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POLLUTION STATUS OF SOILS AND PLANTS AROUND THE FACTORY OF FERROSILICON ALLOYS, EDFO, ASWAN

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ABSTRACT :

A study was carried out in summer 2000 to evaluate the pollution status of the soil and the plants around the factory of Edfo ferrosilicon alloys, Aswan Governorate, Egypt. Three sites were chosen for the study in the south, east and north directions, whereas seven sites were selected in the southeast direction of the factory. These sites were located at different distances from the factory. Soil samples were taken from two depths, i.e. (0-25 cm) and (25-50 cm) at each site. Plant samples were also collected from each site. Each plant sample was divided into two equal subsamples, are washed with dionized water and the other left unwashed. Dust materials from the factory cheminies were collected.

These dusts were found to contain Fe, P, S, K, Ca, Mg, Mn, Zn, Cu, Cd, Pb, Ni and Cr probably resulting from using iron oxide, coke coal and quartiz in the industrial processes of ferrosilicon alloys.

Salinity of the soil increased southward with increasing distance from the factory, whereas the soil samples of the sites that were located away from the factory showed lower pH values than those near the factory.

Concentrations of calcium and magnesium in the soil samples were highest at a distance of 1 km from the factory in the southeast direction. El-Sebaeia phosphate-mine dusts could be responsible for the high extractable levels of P found in soil. Sulfur oxide fumes resulting from factory could be the source of the obtained high levels of extractable S in the soils around the factory. South and southeast sites of the studied area had high levels of DTPA-extractable metals indicating that the factory dusts, smokes and fumes could play an important role in that matter.

Levels of P, K, S, Fe, Mn, Zn, Cu, Cd, Ni, Pb and Cr in plant samples showed pronounced differences due to washing. Significant correlations were found between iron levels in washed sugar-cane samples and its DTPA-extractable levels in the surface layers (0.952*), whereas lead levels in the washed sugar-cane samples were significantly correlated with its levels in the subsurface layers (0.817*). Significant correlations were also found between both manganese and chromium concentrations in date palm trees and their concentrations in the surface soil layer (-0.967* and 0.948*, respectively).

INTRODUCTION :

Pollution in all its forms, is the most serious problem in the industrialized areas of the world. Industrialization has been increasing rapidly throughout different governorates in Egypt during the last 30 years. Most of the industrial factories lie near the agricultural lands. The industrial processes have resulted not only in the contamination of work place environment, but are also discharging huge quantities of wastes into the river and nearby soils[1]. The dusts of these factories are loaded with heavy metals such as Fe, Mn, Zn, Cu, Pb, Cd, Ni and Cr, that fall down onto the surrounding soils and plants. In Alexandria, Egypt, Abu-Qir fertilizers and chemicals industrial company are emitting significant quantities of gases into the atmosphere causing considerable air pollution problems[2]. In Helwan area, the agricultural productivity was seriously lowered in more than 10000 feddans and some limited areas became bare[3]. Concentrations of Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in the top soil of the rural area that are located south and southeast of Cairo were reported to be affected by the metal content of air-borne dust[4].

Naturally, the concentration of undesired elements in the soil solution and in natural waters is low. This situation is changed drastically when the content of available harmful elements in the soil is increased by several orders of magnitude in the industrial areas[5]. The total soil metal concentration indicates the degree of pollution, but it does not provide information about the bioavailability and toxicity[6]. Results of El-Desoky and Ghallab[7] on the industrial area near Assiut city indicated that plant damage was not only a matter of toxic concentration of heavy metals in plant tissue, but also instead it was a direct mechanical effect of dust particulates that continuously covered the above ground plant organs.

In upper Egypt, the ferrosilicon alloys factory located north of Edfo city, Aswan Governorate, uses quartiz, coke coal and iron oxide as row materials. These materials contain several elements, Al, P, S, K, Ca, Mg, Mn, Ni and Cr. Silica fumes (microsilica) is a byproduct that results from the reduction of quartiz with coal in the electric furnaces. Some toxic gases are also evolved to atmosphere when ferrosilicon alloys are exposed to water and water vapor. The deposition of air-borne particulates of the factory on plants and soils nearby the area as well as the huge quantities of gases and fumes emited from the factory probably cause contamination problems, especially with heavy metals. Therefore, the present study aims to evaluate the pollution status of the agricultural area around the Edfo ferrosilicon alloys factory with respect to some soil properties, macronutrients and heavy metals contents.

MATERIALS AND METHODS :

Edfo Ferrosilicon alloys factory is located 100 km north Aswan city, at the northern boarder of Edfo city (25° 00` N and 32° 09` E), Aswan Governorate, Egypt. Most winds that blow to this area come from north or northwest. The average daily temperature is 34.2°C in summer and 16.4°C in winter. Rainfall in the area is very scarce, except some light showers, that rarely fall during winter. Sugar-cane is the main crop cultivated in the agricultural area around the factory. Some date palm and other trees are scattered in the area. Soil and plant samples were collected from 16 sites at different distances from the factory (3 sites in each of the southern, the eastern, the northern directions and 7 sites in the southeastern direction where most of the agricultural lands are located) on summer 2000 (Fig. 1). Soil samples were taken from two depths: 0-25 and 25-50 cm at each site. The plants and trees at each site were also sampled at the same time. The locations of soil and plant samples as well as types of crops grown at each site are shown in Table (1). The soil samples properly prepared and kept for subsequent analysis. A sample from dust materials that were scrubed from the factory cheminies was also collected. Iron, Mn, Zn, Cu, Pb, Ni, Cd and Cr in the soil samples were extracted by DTPA (diethylene triamine pent acetic acid) solution buffered at pH 7.3[8]. Total Fe, P, S, K, Ca, Mg, Mn, Zn, Cu, Cd, Pb, Ni and Cr in the dust materials were determined using a modification of the method of Snow[9] using a 5:1.5:3.5 ratio of concentrated HF : HNO_3 : $HClO_4$ acids. Each plant sample was divided into two parts, one was washed with dionized water and the other was left without washing. All plant samples were oven dried at 70°C and mill- ground. Plant digests were prepared using a 2:1 mixture of conc. nitric and perchloric acids. Iron, Cu, Cd, Ni, Pb, Cr, Mn and Zn in the soil and dust extracts as well as in plant digests were determined using a GBC model 300 atomic absorption spectrophoto-meter. The electrical conductivity (EC) of a 1:1 soil to water extract was determined using a conductivity meter. Soluble Ca and Mg in these extracts were determined by EDTA titration. Extractable K in the soil samples was obtained using a 1.0 N NH_4OAC buffered at pH 7.0[10]. Potassium and Na in soil extracts were determined by Flame photometer. Extractable P in the soil samples was collected using a 0.5 $NaHCO_3$ buffered at pH 8.5[11]. Phosphorus was determined in soil extracts and plant digests by the chlorostannous phosphomolybdic acid method[10]. Extractable sulfur in the soil samples was obtained using 500 ppm P of KH_2PO_4. Sulfur was then determined in soil extracts as well as dust and plant digests by the turbidimetric method[10]. Graphs were drawn with the help of statistica, a computer software package, to show the distribution of EC, pH, Ca, Mg, Na, K, P, K, S, Fe, Mn, Zn, Cu, Cd, Ni, Pb and Cr in both surface and subsurface soils.

Table (1): Locations of soil and plant samples collected from the area around the ferrosilicon alloys factory near Edfo city.

Direction from factory	Location No.	Crops grown	Distance from the factory
South	1	Maize and alfalfa	200 m
	2	Orange, egg plants, mango and maize	500 m
	3	Okra and maize	1 km
East	4	Purslane, date palm and maize	200 m
	5	Date palm and sugar-cane	500 m
	6	Sugar-cane	1 km
South east	7	Date palm and maize	200 m
	8	Sugar-cane and Jew's mallow	500 m
	9	Okra and sugar-cane	1 km
	10	Sugar-cane	1.5 km
	11	Sugar-cane and date palm	3 km
	12	Maize, sesban and jawava	5 km
	13	Osier and alfalfa	7 km
North	14	Maize and sesban	200 m
	15	Tamarix	500 m
	16	Sorghum	1 km

Figure (1) : Location map showing sampling sites in the studied area

RESULTS AND DISCUSSION :

I-Elemental Composition of the Factory Deposits:

The ferrosilicon alloy industry uses quartiz, coke coal and iron oxide as raw materials that contain some elements and heavy metals as impurities such as P, S, K, Ca, Mg, Mn, Zn, Cu, Cd, Pb, Ni and Cr. Dusts, gases and fumes that result from the factory during the production of ferrosilicon alloys contain high concentrations of most of these elements. Table (2) shows the analysis of two deposit samples that were collected from the factory cheminies. Accumulation of such deposites in the nearby agricultural soil is expected to have significant effects on the concentrations of these elements in soils and plants as well as soil characteristics.

Table (2):Percentages of some elements in the Edfo ferrosilicon alloys factory deposits.*

Element	Percentage (%)		
	Sample I	Sample II	Mean
Iron	0.908	0.921	0.915
Phosphorus	0.015	0.017	0.016
Sulfur	0.032	0.036	0.034
Potassium	0.011	0.021	0.016
Calcium	0.022	0.032	0.027
Magnesium	0.015	0.017	0.016
Manganese	0.016	0.017	0.017
Zinc	0.060	0.062	0.061
Copper	0.008	0.008	0.008
Cadmium	0.002	0.002	0.002
Lead	0.007	0.007	0.007
Nickel	0.001	0.001	0.001
Chromium	0.001	0.001	0.001

* Samples were collected from the cheminies of the factory.

II-Soil Characteristics Around Ferrosilicon Alloys Factory:

1. Texture and saturation capacity:

Percentages of clay, silt and sand as well as texture and saturation capacity (SP) of the surface and subsurface soil samples are presented in Table (3). The data show no consistent trend either with respect to depth or in relation to the geographical directions.

2- Soil salinity and pH:

The distribution of the electrical conductivity (EC) and pH values for the surface and subsurface soil samples in the area around the ferrosilicon alloys factory are illustrated in Fig. (2). The EC values for the surface soil samples ranged from 0.56 to 4.05 dS/m while they varied between 0.52 and 2.64 dS/m for the subsurface ones indicating higher salinity in the surface than in subsurface layers. Soil salinity in the southeastern direction increased gradually to reach 4.01 dS/m within a distance of 1 km from the factory and then sharply decreased. In most cases, salinity in the soil samples increased southward with increasing distance from the factory. On the other hand, the sites that were located north of the factory showed a decrease in the soil salinity with distance.

Soil pH values range from 7.62 to 8.59 for the surface samples and from 7.50 to 8.53 for the subsurface ones. Sampling sites that were located far from the factory showed lower pH values compared to those closer.

3- Soluble cations:

Fig. (3) shows the distribution patterns of soluble Ca, Mg, Na and K in the collected soil samples. In the southeastern direction, concentrations of soluble Ca and Mg reached the maximum (23 and 8.5 meq/100g soil, respectively) at a distance of 1 km from factory and then sharply decreased with distance from the factory. The same trend was found in the south direction. The soil sites located in the north direction of the factory had the lowest calcium concentration. Levels of soluble calcium in the surface samples were higher than those of the subsurface ones. However, magnesium showed a relatively different trend. The eastern direction showed the highest magnesium concentration in the subsurface layer. El-Sabbagh[12] reported that Ca and Mg concentrations in the Mostorad area which includes different industries varied from 1.33 to 3.20 g/100 g and 1.0 to 4.0 g/100g, respectively with a mean of 2.37 ± 0.63 g/100g and 2.1 ± 0.09 g/100g, respectively. The supply of Ca to plants depends upon its release from minerals and its retention in exchangeable and soluble forms [13].

According to the data illustrated in Fig. (3), levels of sodium in the surface soil samples tended to be higher than those of the subsurface being varied from 1.47 to 20.08 meq/100g in the surface layer and from 1.69 to 16.52 meq/100g in the subsurface layer. Meanwhile, in most cases, soluble sodium in the soil samples decreased with distances from the factory towards eastern and southeastern directions. In the industrial Mostorad area near Cario, the mean sodium concentration was 89.5 ± 17.4 mg/100g[12].

Soluble K in the studied soil samples varied from 0.153 to 0.717 meq/100g in the surface samples and from 0.102 to 0.717 meq/100g in the subsurface ones, being lower than those of calcium, sodium and magnesium. Concentrations of soluble potassium were higher in surface soil samples compared with subsurface ones.

Table (3): Saturation percentage and particle size distribution of the surface and subsurface soil samples collected from the area around the ferrosilicon alloys factory near Edfo city.

Direction	Location No.	S.P. (%)		Clay (%)	Silt (%)	Sand (%)	Texture	Clay (%)	Silt (%)	Sand (%)	Texture
		Surface	Sub-surface	Surface				Sub-surface			
South	1	50.1	49.9	24.51	34.22	41.27	Loam	18.12	34.11	47.77	Sandy loam
	2	52.2	47.2	35.03	31.81	33.16	Clay loam	25.91	35.12	38.97	Loam
	3	48.1	44.3	31.50	12.16	55.90	Sandy clay loam	16.54	38.12	45.34	Loam
East	4	40.8	42.1	16.12	30.02	53.86	Sandy loam	17.51	33.00	49.49	Loam
	5	44.0	49.2	14.51	29.52	55.97	Sandy loam	28.03	22.31	49.66	Sandy clay loam
	6	52.2	48.3	33.13	29.12	37.75	Clay loam	27.12	27.50	45.38	Clay loam
South east	7	46.1	44.3	25.31	33.00	41.69	Loam	21.13	36.51	42.36	Loam
	8	56.3	50.1	37.12	35.21	27.67	Clay loam	32.51	32.50	34.99	Clay loam
	9	41.2	41.3	15.0	33.50	51.50	Loam	15.00	32.00	53.00	Loam
	10	46.5	45.6	15.12	29.50	55.38	Sandy loam	11.51	32.12	56.37	Sandy loam
	11	41.6	44.8	32.52	15.12	52.36	Sandy clay loam	33.12	9.18	57.70	Sandy clay loam
	12	40.4	42.1	13.12	26.50	60.38	Sandy loam	19.18	29.00	51.82	Sandy loam
	13	41.2	39.8	10.52	29.00	60.48	Sandy loam	13.54	35.12	51.34	Sandy loam
North	14	45.8	47.2	27.51	27.50	44.99	Sandy clay loam	32.00	23.50	44.50	Sandy clay loam
	15	40.5	42.1	14.18	24.50	61.32	Sandy loam	14.50	16.60	68.90	Sandy loam
	16	41.9	43.3	18.18	27.12	54.70	Sandy loam	20.60	19.50	59.9	Sandy clay loam

Surface samples : 0-25 cm, subsurface samples : 25-50 cm.

4-Extractable (available) phosphorus, potassium and sulfur:

Levels of extractable phosphorus in the studied surface soil samples varied from 25 to 132 ppm and from 29 to 79 ppm in the subsurface soil samples (Fig. 4). According to Thomas and Peaslee[14], these are considered high levels. El-Sebaeia phosphate mine which is located close to this area may have played a role in this respect.

The obtained levels of extractable K in the studied soil samples ranged between 200 to 910 ppm and from 170 to 720 ppm for the surface and subsurface layers respectively (Fig. 4). Being high, these levels reached its maximum at a distance of about 500 m from the factory towards the east and southeast.

Levels of extractable sulfur in the surface soil samples ranged between 675 and 4800 ppm and from 550 to 5850 ppm in the subsurface ones (Fig. 4). Extractable sulfur tended to relatively higher in the surface layer than in the subsurface. Extractable S in both surface and subsurface soil samples reached its maximum value at 1 km far from the factory towards the southeastern direction. Sulfur gases and fumes that are driven from the factory could be responsible for these high levels.

5- DTPA-extractable Fe, Mn, Zn, Cu, Cd, Ni, Pb and Cr:

Fig. (5) shows the distribution patterns of DTPA-extractable Fe, Mn, Zn and Cu in both surface and subsurface soil layers around the Edfo ferrosilicon alloys factory. The concentration of DTPA-extractable iron in the soil samples taken from the sites adjacent to the factory in the south and southeast directions was higher than that found in the north direction. Generally, Fe concentration tended to decrease with soil depth in certain directions and with distance from the factory. The high levels of DTPA-extractable Fe, especially in the surface layer, is probably due to the high Fe content in the factory dust.

Levels of DTPA-extractable Mn in the surface layers were relatively higher in the southern direction than that of the subsurface ones, reaching a maximum of 15.78 ppm at a distance of 500 m from the factory. In most cases, extractable Mn decreased with distance from the factory and with depth. Most soil samples had lower extractable Mn levels compared with Fe levels.

Results revealed that DTPA extractable Zn levels varied between 0.48 and 0.954 ppm and from 0.55 to 0.958 ppm in the surface and subsurface layers, respectively (Fig. 5). This points to a relatively mild state of deficiency. Generally, the concentration of Zn exhibited no specific trends either with distance from the factory or with depth.

DTPA-extractable Cu reached its maximum level (1.988 ppm) in the surface layer and (1.898 ppm) in the subsurface one at a distance of 500 m south of the factory where winds usually blow to this area. In the southeastern direction, to which winds also blow, DTPA-extractable Cu increased up to a distance of 1 km and then decreased as one goes far from the factory. Meanwhile levels of extractable-Cu exhibited slight differences with respect to depth. According to Kabata-Pendias and Pendias[15], Cu contamination of soils results from the utilization of Cu-containing materials such as fertilizers, sprays and agricultural and municipal wastes as well as industrial emissions.

In general it can be stated that levels of DTPA-extractable Fe, Mn, Zn and Cu in the studied area around the Edfo ferrosilicon alloys factory vary with direction and location. The soils that lie in wind direction (south and southeast) contain the highest levels of these micronutrients followed by those in the east and finally the soils that are located north of the factory. Most winds that occur in the region come from north or northwest.

Fig. (6) shows the distribution patterns of DTPA-extractable Cd, Ni, Pb and Cr in the soil samples collected from the area around the ferrosilicon alloys factory. DTPA-extractable Cd concentration increased with increasing soil depth and, to a certain extent, with the distance from the factory. The highest level was found at 1 km southeast the factory. Increasing the extractable Cd level with depth may be attributed to the easily downward movement of Cd.

According to the distribution patterns of the DTPA-extractable Ni no definite trend seem to exist with the distance from the factory (Fig. 6). It is clear that the highest values were found in the soil samples located south of the factory. Meanwhile extractable Ni tended to decrease with soil depth. In general, the part of the studied area that was located south and southeast of the factory had the highest levels of extractable Ni confirming the fact that winds that blow to these directions carry factory smokes and dusts to contaminate the soils located there. Nickel has recently become a serious pollutant that is released from the emissions from metal processing operations. Anthropogenic sources of Ni, from industrial activities in particular, have resulted in a significant increase in the Ni content of soils[15].

No consistent trend was shown for the DTPA-extractable Pb with the distance from the factory (Fig. 6). However, it is clear that DTPA-extractable Pb decreased with soil depth. In the south direction, extractable Pb of the surface layer increased from 0.166 ppm adjacent to the factory to 0.262 ppm at a distance of 1 km while in the subsurface layer, it increased from 0.144 to 0.190 ppm at a distance of 500 m from the factory. In this respect, the factory may pollute the soil with lead directly through the air by smokes and particulates that come out of the chimney[3]. Vehicles exhaust on Cairo-Aswan and Edfo-Marsa Alm roads near the investigated area is another source of soil pollution with respect to Pb. Accumulation of Pb on soil surface is of great ecological significance because this metal is known to greatly affect the biological activity in soils.

No clear trends can be noticed with respect to the distribution of DTPA-extractable Cr with either distance from the factory or with soil depth (Fig. 6). Extractable Cr levels in the surface soil samples increased due to industrial contamination occurung around the factory. Hexavalent form of Cr (VI) is known to be soluble over a wide range of pH that can migrate downward in the soil. Moreover, orthophosphate competes with Cr (VI) for anion exchange sites on the soil[16]. This have, possibly, led to a tendency of Cr accumulation in the subsurface if compared with the other studied heavy metals (Cd, Ni and Pb).

It is obvious that the soil samples that were taken from the Edfo ferrosilicon alloys factory area contained DTPA-extractable metals that decreased in the order Fe>Mn>Cu>Zn>Ni>Pb>Cr>Cd. The south and southeast parts of the factory contained the highest extractable levels of these metals. The behavior of extractable heavy metals in the soils of southeastern direction deserves to be considered in particular. In surface layer, the level of Pb exhibited gradual decreases until a distance of 3 km from the factory, afterwhich it maintained constant concentration. In contrast, the level of Pb in the subsurface was gradually elevated until a distance of 1.5 km from the factory where it reached a maximum and returned to decrease sharply with distance (3 km), then tended to keep constant level. It is essential to recall that the most influential wind in this location is that coming from northwest and blouing to the southeastern direction passing by the factory. Therefore, the air loaded with heavy metals is deposited within a distance of 1 to 1.5 km on the soil surface. In presence of agricultural practices excuted in this area, especially irrigation, such loads are mobilized to the subsurface layer causing the levels of these elements to increase. Thereafter, no appreciable changes were manifested with distance.

III- Plant Contents of some Nutrients and Heavy Metal:

1-Phosphorus, potassium and sulfur in plants:

Table (4) shows phosphorus, potassium and sulfur contents of some plant samples taken from the area around Edfo ferrosilicon alloys factory. Phosphorus concentration in the unwashed plant samples ranged between 2.28 and 6.84 g/kg and between 1.20 and 5.79 g/kg in the washed ones. All unwashed plant samples contained higher levels of P compared with the washed samples. The increased level of P previously noticed in the soil is observed also in the growing plants resulting in a high P concentration in the plants, especially alfalfa, maize, orange, egg plant, date palm and sugar-cane in the south, east and southeast directions. It is evident that P distribution in the studied area does not show any specific trend with either direction or distance from the factory.

Data shown in Table (4) indicate that all unwashed and washed plant samples have high concentrations of potassium. Potassium concentration ranged from 7.44 to 79.39 g/kg in the unwashed plant samples and from 5.08 to 54.97 g/kg in the washed samples. The plants located closed to the factory had high amounts of potassium in their tissues.

Sulfur in plant samples varied between 1.56 and 2.22 g/kg before washing and between 1.52 to 2.14 g/kg after washing (Table 4). Plant samples that were not washed had higher levels of S compared with those that were washed. These differences may be due to the deposition of dusts and/or gases coming from the ferrosilicon alloys factory. Plants grown in this area receive high levels of S from the contaminated soil as well as from the atmosphere that is contaminated by the industrial emissions.

2- Heavy metals:

Tables 5 and 6 show the data obtained for the concentrations of Fe, Mn, Zn and Cu in the plant samples before and after washing with dionized water, respectively. Iron in plant samples ranged between 100.80 and 3798.75 ppm before washing and between 57.70 to 1320.05 ppm after washing. Plant samples that were not washed had higher levels of iron compared with those that were washed. The differences in these levels are most probably due to the deposites coming from the ferrosilicon alloys factory. In some cases, Fe concentration reached the toxic level in plant tissues. Plant response to Fe toxicity as well as to Fe deficiency, is known to be highly variable among genotypes and plant species. According to Aboulroos *et al.*[17], the Fe content of corn plants grown on nonpolluted soils of Egypt varied from 88.5 to 122 ppm. Plants grown in this area have, certainly received high levels of iron originating from dusts and/or fumes coming from the factory.

Table (4): Phosphorus (P), potassium (K) and sulfur (S) concentrations in plant samples, collected from locations at different directions and distances from Edfo Ferrosilicon alloys factory.

Direction	Location	Distance (km)	Crop	Mg/kg dry weight (ppm)					
				P		K		S	
				Unwashed	Washed	Unwashed	Washed	Unwashed	Washed
South	1	0.2	Maize	6.74	5.19	28.07	24.12	1.98	1.85
			Alfalfa	6.83	5.79	42.05	39.78	1.89	1.75
	2	0.5	Orange	5.40	4.57	19.68	15.15	1.99	1.85
			Egg plants	5.49	5.45	18.32	16.25	2.02	1.96
			Mango	4.02	2.56	6.64	6.49	2.00	1.73
			Maize	6.16	2.40	31.48	12.43	1.90	1.74
	3	1	Okra	2.86	2.23	22.86	17.62	2.05	2.00
			Maize	5.32	4.48	31.74	22.89	2.00	1.89
East	4	0.2	Purslane	3.32	2.44	79.39	54.97	1.83	1.74
			Date palm	6.12	3.23	10.96	8.97	1.99	1.89
			Maize	4.82	3.00	24.17	21.16	1.89	1.80
	5	0.5	Date palm	3.31	1.20	14.16	8.06	1.99	1.95
			Sugar cane	3.64	1.57	15.17	12.63	1.97	1.89
	6	1	Sugar cane	3.22	2.89	22.39	18.17	2.12	2.06
South east	7	0.2	Date palm	2.92	1.33	17.54	9.75	1.85	1.73
			Maize	2.28	2.08	13.68	6.31	1.74	1.65
	8	0.5	Sugar-cane	5.00	4.74	13.68	5.08	1.96	1.93
			Jew's mallow	5.52	4.78	20.11	16.57	1.86	1.74
	9	1	Okra	4.56	2.23	15.87	6.41	2.21	2.10
			Sugar cane	6.84	4.92	27.16	19.07	2.14	2.01
	10	1.5	Sugar cane	3.08	1.84	7.44	5.83	2.19	2.09
	11	3	Sugar cane	3.46	2.72	20.79	14.16	2.14	2.10
			Date palm	6.40	4.31	20.57	8.22	2.22	2.14
	12	5	Maize	4.91	2.95	31.31	17.80	1.83	1.72
			Sesban	4.00	3.16	10.97	4.89	1.96	1.85
			Jawava	5.46	4.05	22.49	17.96	1.97	1.72
	13	7	Osier	4.64	2.75	9.42	7.48	1.72	1.63
			Alfalfa	6.16	4.95	35.36	29.61	1.66	1.61
North	14	0.2	Maize	5.66	5.49	29.86	27.80	1.56	1.53
			Sesban	3.88	3.78	11.12	10.79	1.63	1.52
	15	0.5	Tamarix	3.03	2.93	10.28	9.34	1.85	1.72
	16	1	Sorghum	3.11	2.48	27.55	26.46	1.73	1.63

Table(5) : Iron, Mn, Zn, Cu, Pb, Ni, Cr and Cd concentrations in unwashed plant samples, collected from locations at different directions and distances from Edfo ferrosilicon alloys factory.

Direction	Location	Distance (km)	Crop	Mg/kg dry weight (ppm)							
				Fe	Mn	Zn	Cu	Pb	Ni	Cr	Cd
South	1	0.2	Maize	108.92	55.93	33.51	17.74	12.57	7.57	1.26	1.08
			Alfalfa	376.56	55.15	97.88	40.74	38.81	12.62	1.13	0.72
	2	0.5	Orange	1494.08	50.19	16.87	39.55	15.09	9.66	1.59	0.001
			Egg plants	1880.41	368.33	39.04	23.00	21.77	12.11	3.05	0.60
			Mango	663.12	37.82	63.59	94.47	24.39	7.72	3.55	1.85
			Maize	1487.09	303.07	34.91	37.73	17.65	13.94	6.40	0.65
	3	1	Okra	307.80	502.67	78.45	39.98	3.06	6.47	1.99	1.90
			Maize	290.48	57.25	50.12	26.12	3.13	9.79	0.37	0.001
East	4	0.2	Purslane	188.87	26.17	59.85	35.04	12.02	2.85	3.05	2.85
			Date palm	611.78	58.33	30.04	21.65	13.91	0.005	2.93	1.09
			Maize	551.99	60.75	34.27	29.01	10.12	0.005	1.56	0.78
	5	0.5	Date palm	266.32	90.02	13.15	23.71	16.76	6.58	6.76	1.59
			Sugar cane	294.41	90.46	23.03	19.08	17.38	9.91	7.38	0.82
	6	1	Sugar cane	230.20	70.40	12.50	15.60	9.18	6.00	1.32	0.50
South east	7	0.2	Date palm	807.35	79.94	19.93	23.03	13.12	0.005	10.41	1.09
			Maize	267.28	45.11	31.97	16.36	11.01	9.13	5.65	1.52
	8	0.5	Sugar-cane	739.14	100.00	57.25	24.16	14.02	9.27	6.59	0.24
			Jew's mallow	1361.03	87.05	22.54	27.18	15.13	0.005	9.50	0.66
	9	1	Okra	3798.75	443.32	28.47	25.48	26.16	8.32	8.32	0.26
			Sugar cane	1276.98	173.74	25.72	25.18	27.18	10.24	5.55	1.25
	10	1.5	Sugar cane	1430.71	159.23	22.98	21.82	36.16	12.72	9.66	2.01
	11	3	Sugar cane	389.28	113.03	22.48	21.40	25.10	1.81	7.39	1.69
			Date palm	307.91	54.09	37.02	38.85	19.12	10.74	9.60	1.53
	12	5	Maize	409.41	157.38	76.67	32.08	9.41	6.52	2.11	0.35
			Sesban	525.37	188.41	49.63	20.25	5.52	3.93	5.62	1.55
			Jawava	381.96	113.18	18.77	35.53	4.32	7.18	4.86	1.47
	13	7	Osier	249.47	80.85	13.72	20.74	1.69	0.005	1.02	1.40
			Alfalfa	206.84	24.90	19.16	18.33	0.52	2.74	2.66	1.42
North	14	0.2	Maize	103.48	39.99	12.53	12.53	9.42	4.42	1.42	0.001
			Sesban	109.59	36.17	19.02	17.02	11.74	3.87	1.74	0.76
	15	0.5	Tamarix	300.30	81.40	18.50	23.40	9.02	3.04	1.52	0.001
	16	1	Sorghum	100.80	35.20	12.20	12.00	3.02	0.005	0.001	11.20

Table (6): Iron, Mn, Zn, Cu, Pb, Ni, Cr and Cd concentrations in washed plant samples, collected from locations at different directions and distances from Edfo ferrosilicon alloys factory.

Direction	Location	Distance (km)	Plant Type	Mg/kg dry weight (ppm)							
				Fe	Mn	Zn	Cu	Pb	Ni	Cr	Cd
South	1	0.2	Maize	57.70	33.00	18.29	11.10	2.52	3.52	0.001	0.001
			Alfalfa	193.59	23.87	30.48	26.28	13.05	8.78	0.001	0.06
	2	0.5	Orange	169.72	30.40	16.37	26.54	2.54	7.35	0.001	0.001
			Egg plants	1320.05	86.12	25.02	19.60	3.81	0.45	0.75	0.41
			Mango	165.79	26.98	14.82	28.50	2.21	2.73	0.001	0.001
			Maize	194.99	106.54	21.35	20.92	4.02	2.01	5.88	0.18
	3	1	Okra	161.68	238.51	33.85	19.30	0.001	3.22	0.001	1.38
			Maize	210.02	48.93	34.25	17.90	0.001	3.30	0.001	0.001
East	4	0.2	Purslane	109.73	13.70	43.97	29.52	0.001	0.001	0.001	0.001
			Date palm	165.32	36.68	11.68	10.22	0.001	0.001	2.72	0.20
			Maize	260.77	34.66	23.05	10.71	0.001	0.001	0.001	0.001
	5	0.5	Date palm	187.88	36.67	12.65	14.24	6.33	0.001	0.80	0.72
			Sugar cane	175.46	74.20	6.96	5.27	5.22	5.22	0.001	0.001
	6	1	Sugar cane	160.46	36.20	10.30	10.00	2.02	2.02	0.001	0.001
South east	7	0.2	Date palm	165.33	36.68	11.68	10.22	3.02	0.001	2.93	0.22
			Maize	160.77	27.40	16.97	9.79	4.13	1.53	3.52	0.05
	8	0.5	Sugar-cane	432.00	46.39	19.36	20.16	6.12	5.75	0.001	0.001
			Jew's mallow	411.78	41.71	22.24	18.93	6.35	0.001	0.001	0.001
	9	1	Okra	492.08	48.34	20.90	14.27	9.13	2.74	0.91	0.001
			Sugar cane	342.26	61.46	20.77	19.77	10.15	6.47	0.001	0.95
	10	1.5	Sugar cane	470.72	62.17	20.52	18.88	17.12	0.001	1.92	0.24
	11	3	Sugar cane	139.20	51.32	19.06	15.06	8.12	0.001	1.99	0.001
			Date palm	254.70	50.69	15.10	21.60	9.13	0.001	7.07	0.001
	12	5	Maize	231.99	119.12	19.99	19.44	2.01	0.001	1.23	0.001
			Sesban	83.78	17.33	18.00	17.56	2.32	0.001	4.44	0.001
			Jawava	149.67	160.35	17.30	18.64	2.50	0.001	0.001	0.001
	13	7	Osier	93.62	19.85	4.97	12.05	0.52	0.001	0.001	0.001
			Alfalfa	76.69	17.53	2.91	11.11	0.33	0.001	0.001	0.001
North	14	0.2	Maize	70.24	20.70	3.34	10.10	2.02	0.001	0.001	0.001
			Sesban	65.33	21.46	4.83	11.39	3.13	2.87	0.001	0.001
	15	0.5	Tamarix	252.83	68.11	14.23	19.72	0.001	0.85	0.001	0.001
	16	1	Sorghum	65.13	29.17	4.00	9.71	0.001	0.001	0.001	0.001

Manganese content in the unwashed plant samples ranged between 24.90 and 502.07 ppm while it was between 13.70 and 238.51 ppm in the washed samples. Manganese has a wide range of distribution among plant species. Okra and egg plants accumulated grater amounts of Mn compared with other plants grown in the studied area. Kabata-Pendias and Pendias[15] reported that most plants show Mn content around 500 ppm. Therefore, Mn level in most plants in the area around the factory are still below these toxic levels. Similar results were obtained by Faiyad *et al.*[18] who recorded a range from 12.8 to 32.8 ppm for Mn in corn plants grown near the superphosphate factory at Kafr-El-Zayat city, Egypt.

Data given in Tables (5 & 6) show that zinc content in the unwashed plant samples varied between 12.2 and 97.88 ppm while it ranged from 7.91 to 43.97 ppm in the washed samples. These ranges seem to be high if compared with normal (uncontaminated) area. Abou El-Naga *et al.*[19] found that plants grown on polluted soils absorbed higher amounts of metal ions than those grown on normal soils. Environmental zinc pollution greatly influences its level in plants. In ecosystems where Zn is an airborne pollutant, plant tops are likely to concentrate most of their Zn content. On the other hand, plants grown on Zn-contaminated soils tend to accumulate a great proportion of the metal in their roots[15].

Data, further, show that levels of copper in both unwashed and washed plant samples were relatively high in all collected samples. Copper concentration ranged between 12.00 to 94.47 ppm in the unwashed plant samples while it was between 5.27 to 28.50 ppm in the washed plant samples. Copper content of whole plant shoots does not often exceed 20 ppm in most plant species growing under a wide range of natural conditions. This value is most often considered to indicate the threshold of excessive Cu contents[15]. Copper content tended to be high in Mango leaves and alfalfa plants than other plants. Gomah[20] reported that levels of copper in corn plants around Assiut superphosphate factory were probably within the toxic range but they were below the toxic level for sorghum.

Contents of Pb, Ni, Cr and Cd in the collected plant samples from around the ferrosilicon alloys factory are given in Tables (5 & 6).

As shown for other heavy metals, the unwashed plant samples contained higher concentrations of lead (0.52-38.81 ppm) than the washed samples (0.001-13.05 ppm). Deposition of airborne suspended particulates emitted from adjacent factories and smelters as well as from traffic roads near the studied area may cause these differences. The cultivated vegetables in Mostorod industrial area contained Pb concentrations that varied from 4 to 259 ppm [12]. Airborne Pb, a major source of Pb pollutant, is also readily taken up by plants through foliage cells. A number of studies have shown that Pb deposited on the leaf surface is absorbed by the cells of these leaves. Although it has been noted that most of the Pb pollution can be removed from the leaf surface by washing with detergents, a significant translo-cation of Pb into plant tissues is still likely to occur[21]. The great variation in Pb contents of plants is influenced by several environmental factors, such as the presence of geochemical anomalies, pollution, seasonal variation, and genotype ability to accumulate Pb. Several plant species and genotypes are adapted to grow in a high Pb concentration in the growth media; being reflected by anomalous amounts of this metal in the plants. The highest bioaccu-mulation of Pb is reported generally for leafy vegetables (mainly lettuce) grown in surround-ings of nonferrous metal smelters where plants are exposed to Pb sources of both soil and air [22].

Environmental Ni pollution greatly influences the concentration of this metal in plants. This is clearly exhibited in the data given in the same tables. Levels of Nickel in the unwashed samples ranged between 0.005 to 13.94 ppm while they varied in the washed samples between 0.001 to 8.78 ppm. Ashton[23] reported that plant tops are likely to concentrate most Ni present in ecosystems where Ni is an airborne pollutant. Under natural conditions, Ni toxicity is associated with serpentine or other Ni-rich soils. Anderson *et al.*[24] reported that oats, a Ni-sensitive crop, that was affected by this metal contained Ni in leaves ranging from 24 to 308 ppm. The phytotoxic Ni concentration varies widely among plant species and cultivars. It has been reported for various plants to be from 40 to 246 ppm[25]. Davis *et al.*[26] found the toxic Ni content, whereas Khalid and Tinsley[27] found that 50 ppm Ni in ryegrass cause slight chlorosis.

Levels of Cr in the unwashed samples ranged between 0.001 and 9.66 ppm while they varied between 0.001 and 7.07 ppm in the washed samples. Common levels of Cr found in plant materials are usually in the range of 0.02 to 0.2 ppm. However, a relatively great variation is observed in the Cr content of food plants, being also dependant upon kinds of tissues and stages of growth[28].

Cadmium levels in the unwashed samples varied between 0.001 and 2.85 ppm while its levels in the washed samples ranged between 0.001 and 0.72 ppm. El-Sabbagh[12] reported that levels of Cd in the vegetables grown around Mostorod area ranged from 0.03 to 3.40 ppm. Kabata-Pendias and Pendias[15] showed that the concentration of cadmium rapidly increased in plants grown in the polluted areas due to its “availability” to the plants from both air and soil sources.

Correlation coefficients were made between the concentration of heavy metals for some plants and trees (maize, sugar cane and date palm) grown on the study area with their concentrations in both surface and subsurface soil layers. Iron concentration in the washed sugar-cane samples was significantly correlated to its concentration in the surface soil layer (0.952*). On the other hand, a significant correlation was found between lead concentrations in the same samples and those in the subsurface soil layer (0.817*). In date palm trees, significant correlations were found between manganese and chromium concentration in washed samples with their concentrations in the surface soil layer (-0.967* and 0.948*, respectively).

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تقييم تلوث التربة والنباتات فى المنطقة المحيطة بمصنع سبيكة الفيروسيلكون بأدفو ـ محافظة أسوان

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أجريت دراسة لتقييم تلوث التربة والنباتات الموجودة فى المنطقة المحيطة بمصنع سبيكة الفيروسيلكون بأدفو ، محافظة أسوان بجمهورية مصر العربية . وتم جمع عينات تربة ونباتات على مسافات مختلفة من المصنع فى صيف عام ٢٠٠٠ . ففى اتجاهات الجنوب والشرق والشمال من المصنع تم اختيار ثلاثة مواقع أما فى اتجاه الجنوب الشرقى فتم اختيار ٧ مواقع . أخذت عينات التربة من هذه المواقع على أعماق (صفر – ٢٥سم) ، (٢٥– ٥٠ سم) فى كل قطاع . وقد قسمت كل عينة نبات مأخوذة من كل موقع إلى قسمين بحيث يتم غسيل إحداهما بالماء المقطر أما الأخرى فتكون بدون غسيل . كما أخذت عينتان من خليط الرماد والأتربة والمخلفات التى تجمع بالقرب من المصنع . وقد وجد أن مخلفات المصنع تحتوى على نسب عالية نسبياً من الحديد والفوسفور والكبريت والبوتاسيوم والكالسيوم والماغنسيوم والكروميوم .

وأظهرت النتائج أيضاً أن ملوحة التربة تزداد باتجاه الجنوب بالبعد عن المصنع . وعلى العكس فإن مواقع العينات الموجودة بعيداً عن المصنع لديها قيم pH أقل نسبياً . كما أن تركيز الكالسيوم والماغنسيوم يصل إلى أقصى قيمة له على مسافة مقدارها ١ كم من المصنع فى إتجاه الجنوب الشرقى . ولأن هذه المنطقة تتأثر بالأتربة المحتوية على الفوسفات القادمة من مناجم الفوسفات بالسباعية القريبة من المنطقة فقد وجد زيادة تركيز الفوسفور المستخلص من عينات التربة .

كما أظهرت النتائج زيادة تركيز الكبريت فى عينات التربة حول المصنع ، والتى قد ترجع الى أبخرة أكاسيد الكبريت الناتجة من المصنع وأن المنطقة المحيطة بالمصنع من جهة الجنوب والجنوب الشرقى تحتوى على أعلى تركيز من العناصر الثقيلة المستخلصة بالـ DTPA مما يؤكد أنها ترجع إلى الأتربة والأدخنة والأبخرة الناتجة من المصنع . كما أوضحت نتائج تحليل العينات النباتية أن تركيزات الفوسفور والبوتاسيوم والكبريت والحديد والمنجنيز والزنك والنحاس والكادميوم والنيكل والرصاص والكروميوم فى العينات الغير مغسولة أعلى منها فى العينات المغسولة بالماء المقطر ، والذى قد يرجع إلى التلوث الحادث نتيجة مخلفات المصنع .

ووجد ارتباط معنوى بين كل من تركيزى الحديد والرصاص فى عينات نبات قصب السكر المغسولة وتركيزهما فى التربة السطحية وتحت السطحية ومقدارهما ٠,٩٥٢*، ٠,٨١٧ * على التوالى . وكان الارتباط معنوياً أيضاً بين تركيزى المنجنيز والكروميوم فى أوراق نخيل البلح وتركيزهما بطبقة التربة السطحية ومقدارهما ٠,٩٦٧ * ، ٠,٩٤٨ * على التوالى . وفى معظم الأحوال فإن تركيز معظم العناصر التى تنتج من أتربة وأبخرة وأدخنة المصنع تسبب مشاكل بيئية كبيرة فى هذه المنطقة .