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Heavy Metal Contamination and Physicochemical Properties of Soils in Municipal Solid Waste Dumpsite, Hurghada, Red Sea, Egypt

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ABSTRACT

A field study was conducted to assess soil quality at a municipal solid waste dumpsite in Hurghada, which includes the old dumpsite and new dumpsite. These dumpsites were filled with the following wastes: paints, plastic, electric, metal, textile, wood, food, cosmetic, packing, machinery, agricultural, chemical, and automotive remains. Soil samples were randomly collected from the two waste dumpsites and two dry drainage patterns, located away from the waste dumpsites, at a depth of 50cm. The soil physicochemical properties, such as pH, electrical conductivity, total organic matter, and TDS in addition to grain size distribution were determined. Aso, an assessment of heavy metal pollutants was conducted using contamination factor ratios (CF), and geoaccumulation index This study revealed that the heavy metals in soil followed the order of Fe>Al> Ba> Zn>Pb> Cu> Co> Cr>Ni>Cd. The distribution pattern of heavy metals in both drainage pattern samples exhibited decreasing concentrations of these metals than those found in the nearby two dumpsites. The heavy metals concentrations of soils in municipal solid waste dumpsite exceed the background value of soils from the earth's crust except for Fe and Al. The characteristics study of soil samples from the dumpsites showed that the solid waste dump had changed the soil characteristics, which were higher limits at certain places only. Contaminations in soil samples were classified using geoaccumulation index and contamination factor to make sure that heavy metal pollution levels of soils collected from dumpsites are greater than those from drainage pattern samples. (Igeo) methods.

INTRODUCTION

Municipal solid waste normally termed as ''garbage'' or ''trash'' is an inevitable byproduct of human activity. Urban Municipal solid waste is usually generated from human settlements, small industries and commercial activities **(Singh *et al.*, 2011)**. Solid waste disposals (open dumps, landfills, sanitary landfills or incinerators) represent a significant source of metals released into the environment. The major sources of heavy metals in landfills are the co-disposed industrial wastes and household hazardous such as batteries, paints, dyes, inks, etc. **(Erses and Onay, 2003; Bretzel and Calderisi, 2011)**.

Heavy metals like iron, copper, manganese, chromium, nickel and lead as well as organic compounds such as phenols, poly-aromatic hydrocarbons, acetone, benzene, toluene, chloroform are generally found in leachate from a solid waste dumpsite **(Alker *et al.*, 1995)**. The concentration of these metals in such leachate, that generated from landfill sites, pose serious environmental risks to the surrounding soil **(Ali *et al.*, 2013; Nta and Odiong,2017)**. Due to migration of leachate, soils have been contaminated with nonbiodegradable metals which lead to serious environmental problems **(Hong *et al.*, 2002).**

The dumping solid waste often releases byproducts as well as interstitial liquids containing several different organic and inorganic compounds. These compounds contaminate the water moving through the deposit, that sit at the bottom of the deposit and seep into the soil, affecting its physical and chemical properties **(Al-Yaqout and Hamoda, 2003)**. Several scholars have reported on the characterization and management of municipal solid waste around the worldwide **(Agunwamba *et al*., 2003; Nabegu, 2010 and Nkwachukwu *et al.*, 2010)** and their effect on groundwater.

The objective of this study is to determine the physicochemical properties of soils and heavy metal concentrations within two dumpsites. Compar these data with those of the natural soil from two dry drainage patterns. Then analyzing these data to evaluate the impact of pollution on soil in the region of Hurghada, Red Sea, Egypt.

MATERIALS AND METHODS

1. The study area

Hurghada dumping site is considered as the oldest site along the Egyptian Red Sea coast. It is found at about 6 km outer the ring road of Hurghada city at the west side of Red Sea coast, and at about 11Km south west Hurghada Airport. Geologically, the dumpsite is located in the distal desert area on plateau, rises 85m above sea level, between two dry drainage patterns of Wadi Falk El Shal. This area is about 7.5km^{2}, with surface sediments mainly composed of recent alluvial sediments and underlain rock formations composed of limestone that belong to the Quaternary age.

Almost 96% of the total waste generated from residential and tourism resorts; agricultural areas and commercial sites of the city. These wastes usually contain about 140–150 metric tonnes per day of solid wastes. Access to the sites is regularly utilized by scavengers for sorting wastes and freely by a variety of animals, including cats, dogs, and foxes.

The study dumpsite falls in the arid zone having moderate summer and winter temperature. The mean maximum temperature of the Hurghada city reaches 37^{o}C during the summer and the mean minimum temperature is 21^{o}C during winter. Monsoon prevails from Marsh to July, where average wind speed reaches 22.04 km/h during winter season and 19.23 km/h during the summer season (**Mansour *et al.*, 2000)**. A monsoonal climate of Hurghada is dry winter season with light rainfall averaging of 3 mm/year **(Edward and Head, 1987)**.The studied area includes two dumpsites (old dumpsite and new one separated by internal asphalt road, Figure (1).

1.1. Old dumpsite:

This site is located at coordinates 27°4´ 27.80″ N - 33°47´ 15.95″ E and covers an area of about 5 km^2 which is mostly filled with large heaps of garbage dumped on 20 opened wide pits. Currently, it is closed since 2014 and it considered as primitive dumpsite without sorting process.

1.2. Newdumpsite:

The new site have an area about 2.5 km^2 and lies at latitudes 27°4´ 19.13″ N and longitudes 33°47´ 37.15″E including 14 pits buried. The process of waste sorting perform manually to collect the wood, glass, tin, metals, plastic and transfers to the recycling factors in Cairo, while organic matters, trash and garbage were buried in pits, each pit had the following dimension (40m wide, 100m long and 4m depth) which completely filled with 16000 tonnes of waste, then covered with soils.

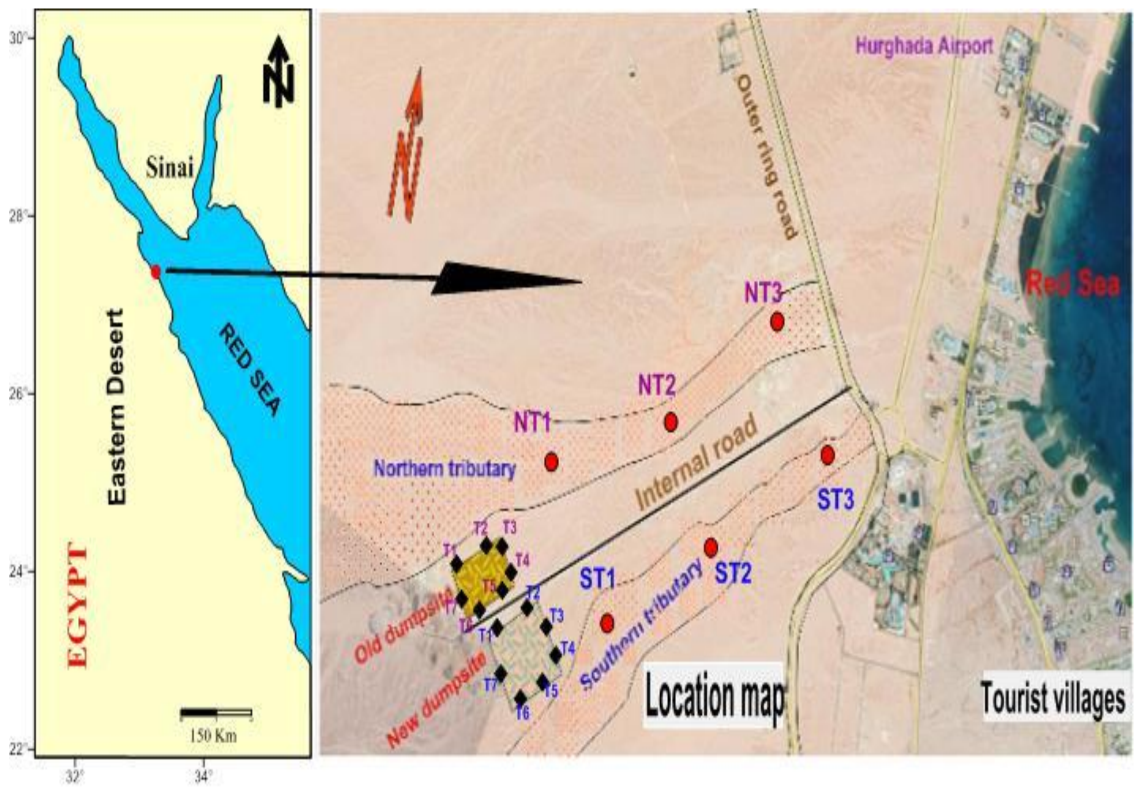

Fig.1. Sampling locations map of the study area.

2. Field work

According to the aim of this study, from two waste dumpsites using a soil hoe fourteen soil samples from the depth of 50cm were randomly collected and from two dry drainage patterns of Wadi Falk El Shalaway six samples were collected during November2018, in order to assess the quality of soil and compare between two dumpsites and two dry drainage patterns. All soil samples were taken from each station and placed immediately in polyethylene bags, then transferred to Central Laboratories for Environmental Quality Monitoring (CLEQM), Ministry of Water Resources and Irrigation, Cairo and prepared for further analyses. Global Position System GPS (Magellan 1000) was recorded of each sample.

3. Laboratory Methods:

Several analyses were performed in order to study the parameters that evaluate soil quality. The soil samples were dried in the sunlight to avoid any change in their physical and chemical properties. The pH, Electrical Conductivity (EC),and Total Dissolved Solids (TDS) were determined for each sample, also the Total Organic Matter (TOM) was calculated according to **(Bernner and Binford, 1988)**.The grain size analysis was done using sieves arrange at 1Φ interval according to **(Folk and Ward, 1957)**.

Ten grams of each soil sample were dried in an oven at 50 ± 5 °C overnight to a constant weight and were grounded using electric agate mortar for 20 minutes, then were filtered through a 80-mesh size sieve. Half gram of each grinded sample was digested using 10 ml of mixed reagents (HF: $HClO_4$: HNO_3 acids) with ratio 1:2:3, respectively, **(Oregioni and Aston, 1984)**, then diluted to 50 ml with deionized water. The analytical determination of Manganese (Mn), Iron (Fe), Aluminum (Al), Barium(Ba), Zinc (Zn), Lead (Pb), Copper (Cu), Cobalt (Co), Chromium (Cr), Nickel (Ni)and Cadmium (Cd) in the dissolved phase was carried out by GBC atomic absorption reader (Model Savant AA AAS with GF 5000 Graphite Furnace) at CLEQM.

4. Statistical Analysis

Statistical analyses of data were performed by a SPSS 22. Pearson’s correlation coefficients were used to verify the relationships among variables. Classify heavy metals by their similarities using hierarchical cluster analysis (HCA) were done. Also, the contamination factor (CF) and geoaccumulation index (I*geo*) were calculated for the soil samples **(Taylor, 1964; Wedepohl, 1995)**.

RESULTS AND DISCUSSION

1. Physicochemical properties of soil samples

Soil pH is extremely important for the decomposition of rock’s minerals into essential elements. From the physicochemical properties of the soil samples (Table 1), it was observed that the pH values of the soil samples were alkaline in nature with an average value of 7.99 to 8.12 at old and new dumpsites respectively, while the average values of pH at northern and southern drainage samples were 7.85and 7.77 respectively. The pH of the soil samples in two dumpsites higher than that of the two drainage samples, whereas the average pH values in present study were higher than values reported by **Osakwe, 2014,** and lower than values illustrated by **Jintao *et al.*, 2011**.

Electrical conductivity is a measure of the ability of a material to transmit charges. The electrical conductivity of the soil samples from the two dumpsites was higher than those of the two drainage samples. A significant difference in the values of EC was observed in the soil samples as following: 7.11 dS/m at old dumpsite, 0.36 dS/m at new one, 0.36 dS/m at northern drainage and 0.33dS/m at southern one). Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid, molecular, ionized or micro-granular suspended form. In the present study, the average values for TDS at both old and new dumpsites were 1849.63ppm and 1616.73 ppm respectively, while at northern and southern drainage samples were recorded as 180.21 ppm and 247.26 ppm respectively.TDS was found higher at both old and new waste dumpsites than those in both two drainage samples, Table (1).

The Total Organic Matter (TOM) not only determined the nutritional status, but also affected the migration of heavy metals, and it is due to decomposition of organic matter **(Al-Yaqout and Hamoda, 2003)**. The effect of municipal solid wastes on soil physical properties largely depends on the rate of decomposition of wastes and its contribution to soil organic matter. **Khaleel *et al.*, 1981** represented the factors affecting the rate of decomposition: (i) chemical composition of the waste; (ii) temperature, (iii) soil moisture; (iv) method of waste application and (v) rate of application.

TOM values at two dumpsites were higher than that of both drainage samples, where the average value of TOM in all sites were 25.86% of old dumpsite;20.43% of new dumpsite; 6.0% % of northern drainage and 16.67% of southern drainage samples, Table (1). The decline in soil organic matter content in the drainage samples (northern and southern sites) may be as a result of leaching problem that may be attributed to the high sand content.

Particle size distribution showed 68.81% of sand, 24.88 % of gravel and 6.32 % of silt in old dumpsite, while in new dumpsite soil contained 68.69 % of sand, 29.71 % of gravel and 1.61% of silt. Also, particle size in northern drainage samples were found to be 62.47 % of sand, 29.22 % of gravel and 8.31% of silt, while in southern one soil showed 75.75 % of sand, 18.43 % of gravel and 6.07 % of silt, Table (1).

Particle size distribution in the studied soil showed that, sand fractions were predominant, followed by gravel, then silt with low percentage, while clay was not available in all samples. Similar observation of absence of clay in all samples was reported by **(Egharevba and Odjada, 2002)**. Soil texture plays an important role in mobility of metals in soil. The textural class for most of the studied soil samples was gravelly sand. The proportion of sand, gravel and silt suggests that the soils were coarse grained.

Table1. Coordinates, grain size distribution and physicochemical properties of studied soil samples.

S. N.	Site	Lat.	Long.	Gravel	Sand	Silt	TOM	pH	EC	TDS
O_1	Old dumpsite	27° 4' 23.85"	33° 47' 11.37"	26.08	68.92	5	16	7.6	21.5	1376
O_2		27° 4' 26.71"	33° 47' 17.91"	24.48	71.97	3.55	26	7.8	7.31	1432
O_3		27° 4' 28.60"	33° 47' 19.20"	27.02	66.46	6.52	18	8.2	2.19	1401.6
O_4		27° 4' 33.51"	33° 47' 16.96"	36.39	60.29	3.32	40	7.67	8.12	1990.8
O_5		27° 4' 35.69	33° 47' 13.37"	20.71	66.91	12.38	37	8.12	2.98	1907.2
O_6		27° 4' 32.76"	33° 47' 10.99"	15.12	78.87	6.00	24	8.13	3.11	1915
O_7		27° 4' 28.75"	33° 47' 11.17"	24.34	68.23	7.43	20	8.4	4.57	2924.8
Min.				15.12	60.29	3.32	16	7.60	2.19	1376.0
Max.				36.39	78.88	12.38	40.	8.40	21.50	2924.8
Stdv				6.48	5.68	3.07	9.32	0.30	6.73	545.13
Averg.				24.88	68.81	6.32	25.9	7.99	7.11	1849.6
N_1	New dumpsite	27° 4' 19.41"	33° 47' 36.35"	27.74	70.71	1.578	15	8.05	5.77	3692.8
N_2		27° 4' 26.42"	33° 47' 36.14"	29.01	68.46	2.533	23	8.14	1.481	915.8
N_3		27° 4' 25.68"	33° 47' 39.25"	36.26	63.12	0.623	18	8.16	2.08	1331.2
N_4		27° 4' 20.35	33° 47' 44.54"	37.61	62.07	0.318	30	8.21	3.42	1365.2
N_5		27° 4' 16.14	33° 47' 45.66"	29.11	70.19	0.702	29	8.21	2.26	1446.4
N_6		27° 4' 17.82"	33° 47' 41.46"	29.21	67.58	3.212	8	8.11	4.25	1470
N_7		27° 4' 19.07"	33° 47' 39.10"	19.01	78.69	2.303	20	7.94	1.712	1095.7
Min.				19.01	62.07	0.32	8.00	7.94	1.48	915.8
Max.				37.61	78.69	3.21	30.0	8.21	5.77	3692.8
Stdv				6.12	5.51	1.11	7.76	0.10	1.57	937.03
Averg.				29.71	68.69	1.61	20.4	8.12	2.97	1616.7
SD_1	South drainage	27° 4' 38.60"	33° 47' 50.19"	18.50	72.04	9.46	16	7.93	0.42	1926.4
SD_2		27° 4' 48.26"	33° 48' 13.15"	15.53	76.93	7.53	14	7.73	0.27	2950.4
SD_3		27° 5' 18.96"	33° 48' 39.19"	21.25	78.27	1.21	20	7.66	0.31	2540.0
Min.				15.53	72.04	1.22	14.0	7.66	0.27	1926.4
Max.				21.25	78.27	9.46	20.0	7.93	0.42	2950.4
Stdv				2.86	2.58	3.89	3.03	0.11	0.06	419.75
Averg.				18.43	75.75	6.07	16.7	7.77	0.33	247.3
ND_1	Northern drainage	27° 4' 49.75"	33° 47' 30.42"	39.12	59.07	1.81	12	8.33	0.286	183.04
ND_2		27° 5' 12.02"	33° 47' 46.48"	29.55	62.34	8.1	5	7.54	0.456	180.2
ND_3		27° 5' 37.83"	33° 48' 14.82"	19.00	65.99	15.0	1	7.69	0.324	177.4
Min.				19.00	59.07	1.81	1.00	7.54	0.29	177.4
Max.				39.12	66.00	15.00	12.00	8.33	0.46	183.0
Stdv				175.34	374.8	49.82	36	47.12	2.132	1081.28
Averg.				29.22	62.47	8.31	6.00	7.85	0.36	180.2

2. Heavy metal concentrations in soil samples from studied sites

Metal content of soils at waste dumpsites and two drainage patterns is shown in Table (2). Mn had highest average concentration (10896 mg/kg), followed by Fe (7959 mg/kg), Al (6191mg/kg), Ba (1402 mg/kg), Zn (492 mg/kg),Pb (470 mg/kg), Cu (402 mg/kg), Co (234 mg/kg), Ni (114 mg/kg), Cr (68 mg/kg), and Cd (44 mg/kg) in old dumpsites, while in new dumpsite; also Mn had highest average concentration (12815 mg/kg), Fe (5875 mg/kg), Al (5772 mg/kg), Ba (617 mg/kg), Zn (328 mg/kg), Pb(492 mg/kg),Cu (375 mg/kg), Co (310 mg/kg), Ni (139 mg/kg), Cr (32 mg/kg) and Cd (21 mg/kg).

On the other hand, the average values of Fe, Mn, Ba, Al, Zn, Cu, Pb, Ni, Co, Cr and Cd at samples from northern drainage were 8131 mg/kg, 7201 mg/kg, 4430 mg/kg, 4130 mg/kg, 787 mg/kg, 450 mg/kg, 232 mg/kg, 153 mg/kg, 137 mg/kg, 129 mg/kg and 10 mg/kg, respectively. While that of samples from southern drainage were 145 mg/kg, 11988 mg/kg, 828 mg/kg, 8898 mg/kg, 278 mg/kg, 240 mg/kg 138 mg/kg, 127 mg/kg, 203 mg/kg, 29 mg/kg, and 12 mg/kg, respectively.

The physical composition of municipal solid wastes (MSW) could affect the types and contents of heavy metals in MSW. A very high concentration of Mn and Fe were noticed at all sites, while high concentrations of Al and Ba were found at drainage samples. The iron component occupies the fourth position after each element of oxygen, silicon and aluminum in terms of availability in the earth's crust **(AL-Hadethi *et al.*, 2016)**. The abundance of Mn, Fe and Ba in soil is due to specify the weathering of rocks from the adjacent areas as a potential source of igneous rocks.

The high concentrations of Pb, Cu and Cd in these sites may have resulted from inclusions of chalcopyrite in nickel-cadmium batteries and printed matter. Cr and Ni may found in storage batteries, household appliances and kitchen wastes. Zn came from pharmaceuticals, galvanizing, paints, pigments, insecticides, cosmetic sand packing papers **(Germani *et al.*, 1981; Chimezie *etal.*, 2013 ; Yin *et al.*, 2015)** and Co came from Dyes, glass, ceramic paints and coatings **(Lahal *et al.*, 2016)**.

Table 2.Heavy metal concentrations of all studied sites.

Site	S. No.	Mn	Fe	Al	Ba	Zn	Pb	Cu	Co	Ni	Cr	Cd
New Dumpsite	**N1**	12960	8110	1375	268	278	875	60	170	142	47	22
	N2	11340	8119	2165	432	211	432	117	217	122	31	17
	N3	10560	8130	4892	1140	159	526	180	326	162	24	14
	N4	15260	8158	8380	384	335	570	875	711	136	48	41
	N5	13630	8187	8270	881	495	312	260	139	141	22	9
	N6	12396	7231	8132	532	357	425	356	167	155	27	22
	N7	13560	7192	7190	681	464	307	780	440	118	27	21
	Min.	10560	7192	1375	268.0	159	307.0	60.0	139	118	22	9
	Max.	15260	8187	8380	1140	495	875	875	711	162	48	41
	Aver.	**12815**	**7875**	**5772**	**617**	**328**	**492**	**375**	**310**	**139**	**32**	**21**
Site	**S.No.**	**Mn**	**Fe**	**Al**	**Ba**	**Zn**	**Pb**	**Cu**	**Co**	**Ni**	**Cr**	**Cd**
Old Dumpsite	**O1**	12360	7107	6620	391	275	392	70	20	84	68	16
	O2	13950	8165	6310	350	531	657	90	470	87	48	22
	O3	12260	9133	7370	1616	407	518	920	606	178	40	53
	O4	11320	7142	6532	469	354	470	368	321	96	56	66
	O5	10121	11290	6859	352	288	576	570	20	85	77	88
	O6	11241	7562	5369	2361	641	436	387	77	96	88	54
	O7	5017	5315	4276	4276	951	244	411	125	175	100	11
	Min.	5017	5315	4276	350	275	244	70	20	84	40	11
	Max.	13950	11290	7370	4276	951	657	920	606	178	100	88
	Aver.	**10896**	**7959**	**6191**	**1402**	**492**	**470**	**402**	**234**	**114**	**68**	**44.3**
Site	**S.No.**	**Mn**	**Fe**	**Al**	**Ba**	**Zn**	**Pb**	**Cu**	**Co**	**Ni**	**Cr**	**Cd**
Southerm drainage	**ST1**	15290	177	1375	1194	457	195	320	266	141	48	17
	ST2	11423	135	8380	753	246	122	233	177	122	21	9
	ST3	9251	123	16940	536	132	96	167	166	117	19	11
	Min.	9251	123	1375	536	132	96	167	166	117	19	9
	Max.	15290	177	16940	1194	457	195	320	266	141	48	17
	Averag.	**11988**	**145**	**8898**	**828**	**278**	**138**	**240**	**203**	**127**	**29**	**12**
Site	**S.No.**	**Mn**	**Fe**	**Al**	**Ba**	**Zn**	**Pb**	**Cu**	**Co**	**Ni**	**Cr**	**Cd**
Northern Drainage	**NT1**	6660	8131	4100	4100	815	362	517	147	187	170	12
	NT2	9310	8640	5080	5080	925	200	520	181	174	130	8
	NT3	5632	7621	3211	4111	621	135	312	83	98	88	9
	Min.	5632	7621	3211	4100	621	135	312	83	98	88	8
	Max.	9310	8640	5080	5080	925	362	520	181	187	170	12
	Aver.	**7201**	**8131**	**4130**	**4430**	**787**	**232**	**450**	**137**	**153**	**129**	**10**

3. Assessment of metal contamination

About the index of geoaccumulation (I*geo*) and contamination factor, the results of the calculations are presented in (Table 3 and Figure 2). In the new dumpsite; I*geo* values for Mn, Fe, Al, Ba, Cu, Ni and Cr (<1) ranged between the uncontamination level and the moderately contamination level. Mean I*geo* values of Zn and Cd were moderately contamination level, Co I*geo* value (3.27) were at the heavily contamination level and Pb I*geo* value (4.94) ranged from heavily to very heavily contamination level.

In old dumpsite, Cd, Zn, Cu and Pb showed I*geo* values above 5 (extremely contamination level), while I*geo* value of Fe, A, Ba and Cr exhibited uncontaminated to moderately contaminated level. Also, average I*geo* values of Mn and Co ranged from heavily to very heavily contamination level, while I*geo* value for Ni indicated moderately contamination level.

Table 3.Minimum, maximum and average values of the different pollution indicators in the present study.

Site	Metal	CF			Igeo			Site	Metal	CF			Igeo		
		Min.	**Max.**	**Aver.**	**Min.**	**Max.**	**Aver.**			**Min.**	**Max.**	**Aver.**	**Min.**	**Max.**	**Aver.**
New dumpsite	**Mn**	11.12	16.06	13.49	0.02	4.93	0.72	**Southern drainage**	**Mn**	9.74	16.09	12.62	3.52	5.82	4.56
	Fe	0.13	0.15	0.14	0.00	0.05	0.04		**Fe**	0.002	0.003	0.003	0.00	0.00	0.00
	Al	0.02	0.10	0.07	0.00	0.02	0.01		**Al**	0.02	0.21	0.11	0.00	0.04	0.02
	Ba	0.63	2.68	1.45	0.08	0.34	0.19		**Ba**	1.26	2.81	1.95	0.16	0.36	0.25
	Zn	2.27	7.07	4.69	0.61	1.91	1.27		**Zn**	1.89	6.53	3.98	0.51	1.76	1.07
	Pb	24.56	70.00	39.39	3.08	8.78	4.94		**Pb**	7.68	15.60	11.01	1.13	2.30	1.63
	Cu	1.09	15.91	6.83	0.13	1.85	0.79		**Cu**	3.04	5.82	4.36	2.34	4.49	3.37
	Co	5.56	28.44	12.40	1.47	7.51	3.27		**Co**	6.64	10.64	8.12	2.87	4.60	3.51
	Ni	1.57	2.16	1.86	0.35	0.48	0.41		**Ni**	1.56	1.88	1.69	0.13	0.15	0.14
	Cr	0.22	0.48	0.32	0.05	0.11	0.07		**Cr**	0.19	0.48	0.29	0.11	0.28	0.17
	Cd	45.00	205.00	104.29	0.54	2.47	1.26		**Cd**	45.00	85.00	61.67	17.71	33.44	24.26
Site	**Metal**	**CF**			**Igeo**			**Site**	**Metal**	**CF**			**Igeo**		
		Min.	**Max.**	**Aver.**	**Min.**	**Max.**	**Aver.**			**Min.**	**Max.**	**Aver.**	**Min.**	**Max.**	**Aver.**
Old dumpsite	**Mn**	5.28	14.68	11.47	1.91	5.31	4.15	**Northern drainage**	**Mn**	5.92	9.80	7.58	2.14	3.54	2.74
	Fe	0.09	0.20	0.14	0.01	0.07	0.05		**Fe**	0.14	0.15	0.14	0.05	0.06	0.05
	Al	0.05	0.09	0.08	0.01	0.02	0.02		**Al**	0.04	0.06	0.05	0.01	0.01	0.01
	Ba	0.82	10.06	3.30	0.11	1.28	0.42		**Ba**	13.25	21.91	16.94	1.23	1.53	1.33
	Zn	3.93	13.59	7.03	0.61	32.26	11.43		**Zn**	8.87	13.21	11.24	2.40	3.57	3.04
	Pb	19.52	52.56	37.63	2.88	7.76	5.55		**Pb**	10.80	28.96	18.59	1.59	4.27	2.74
	Cu	1.27	16.73	7.31	0.98	12.91	5.65		**Cu**	5.67	9.45	8.17	4.38	7.30	6.31
	Co	0.80	24.24	9.37	0.35	10.48	4.05		**Co**	3.32	7.24	5.48	1.44	3.13	2.37
	Ni	1.12	2.37	1.53	0.91	1.92	1.23		**Ni**	1.31	2.49	2.04	1.06	2.02	1.65
	Cr	0.40	1.00	0.68	0.23	0.57	0.39		**Cr**	0.88	1.70	1.29	0.50	0.97	0.74
	Cd	55.00	440.00	221.43	21.64	173.12	87.12		**Cd**	40.00	60.00	48.33	15.74	23.61	19.02

Mean I*geo* value of Cd in southern drainage samples was at the extremely contamination level, while Mn ranged between heavily and very heavily levels of contamination, and heavily levels of Co and Cu contamination were found in this site samples. Pb and Zn at this site showed moderately level of contamination, where I*geo* values of Fe, Al, Ba, Ni and Cr ranged from uncontamination to moderately contamination level. In northern drainage soil samples; I*geo* values of Cd and Cu were (19.02 and 6.31) showed very extreme level of contamination, while Zn I*geo* value (3.04) showed heavy level of contamination. Moderately to heavily Mn, Pb and Co contamination was detected in this site samples, whereas Fe, Al and Cr present uncontamination to moderately contamination level. Mean I*geo* values of all sampling sites clearly showed that soil at the new dumpsite were less contaminated than that from the old dumpsite, same results were obtained between soil samples from southern drainage and northern one.

According to the contamination Factor (CF) values (Table 3), the average values of Cd in both two drainage patterns and old dumpsite showed very high contamination to extremely high contamination, as well as the (I*geo*) levels of Cd agree with CF and indicated extremely high contamination level.

Accordingly, new dumpsite soils were moderately contaminated with respect to Ba and Ni; considerably with respect to Zn; and extremely high with respect to Mn, Pb, Cu, Co and Cd. The highest contamination of CF value (extremely–heavily contamination) for Mn, Cu, Zn, Co Pb and Cd was found in the old dumpsite samples, moderately to Ni and considerably with respect to Ba.

The elements in the two dry drainages were found to be as the following; the CF was observed for Cd (48.33 and 61.67) in northern drainage and southern one respectively, indicated a very high contamination level. Also, the CF>7 was recorded for Mn and pb in both drainage samples. The CF was recorded at the moderate contamination level for Ni and the low contamination level for Fe and Al in both dry drainage soils. Thus, contamination factor values confirmed that heavy metal pollution levels of soils collected from dumpsites were greater than those from drainage pattern samples.

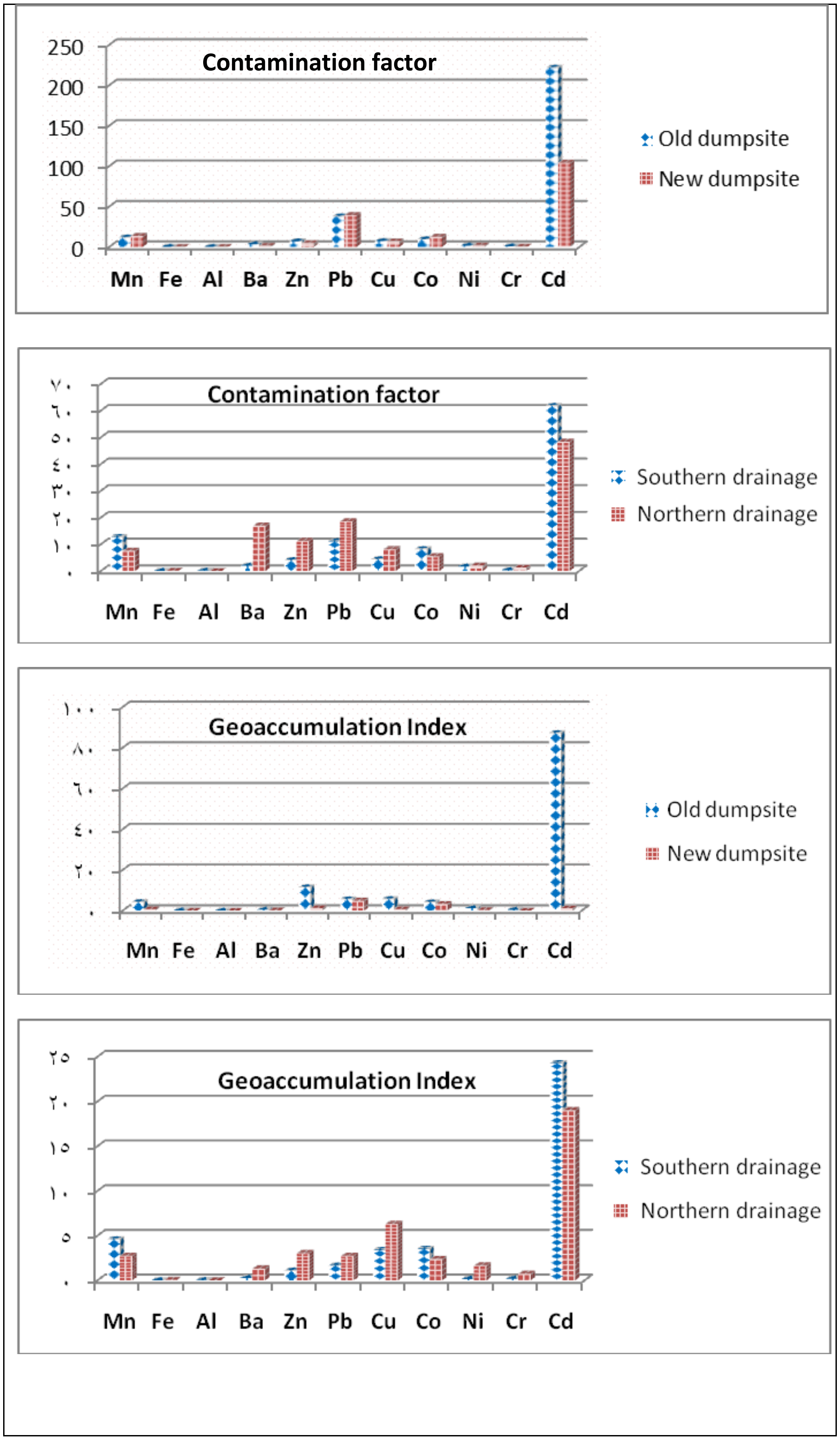

Fig.2. Mean value of the CF and I*geo* of all studied soil samples.

4. Cluster analysis

Dendrogram for hierarchal clusters analysis was performed on data using Word's method to measure proximity between samples. Results of (HCA) were showed in Figure 3. Soil samples of old dumpsite area formed two distinctive clusters. Cluster 1 constituted of Cr, Cd, Ni, Pb, Cu, Co, Zn and Ba which showed higher values than those recorded in background. These metals were found to be strongly associated with various household appliances, tires and engine parts and photographic equipment. The second cluster consisted of three metals Fe, Al and Mn and the reason of their grouping may attributed to their high concentration values in soil. This group had values lower than those in background except Mn which had higher value than that of the background (Fig.3-A), and they had high concentrations supported by abundance of these metals from the weathering processes from rocks and soils of the adjacent areas.

Two major groups were formed as a result of clustering at new dumpsite. First group was represented by metals Cr, Cd, Ni, Pb, Cu, Co, Zn and Ba which had greater similarities and low linkage distances. This group had values higher than background values which was recorded by **Wedepohl, 1995.** While the second one, which consisted of Fe, Al and Mn that originated from lithogenic sources, had values lower than those recorded in background except Mn which have high value than background (Fig.3-B). In the southern drainage site; two main clusters were obtained, cluster 1 consisted of 9 metals and it represented the lowest cluster and recorded relatively high concentrations of these metals than those in the background. Cluster 2 contained two metals Mn and Al and characterized by high concentration values compared to the second cluster at northern drainage site (Fig.3– C).

Also, the heavy metals at northern drainage; were classified into two different clusters: first cluster included Co, Ni, Cr, Pb, Cd Zn, and Cu. The second one included Al, Ba, Mn and Fe which recorded the highest average values of metals (Fig.3-D). Results of dendrogram cluster analysis suggested mixed origins of metal sources including household appliances and lithogenic occurrences.

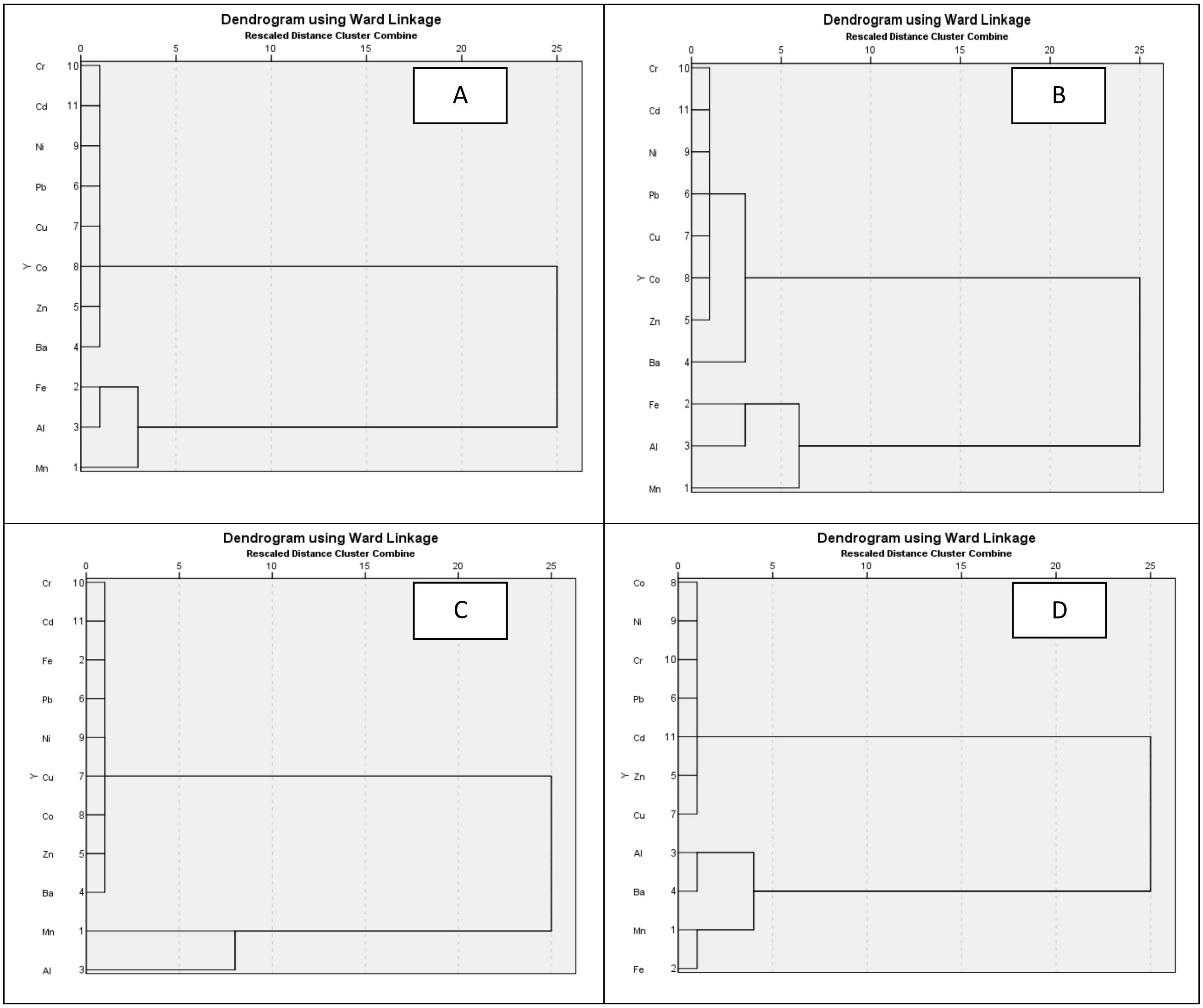

Fig.3.Dendrogram for hierarchal clusters analyses of old dumpsite (A), new dumpsite (B), southern drainage (C) and northern drainage (D).

Pearson's correlation analysis between all the variables was performed (Table 4), and they were significant at a level of 0.05. In old dumpsite; the highest positive correlations were found between Mn–Al (r=0.83), Mn–Pb (r=0.84),Fe–Pb (r=0.81), Ba–Zn (r=0.92). Fe and Al were weakly negative correlated with Ba, Zn, Ni and Cr at the significance level of 0.05. Significant and high correlations between these metals indicated that contaminants and hazardous metals in the old dumpsite soils had a similar source which originated from the decomposition of disposal wastes.

Table4.Pearson's correlation coefficient matrix for elements in all studied samples.

Old dumpsite

	Mn	**Fe**	**Al**	**Ba**	**Zn**	**Pb**	**Cu**	**Co**	**Ni**	**Cr**	**Cd**
Mn	1.00										
Fe	0.58	1.00									
Al	**0.83**	0.79	1.00								
Ba	-0.45	-0.37	-0.50	1.00							
Zn	-0.31	-0.38	-0.52	**0.92**	1.00						
Pb	**0.84**	**0.81**	0.79	-0.47	-0.28	1.00					
Cu	0.11	0.54	0.45	0.32	0.11	0.25	1.00				
Co	0.52	0.23	0.51	-0.03	0.06	0.54	0.46	1.00			
Ni	-0.24	-0.12	-0.05	0.75	0.58	-0.23	0.68	0.46	1.00		
Cr	-0.28	-0.08	-0.35	0.69	0.66	-0.28	0.04	-0.54	0.16	1.00	
Cd	0.36	0.79	0.60	-0.23	-0.31	0.56	0.61	0.10	-0.12	0.06	1.00

New dumpsite

	Mn	**Fe**	**Al**	**Ba**	**Zn**	**Pb**	**Cu**	**Co**	**Ni**	**Cr**	**Cd**
Mn	1.00										
Fe	0.21	1.00									
Al	0.65	-0.04	1.00								
Ba	-0.15	0.23	0.44	1.00							
Zn	0.75	-0.09	0.74	0.18	1.00						
Pb	0.17	0.51	-0.34	-0.29	-0.27	1.00					
Cu	0.77	-0.14	0.74	0.05	0.57	-0.17	1.00				
Co	0.61	0.17	0.46	0.02	0.16	0.10	**0.86**	1.00			
Ni	-0.06	0.34	0.31	0.53	-0.06	0.39	-0.15	-0.08	1.00		
Cr	0.58	0.43	-0.08	-0.54	-0.01	**0.81**	0.30	0.51	0.02	1.00	
Cd	0.71	0.17	0.38	-0.34	0.16	0.43	0.73	**0.82**	0.05	**0.81**	1.00

Southern tributary

	Mn	**Fe**	**Al**	**Ba**	**Zn**	**Pb**	**Cu**	**Co**	**Ni**	**Cr**	**Cd**
Mn	1.00										
Fe	**0.99**	1.00									
Al	**0.01**	**0.01**	1.00								
Ba	**0.99**	**0.99**	0.01	1.00							
Zn	**0.99**	**0.99**	0.01	**0.99**	1.00						
Pb	**0.99**	**0.99**	0.01	**0.99**	**0.99**	1.00					
Cu	**0.99**	**0.98**	0.00	**0.99**	**0.99**	**0.99**	1.00				
Co	**0.98**	**0.99**	0.01	**0.98**	**0.98**	**0.99**	**0.96**	1.00			
Ni	**0.99**	**0.99**	0.01	**0.99**	**0.99**	**0.99**	**0.98**	**0.99**	1.00		
Cr	**0.97**	**0.99**	0.02	**0.98**	**0.97**	**0.99**	**0.95**	**0.99**	**0.99**	1.00	
Cd	**0.91**	**0.95**	0.14	**0.92**	**0.91**	**0.94**	**0.88**	**0.97**	**0.95**	**0.97**	1.00

	Mn	Fe	Al	Ba	Zn	Pb	Cu	Co	Ni	Cr	Cd
Mn	1.00										
Fe	**0.97**	1.00							**Northern tributary**		
Al	**0.98**	**0.99**	1.00								
Ba	**0.96**	**0.86**	**0.88**	1.00							
Zn	**0.92**	**0.99**	**0.98**	0.77	1.00						
Pb	0.03	0.28	0.25	-0.25	0.43	1.00					
Cu	0.72	**0.87**	**0.86**	0.50	**0.94**	0.71	1.00				
Co	**0.91**	**0.98**	**0.98**	0.76	**0.99**	0.44	**0.94**	1.00			
Ni	0.61	0.79	0.77	0.37	**0.88**	**0.81**	**0.99**	**0.89**	1.00		
Cr	0.28	0.51	0.49	0.00	0.64	**0.97**	**0.87**	0.65	**0.93**	1.00	
Cd	-0.47	-0.24	-0.27	-0.70	-0.08	**0.87**	0.27	-0.07	0.40	0.71	1.00

* Correlation is significant at the 0.05 level (2-tailed).

While in new dumpsite; the highest positive correlations were found between Pb–Cr (r=0.81), Cu–Co (r=0.86), Co–Cd(r=0.82) and Cd–Cr (r=0.81), but lowest negative correlations were found between Ni–Mn (r=-0.06), Fe–Zn (r=-0.09), Ni–Co (r=-0.08) and Al–Cr (r=-0.08). The correlation between metals in soil samples usually related to discharg of contaminants and their effect on partitioning of metals and may be influenced by differences in physicochemical properties of soil.

In the southern drainage soil samples, heavy metals were generally closely associated with each other. Mn had a very strong positive correlation with all metals (Fe, Ba, Zn, Pb, Cu, Co, Ni, Cr and Cd). The presence of geologic factor that yield high correlations could indicate that these elements were of lithogenic origin. Al had weak positive correlation with all heavy metals revealed feeble relationship in the soil sample.

The correlation matrix of northern drainage samples showed that a significant positive correlation (r=0.97, 0.98, 0.96, 0.92, 0.91) was obtained between metal pairs Mn and Fe, Al, Ba, Zn, Co, as well as between Fe and Al, Ba, Zn, Cu, Co (r=0.99, 0.86, 0.99, 0.87, 0.98 respectively), also between metal pairs Al and Ba, Zn, Cu, Co (r=0.88, 0.98, 0.86, 0.98 respectively). The levels of Zn positive correlated significantly with Co (r=0.99), Cu (r=0.94) and Ni (r=0.88). Also significant positive correlation (r=0.97, 0.87, 0.81) was found between Pb and Cr, Cd, Ni, similarly the same correlation was recorded between Cu with Ni (r=0.99), Co (r=0.94) and Cr (r=0.87). The levels of Ni positively correlated in a significant way with Co (r=0.89) and Cr (r=0.93). The distribution pattern of heavy metals in both drainage samples exhibited decreasing concentrations of these metals than those found in the nearby dumpsites.

CONCLUSION

- The pH values of the studied soils were alkaline.
- The total organic matter, pH, electrical conductivity and total dissolved solids were higher at both dumpsites than those in two dry drainage sites.
- In present study; the recorded concentration levels of some heavy metals such as Zn, Pb, Cu, Co, Ni, Cr and Cd were higher than the background values, while Mn, Fe and Al were lower than background values in continental crust.
- The concentrations of some selected metals in the soils studied were generally higher in two dumpsites than drainage sites, indicating some degrees of contamination.
  - Mean concentration values of heavy metals in the soil samples of two dumpsites were in the following order: Mn > Fe > Al > Ba > Zn > Pb > Cu > Co > Ni > Cr > Cd.
- Contaminations in soils were classified using geoaccumulation index and contamination factor to make sure that heavy metal pollution levels of soils collected from dumpsites were greater than those from drainage pattern samples.

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