IMPACT OF MUNICIPAL AND INDUSTRIAL WASTES ON THE DISTRIBUTION AND ACCUMULATION OF SOME HEAVY METALS IN SANDY SOILS

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ABSTRACT

An experiment was conducted to study the distribution and accumulation of Pb, Ni, Co, Cu, Zn, Mn, and Fe in sandy soils contaminated with municipal and industrial wastes. Surface and subsurface soil samples were collected from three sites namely; Aldahy, Almota and Alsenayh, which representing the major agricultural soils of Qassim, central region of Saudi Arabia. These sites have been used for dumping domestic and industrial wastes for more than 20 years to evaporate and infiltrate solid and liquid industrial waste. The obtained results indicated that the application of municipal and industrial wastes resulted in a marked increase in the total amount of studied metals. Maximum concentrations of metals were found in the surface 30 cm of the soil where Fe > Mn > Zn > Ni > Pb > Cu > Co in most cases. Most movement and amount of metals recovered from soil were predominantly limited to the upper 30 cm depth. The DTPA fraction of metals was relatively small, comparing either to the total soil content and/or the 0.5 N HNO3 extractable fractions. For example, the average DTPA extractable Pb was highest (4.04 µg g⁻¹) in Almota soils, while it was 2.30 µg g⁻¹ in Aldahy soil and 1.25 µg g⁻¹in Alsenayh soil. The respective Pb values extracted by 0.5 N HNO₃ for the three sites were 6.75, 5.37 and 4.49 µg g⁻¹. Total Pb values were 23.23, 21.77 and 15.95 µg g⁻¹, respectively. All the three forms were highest in Almota area and lowest in Alsenayh area. The average of Ni content of the three soils was more or less in the same range as Pb. However, total Ni values were 2 to 3 times higher in Alsenayh soils. Though, these values were still low as compared to the contaminated reported levels but it indicated that these sites have been contaminated with the dumping of industrial waste. The values of Co for DTPA, HNO₃ and total extracts were relatively low when compared to Pb and Ni. Average of DTPA content was 0.25 µg g⁻¹ for Alsenayh, while it was 0.16 µg g⁻¹for Aldahy and 0.10 µg g⁻¹ for Almota soils. The data shows a high accumulation of these metals in contaminated area. Accumulation rate was highest for Ni, Cu, Co, Pb followed by Fe, Zn, and Mn.

Keywords: heavy metals, accumulation, mobility, municipal and industrial wastes

INTRODUCTION

Increasing waste production by human activities has increased the problem of how to get rid of it without causing undesirable impact on the environment and human health. Traditional approaches, incineration and land filling, for remediation of toxic heavy metal contaminated soils are typically expensive, labor intensive, and environmentally hazard. In principal land disposal is more popular than other means including landfills, incineration, and dumping at sea, because it is relatively inexpensive. Unfortunately, land used for wastes disposal is a potential risk for human safety due to inorganic pollutants such as heavy metals borne in these wastes. Concern about metal contamination of soils relates directly to the extent to which natural background levels are exceeded and to the mobility of these metals in terms of bioavailability to plants and the movement to ground water.

It has been generally assumed that since heavy metals are strongly bound by the soil, leaching of metals downward into ground water is not an environmental issue. However, in recent years, this assumption is challenged and metal leaching from sludge treated soil has been observed in several studies. Heavy metals are associated with various soil components in different ways and these associations indicate their mobility in soils as well as their bioavailability (Ahumada *et al.*, 1999 and Al-Oud 2000). The degree of metal association with different chemicals forms depends on soil properties such as pH, organic matter, redox condition, and soil texture (Tagwira *et al.*, 1993 and Zhang *et al.*, 1997).

Land application of bio-solids and industrial wastes can significantly increase heavy metals concentrations in agricultural soils. Fields studies have generally shown no difference in heavy metals concentration below 30 cm between treated and untreated soils with bio-solids (Chang et al., 1982 & 1983; Dowdy and Volk, 1983; Williams et al., 1985 and Al-Oud 2003). However, leaching of some heavy metals to 60 cm depth can occur when large amounts of liquid sewage sludge are applied (Robertson et al., 1982). Fuller (1997) reported that Cd fairly mobile in soils of pH 4.6 to 6.6 and moderately mobile in soils with pH range 6.7-7.8. Sanchez-Martin and Sanchez-Camazano (1993) in their study concluded that Cd was slightly mobile in 27%, moderately mobile in 14%, mobile in 41% and highly mobile in 18%. They further reported that, the pH, exchangeable bases and clay content of soil have a significant effect on Cd mobility. Scokart et al., (1983) observed higher accumulation of Cd and Zn in loamy soils than for sandy soils even though they have the same CEC. According to Elliot and Denny (1982), the addition of organic rich waste such as municipal sludge and industrial wastes can provide enough organic matter to the soils to bind toxic heavy metals like Cd, Zn, and Pb. Also, Kabala and Singh (2001) reported that organic matter had high ability to absorb or complex many metals. In addition, adsorptions on hydrous oxides of iron and cation exchange reactions are important modes of metal immobility (Pilar et al., 2006). In most cases, the metals are present in an immobile form at the time they are added to the soil. Heavy metals are associated with various soil components in different ways and these associations indicate their mobility in soils as well as their bioavailability. Ahumada et al., (1999) and Tania et al., (2003) pointed out that hydrosoluble and exchangeable fractions are considered readily mobile and bioavailable.

A large number of articles on heavy metals concentration in agricultural soils can be found in the literature, however, elemental background or reference values in uncultivated soil are limited (Chen *et al.*, 1991; Angelone & Bini 1992 and Ma *et al.*, 1997). Knowledge on this topic is scare with a shortage in the information in the Kingdom of Saudi Arabia.

Therefore, the present research was carried out with the objective to evaluate contamination degree of heavy metals and their mobility in some major agricultural soils of Qassim region due to human activities and industrial waste disposal.

MATERIALS AND METHODS

In 15 May, 2007, surface and subsurface soil samples, were collected from three sites namely; Aldahy, Almota and Alsenayh, which representing the major agricultural soils of Qassim, central region of Saudi Arabia. These soils are classified as Torriorthent according to the taxonomy of the Soil Survey Staff (1999). These sites have been used for dumping domestic and industrial wastes. Site 1 (Almota) is industrial waste, home garbage and auto wrecks. This site used by Buriedah city as a landfill from early 1950s until late 1970s. The land surrounding this site is a semi-rural, residential and farming field. Site 2 (Aldahy) used to dispose excess rain from the Buriedah city streets and overflow of municipal water form 1960s to 1970s. The land surrounding this site is residential community. Site 3 (Alsenayh), is being used since 1970 until now to discharge solid as well as liquid industrial waste. It is mainly surrounded by factories and farming fields. Sixteen soil samples representing four profiles were collected from Alsenayh site, to study the mobility of heavy metals in this area which is being dumped with industrial city waste.

Soils were air dried, passed through 2 mm sieve and stored for analysis. Particle size distribution was determined by the hydrometer method (Gee and Bauder 1996). Content of $CaCO_3$ was determined by calcimeter method (Loeppert and Suarez 1996). Soil organic matter of the soil samples were determined by digested them using concentrated H₂SO₄ (Nelson and Sommers 1996). Soil pH and EC were measured in distilled water extracts after equilibration for 24 h. The ratio of soil and distilled water was 1:1 (Thomas 1996 and Rhoades 1996). Table (1) depicts some physical and chemical properties of the studied soils.

Table 1: General characteristics of the studied soils.

Soil Properties	Alsenayh Soil	Aldahy Soil	Almota Soi
Sand %	83.80	78.30	84.30
Silt %	6.60	11.30	7.40
Clay %	9.60	10.40	8.30
pH 1:1	8.12	8.32	8.41
O.M (%)	1.22	0.38	0.55
CaCO ₃ (%)	3.40	2.25	4.25
E.C (ds/m)	6.05	3.79	4.20

Heavy metals (Pb, Ni, Co, Cu, Zn, Mn, and Fe) were extracted by DTPA as described by Lindsay and Norvell (1978). Acid extractable metals were determined using 0.5 N HNO₃ as described by Sloan *et al.*, (1997). Moreover the total content of heavy metals in soils were digested by using a mixture of concentrated HClO₄ and HNO₃ at 2:1 ratio and then dissolving the extracts in 0.5 N HCl. The metals in the three extracts were determined using ICP spectroscopy, model GBC-XI, Integra. All the analysis was doubled read for each sample and the data presented in this paper are the average of three replicates of each sample.

RESULTS AND DISCUSSION

Accumulation of heavy metals:

Average DTPA extractable Pb content was highest (4.04 μ g g⁻¹) in Almota site, 2.30 Aldahy site and 1.25 in Alsenayh site. The respective Pb values extracted by 0.5 N-HNO₃ for the three sites were 6.75, 5.37 and 4.49 μ g g⁻¹. Total Pb values were 23.23, 21.77 and 15.95 μ g g⁻¹, respectively (Tables 2 a&b).

Table 2a. Content of different forms of heavy metals (µg g⁻¹) extracted from the experimental sites.

Location	Depth		Pb			Ni		Со			
Location	(cm)	Α	В	С	Α	В	С	Α	В	С	
	0-30	0.54	12.1	18.33	0.96	2.65	50.00	0.17	1.65	2.74	
	0-30	0.53	2.90	19.90	1.10	3.80	48.75	0.21	1.25	2.19	
	0-30	1.60	2.95	15.74	1.83	1.90	36.50	0.33	1.00	2.08	
Alsenayh site	0-30	1.02	1.65	11.50	1.62	2.70	38.75	0.07	1.05	2.65	
	0-30	1.22	1.85	15.75	1.38	1.35	59.25	0.58	1.70	3.50	
	0-30	2.59	5.50	14.50	0.98	1.55	64.50	0.12	1.50	4.59	
	Mean	1.25	4.49	15.95	1.31	2.33	49.63	0.25	1.36	2.96	
	0-30	2.10	1.95	27.00	1.57	1.20	6.50	0.30	1.60	2.65	
Aldohy site	0-30	2.05	1.80	12.82	1.12	1.55	4.93	0.11	1.35	3.08	
Alually site	0-30	2.75	12.35	25.50	1.05	1.75	5.75	0.08	1.70	3.90	
	Mean	2.30	5.37	21.77	1.25	1.50	5.73	0.16	1.55	3.21	
	0-30	3.71	8.75	21.25	1.24	1.60	17.00	0.11	1.70	4.53	
Almota sita	0-30	4.95	6.25	38.50	1.50	1.45	17.50	0.15	1.75	5.84	
Allilota Site	0-30	3.47	5.25	9.95	1.86	1.40	17.00	0.05	1.55	3.03	
	Mean	4.04	6.75	23.23	1.53	1.48	17.17	0.10	1.67	4.47	

A = available forms extracted with DTPA

B = mobile forms extracted with 0.5 N HNO₃

C = Total heavy metals extracted with a mixture of concentrated HCIO₄ and HNO₃ at 2:1 ratio and then dissolving the extracts in 0.5 N HCI

Table 2b. C	Content of	different f	forms o	of heavy	metals	(µg g⁻¹) extracted
	from the e	xperiment	al sites				

Depth		Cu				Zn			Mn		Fe			
Location	(cm)	Α	В	С	Α	В	С	Α	В	С	Α	В	С	
	0-30	0.88	2.00	4.50	19.82	40.80	44.0	11.73	19.60	77.25	34.89	831.0	5280	
	0-30	0.91	0.35	4.25	11.20	24.80	32.45	2.98	11.60	68.50	49.72	705.0	5990	
Aleeneyk	0-30	0.03	0.06	3.50	1.96	3.50	13.25	2.69	11.35	75.80	26.62	462.5	5230	
Alsenayn	0-30	1.09	0.03	6.00	9.50	20.04	33.00	8.91	24.60	145.0	34.94	431.0	6710	
SILE	0-30	0.75	0.08	16.00	1.81	6.60	53.00	8.13	9.20	280.0	1.69	13.55	6300	
	0-30	0.22	0.03	6.75	0.92	2.52	22.10	1.80	18.20	239.8	1.64	14.60	6800	
	Mean	0.65	0.43	6.83	7.54	16.38	32.97	6.04	15.76	147.73	24.92	409.61	6051	
	0-30	0.43	0.03	13.88	1.39	5.10	41.50	7.44	9.95	255.0	7.28	38.50	19600	
Aldahy	0-30	0.30	1.10	7.58	2.55	39.60	59.73	2.41	22.75	203.4	1.61	43.6	12600	
site	0-30	1.19	2.20	15.30	12.49	46.80	177.7	7.01	45.02	258.2	5.01	43.7	12400	
	Mean	0.64	1.11	12.25	5.48	30.50	92.98	5.62	25.91	238.87	4.63	41.93	14866	
	0-30	1.79	1.10	20.88	6.83	41.16	97.25	6.17	28.35	168.6	3.82	35.4	15400	
Almota	0-30	3.66	0.30	29.50	13.3	41.20	248.7	7.90	22.65	198.3	4.51	27.50	14600	
site	0-30	0.62	0.20	7.10	1.97	2.44	21.13	5.70	21.85	102.9	4.24	19.60	9900	
	Mean	2.02	0.53	19.16	7.37	28.27	122.36	6.59	24.28	156.60	4.19	27.50	13300	

A = available forms extracted with DTPA

B = mobile forms extracted with 0.5 N HNO₃

C = Total heavy metals extracted with a mixture of concentrated $HCIO_4$ and HNO_3 at 2:1 ratio and then dissolving the extracts in 0.5 N HCl.

All the three forms were highest in Almota site and lowest in Alsenayh site. When these values were compared with the values (10-100 μ g g⁻¹) reported by Alloway (1990) fall in a critical range.

The average Ni content of the three soils was more or less in the same range as Pb. However, total Ni values were 2 to 3 times higher in three Alsenayh soils. Though, these values were still low as compared to the contaminated reported levels but it indicated that these sites have been contaminated with the dumping of industrial waste. The values of Co for DTPA, HNO₃ and Total extracts were relatively low when compared to Pb and Ni. Average of DTPA content was 0.25 μ g g⁻¹ for Alsenayh, 0.16 μ g g⁻¹ for Aldahhy and 0.10 μ g g⁻¹ for Almota soils. The respective, average content of Cu extracted by HNO₃ in the three sites were 1.36, 1.55 and 1.67 μ g g⁻¹. Total average values for Cu were 6.8, 12.25 and 19.16 μ g g⁻¹, respectively. All the three forms were highest in Almota area and lowest in Alsenayh area. DTPA extractable Zn values were some what higher in the three soils (mean values were 7.5, 5.48 and 7.37 μ g g⁻¹) reaching to as high as 19.8 μ g g⁻¹ in soil No. 1 of Alsenayh.

The respective Zn values extracted by HNO₃ for the three sites were 16.38, 30.50 and 28.2 μ g g⁻¹. Total Zn values were 32.97, 92.98 and 122.36 μ g g⁻¹, respectively. It seems from the results that Zn is being added to soil from outer source. The reported content of Zn extracted by AB-DTPA in previous studies ranged in 0.14–7.46 μ g g⁻¹ (Ayed and Choudhary 1989). While, Bashour *et al.*, (1983) reported that similar results (0.2 -3.2 μ g g⁻¹) when Zn was extracted with DTPA. High values found in our soils gave a clear indication that soils are contaminated as the sites were used for dumping of wastes. Content of DTPA and HNO₃ extractable Mn were same as Zn. However, total average contents were 147.73, 238.87 and 156.6 μ g g⁻¹ for Alsenaeyh, Aldahy and Almota sits, respectively. DTPA extractable Fe was very high in Alsnaeyah with an average of 24.92 μ g g⁻¹ that reaching up to 49.72 μ g g⁻¹. HNO₃ content for the soil soils was 409.6 μ g g⁻¹.

The data shows a high accumulation of such metals in contaminated area. Accumulation rate was highest for Ni, Cu, Co, Pb followed by Fe, Zn, and Mn. Though all these metals contents were well in normal range (Alloway, 1990 and Kabata–Pendias & Pendias 1992) in natural soils but their concentrations have increased to critical levels according to criteria laid by Alloway (1990). Ni has touched to 218 mg kg⁻¹, while toxic level was put > 100 mg kg⁻¹ by Kabata–Pendias and Pendias (1992).

Movement of heavy metals: In all the four profile DTPA extractable as well as 0.5 N HNO₃ digested soils (Tables 3a and 3b) for all the metals studied were highest in the surface soils (0-30 cm) and their concentrations decreased with depth. Profile no. 3 and 4 have much higher concentrations of Zn, Mn, and Fe in surface and subsurface soils. Such findings were stood in agreement with those of Ahumada *et al.*, (1999) and Pilar *et al.*, (2006). On the other hand, the concentrations of Fe seem to be high however, it is still in the common ranges in the soils found by Lindsay (1979). Higher content of

these metals may create a risk for contamination of agricultural crops grown in the surroundings.

Profile	Depth		Pb			Ni		Со			
No.	(cm)	Α	В	С	Α	В	С	Α	В	С	
1	0-30	0.1	2.45	19.6	2.46	3.75	120	0.11	2.15	2.56	
I	30-60	0.06	1.60	8.9	1.65	1.70	84	0.03	0.95	2.29	
	0-30	0.31	1.85	23.0	1.78	3.52	218	0.14	1.35	2.56	
2	30-70	0.29	2.20	21.3	0.03	2.35	158	0.10	1.30	2.53	
	70-100	0.11	10.0	17.4	0.98	1.75	130	0.06	0.85	1.84	
	0-20	2.5	5.25	49.8	2.68	8.15	185	0.79	1.80	1.89	
	20-40	0.62	5.20	28.3	1.34	1.95	169	0.67	1.10	1.69	
3	40-60	0.71	2.25	27.0	1.91	1.95	150	0.62	1.15	1.65	
	60-80	0.14	1.85	14.0	1.09	1.85	125	0.62	1.10	1.63	
	80-100	0.02	1.50	8.3	0.93	1.60	123	0.55	1.00	1.60	
	0-20	0.33	0.25	21.8	2.13	3.55	74	0.60	1.55	11.1	
	20-40	1.48	2.10	15.3	1.15	2.30	74	0.52	1.50	5.0	
4	40-60	0.63	0.95	9.7	1.00	2.60	67	0.50	1.30	3.6	
4	60-80	0.44	3.30	7.3	0.56	2.55	61	0.45	1.15	2.8	
	80-100	0.41	2.89	6.0	0.37	1.60	43	0.22	1.10	1.3	
	100-120	0.26	0.75	3.5	0.29	2.65	32	0.12	0.42	0.85	

Table 3a. Distribution of different forms of heavy metals (µg g⁻1) extracted from Alsenayh soils.

A = available forms extracted with DTPA

B = mobile forms extracted with 0.5 N HNO₃

C = Total heavy metals extracted with a mixture of concentrated $HCIO_4$ and HNO_3 at 2:1 ratio and then dissolving the extracts in 0.5 N HCI.

Table	3b.	Distribution	of	different	forms	of	heavy	metals	(µg	g ⁻¹	1)
		extracted fro	m A	Alsenayh s	soils						

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Profile	Depth	Cu			Zn				Mn		Fe				
No.	(cm)	Α	В	С	Α	В	С	Α	В	С	Α	В	С		
1	0-30	0.80	2.23	4.5	0.72	4.2	10.3	4.3	65.2	110.0	18.7	739	8900		
	30-60	0.02	0.62	3.75	0.52	2.45	8.1	3.53	31.5	100.0	16.5	291.5	7100		
	0-30	0.43	1.20	4.58	0.62	1.91	15.4	3.10	48.2	137.5	16.8	1010.5	7700		
2	30-70	0.03	0.37	3.25	0.85	2.80	13.1	1.80	29.6	125.0	2.57	240.5	3900		
	70-100	0.02	0.19	3.05	0.53	2.3	12.7	0.98	26.1	80.0	1.13	172.5	3200		
	0-20	2.19	9.75	14.0	49.1	114.4	49.4	24.0	46.0	110.0	44.1	950.0	7600		
	20-40	0.07	1.03	6.38	1.52	4.1	15.4	17.4	31.1	78.5	26.1	715.0	6600		
3	40-60	002	0.92	5.75	1.40	3.05	14.3	16.74	29.6	73.0	26.0	697.0	6300		
	60-80	0.02	0.88	4.00	1.39	2.3	12.4	12.9	23.1	74.03	19.1	679.0	5500		
	80-100	0.02	0.39	2.80	1.13	2.05	12.1	5.2	11.1	72.5	16.7	325.0	4500		
	0-20	0.75	1.35	4.50	1.58	3.43	21.8	4.62	69.0	196.5	25.9	914.5	10100		
	20-40	0.03	0.60	4.10	1.22	6.0	19.8	4.40	37.6	158.5	17.1	178.5	10400		
	40-60	0.02	0.25	3.00	0.98	3.05	18.4	2.72	31.2	149.5	14.6	175.5	9900		
4	60-80	0.02	0.18	2.25	0.48	1.90	15.7	2.04	21.1	143.4	11.0	161.0	7900		
	80-100	0.01	0.15	1.73	0.44	1.78	15.0	1.69	17.8	79.5	6.09	117.5	5400		
	100- 120	0.01	0.05	0.48	0.29	1.70	11.1	1.67	14.9	30.0	5.12	123.0	4800		

A = available forms extracted with DTPA

B = mobile forms extracted with 0.5 N HNO₃

C = Total heavy metals extracted with a mixture of concentrated HClO₄ and HNO₃ at 2:1 ratio and then dissolving the extracts in 0.5 N HCl.

These findings were in agreement with Kashem and Singh (2002) who reported that Cd highest in the surface layer and decreased from A to C horizon. Many other researchers have found no difference in heavy metals concentrations below 30 cm between treated and untreated soils with biosolids (Chang et al., 1982 & 1983; Dowdy and Volk 1983; Williams et al., 1985; Zhang et al., 1997 and Pilar et al., 2006). There was little evidence of downward movement of Ni, Co and Cu. These soils are calcareous in nature and probably most of the metals may precipitate with calcium carbonate and also due to a high pH value about 8, most of heavy metals may precipitate in their hydroxide form. Therefore, restricts their mobility to the lower depth. However, if heavy metals contamination exceeds the binding capacity of the soil, there is a danger that heavy metal compounds can percolate into the groundwater. For Pb only mobile form extracted by 0.5 N HNO3 showed different pattern of distribution. It did not follow the decreasing pattern. Profile 2 and in particular profile 4 there was 2-3 fold higher Pb concentration at 60-80 cm and 80-100 cm depth. This shows that Pd is more susceptible to mobility than other elements. For total Pb it decreased with depth similar to DTPA extractable Pb. Also, DTPA, 0.5 N HNO₃ and Total Ni content though high but their concentrations decreased with depth.

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تأثير المخلفات البلدية والصناعية على توزيع وتراكم بعض الفلزات الثقيلة فى التربة الرملية سعود بن سبيل العود قسم علم والتربة ، كلية علم والاغذية والذراعة ، حامعة الملك سعود ، إلرياض ، المملكة العربية

قسم علوم التربة ، كلية علوم الاغذية والزراعة ، جامعة الملك سعود ، الرياض ، المملكة العربية السعودية

أجريت تجربة لدراسة توزيع وتراكم الرصاص والنيكل والكوبالت والنحاس والزنك والمنجنيز والحديد في ترب رملية ملوثة بمخلفات بلدية وصناعية. تم جمع عينات من الطبقة السطحية وتحت السطحية للتربة من ثلاث مواقع وهي الضاحي والماطة والصناعية والتي تمثل ترب زراعية رئيسية بالقصيم بالمنطقة الوسطي بالمملكة العربية السعودية ، حيث تستخدم هذه المواقع كمقلب للمخلفات البلدية والصناعية لأكثر من 20 عام للتخلص من المخلفات الصناعية الصلبة والسائلة. وقد اوضحت النتائج المتحصل عليها ان تراكم المخلفات الصناعية نتج عنها زيادة واضحة في الكميات الكلية للفلزات المدروسة. وبصفة عامة فإن اعلى تركيزات لفلزات الحديد والمنجنيز والزنك والنيكل والرصاص والنحاس والكوبالت على التوالي وجدت على بعد 30 سم من سطح التربة. كان استخلاص الفلزات باستخدام طريقة DTPA اقل نسبياً بالمقارنة بكل من الاستخلاص الكلي للتربة او الاستخلاص بإستخدام 0.5 عياري من حمض النيتريك ، حيث كان متوسط استخلاص الرصاص باستخدام DTPA أعلى في تربة الماطة (4.04 ميكروجرام لكل جرام) في حين بلغ 2.30 ميكروجرام لكل جرام في تربـة الضـاحي و 1.25 ميكروجرام لكل جرام في تربـة المنطقة الصناعية. بينما كانت قيم الرصاص المستخلصة باستخدام 0.5 عيارى من حمض نيتريك 6.75 ، 5.37 ، 4.49 ميكروجرام لكل جرام ، كما بلغت قيم الرصاص الكلية 23.23 ، 21.77 ، 15.95 ميكروجرام لكل جرام على التوالي. بصفة عامة كمان استخلاص الفلزات بصوره الثلاثة اعلى في منطقة الماطة واقلها في المنطقة الصناعية. وكان متوسط محتوى النيكل في الترب الثلاثة متقارب من مستوى محتوى الرصاص. مع ذلك كان محتوى قيم النيكل الكلية اعلى مرتين الى ثلاث مرات في تربية المنطقة الصناعية. ومع ان هذه القيم كانت منخفضة بالمقارنية بمستويات التلوث المذكورة عالمياً ، ولكنها في نفس الوقت هي مؤشر على ان هِناك تلوث بمقلب المخلفات الصناعية. كانت قيم الكوبالت (بإستخدام المستخلصات الثلاثة) اقل نسبياً مقارنة بكل من الرصاص والنيكل ، حيث بلغ متوسط هذه القيم 0.25 ميكروجرام لكل جرام باستخدام مستخلص DTPA في المنطقة الصناعية، بينما بلغ 0.16 ، 0.10 في منطقتي الضباحي والماطبة على التوالي. وبصفة عامة اشارت النتائج إلى وجود تراكم عالى لهذه الفلزات في المناطق الملوثة وأن معدل التراكم كان أعلى لكل من النيكل والنحاس والكوبالت والرصاص ويليهم الحديد والزنك والمنجنيز .