley and Sons, 1989, p. 357.

[17] U.S. Environmental Protection Agency, *Guidelines for Estimating Exposures. Federal Register*, 1986, 51, 34042–34054.

WPŁYW JAKOŚCI KOMPOSTU POCHODZĄCEGO Z ODPADÓW MIEJSKICH W KAIRZE NA PŁODY ROLNE

Próbki kompostu pochodzące z odpadów miejskich w Kairze pobierano z kompostowni Shoubra w latach 1994–1995. Sporządzono fizyczną i chemiczną charakterystykę kompostu oraz określono zawartość w nim metali ciężkich takich, jak: Fe, Co, Cr i Zn metodą instrumentalnej neutronowej analizy aktywacyjnej. Stężenie Mn, Cu, Cd, Pb i Ni w badanych próbkach kompostu oznaczano metodą atomowej spektroskopii absorpcyjnej. W warunkach terenowych zbadano wpływ nawożenia gleby piaszczystej kompostem na wzrost dwóch rodzajów upraw (kukurydzy i sezamu). Zastosowano kilka dawek kompostu (2, 6, 8%). Stopień

akumulacji metali ciężkich w płodach rolnych określono metodą absorpcji atomowej, co umożliwiło oszacowanie przydatności kompostu do nawożenia gleby.

Okazało się, że w Kairze poziom stężeń badanych metali był zawsze niższy niż w analogicznych próbach analizowanych w USA i Niemczech z wyjątkiem Cu i Cr, których stężenie było 2,5 raza większe niż w próbach niemieckich. Wydaje się, że nawożenie gleby piaszczystej kompostem stymuluje wzrost badanych upraw i badany kompost może być wykorzystany jako kondycjoner glebowy. Obliczono współczynniki przenoszenia (TF) dla metali ciężkich. Stwierdzono, że średnie wartości współczynników dla ziarna kukurydzy były większe niż dla ziarna sezamu. W przypadku ziarna kukurydzy wartości współczynników przenoszenia metali układały się w następującej kolejności: Co = Fe > Cd > Cu > Pb > Zn > Mn > Ni, a dla ziarna sezamu – Co > Fe > Cd = Zn > Ni > Cu = Mn > Pb.