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POLLUTION IMPACT ON SOILS AND PLANTS IN AN INDUSTRIAL AREA NEAR ASSIUT CITY

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ABSTRACT :

Soil and plant samples were collected from 19 sites located around the superphosphate factory that lies 9 km North of Assiut city, Egypt, to evaluate soils and plants with respect to some elements and heavy metals pollution. Surface and subsurface soil samples were taken from each site. Each plant sample was divided into 2 subsamples, one was washed with dionized water and the other was left unwashed.

In most cases, salinity and extractable P in the soil decreased with distance from the factory in both south and southeast directions. Dominance of soluble Ca, Mg salts as well as extractable P in the soil material around the factory indicates that phosphate dusts are the main contaminants in this area. Sulfur oxide fumes resulting from the factory could be the source of obtained high levels of extractable S in the soils around the factory. The eastern and southeastern parts of the studied area showed the highest levels of DTPA-extractable metals indicating that factory dusts and smokes could be the reason for soil pollution.

Pronounced differences in P and K contents between the washed and unwashed plant samples were observed. Concentrations of P and K in a variety of plants decreased with distance far from the factory. No significant differences in S concentrations in plants with distance from the factory or between washed and unwashed plants was observed. Unwashed plant samples had higher levels of heavy metals than dionized water washed samples. However, concentrations of these metals in plant tissue did not reach the phytotoxic levels. Most studied metals in plants did not show a specific trend of distribution with distance from the factory.

INTRODUCTION :

One of the most serious problems in the world nowadays is the environmental pollution. The list of pollutants, that are potentially hazardous to the human and animal life, has increased rapidly in the last 40 years. As a result of industrial practices, a redistribution of mineral elements in the environment has taken place, causing, in certain areas, the soil to become depleted in one or more essential elements. At the same time, other elements have been introduced into the environment of air, water and surface soil, which ultimately appear in the food chain as they accumulate in plants and animals. Some of these elements are essential, while others are toxic metals [1].

Sedimentation and deposition of air-borne particulates on plants and soils is probably the most important source of soil and plant contamination with heavy metals, particularly near industrial zones. An elemental deposition of 2.5 kg ha^{-1} was assumed to be equivalent to an increase of 1 mg kg^{-1} in the top 20 cm of the soil. Contribution from atmospheric sources to soil contamination is particularly important for Cd, Cu, Hg, Pb and Zn. Deposition rates reported from USA, The Netherlands and West Germany gave similar values, indicating that this source of heavy metals in soils is of considerable importance in industrialized countries [2].

Concentrations of Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in the top soil of rural area located south and southeast of Cairo were reported to be affected by the metal content of air-borne dust, which is influenced by industrial metal emissions in other areas of the city [3]. In the normal alluvial soils of Nile Delta in Egypt, Rashad [4] showed that the total contents of Mn, Pb and Ni in these soils ranged from 720 to 1080 ppm, from 32.0 to 48.0 ppm, and from 21.0 to 44.0 ppm, respectively.

The heavy metals are the main pollutants that were produced after most of industrial activities [5]. The content and type of an element depend upon the type of industrial activities. Abu-Qir fertilizers and chemicals Industrial company are emitting significant quantities of gases into the atmosphere, causing considerable air pollution problems [6]. The litter layer and top 2.5 cm of the soil at sites within 5 Km of the center of industrial north western India were highly contaminated with Cd, Zn, Cu and Pb. They also added that the levels of Cd and Zn decreased rapidly with distance to the south and east, while Cu and Pb decreased more erratically [7].

In polluted alluvial soils, the total Pb ranged between 84.4 and 101.1 ppm with an average of 92.8 ppm [8]. The total Fe in alluvial soils irrigated with liquid industrial wastes at El-Saff reached 16.6% in the surface layer. They showed that the total Mn was as high as 2550 ppm [9]. Also, the total Ni in contaminated alluvial soils at El-Fayoum was 55.3 ppm. In an industrial area north of great Cairo [10], the highest enrichment factor ratios were for Pb in the soil clay fraction, for Mn in the sand fraction, and for Fe, Mn and Pb for silt fraction [11].

Some industrial factories such as superphosphate factory and cement factory are located north and north west of Assiut city. Sometimes they cause some pollution

problems in Assiut area due to airborne dusts and smokes. Some problems are related to soil contamination with heavy metals, plant damage from industrial dusts and airfumes that may also contain some heavy metals. The environment in which we survive is our responsibility to preserve, conserve and cherish. So, the present study aims to evaluate soils and plants around superphosphate factory with respect to some elements and heavy metal pollution.

MATERIALS AND METHODS :

Study site :

The superphosphate factory is located 9 km north of Assiut city (27° N and 31°E). It lies between the Nile river (East) and Ibraheemia canal (West). The area around the factory was cultivated with some main crops such as wheat, faba bean and clover in winter and sorghum, maize and cotton in summer. In addition, some fruit orchards like grapes, banana; jawava and figs are found in the area.

Soil and plant samples were collected from 19 sites located around the factory under study (Figure 1). Two soil samples were taken for each site, one at 0-20 cm depth and the other at 20-40 cm depth. Plant samples were also collected at the same time from the crops or orchards that were grown on the soil at each site. Table (1) show location of soil and plants samples as well as plant type and location with respect to the factory.

Soil samples were air dried, crushed, passed through 2 mm sieve and kept for analysis. On the other hand, 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. Ground plant samples were digested by H_2SO_4-H_2O_2 method [12]. Iron, Mn, Zn, Cu, Pb, Ni, Cr and Cd were determined using a GBC model 300 atomic absorption spectrophotometery. Other plant samples were prepared for phosphorus, potassium and sulfur determinations using a mixture of nitric and perchloric acids of 2:1 ratio, respectively.

The electrical conductivity (EC) was determined in 1:1 soil to water extracts using a conductivity meter. Soluble Ca and Mg in these extracts were determined by EDTA titration. Available K in soil samples was extracted using 1.0 N NH_4OAC [13]. K and Na in soil extracts were determined by Flame Photometer. Available P in soil samples was extracted with the 0.5 $NaHCO_3$ [14]. Phosphorus was determined in soil extracts and plant digests [13]. Available sulfur in soil samples were extracted using 500 ppm P of KH_2PO_4 . Also, sulfur was determined in soil extracts and plant digests by turbidemtric method [13].

RESULTS AND DISCUSSION :

A-Soil Characteristics Around Industrial Area Near Assiut City :

1–Particle size distribution of soil samples :

Particle size distribution of the surface and subsurface soil samples that represent the area around the superphosphate factory near Assiut city is presented in table (2). For most surface soil samples

(0-20 cm), the texture grade ranges between silt loam and loam. Few surface soil samples have sandy loam and loamy sand texture. Moreover, most subsurface soil samples (20-40 cm) have silt loam or loam textures. However, few subsurface soil samples show silty clay loam and loamy sand textures. Although most of the subsurface layers of these alluvial soils contain higher clay contents than the surface ones, some surface layers, especially at locations, 1, 2, 6, 9, 14, 15, 18 and 19, contain relatively high clay contents. This may be related to the continuous deposition of the fine industrial dust on the soil surface at sites located in the air direction.

Figure (1) : Location map of the studied area.

Table (1) : Locations of soil and plant samples collected from the studied industrial area near Assiut city.

Location No.	Soil sample No.	Plant Type	Distance and Location from the factory
1	1 and 2	Wheat and Onion	50 m South
2	3	Wheat	500 m South
3	4	Wheat	1 Km South
4	5	Cabbage, Faba bean, Clover, Clover and Mango	2 Km south
5	6 and 7	Faba bean, Lemon, Banana and Mango	3 Km South
6	8	Jawava	4.5 Km South
7	9	Figs	50 m North
8	10	Camphor	400 m North
9	11	Lemon and Grapes	1 Km North
10	12	Jawava	1.5 Km North
11	13	Jawava	500 m North West
12	14	Loofa and Egg plants	500 m South West
13	15	Jawava	1.5 Km South West
14	16	Nabak	4 Km South West
15	17	Mulberry	2 Km South East
16	18	Figs	2.5 Km South East
17	19	Clover and Banana	3 Km South East

Table (2) : Particle size distribution of the surface and subsurface soil samples collected from the area around the superphosphate factory near Assiut city.

Location No.	Sample No.	Surface				Subsurface			
		Clay %	Silt %	Sand %	Texture grade	Clay %	Silt %	Sand %	Texture grade
1	1	18.21	53.07	28.69	Silt loam	13.08	44.82	42.10	Loam
	2	26.77	48.13	25.10	Loam	22.20	55.49	22.31	Silt loam
2	3	22.86	68.55	8.59	Loam	23.15	74.34	2.51	Silt loam
3	4	7.80	57.68	34.52	Silt loam	23.91	53.00	23.09	Silt loam
4	5	21.11	50.45	28.44	Loam	32.07	62.12	5.81	Silty clay loam
5	6	10.53	52.71	36.76	Silt loam	8.99	57.87	33.14	Silt loam
	7	20.90	50.30	28.80	Silt loam	32.17	61.00	6.83	Silty clay loam
6	8	16.25	54.94	28.81	Silt loam	14.45	57.58	27.97	Silt loam
7	9	19.86	50.31	29.83	Silt loam	26.96	50.85	23.19	Silt loam
8	10	18.51	66.25	15.24	Silt loam	20.04	33.05	46.91	Loam
9	11	13.69	76.32	9.99	Silt loam	22.13	74.86	3.01	Silt loam
10	12	5.81	17.04	77.15	Loamy sand	23.59	48.50	27.91	Loam
11	13	11.75	44.24	44.01	Loam	20.17	42.98	36.85	Loam
12	14	23.20	49.95	26.85	Loam	5.55	66.99	27.46	Silt loam
13	15	14.31	52.71	32.98	Silt loam	13.76	57.00	29.24	Silt loam
14	16	21.21	45.57	33.22	Loam	28.45	54.28	17.27	Silt loam
15	17	9.79	22.71	67.50	Sandy loam	7.54	16.60	75.86	Loamy sand
16	18	8.05	39.67	52.28	Sandy loam	5.06	38.64	56.30	Sandy loam
17	19	19.13	69.83	11.04	Silt loam	24.16	55.05	20.79	Silt loam

2 - Soil salinity and soluble cations :

The distribution of the electrical conductivity (EC) and soluble cations of the soil samples in the areas around the superphosphate factory near Assiut is shown in table (3). The EC values of the surface soil samples ranged between 0.42 and 3.00 dS/m. The EC of subsurface soil samples lied between 0.35 and 1.70 dS/m. Thus, Surface soil samples contained higher salinity than subsurface ones. In most cases, salinity in soil samples decreased southward with increasing distance from the factory. Sampling sites that were located north and south west did not show clear trend of salinity distribution. However, they had lower salinity than those located southwards. Levels of soluble sodium and potassium in both surface and subsurface soil samples were lower than those of calcium and magnesium (Table 3). Most soil samples showed high levels of soluble cations, especially Ca and Mg, in the surface than in the subsurface. Predominance of soluble calcium and magnesium salts in soils near the superphosphate factory confirms that these soils are contaminated by the phosphate dusts that contain high levels of calcium and magnesium.

3-Extractable phosphorus, potassium and sulfur :

Extractable phosphorus in the studied soil samples varied from 25 to 44 ppm and from 20 to 35 ppm in the surface and subsurface samples, respectively (Table 4). Most of these samples show high levels of extractable phosphorus in comrison with Thomas and Peaslee [15]. All studied soil samples have higher levels of extractable phosphorus in the surface layer compared with those of the subsurface. Generally, extractable P in both surface and subsurface soil samples decreased eastward and south-eastward with increasing the distance from the factory. This verifies that superphosphate dusts resulting from the factory are the main contaminant around this factory.

Levels of extractable K of the surface soil samples ranged between 140.4 to 959.4 ppm (Table 4). Most of these samples, however, contained high levels of extractable potassium. On the other hand, levels of extractable K in the subsurface samples varied from 81.9 to 581.1 ppm. According to Doll and Lucas [16], most of these soils contain sufficient amounts of extractable K. There was no distribution trend of extractable K with distance from the factory, especially in the surface layer. However, surface samples contained higher K levels compared with the subsurface ones.

Extractable sulfur in the studied area ranged from 1800 to 3000 ppm in the surface layers and from 1700 to 3000 ppm in the subsurface samples (Table 4). There was no clear trend of extractable S distribution between surface and subs-urface samples. However, in most cases, extractable S in soil samples decreased far from the factory towards the east, southeast, south and northeast. Sulfur oxide fumes resulting from the factory could be the source of the high levels of extractable S in soils around this factory.

Table (3): Electrical conductivity (EC) and soluble cations of the surface and subsurface soil samples collected from the area around the superphosphate factory near Assiut city.

Location No.	Sample No.	$EC_{1:1}$ dS/m		meq/100 g soil							
				Ca^{2+}		Mg^{2+}		Na^{+}		K^{+}	
		Sur*	Sub**	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
1	1	2.25	1.70	1.12	0.82	0.84	0.70	0.23	0.14	0.05	0.04
	2	3.00	1.57	1.40	0.75	1.50	0.78	0.07	0.03	0.016	0.006
2	3	1.21	1.03	0.44	0.59	0.73	0.44	0.04	0.03	0.008	0.01
3	4	1.58	1.33	0.80	0.86	0.58	0.41	0.05	0.04	0.006	0.02
4	5	1.70	0.71	0.78	0.40	0.82	0.28	0.06	0.03	0.02	0.006
5	6	0.72	0.55	0.42	0.30	0.26	0.22	0.04	0.02	0.008	0.008
	7	0.76	0.66	0.45	0.40	0.27	0.20	0.02	0.02	0.004	0.01
6	8	0.70	0.50	0.30	0.29	0.36	0.19	0.02	0.02	0.002	0.004
7	9	0.61	0.46	0.32	0.23	0.25	0.20	0.03	0.02	0.008	0.008
8	10	1.25	0.56	0.50	0.25	0.68	0.29	0.07	0.02	0.005	0.003
9	11	0.90	0.75	0.45	0.26	0.39	0.36	0.04	0.03	0.02	0.006
10	12	0.62	0.60	0.28	0.35	0.32	0.23	0.02	0.02	0.006	0.010
11	13	0.77	0.65	0.42	0.40	0.30	0.23	0.03	0.03	0.004	0.008
12	14	0.86	0.77	0.44	0.50	0.40	0.26	0.04	0.03	0.006	0.004
13	15	0.62	0.35	0.30	0.14	0.25	0.20	0.03	0.03	0.008	0.01
14	16	0.94	0.82	0.62	0.54	0.28	0.25	0.03	0.02	0.014	0.016
15	17	0.42	0.36	0.23	0.20	0.17	0.13	0.01	0.01	0.003	0.004
16	18	1.48	0.92	0.66	0.57	0.52	0.28	0.09	0.06	0.008	0.01
17	19	0.69	0.46	0.40	0.18	0.24	0.26	0.03	0.03	0.006	0.012

*** Sur = surface soil sample (0-20 cm).**
****Sub = subsurface soil sample (20-40 cm)**

Table (4): Extractable phosphorus, potassium and sulfur in surface and subsurface soil samples collected from the area around the superphosphate factory near Assiut city.

Location No.	Sample No.	ppm					
		P		K		S	
		Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
1	1	41	32	171.6	81.9	2700	3000
	2	40	35	280.8	148.2	2400	2500
2	3	33	30	499.2	230.1	3000	3200
3	4	31	29	401.7	179.4	2500	2700
4	5	31	25	358.8	218.4	2400	3000
5	6	30	23	214.5	179.4	2700	2400
	7	25	20	358.8	288.6	2400	2200
6	8	39	30	959.4	581.1	1800	2000
7	9	42	30	89.7	191.1	2000	1900
8	10	32	23	378.3	339.3	1800	2700
9	11	30	30	429.0	401.7	3000	2700
10	12	32	27	300.3	308.1	2400	2000
11	13	30	25	300.3	241.8	1800	1700
12	14	44	35	230.1	140.4	3000	2700
13	15	33	24	401.7	261.3	2400	2000
14	16	29	23	331.5	241.8	2100	2700
15	17	35	31	218.4	179.4	2700	2900
16	18	30	28	140.4	109.2	2200	2500
17	19	40	34	401.7	351.0	1900	2400

4-DTPA-extractable metals :

Data in table (5) show the distribution of DTPA-extractable Fe, Mn, Zn and Cu in the soil samples around the superphosphate factory near Assiut city. Levels of DTPA-extractable Fe lied between 1.84 and 8.06 ppm, except sample no. 17, that represents site 15, which had very high levels (27.45 and 18.37 ppm for surface and subsurface samples, respectively). Generally, soil extractable Fe decreased with distance far from the factory. Also at any distance from the factory, the surface layer showed higher levels of extractable Fe than the subsurface. These results agree well with those reported by Abdel-Mottaleb [5] at Abo-Zabal area.

DTPA-extractable Mn in the surface layer of the study area ranged from 1.19 to 49.20 ppm and between 1.06 to 10.90 ppm in the subsurface layer. Most of these soils have sufficient levels of available Mn [17]. Extractable Mn in most cases decreased in all directions with distance far from the factory and with depth. Most soil samples had higher extractable Mn levels compared with Fe levels, especially in the area south of the factory. Manganese has not been considered to be a polluting metal in soils. Grove and Ellis [18] found more water soluble Mn in soil after fertilization, whereas Diez and Rosopulo [19] observed a lower Mn uptake by plants from soil after sludge application. However, manganese that is accumulated in top soil due to Mn application over a long period of time was reported to have toxic effects on some plants.

The lowest extractable levels of micronutrient cations in the studied soil samples are those of Zn (Table 5). All Zn levels in the soil samples were below 1 ppm, except the surface sample no. 2 located at site 1. There were no definite trends for Zn extractable levels with respect to its distribution with distance from the factory or with depth.

Extractable copper of the surface layers varied between 2.86 and 6.90 ppm, whereas that of the subsurface layer ranged between 1.70 and 736 ppm. There is no clear relationship between levels of extractable Cu content and the distance from the factory. On the other hand, extractable Cu, in most cases, was higher in the subsurface layer compared with that of the surface one. According to Viets and Lindsay [17], The most of these soils have sufficient levels of available Cu. Contamination of soils by Cu compounds results from utilization of Cu-containing materials such as fertilizers, sprays and agricultural and municipal wastes as well as industrial emissions [20].

It is obvious that levels of DTPA-extractable Fe, Mn, Cu and Zn in the studied area around the superphosphate factory vary with direction and with distance from the factory. The area located east of the factory (Sample nos. 1 to 8) contains the highest levels of the studied micronutrients, followed by the southeastern part, the south part, and finally the area that lies at the northeast of the factory. Most winds, that carry dust and smokes emitted from the factory, come from the west or northwest directions.

The distribution of DTPA-extractable Pb, Ni, Cr and Cd in the soil samples collected from the area around the superphosphate factory near Assiut city is

presented in Table (6). DTPA-extractable Pb decreased with soil depth. Extractable Pb showed only a decrease with distance far from the factory in both southwest and north directions. The factory may contamination with lead, directly through smokes could occur, as it was indicated [5]. Lead may reach the surface soil from superphosphate factory chimnies, as white particles resulting from phosphate rock grinding, during the process of superphosphate fertilizer production [21]. Levels of Pb in soils that are toxic to plants are not easy to evaluate, however, several authors have given quite similar total Pb levels, ranging from 100 to 500 ppm. Accumulation of Pb on surface soil samples is of great ecological significance because this metal is known to greatly affect the biological activity in soils. Levels of total Pb in some Egyptian polluted soils were shown to vary between 17.0 to 233 ppm [8,11 &22].

It is evident that distribution of extractable Ni shows no systematic trend of distribution with distance far from the factory (Table 6). The highest extractable Ni level was in sample no. 2 at site 1 located very close to the factory. Also, no clear trend was observed for extractable Ni with depth. Soluble Ni^{2+} was found to form stable soluble complexes with inorganic and organic ligards that are able to migrate down ward in this soil [23]. In general, the part of the studied area east to southeast of the factory had the highest levels of extractable Ni. This emphasizes the role of winds in carrying factory smokes and dusts eastward to contaminate the soils located there. Nickel recently has become a serious pollutant that is released from metal processing operations. The application of sludges and certain phosphate fertilizers also may be an important source of Ni. Anthropogenic sources of Ni, from industrial activity in particular, have resulted in a significant increase in Ni content of soils [20].

No systematic trends were observed for extractable Cr levels with either distance from the factory or with soil depth (Table 6). Extractable Cr levels of surface soil is known to increase due to industrial contamination. However, hexavalent form of Cr (VI) is 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 [24].

Data in Table (6) also show no systematic trend for extractable Cd neither with distance from the factory nor with depth. NH_4OAC-extractable Cd was found to range from 0.015 to 0.095-µg/g [25].

It is obvious that soil samples representing the area around the superphosphate factory contain DTPA-extractable metals that decrease in the order of Pb>Ni>Cr>Cd. The part of this area that is located south of the factory contains the highest extractable levels of these studied metals. This indicates the role of the factory dusts and smokes that are carried by wind toward the east and southeast.

Table (5): DTPA-extractable iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) of surface and subsurface soil samples taken from the area around the superphosphate factory near Assiut city.

Location No.	Sample No.	ppm							
		Fe		Mn		Zn		Cu	
		Surface	Subsurface	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
1	1	4.62	4.61	9.93	6.68	0.49	0.02	5.23	3.89
	2	8.06	5.26	49.20	10.90	1.26	0.67	6.90	7.00
2	3	4.41	3.92	8.31	5.03	0.49	0.13	6.58	7.36
3	4	5.91	4.11	5.96	9.99	0.28	0.46	6.49	6.30
4	5	4.10	3.65	5.16	5.24	0.08	0.10	5.91	5.90
5	6	3.01	2.94	5.11	4.30	0.48	0.02	4.85	5.15
	7	2.80	2.42	1.90	1.63	0.21	0.34	2.86	3.88
6	8	2.84	2.02	1.41	0.98	0.44	0.07	2.91	3.03
7	9	3.23	2.13	2.94	3.39	0.35	0.67	5.26	5.50
8	10	2.25	2.23	8.58	4.42	0.37	0.92	3.09	5.70
9	11	3.20	2.88	2.66	1.98	0.62	0.41	4.14	4.02
10	12	3.04	2.77	3.70	3.09	0.18	0.06	3.25	3.36
11	13	2.32	2.00	1.35	1.50	0.28	0.34	3.62	6.06
12	14	2.65	2.41	2.03	1.63	0.24	0.01	5.10	4.70
13	15	3.05	2.36	2.12	2.03	0.51	0.06	5.06	4.45
14	16	1.91	1.84	1.19	1.06	0.06	0.06	3.10	2.46
15	17	27.45	18.37	3.24	6.36	0.01	0.01	5.49	6.18
16	18	3.26	2.91	3.40	2.45	0.15	0.08	4.90	1.70
17	19	3.03	3.28	1.95	2.70	0.09	0.10	4.07	4.90

Table (6): DTPA-extractable lead (Pb), nickle (Ni), chromoium (Cr) and cadmium (Cd) in surface and subsurface soil samples collected from the area around the superphosphate factory near Assiut city.

Location No.	Sample No.	ppm							
		Pb		Ni		Cr		Cd	
		Surface	Subsurface	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
1	1	1.082	0.864	0.362	0.166	0.082	0.188	0.028	0.026
	2	0.102	0.114	0.894	0.102	0.444	0.048	0.138	0.020
2	3	0.228	0.552	0.228	0.228	0.192	0.116	0.026	0.038
3	4	0.506	0.114	0.372	0.506	0.032	0.042	0.022	0.032
4	5	1.038	0.755	0.356	0.390	0.050	0.032	0.002	0.002
5	6	0.666	0.204	0.306	0.056	0.220	0.248	0.020	0.014
	7	0.390	0.166	0.052	0.420	0.090	0.012	0.140	0.008
6	8	0.433	0.376	0.090	0.124	0.022	0.056	0.010	0.002
7	9	0.356	0.178	0.132	0.150	0.080	0.162	0.012	0.014
8	10	0.400	0.364	0.094	0.130	0.146	0.426	0.018	0.008
9	11	0.583	0.306	0.158	0.142	0.074	0.280	0.032	0.006
10	12	0.666	0.138	0.206	0.144	0.026	0.306	0.014	0.024
11	13	0.584	0.194	0.166	0.156	0.306	0.436	0.002	0.006
12	14	0.874	0.318	0.112	0.110	0.342	0.456	0.002	0.002
13	15	0.368	0.210	0.252	0.170	0.402	0.180	0.006	0.014
14	16	0.296	0.136	0.134	0.054	0.056	0.194	0.008	0.018
15	17	0.398	0.374	0.334	0.508	0.325	0.213	0.002	0.014
16	18	0.532	0.350	0.084	0.176	0.134	0.470	0.002	0.008
17	19	0.580	0.336	0.198	0.252	0.296	0.112	0.008	0.014

B-Elemental Contents of Some Plants Grown Around the Superphosphate Factory, Assiut city:

1-Phosphorus, potassium and sulfur in plants :

Contents of phosphorus, potassium and sulfur in some plant samples, taken from the area around the superphosphate factory near Assiut city, are present in Table (7). All unwashed plant samples have quite higher levels of P and K compared with washed samples. For example, unwashed wheat, faba bean, banana, and egg plants samples, that were grown in sites 1, 4, 5 and 12, contained P concentrations of 2.80, 3.188, 2.750 and 2.750 g/kg, respectively. On the other hand, washed samples of these respective plants had P levels of 2.188, 0.823, 0.938 and 0.423 g/kg (Table 7). Potassium concentrations in unwashed wheat, cabbage, jawava, and banana plants grown on sites 1, 4, 11 and 17 was 10.120, 16, 875, 33.750, and 33.750 g/kg, respectively, whereas it concentrations of the element in washed plant samples were 8.125, 4.375, 19.375, and 21.250 g/kg, respectively.

Superphosphate factory uses phosphate rock and sulfuric acid to produce superphosphate. Dusts that result from the factory during superphosphate production contain phosphate particulates as well as other mineral impurities such as feldspars and micas that contain potassium. These dusts are expected to raise levels of both P and K of the unwashed plant samples. Increased levels of P and K in the soil are also observed on growing plants that show higher P and K concentrations compared with those plants grown for from the factory.

This was greatly emphasized in the case of evergreen trees, such as banana and jawava that had high levels of P and K deposited on their leaves as dusts. Contents of P and K in a specific plant (unwashed or washed) decreased with distance far from the factory.

These pronounced differences in P and K between unwashed and washed plants samples indicate that considerable amounts of industrial dusts are deposited on plants growing around the factory and reflect the impact of the industrial pollution in the area.

Differences in plant S levels between unwashed and washed plant samples are not so large as in P and K levels. Sulfur concentrations in unwashed onion, mango, grapes and loofa leaves sampled from sites 1, 5, 9, and 12, respectively, were 2.250, 1.750, 2.000 and 1.875 g/kg, respectively. Washed samples of these respective plants, show concentrations of 1.625, 1.488, 1.800 and 1.613 g/kg, respectively. Sulfur source is mainly various sulfur oxide gasses that are distributed in the air could spread over a wide area around the factory. Accordingly, no significant differences in S concentrations in either washed or unwashed plant samples with distance far from the factory were observed. Sulfur oxide gasses that are emitted from the factory during formation of sulfuric acid from elemental sulfur can be absorbed by plant leaves.

Table (7): Phosphorus (P), potassium (K) and sulfur (S) contents of some plant samples collected around the superphosphate factory near Assiut city.

Location	Plant type	g/kg					
		P		K		S	
		unwashed	washed	unwashed	washed	unwashed	washed
1	Wheat	2.800	2.188	10.120	8.125	1.775	1.638
	Onion	1.563	1.351	20.000	15.500	2.250	1.625
2	Wheat	1.938	1.438	9.500	4.375	1.775	1.750
3	Wheat	2.063	1.770	8.125	7.250	1.725	1.638
4	Cabbage	1.875	0.688	16.875	4.375	1.725	1.650
	Faba bean	3.188	0.823	17.500	13.000	1.625	1.500
	Clover	2.125	1.250	17.250	14.500	1.750	1.725
	Clover	2.688	0.563	19.375	15.875	1.725	1.713
	Mango	2.500	1.000	7.500	5.500	1.750	1.688
5	Faba bean	2.750	0.594	10.500	9.625	1.763	1.763
	Lemon	1.704	1.000	8.120	7.500	1.775	1.775
	Banana	2.750	0.938	22.250	19.375	1.763	1.750
	Mango	2.688	0.531	12.875	7.500	1.750	1.488
6	Jawava	2.688	0.656	7.250	3.625	1.750	1.725
7	Fig	2.813	0.781	7.750	4.500	1.775	1.563
8	Camphor	2.188	1.000	6.250	4.500	1.788	1.613
9	Lemon	2.562	0.781	11.750	7.000	1.788	1.725
	Grapes	2.250	1.343	15.000	13.125	2.000	1.800
10	Jawava	2.750	0.813	11.750	10.625	1.713	1.675
11	Jawava	2.563	0.938	33.750	19.375	1.775	1.750
	Grapes	2.000	1.938	17.500	12.125	1.800	1.725
12	Loofa	1.688	1.625	17.750	7.250	1.875	1.613
	Egg plants	2.750	0.423	4.375	2.000	1.813	1.783
13	Jawava	1.920	1.250	8.520	7.125	1.763	1.625
14	Nabak	2.313	1.000	11.250	7.500	1.800	1.794
15	Mulberry	2.750	0.938	7.250	4.250	1.875	1.750
16	Fig	1.293	0.500	11.250	9.125	1.737	1.700
17	Clover	2.063	1.813	36.250	36.250	1.713	1.688
	Banana	3.313	0.938	33.750	21.250	1.750	1.663

2-Heavy metals in plants:

Plant samples were taken from 17 sites around the superphosphate factory. In some sites, more than one sample were taken, depending upon plant types that were found. Table (8) shows concentrations of Fe, Mn, Zn and Cu in the plant tissue before and after washing by dionized water.

Iron in plant samples ranged between 49.3 and 2185.1 ppm before washing and between 33.9 to 1082.9 ppm after washing. Plant samples that were not washed had much higher levels of Fe, Mn, Zn and Cu compared with the ones. Plants grown in this area absorb high levels of these metals from the contaminated soil in addition to the accumulation of these metals from dust-rich atmosphere around the factory. Most dicotyledon plants, absorb more heavy metals than monocotyledons. An exception is ryegrass which absorb Ni in unusually large amounts [26]. The distribution of Fe did not show a certain trend of distribution with distance far from the factory. It is

evident that, in some cases, concentrations of Fe reach the toxic levels in plant tissues. According to Kabata-Pendias and Pendias [20], the natural Fe content of fodder plants ranges from 18 to about 1000 ppm.

Manganese content in the unwashed plant samples varied between 23.7 and 319.5 ppm while, in the washed samples, it ranged from 5.7 to 230.5 ppm (Table 8). Manganese behavior showed various patterns of distribution for different plants species. Banana leaves accumulated greater amounts of Mn compared with other plants. The Mn showed a particularly wide variation among plant species grown on the same soil, ranging from an average of 30 ppm to around 500 ppm [27]. The critical Mn deficiency level for most plants ranges from 15 to 25 ppm whereas the toxic concentration of Mn to plants is more variable, depending upon both plant and soil factors. Generally, most plants show Mn content around 500 ppm. Reported toxic levels for Mn range from 80 to 5000 ppm [28]. However, the accumulation above 1000 ppm also has been often reported for several more resistant species or genotypes [20]. Therefore, Mn level in the studied plants is still below the toxic range.

Levels of zinc in the studied plants were relatively high in all samples. Zinc concentration ranges between 24.5 and 87.9 ppm in unwashed samples while it varies from 4.1 to 35.2 ppm in washed samples. Abou El-Naga [29] found that plants grown in a polluted soil absorbed higher amounts of metal ions than those in a normal one . Environmental Zn pollution greatly influences levels of this metal in plants. In ecosystems where Zn is an airborne pollutant, plant tops are likely to concentrate the most level of Zn. On the other hand, plants grown in Zn-contaminated soils accumulate a great proportion of the metal in the roots [20].

Copper content of unwashed plant samples ranged between 16 and 91.2 ppm, while it was between 4.1 and 85.8 ppm in washed samples (Table 8). Kabata-Pendias and Pendias [20] pointed out that some plant species with great tolerance to increased concentration of Cu can accumulate extremely high amounts of this metal in their tissues. In several species growing under a wide range of natural conditions, Cu contents of whole plants shoots do not often exceed 20 ppm, and, thus, this value is most often considered to indicate the threshold of excessive contents [20]. However, under both natural and man-induced conditions, the majority of plant species can accumulate much more Cu, especially in root storage tissues. Therefore, the significance of the obtained levels of Cu, especially in plants consumed by animals and humans, have to be evaluated.

Contents of Pb, Ni, Cr and Cd in the investigated plant samples, collected from the area around the superphosphate factory, are given in Table (9). Contents of Pb in the unwashed plant samples (6.00-40.18 ppm) are quite high, compared with the washed samples (0.34 to 29.53 ppm). Deposition of airborne suspended particulates emitted from the factory may cause these differences. El-Sabbagh [22] found that the cultivated vegetables in industrial Mostorod area contained Pb concentrations that vary from 4 to 259 ppm .

Levels of Ni in the unwashed sample ranged between 1.21 and 12.79 ppm, while in the washed samples showed concentrations between 0.32 and 5.08 ppm. The mean levels of Ni were found to vary from 0.1 to 1.7 ppm in grasses, 1.2 to 2.7 ppm in clovers, 0.2 to 3.7 ppm in vegetables, and from 0.2 to 0.6 ppm in wheat grains [30]. Environmental Ni pollution greatly influences the concentration of this metal in plants. In ecosystems where Ni is an airborne pollutant, plant tops are likely to concentrate the most Ni, which can be washed from the leaf surfaces quite easily [31]. This agrees well with the obtained data of Ni.

Chromium levels ranged between 3.80 and 39.41 ppm in the unwashed plant samples and between 1.12 and 15.67 ppm in washed samples. Anderson [32] reported that toxicity occurs in oats having a Cr content of 49 ppm and grown on soil containing 634 ppm Cr. Turner and Rust [33] observed initial symptoms of Cr toxicity with the addition of as little as 0.5 ppm Cr to the nutrient culture and 60 ppm to the soil culture. So, levels of Cr in plants of the studied area are still below the critical levels reported.

The concentration of Cd in unwashed samples ranged from 0.66 to 3.21 ppm. It was between 0.11 and 1.93 ppm for washed samples (Table 9). These data agree with those reported by Abdel-Mottaleb [5]. These data indicate that considerable amounts of cadmium accumulate on plant surface from dusts carried from the factory chemnies. This was reported in similar areas by El-Sabbagh [22] who found reported that levels of Cd in vegetables grown around Mostorod area ranged from 0.03 to 3.40 ppm.

It is evident that the concentration of heavy metals did not reach the toxic levels in plant tissues. This indicates that plant damage in the investigated area is not a matter of toxic concentration of heavy metals in plant tissue, but instead it seems to be the direct mechanical of dust particulates that continuously cover over ground plant organs. Similar results were obtained by Abdel-Mottaleb [5] and Abd El-Tawab [34]

However, such high concentrations of heavy metals could have undesirable effects on animals and humanbeings. Ramadan [8] pointed out that Berseem plants grown on nearby industrial Mostorod area possessed unexpected high levels of Pb and Cd. Such plants, therefore, are not suitable for grazing of feeding domestic animals. Moreover, vegetables, such as roket, mallow, spinach, turnip, onion and lettuce that contained high levels of Zn, Cu, Pb and Cd and are not suitable for human use.

Table (8): Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) contents of some plant samples collected around the superphosphate factory near Assiut city.

Location	Plant type	ppm							
		Fe		Mn		Zn		Cu	
		unwashed	washed	unwashed	washed	unwashed	washed	unwashed	washed
1	Wheat	185.6	181.9	50.2	36.2	44.0	35.2	45.2	37.3
	Onion	138.1	125.1	26.2	23.4	34.6	18.9	25.4	13.2
2	Wheat	257.1	157.4	56.4	49.7	56.8	30.4	30.2	20.9
3	Wheat	252.3	161.9	49.8	46.4	55.1	33.5	30.4	16.8
4	Cabbage	49.3	36.0	23.7	12.1	36.7	17.6	16.0	4.1
	Faba bean	1348.9	33.9	51.6	5.7	32.4	19.7	42.8	10.5
	Clover	1000.9	172.7	53.5	27.8	34.0	15.9	53.3	43.6
	Clover	953.5	422.3	51.0	45.9	39.3	22.6	57.4	36.7
	Mango	939.5	342.2	42.0	12.5	37.7	18.2	46.2	31.2
5	Faba bean	1150.1	813.1	32.3	11.2	53.7	18.7	33.4	18.9
	Lemon	2185.1	313.5	64.8	46.8	87.9	21.1	39.0	32.9
	Banana	1473.1	254.5	280.0	113.2	32.0	19.5	70.8	22.0
	Mango	1694.7	559.6	136.8	97.1	46.5	28.7	27.7	13.4
6	Jawava	512.2	312.3	230.4	214.8	38.9	28.4	90.7	76.7
7	Fig	512.1	401.9	57.8	16.3	52.9	51.9	29.9	19.1
8	Camphor	467.5	113.7	46.5	20.7	25.6	4.1	40.8	24.1
9	Lemon	630.8	448.4	49.0	47.1	52.1	19.2	87.4	20.7
	Grapes	1622.9	1082.9	89.6	78.1	46.9	23.3	49.9	36.0
10	Jawava	412.3	290.2	236.9	34.6	43.5	29.1	91.2	85.8
11	Jawava	310.1	287.6	99.3	19.6	55.8	14.1	75.5	37.4
	Grapes	623.2	533.9	50.3	19.1	57.0	14.9	45.6	36.2
12	Loofa	1017.0	480.8	89.6	75.0	24.5	23.5	32.2	27.6
	Egg plants	2054.2	436.6	77.9	67.0	80.7	35.5	80.7	79.6
13	Jawava	550.9	330.5	90.5	5.9	24.9	16.8	73.8	63.2
14	Nabak	1234.5	107.6	92.3	68.6	79.8	31.0	38.5	32.8
15	Mulberry	1463.3	434.4	110.1	67.6	24.5	12.3	49.5	23.3
16	Fig	1621.0	209.5	99.0	89.7	24.7	18.7	59.2	30.9
17	Clover	856.9	327.7	42.2	36.6	68.1	27.3	58.2	50.2
	Banana	966.4	471.5	319.5	230.5	53.9	18.3	55.2	34.1

Table (9): Lead (Pb), nickle (Ni), chromoium (Cr) and cadmium (Cd) contents of some plant samples collected around the superphosphate factory near Assiut city.

Location	Plant type	ppm							
		Pb		Ni		Cr		Cd	
		unwashed	washed	unwashed	washed	unwashed	washed	unwashed	washed
1	Wheat	21.11	18.51	6.07	1.08	10.40	2.43	1.83	0.11
	Onion	40.18	20.36	3.28	1.80	17.08	7.06	0.66	0.12
2	Wheat	11.08	9.90	3.50	1.18	8.65	4.60	1.41	0.83
3	Wheat	11.21	9.38	3.43	2.35	3.80	1.12	1.34	0.83
4	Cabbage	21.06	13.82	3.89	0.44	11.66	5.88	1.88	0.44
	Faba bean	24.90	10.27	9.62	0.91	25.19	15.28	1.19	0.36
	Clover	6.00	0.67	10.25	1.05	12.36	3.50	1.83	0.75
	Clover	7.35	1.48	11.30	1.47	7.18	4.90	1.69	1.63
	Mango	4.49	0.97	5.16	0.97	19.91	7.63	2.36	1.93
5	Faba bean	9.27	3.94	4.42	1.02	17.90	6.71	3.21	1.68
	Lemon	34.15	5.13	6.81	0.36	21.01	12.23	2.63	0.24
	Banana	20.41	2.26	4.83	0.32	20.10	10.20	1.21	0.60
	Mango	19.86	12.96	5.78	3.43	20.42	9.79	0.86	0.20
6	Jawava	26.81	16.91	5.98	5.08	39.41	4.61	2.13	0.33
7	Fig	33.62	29.53	3.85	2.93	26.15	15.67	1.80	0.91
8	Camphor	6.34	2.62	12.79	4.76	18.65	4.83	1.71	0.10
9	Lemon	21.77	4.11	8.68	4.84	21.87	14.97	2.06	1.00
	Grapes	16.45	9.74	8.33	2.43	32.12	3.08	1.32	0.38
10	Jawava	6.18	0.34	7.91	0.84	7.11	5.55	1.38	0.31
11	Jawava	16.18	15.14	5.56	0.89	13.61	5.44	2.25	0.80
	Grapes	17.06	3.56	3.56	1.08	11.07	3.11	2.51	0.82
12	Loofa	18.24	15.48	1.53	1.14	33.00	7.66	1.79	1.11
	Egg plants	16.04	6.21	4.12	1.40	19.90	11.01	1.73	0.71
13	Jawava	10.47	1.38	3.64	0.69	12.29	0.91	2.50	1.29
14	Nabak	11.58	9.45	2.99	0.60	16.34	2.68	0.99	0.45
15	Mulberry	14.34	8.91	4.46	0.69	18.67	1.52	2.28	0.87
16	Fig	29.74	2.19	2.19	0.83	12.87	6.06	2.19	1.36
17	Clover	13.35	12.34	1.21	0.49	17.45	7.83	2.97	0.37
	Banana	23.42	21.38	9.29	0.93	10.09	2.72	1.28	1.04

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تأثير التلوث على الأراضى والنباتات فى المنطقة الصناعية بالقرب من مدينة أسيوط

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قسم الأراضى والمياه – كلية الزراعة – جامعة أسيوط

تم جمع عينات تربة (سطحية وتحت سطحية) وعينات نباتية من ١٩ موقعاً فى المنطقة التى تحيط بمصنع السوبر فوسفات ، والذى يقع على بعد ٩ كم شمال مدينة أسيوط ، وذلك لتقييم الأراضى والنباتات فى هذه المنطقة من ناحية التلوث ببعض العناصر وخاصة العناصر الثقيلة .وقد قسمت كل عينة نبات إلى قسمين بحيث يتم غسيل إحداها بالماء المقطر أما الأخرى فتكون بدون غسيل .

فقد وجد فى أغلب الأحيان أن تركيز الأملاح والفوسفور المستخلص فى التربة يتناقص فى إتجاه الجنوب والجنوب الشرقى مع البعد عن المصنع مع سيادة أملاح الكالسيوم والماغنسيوم الذائبة مما يوضح أن الملوثات الرئيسية فى هذه المنطقة هى أتربة الفوسفات. كما تم التحصل على مستويات مرتفعة من الكبريت المستخلص فى هذه الأراضى قد يكون راجعاً ذلك إلى أبخرة أكاسيد الكبريت التى تنتج من المصنع . وأوضحت النتائج أيضاً احتواء أراضى هذه المنطقة الواقعة فى الجزء الجنوبى والجنوب الشرقى من المصنع على أعلى نسب من العناصر الثقيلة المستخلصة بالـ DTPA.

وقد وجدت فروق معنوية فى مستويات الفوسفور والبوتاسيوم بين عينات النبات المغسولة وغير المغسولة مع تناقص تركيزها فى النبات بالبعد عن المصنع ، وعدم وجود فروق معنوية فى مستوى الكبريت بين النباتات المغسولة وغير المغسولة .

كما أظهرت النتائج أن محتوى النباتات من العناصر الثقيلة قبل الغسيل أعلى منه بعد الغسيل . إلا أن تركيز هذه العناصر فى النبات لم تصل الى حدود السمية . كما أن معظم العناصر الثقيلة المدروسة فى النبات لم تظهر إتجاه معين فيما يتعلق بالبعد عن المصنع .