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STUDIES ON Fe, Mn, Ni AND Pb LOAD ON SOIL AND ITS ENRICHMENT FACTOR RATIOS IN DIFFERENT SOIL GRAIN SIZE FRACTIONS AS AN INDICATOR FOR SOIL POLLUTION

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ABSTRACT :

An industrial area north of greater Cairo was selected to investigate the impact of intensive industrial activities on soil characteristics and Fe, Mn, Ni and Pb total contents. The studied area was divided into six sectors according to its source of irrigation water and/or probability of pollution. Sixteen soil profiles were dug and soil samples were taken, air dried, fractionated to different grain size fractions, then total heavy metals (Fe, Mn, Ni and Pb) were determined using ICP technique. The enrichment factor for each metal for each soil fraction/soil layer was estimated and discussed.

The highest EF ratio in the clay fraction was mainly with Pb which indicates the industrial impact on the soil. In case of sand fraction, Mn was the highest when compared with other studied metals. Concerning silt fraction, a varied accumulation of Fe, Mn and Pb was observed with soil depth and different soil profiles.

INTRODUCTION :

The cycle of elements in nature is limited on earth and life has adopted itself to it. Naturally, the concentrations of undesired elements both in the soil solution and in natural waters is low. This situation may change drastically when the content of available harmful elements in soil is increased by several orders of magnitude in industrial areas. Based on the characteristics of soil, i.e., its large volume, buffering

capacity and biological activity, not every enrichment of the soil is to be considered as pollution. The concept of soil pollution must be restricted to accumulation of heavy metals at a reactive level which is toxic to living soil organisms and harming the plant production [1]. Soil pollution may occur as a consequence of diff-erent types of input of unwanted substances such as sewage sludge applications, irrigation with polluted wastewater, pesticides and intensive fertilization.

Abdel Kareim [2] reported that the average value of total Fe in alluvial soils of Monofia Governorate was 4.7%. Concerning the total content of Fe in contaminated alluvial soils, Rabie [3] reported that the highest value was 16.6 % in the surface layer of alluvial soils at El-Saff region due to the irrigation with liquid industrial wastes.

Manganese is not distributed uniformly in soil substrata and, in addition to various nodules, is known also, to be concentrated at certain spots which are usually enriched with several trace elements. Although Mn can be concentrated in various soil horizons, particularly in those enriched with Fe oxides or hydroxides, usually this element is also accumulated in top soils as the result of its fixation by organic matter. Manganese toxicity symptoms have observed in a wide range of crops, including soybean, cotton, tobacco and upland rice grown on soils with high available Mn. Reported toxic concentrations for Mn ranged from 80 to 5000 mg/kg soil [4]. In Egypt, Rashad [5] found that the content of total Mn in the normal alluvial soils of Delta ranged between 720 and 1080 ppm with an average of 926 ppm. Concerning the total Mn in contaminated alluvial soils of Egypt, Rabie [3] reported that the highest value (2550 ppm) was observed in the surface layer of alluvial soils at El-Saff area due to irrigation with liquid industrial wastes. El-Leithi [6] found that the total content of Mn in contaminated alluvial soils of Delta ranged between 515.2 to 1341.1 ppm. El-Sebaay [7] found that the values of both total and available Mn were increased by irrigation with wastewater.

Lead is found in uncontaminated soils at concentrations<20.0 mg/kg. Much higher concentrations have been reported in many areas as a consequence of anthropogenic emissions, (often over many years). Nriagu [8] reported a mean of 17.0 mg Pb /kg soil, while, Davies [9] reported that the normal Pb content in uncontaminated soils was about 40 mg/kg. In Egypt, Rashad [5] found that the normal level of Pb in the alluvial soil of Nile Delta ranged between 32.0 and 48.0 ppm with an average of 41.0 ppm for total content. El-Sabbagh [10] found that the total content of Pb in the surface layer of the soil ranged between 17.0 and 48.0 ppm with an average of 29.0 ppm. Ramadan [11] reported that the total content of Pb ranged between 84.4 and 101.1 ppm with an average of 92.8 ppm in polluted alluvial soils.

Recently, nickel has become a serious pollutant element that released in the emissions from metal processing operations

and from the combustion of coal and oil [4]. The average concentration of Ni in world soils is probably 20.0 mg/kg, which obscures much variation between soil types. The application of sludges and certain phosphate fertilizers also may be important sources for Ni. In particular, Ni in sewage sludge, that is present mainly in organic chelated forms, is readily available to plants and therefore may be highly phytotoxic. In Egypt, Rashad [5] found that the normal level of total Ni in alluvial soils of Nile Delta ranged between 21.0-44.0 ppm (average 32.0 ppm). Concerning contaminated alluvial soils of Egypt, El-Sayed and Hegazy [12] reported that the total content of Ni in contaminated alluvial soils of El-Fayoum Governorate ranged between 33.5 and 77.0 with an average of 55.3 ppm. The goal of this study is to investigate the effect of industrial wastewater on soil pollution and heavy metals accumulation in the soil profile.

MATERIALS AND METHODS :

The studied area was divided into six sectors according to the source of irrigation water and the probability of pollution with organic and inorganic wastes (Fig 1). Sixteen soil profiles were dug and soil samples were taken from different layers. Another soil samples were taken from a virgin soil at the vacinity to represent uncultivated control soil (Group A) which is represented by soil profile No. 1 .

Sector B : the source of irrigation water for the soils of this sector is regular fresh water from El-Boulaqeyah canal which is located far from the pollution sources of the studied area. These soils are considered non-polluted and are taken as control. Profile No. 2 represents this sector.

Sector C: The soils of this sector are subjected to irrigation with heavily polluted wastewater from Shebin El-Qanater collector, profile No.3 represents these soils.

Sector D: These soils are located at the downstream of El-Shaboura canal, so it subjected to be irrigated with polluted water (site 6 and 7 at the end of the canal). Soil profile No. 4 represents these soils.

Sector E: The soils of this sector are subjected to be irrigated with combination of El-Shaboura canal water and either Mostorod collector wastewater (Profiles No. 5,6,7) or Shebin El-Qanter collector wastewater (Proffiles No. 8, 9, 10).

Sector F : These soils are subjected to be irrigated from El-Boulaqeyah canal water and Laza agricultural drain wastewater (profiles, No. 11, 12, 13, 14 and 15).

Sector G: The source of irrigation water for the soils of this sector is heavily polluted wastewater of Mostorod collector (Profile No. 16).

Soil analyses :

Disturbed soil samples were collected from different layers of the studied soil profiles. These samples were air-dried, crushed, ground by wood rod and sieved through 2 mm sieve. Fractions below 2

mm were maintained and stored in plastic bottles for physical and chemical determinations. Pipette method [13] was used for the determination of the soil fractions. Different grain size fractions (< 2 µ "clay", 2-50 µ "silt", and 50-2000 µ "sand") were separated by sedimentation and decantation. Total contents of Fe, Mn, Pb and Ni, either in the whole soil sample or in the different soil fractions were extracted by wet digestion of 1.0 g. sample with HF/$HClO_4$ [14] and using the heavy metals were measured Ion coupled plasma (ICP).

RESULTS AND DISCUSSIONS :

In this work, the total heavy metals were determined in some selected soil samples and in different grain size fractions of these samples to asses their accumulation and movement in soil.

Total Fe:

The amount of total iron in the investigated soils ranged between 3.82-7.68%. The data of table 1 show that the total amount of Fe in the uncultivated control soil (A) ranged between 3.82 and 3.81%, while in the cultivated control soil B and subjected to the irrigation with fresh water of El-Boulaqeyah canal ranged between 3.81 and 3.92%. Using irrigation with wastewater for increased total Fe from 3.82% in the surface layer of uncultivated control soil (A) to 7.68, 6.65 and 6.01% in the soils of group C (subjected to be irrigated with wastewater of Shebin El-Qanater collector), D (subjected to irrigation with polluted water of El-Shaboura canal) and G (subjected to be irrigated with wastewater of Mostorod collector), respecively. As previously mentioned, the total Fe in the wastewater of Shebin El-Qanater collector, polluted water of El-Shaboura canal and wastewater of Mostorod collector are fairly high to about 14046, 4643 and 12551 µg/L, respectively, [15, 16]. Therefore, there is no doubt that the high contents of Fe in the investigated soils resulted from using such polluted waters for irrigation. El-Sebaay[7] reported indicated that using waste-water for irrigation increased markedly the total Fe in the surface layers of agricultural soils of Egypt to 4.0-8.7%. Concerning the distribution of total Fe in investigated soils, it is clear from Table (1) that irrigation by wastewater tends to increase total Fe up to about 60 cm depth. Generally, the highest values of total Fe were observed in the surface layers of the soils of groups C, D and G (6.01-7.68%) which were decreased with depth (4.80-4.86%).

Distribution of Fe between different grain size fractions:

The amount of total Fe in different grain size fractions (Clay, silt and sand) in different layers of investigated soils are given in Table (2). The data shows that the clay fraction has the highest

amount of Fe in all investigated soils. In both uncultivated control soil (A) and cultivated control soil B (irrigated with fresh water of El-Boulaqeyah canal), Fe contents in the three fractions ranged between (4.34 and 5.02%) for clay fraction, (3.52-4.83%) for silt fraction and (1.48-1.94%) for sand fraction.

Concerning investigated soils irrigated with lower water qualities, the fractions of surface layer of the soils of groups D (irrigated with polluted water of El-Shaboura canal) and G (irrigated with wastewater of Mostorod collector) have the highest levels of Fe. Where, clay fraction has 6.89-7.94%, silt has 6.19-6.61% and sand has 3.25-3.77%. Rabie [3] reported that the distribution of Fe in grain size fractions of alluvial soils at Helwan-El-Saff area was as follows: Clay > Silt > Sand. On the other hand, it seems from the distribution of Fe in the different grain size fractions of cultivated control soil B (irrigated with fresh water of El-Boulaqeyah canal) and the soils of groups C, E and F (irrigated with wastewater) that there is no observed differences between these soils (Table 2). The distribution of total Fe in the different fractions of these soils, mostly, exhibit similar trend. This is due to that these soils are derived from the same origin (recent alluvial deposits), in the same time. The amounts of Fe added from irrigation wastewater are relatively small in countered with the initial content of Fe in the soil.

Total Mn:

Table (1) show that the total amounts of Mn in the uncultivated control soil (A) ranged between 865 and 915 ppm, while in the cultivated control soil (B) it ranged between 981 and 1150 ppm. The normal Mn levels in the agricultural alluvial soils of Egypt was reported to be in the range from 720 to 1080 ppm with an average mean of 926 ppm. El-Toukhy [17] found that the total content of Mn in agricultural alluvial soil North Nile Delta ranged between 483 and 976 ppm with an average of 730 ppm.

The highest values of total Mn were observed in the surface layers of both groups D (subjected to irrigation with polluted water of EL-Shaboura canal) and C (subjected to irrigation with wastewater of Shebin EL-Quanater collector), as they were 1677 and 1624 ppm, respectively. A significant Mn-enrichment was observed in the subsurface layers of groups C, D and G (subjected to irrigation with wastewater). It seems from this data that irrigation with wastewater tend to increase Mn content in these soils compared with the uncultivated (A) and cultivated (B) control soils. The distribution of the total Mn through the soil profile varied due to different conditions of each tested soil (cultivation, type of irrigation water and its Mn content, as well as other specific factors).

Distribution of Mn between the different grain size fractions:

Manganese distribution behavior showed various patterns of distribution for the different size fractions from one profile to another. In both, uncultivated and cultivated control soils (A & B), the average values of total Mn in the three fractions clay, silt and sand are (428-1134 ppm), (792-1626 ppm) and (405-1430 ppm), respectively. Concerning the investigated soils (subjected to irrigation with wastewater), the average mean values of total Mn in these fractions are 914.6, 897.5 and 2130.7 ppm, respectively. Generally, as is shown in Table (2), calculating the relative contribution of different fractions to the total Mn content indicated, that the sand fraction has the highest ratio (38.7-41.6%) followed by silt fraction (28.6-38.2%) and clay fraction (23.1-29.8%). Increments in Mn content in the coarser fraction is probably due to the formation of hydrated Mn oxides of sizes greater than that of clay fraction [18]. Also, precipitation of Mn compounds on particle surfaces of coarser fractions might be more persistent and the formation of Mn-nodules may occur. However when the soil samples are ground, these formations may be disintegrated into fragments of the same size as the coarser grain fractions.

A- Total Pb :

Total amounts of Pb in the studied soils are given in Table (1). The amount of total Pb in the uncultivated control soil (A) seems to be higher (between 66.0 and 70.6 ppm with an average of 68.3 ppm) than previous reported levels for soils. While in cultivated control soil B (irrigated with fresh water), its range between 68.1 and 72.0 ppm with an average of 74.0 ppm. Rashad [5] reported that the normal level of total Pb in the alluvial soils of Nile Delta ranges between 32.0 and 48.0 ppm with an average of 40.0 ppm. These results may suggest precipitation of air suspended particulates emmited from several smelters in the nearby area. Concerning the investigated soils subjected to be irrigated with wastewater, the amount of total Pb in the surface layers are noticably higher than those of the control soils (A and B). Thus, the highest values were obtained in the surface layers of soils of groups C (irrigated with wastewater of Shebin El-Qanater collector), D (irrigated with polluted water of El-Shaboura canal) and G (irrigated with wastewater of Mostorod collector). These values are 233.0, 184.0 and 180.0 ppm respectively which are higher than those of uncultivated control soil (A) by 3.3, 2.6 and 2.5, respectively. As shown in Table (2), the amount of total Pb decreases with depth as the total Pb in the deepest layers of these soils (C, D and G) are 109.0, 102.0 and 145.8 ppm,

respectively. Similar results were obtained by El-Sabbagh and Ramadan [10, 11]. The reported that total content of Pb increased up to about 101.1 ppm in the surface layer of these soils (Mostorod area) this is due to industrial activities and irrigation with polluted water of El-Shaboura canal and wastewater of Mostorod collector. Rabie [3] recorded 129.0-189.0 ppm for total Pb in the surface layers of the alluvial soils at Helwan El-Saff area. They attributed due to the increase of the total and the available Pb in these soils to, both, industrial activities and irrigation with wastewater.

Distribution of Pb between the different grain size fractions:

The total amount of Pb in the different grain size fractions of the investigated soils are given in Table (2). The data show that the different fractions in both uncultivated (A) and cultivated (B) control soils, have an average of (94.7-105.13 ppm), (51.3-89.6 ppm) and (7.3-16.8 ppm) in the clay, silt and sand fractions, respectively. Concerning contaminated soils (C, D and G), the three fractions clay, silt and sand contain (188.5-298.0 ppm), (178.0-198.8 ppm) and (11.5-64.2 ppm), respectively. It is clear that the clay has the highest content of Pb which is about 7-9 times the sand fraction. The data in Table (2) indicates that clay fraction contributes with 46.4-52.1 % of the total Pb, while silt fraction has 39.9-40.4 and sand fraction with 7.5-13.7%, which is this confirmed by the previous studies [19].

Total Ni:

Total amounts of Ni in the investigated soils are given in Table (1). The amount of total Ni in the uncultivated control soil (A) ranges between 40.8 and 43.8 ppm, while in the cultivated control soil (B) ranges between 52.0 and 67.0 ppm. Rashad [5] reported that the amount of total Ni in nonpolluted alluvial soils of Nile Delta ranges between 21.0 and 44.0 ppm with an average of 32.0 ppm. Concerning the investigated soils which were, subjected to be irrigated with different wastewater sources, the data show that the highest values of total Ni were obtained in the surface layers of soils of groups C (irrigated with wastewater of Shebin El-Qanater collector) and D (irrigated with polluted water of El-Shaboura canal) which are 177.0 and 98.0 ppm, respectivily while the total amount of Ni in the deepest layers of the same soils are 112.0 and 83.0 ppm, respectively. These values reflect the effect of irrigation with wastewater of Shebin El-Qanater collector and polluted water of El-Shaboura canal (which have an average value of about 314 and 62.5 μg/L Ni, respectively, as indicated by Abdel-Sabour [15].

Distribution of Ni between different grain size fractions:

The amount of Ni in the different grain size fractions of studied soils are given in Table (2). The data show that the different fractions in both uncultivated (A) and cultivated (B). Control soils have an average of (63.7-77.7 ppm), (31.0-74.0 ppm) and (9.8-12.8 ppm) in the clay, silt and sand fractions respectively. Also, data in Table (2) indicate that clay fraction contributes with 53.8-54.0% of the total Ni while silt fraction with 37.3-38.4% and sand fraction with 7.6-8.9%. Concerning the investigated soils subjected to irrigation with wastewater from different sources. The data show that Ni content in the surface layers increased markedly compared with control soils. Soils of group C have the highest values of Ni content in the three fractions, where clay has 280.0 ppm, silt has 180.0 ppm and sand has 18.8 ppm. It is clear that the enrichment of Ni in the clay fraction is about 10 times the sand fraction. Data in Table (2) indicate that clay fraction contributes (unpolluted soil) with 50.9-52.5% of the total Ni while silt fraction with 40.9% and sand fraction with 6.6-8.2%.

Enrichment factor of heavy metals in different grain size fractions:

A number of authors have fractionated soil in order to determine the relative contributions of clay, silt and sand in heavy metal content of a certain soil. Rabie [20] found that Zn, Co, Cu and Cd are bound up in the clay and /or silt fractions. Total metal content of the soil and metal content of each fraction were used to calculate the enrichment factor for each fraction at different soil layers according to Davies [9].

Table (3) showed that enrichment factor of heavy metals in different soil fractions of different soil layers (studied soil profiles) as affected by different wastewater, used for irrigation. The enrichment of Fe in clay fraction is about 3-4 times the sand fraction. This is due to captured that Fe can be captured in the octahedral positions of clay interlatices, in addition to the formation of Fe-hydrated oxides which often precipitate between the inter surfaces of silicate minerals [21].

The presented data indicate that clay fraction is enriched in most heavy metals compared with other soil grades, particularly in surface layers (0-15 cm) except in case of Mn which tends to accumulate in the sand fraction. These results agree with those obtained by Nair and Cottenie [19]. Concerning Ni, calculated EF indicate that this metal was always associated with the clay fraction in all layers of the investigated soil profiles. It is worth to mention that the increase of EF- values with soil depth, in some cases, may suggest that some heavy

metals in the contaminated soils are mobile and reachable through the soil profile due to the presence of organic complexes usually found in wastewater effluent. These dissolved organic compounds act as a chelating agents and protect metals from the ordinary precipitation and fixation process in arid soils. This trend confirms other data reported for Cd, Zn, Co and Cu [20].

CONCLUSION :

In conclusion, continuos irrigation with wastewater has a marked increase on the amount of heavy metals in the surface layers of the studied area. It is clear that the highest EF ratios in the clay fraction was mainly with Pb which indicates the industrial impact on the soil. In case of sand fraction, Mn was the highest always compared with other studied metals. Concerning silt fraction, a varied accumulation of Fe, Mn and Pb was observed with soil depth and different soil profiles.

Table (1): Soil fractions % and total content of Fe, Mn, Pb and Ni in the investigated soils.

Profile groups	Soil depth (cm)	%			Total heavy metals (μg/g)			
		clay	silt	Sand	Fe	Mn	Pb	Ni
A	0-15	45.8	31.5	20.0	38200	915	70.6	43.5
	15-30	43.8	35.5	19.5	38800	880	68.5	43.8
	30-60	39.5	41.2	18.0	38600	865	66.0	40.8
B	0-15	34.8	32.0	28.2	38100	981	72.0	52.0
	15-30	47.0	35.2	32.5	39200	1150	68.1	67.0
	30-60	33.0	26.8	28.0	43500	1012	70.4	60.0
C	0-15	55.6	23.5	18.0	76800	1624	233	177
	15-30	62.2	29.3	6.2	68200	1499	169	102
	30-60	70.4	25.9	3.4	49500	1200	109	112
D	0-15	70.9	22.9	3.5	66500	1677	184	98
	15-30	72.6	21.7	5.1	59200	1477	164	81
	30-60	75.9	23.2	1.0	48006	1342	102	83
E	0-15	64.7	28.9	20.7	46540	1136	162	77.8
	15-30	49.1	24.6	21.3	45740	1051	140	77.5
	30-60	49.0	27.0	17.5	45750	981	95.3	78
F	0-15	52.3	28.3	15.7	43500	1280	111.8	75.4
	15-30	49.6	31.6	16.5	45050	1438	89.6	67
	30-60	54.0	25.2	15.1	48125	982	86.1	68.6
G	0-15	33.2	33.7	26.8	60100	985	180.1	51
	15-30	34.7	31.5	25.2	58200	1205	169.7	46
	30-60	45.5	31.9	14.8	58000	1181	145.8	31

Fig. (1) : Location of water samples and soil profiles (1-16) .

• Canals water samples. ■ Collectors waster water samples. ▼ Factories outlet samples. © Sewage and domestic wastes samples.

Table (2) Distribution of tested metals (µg/g fraction) between various particle size fractions in investigated soils.

Profile groups		**Soil layer 0 –15 cm**				**Soil layer 15 –30 cm**			
		Fe	**Mn**	**Pb**	**Ni**	**Fe**	**Mn**	**Pb**	**Ni**

A	**Clay**	**44633**	**691**	**105**	**64.9**	**43436**	**1134**	**101**	**63.7**
	Silt	**35400**	**980**	**54.5**	**35.6**	**35200**	**792**	**51.3**	**31.3**
	Sand	**14772**	**936**	**16.8**	**9.8**	**14980**	**405**	**14.7**	**10.6**
	Clay	**50298**	**428**	**113.1**	**74.6**	**51085**	**993**	**94.7**	**77.7**
B	**Silt**	**47407**	**1626**	**85.9**	**67.8**	**43611**	**810**	**89.6**	**74.0**
	Sand	**27040**	**995**	**7.3**	**10.0**	**16950**	**1430**	**8.15**	**12.8**
	Clay	**51072**	**837**	**268**	**280**	**51203**	**811**	**118**	**105**
	Silt	**42406**	**1119**	**252**	**180**	**47639**	**922**	**105**	**94**
C	**Sand**	**35002**	**2555**	**30.5**	**18.8**	**31718**	**3176**	**120**	**16.5**
	Clay	**50600**	**1369**	**188.5**	**108.5**	**50500**	**1199**	**183.1**	**89.9**
	Silt	**44543**	**1480**	**198.8**	**80.1**	**49900**	**1359**	**98.1**	**62.2**
	Sand	**22500**	**2880**	**11.5**	**14.8**	**20400**	**2537**	**7.0**	**8.8**
D	**Clay**	**52591**	**52591**	**729**	**215.5**	**50670**	**700**	**91.7**	**114**
	Silt	**49201**	**49201**	**925**	**325**	**49037**	**839**	**113.3**	**188**
	Sand	**31090**	**31090**	**2237**	**79.0**	**33943**	**3069**	**40.9**	**15.3**
E	**Clay**	**54421**	**1199**	**116.8**	**83**	**58378**	**860**	**101.2**	**82.3**
	Silt	**40100**	**1496**	**98.5**	**70.2**	**42700**	**1429**	**90.2**	**64.5**
	Sand	**20100**	**1180**	**14.8**	**5.2**	**22800**	**900**	**8.6**	**2.8**
	Clay	**79433**	**707**	**298**	**119**	**69495**	**735**	**170.7**	**37.4**
F	**Silt**	**66132**	**723**	**178**	**71.3**	**62113**	**1188**	**157.5**	**31.6**
	sand	**37679**	**1047**	**64.2**	**16.5**	**30300**	**1726**	**79.5**	**14.5**
G									

Table (3) Enrichment factors for selected heavy metals between various particle size fractions in investigated soils.

Profile groups		Soil layer 0 –15 cm				Soil layer 15 –30 cm			
		Fe	Mn	Pb	Ni	Fe	Mn	Pb	Ni
A	Clay	1.28	1.08	1.52	1.50	1.25	1.12	1.55	1.59
	Silt	1.00	1.10	0.79	0.83	1.01	1.00	0.79	0.78
	Sand	0.42	0.71	0.24	0.23	0.43	0.69	0.23	0.21
B	Clay	1.37	0.40	1.63	1.47	1.31	0.3	1.57	1.47
	Silt	1.18	1.67	1.24	1.33	1.18	1.48	1.28	1.31
	Sand	0.48	0.98	0.11	0.20	0.48	1.18	0.96	0.17
C	Clay	1.13	0.7	1.20	1.50	1.06	0.8	1.24	1.12
	Silt	0.94	0.91	1.31	0.64	0.98	0.94	0.79	0.99
	Sand	0.77	2.08	0.14	0.11	0.66	2.59	0.13	0.18
D	Clay	1.07	0.8	1.04	1.13	1.04	0.90	1.06	1.12
	Silt	0.94	0.91	1.10	0.83	1.02	1.00	1.04	0.83
	Sand	0.47	1.78	0.06	0.15	0.42	2.02	0.06	0.16
E	Clay	1.14	0.5	1.61	1.7	1.13	0.6	1.38	1.32
	Silt	1.07	0.96	1.11	0.93	1.05	0.8	1.28	1.27
	Sand	0.72	1.73	0.06	0.15	0.43	1.91	0.05	0.18
F	Clay	1.22	0.7	1.36	1.39	1.22	0.7	1.36	1.39
	Silt	1.06	0.85	1.16	1.06	1.00	0.9	1.11	1.06
	Sand	0.48	1.58	0.09	0.14	0.56	1.75	0.09	0.13
G	Clay	1.25	0.90	1.65	1.66	1.28	0.7	1.56	1.69
	Silt	1.05	0.87	1.00	1.10	1.09	1.15	1.06	1.01
	sand	0.69	1.26	0.56	0.25	0.63	1.12	0.40	0.28

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دراسة تراكم الحديد والمنجنيز والرصاص على التربة وعلى نسب معامل الإثراء فى مختلف حبيبات التربة كدليل على التلوث

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الملخص :

تم إجراء هذا البحث فى منطقة مسطرد الصناعية شمال القاهرة الكبرى (مساحة ٢٤ كم٢) وذلك لدراسة الواقع البيئى للنشاط الصناعى المكثف بالمنطقة على محتوى قطاع التربة من عناصر الحديد والمنجنيز والنيكل والرصاص . حيث تم تقسيم أراضى المنطقة إلى ستة قطاعات وفقاً لمصدر النشاط الصناعى واحتمالات تلوث التربة . تم حفر ١٦ قطاع تربة إلى عمق ٦٠-١٠٠ سم وقسمت إلى طبقات من صفر -١٥ سم ، ١٥-٣٠ ، ٣٠-٤٥ ، ٤٥-٦٠ سم .أخذت عينات تربة ممثلة من كل طبقة / قطاع وتم فصل مكونات التربة لكل عينه (طين - سلت - رمل) حيث تم تقدير المحتوى الكلى من العناصر تحت الدراسة لكل مكون على حده وكذلك للتربة ككل باستخدام تقنية **ICP** . حيث أمكن حساب معامل الإثراء لكل عنصر فى كل مكون من حبيبات التربة / لكل طبقة لمختلف القطاعات والأعماق .

أوضحت النتائج أن أعلى قيمة لمعامل الإثراء كانت فى حالة الرصاص فى حبيبات الطين مما يظهر أثر التلوث الصناعى على التربة خاصة الطبقة السطحية . أما فى حالة عنصر المنجنيز فكان تجمعه فى صورة مقعدات مشابه لأحجام الرمل . أما فى حالة محتوى حبيبات السلت من العناصر تحت الدراسة فكانت قيم معامل الإثراء متباينة مع العمق واختلاف قطاع التربة (أى مصدر التلوث) .