



STATUS OF SOME NUTRIENTS AND HEAVY METALS WITH RELATIONS TO THEIR BEARING MINERALS IN THE SOILS OF NILE TERRACES AT ASSIUT, EGYPT

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ABSTRACT:

Nine soil profiles were selected from various Nile terraces located south Assiut barrage at Assiut city, Egypt to a) examine levels and distributions of some available nutrients (P, K, Fe, Mn, Zn and Cu) and some heavy metals (Ni, Pb and Cd), b) clear up their relations with some physical and chemical soil properties, and c) evaluate their relations to their bearing minerals in the soils of the most recent and old Nile terraces.

Results showed soil available phosphorus values are higher in the oldest terraces on both Nile sides than in the youngest ones. However, most soil layers of the youngest Nile terraces show greater available potassium levels than the oldest ones. The recent and old Nile terraces soils exhibit very high level of P and medium amounts of K. In most cases, there are no consistent changes in the levels of either available phosphorus or potassium with depth.

Highly significant positive correlations were obtained between the available P and K and soil contents of silt, clay, organic matter and CEC. On the other hand, highly significant negative correlations were recorded with sand, pH and CaCO₃ contents. Significant positive correlations were found between the phosphorus levels and both monazite and the sum of apatite + monazite minerals. However, insignificant, positive correlations between available potassium and its bearing minerals were recorded, except the case of feldspars in the clay fraction was a highly significant, positive correlation.

The highest levels of DTPA-extractable Fe are obtained in the oldest Nile terrace soils. Whereas, extractable Mn levels are high in the youngest terraces on both Nile sides. Moreover, the soils of the youngest and oldest terraces are Fe and Mn sufficient. However, most soils of the terrace bench in the interference zone and the terrace rear suture in desert fringes are considered Fe and Mn deficient. The levels of soil extractable Cu are quite variable among the youngest and oldest Nile terraces, and all the investigated soils are Cu-nondeficient. On the other hand, most examined soils are considered Zn-deficient. No clear pattern of distributions of these investigated micronutrients was observed with depth.

Highly significant positive correlations expressed the relations between fine particles, organic matter and CEC contents and extractable Fe, Mn and Cu. However, highly significant negative correlations were observed with amounts of sand, CaCO₃ and soil pH. The DTPA-extractable Zn did not show any significant correlations with all the considered soil properties. The extractable Fe and Cu showed highly significant positive correlations with epidotes, biotite and feldspars of both sand and clay fractions. Also, the extractable Mn has significant positive correlations with epidotes, hornblende, smectites and chlorite. However, low positive correlations occurred between the extractable Zn with both hornblende and

pyroxene.

Generally, DTPA-extractable Ni and Pb are slightly higher in the youngest Nile terrace soils than in the oldest ones, without any clear trend of their distributions with depth. Moreover, the youngest and oldest Nile terraces soils contain similar very low amounts of extractable Cd. Correlations between extractable Ni and contents of clay, silt, organic matter and CEC are highly significant and positive, whereas, they are highly significant and negative with sand, pH, EC_e and $CaCO_3$ contents. The extractable Pb has significant positive correlations with the soil contents of silt, clay, and CEC, but, negative significant correlations with both sand and $CaCO_3$ contents. Slightly significant positive correlations between the extractable Ni and Pb and hornblende are recorded. Both biotite and chlorite were highly significant positive correlated to Ni.

INTRODUCTION:

Sediment transfer from continents to oceans or seas via rivers is one of the important processes regulating river-bank stabilization, soil formation, biogeochemical cycling of elements and many other earth-related processes (Chakrapani, 2005). Aswan High Dam construction and increased human activities in the Nile valley have drastically changed the chemistry and mineralogy of the river flux. Dissolved transport is a major process for Ca, K, Sr, Zn, Cu, Ni and V. Manganese, Fe and Cr are mainly carried by suspended matter. Along the course of the river, the distribution of elements in the suspended matter and sediments is generally controlled by natural processes, the relative importance of elemental transport phases, as well as the oxidation, precipitation and sedimentation of mineral species through the varying physico-chemical conditions of the environment. Pollution input in the Nile particulate load is not major, compared to the natural ones (Dekov *et al.*, 1997).

Two main sources of heavy metals in the soil include: (i) the natural background, which represents the heavy metal concentration that is derived from parent rocks, and (ii) the anthropogenic contamination, that represents the human applications of agrochemicals, organic amendments, animal manure, mineral fertilizers, industrial manufacturing wastes, domestic refuse and waste materials. Generally, there are more heavy metals in soils originated from anthropogenic sources than natural sources (Nriagu and Pacyna, 1988; Stehouwer

et al., 2000; Jjemba, 2004; Wei *et al.*, 2007; Yadav *et al.*, 2009). Iron, Zn, Cu and Ni in alluvial deposits are mainly originated from the terrestrial (rock and soil) weathering that is considered a natural source. However, Pb, Ni, Zn, Cu and Cd may come from some anthropogenic sources (Jakovljevic *et al.*, 1997; Zhou *et al.*, 2004; Jjemba, 2005; Jinling *et al.*, 2009).

There is a great diversity of possible associations of trace elements with the various substrates. These elements can be adsorbed on the particle surface of clays or organic matter and present in the lattice of secondary and primary minerals (Tessier and Campbell, 1988). The grain size and heavy minerals control the distribution of chemical elements in alluvial soils (Zhou, *et al.*, 2004). The fine sand fraction in soils is likely to have been derived from the more easily weathered minerals, which are also the main source of trace elements (Sillanpaa, 1972). The bioavailability of metals in soils is a dynamic process that depends upon specific combinations of chemical, biological, and environmental parameters (Li and Thornton, 2001; Peijnenburg and Jager, 2003; Panuccio *et al.*, 2009). Mohamed (1990) found that soil texture, mineral composition, CaCO₃, organic matter and pH were the most important factors that affect the total and available micronutrients in both alluvial and calcareous soils.

Several investigators reported the levels of various extractable nutrients and their correlations with some properties of alluvial soils (Khalil *et al.*, 1990; Amer *et al.*, 1991; El-Shazely *et al.*, 1991; Farragallah, 1995; Khalifa *et al.*,

1996; El-Desoky, and Ghallab, 2000; Ghallab, 2002; Abdel-Mawgoud and Faragallah, 2004; Faragallah and Essa, 2005; Gomah *et al.*, 2007). Few researches have been focused on the relations between various extractable nutrients and heavy metals and their bearing-minerals in alluvial soils.

The current work was carried out to (1) examine levels and distributions of available some macro- micronutrients (P, K, Fe, Mn, Cu and Zn) and some heavy metals (Ni, Pb and Cd), (2) clear up their correlations with some physical and chemical soils properties, and (3) evaluate their relations to bearing-minerals in the soils of the most recent and old Nile terraces at Assiut, Egypt.

MATERIALS AND METHODS:

Nine profiles were selected to cover various Nile terraces located south Assiut barrage, Assiut governorate. Profiles 1 and 5 represented the most recent Nile terraces in the eastern and western banks of the Nile stream, respectively. Profiles 2, 6 and 7 represented the succeeding terraces; profiles 2 and 7 are scarps of flood plain in the eastern and western sides of the Nile River, respectively. Profiles 3 and 8 represented the terrace bench or plain that located in the Nile valley-desert interference zone which they are close to the eastern and western desert, respectively. Profiles 4 and 9 represented the terrace rear suture that presented in the fringes of the eastern and western desert, respectively (Fig. 1).

Soil samples were taken from the layers of the profiles that represent the studied Nile terraces, air-dried, crushed, sieved with a 2 mm sieve and kept for physical, chemical and mineralogical analysis. The particle-size distribution of the soil samples was performed according to Piper (1950) and Jackson (1973). Organic matter in the soil samples was determined using Walkely-Black method (Jackson 1973). Soil calcium carbonate was measured by the calcimeter method, according to Nelson (1982). Soil pH was measured in a 1:1 water suspension of soil to water using a glass electrode as reported by Mclean (1982). The electrical conductivity (EC_e) was measured in the saturated soil paste extract using a conductivity meter. Soluble ions were also determined in the saturated soil paste extract using the methods of Jackson (1973). Cation exchange capacity (CEC) of the soil samples was determined using NaOAC at pH 8.2 as a saturating solution and NH₄OAC at pH 7.0 as a displacing solution, and then sodium was measured by flamephotometer (Jackson, 1973). These examined physical and chemical properties of the studied soil samples are present in Table (1).

Available P and K were extracted and determined according to Soltanpour and Schwab (1977). Available iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), nickel (Ni), lead (Pb) and cadmium (Cd) were DTPA-extracted according to the method described by Lindsay and Norvell (1978) and determined using atomic absorption (model Perkin-Elmer 1999).

Heavy and light minerals were separated from fine and very fine sand fractions (0.25 to 0.063 mm) using the procedure of Brewer (1964). These minerals were identified according to Milner (1962). Percentages of the heavy and light minerals in the fine and very fine sand fractions of the studied soil samples are given in Table (2).

The clay-size fractions were separated from the studied soil samples, prepared and investigated using X-ray diffractometer. The clay minerals were identified and their relative proportions were determined according to Schultz (1964). Relative abundance of the identified minerals in the clay fraction of the studied soil samples is present in Table (3).

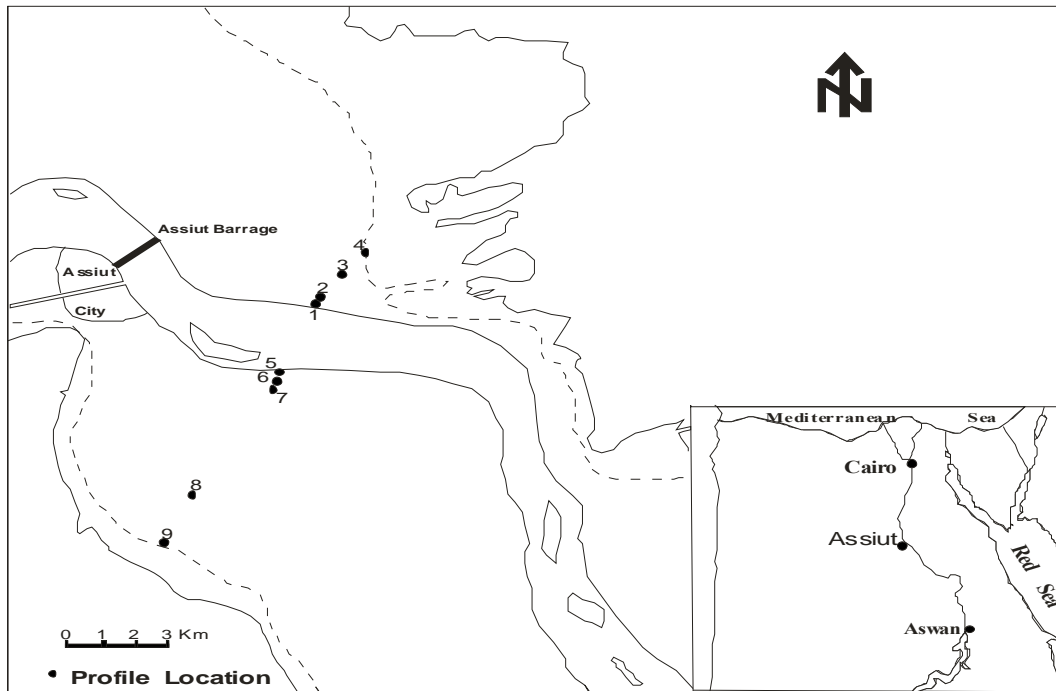


Fig. (1): Location map of the studied Nile terraces south Assiut barrage

Table 1: Some physical and chemical properties of the investigated soil profiles of the studied Nile terraces

Profile No.	Depth (cm)	Particle size distribution			Texture grade	O.M (%)	CaCO ₃ (%)	pH (1:1)	EC _e dsm ⁻¹	Soluble cations (meq/l)				Soluble anions (meq/l)			CEC (Cmol ⁺ /kg)
		Sand (%)	Silt (%)	Clay (%)						Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	Cl ⁻	HCO ₃ ⁻	SO ₄ ⁻	
1	0 - 15	41.86	35.23	22.91	Loam	1.90	3.89	8.03	0.91	5.74	2.46	0.28	0.43	3.56	1.80	3.50	34.90
	15 - 25	36.35	28.75	34.90	Clay loam	1.52	3.31	8.01	0.85	4.06	3.88	0.18	0.22	2.95	3.60	2.00	40.15
	25 - 35	41.29	34.77	23.94	Loam	1.89	2.48	8.12	0.66	4.28	1.83	0.23	0.17	2.66	2.25	1.50	30.86
	35 - 70	30.88	34.10	35.02	Clay loam	1.62	3.73	8.06	0.52	3.06	1.83	0.13	0.18	1.84	2.25	1.00	36.99
2	0 - 40	31.96	37.36	30.68	Clay loam	2.78	3.06	8.05	0.82	5.12	2.46	0.23	0.41	3.51	2.66	2.00	34.86
	40 - 70	35.91	32.84	31.25	Clay loam	1.79	2.48	8.22	0.98	6.12	3.28	0.30	0.15	2.66	3.60	3.50	42.93
	70 - 95	47.22	15.35	37.43	Sandy clay	2.09	4.97	7.83	1.17	8.20	3.06	0.34	0.13	3.81	4.05	4.00	36.56
	95 - 195	38.34	32.04	29.62	Clay loam	1.87	4.14	7.99	0.88	6.12	2.46	0.06	0.11	2.95	2.25	3.50	37.10
	195 - 235	32.40	42.87	24.73	Loam	1.98	3.31	7.95	0.63	4.28	1.64	0.34	0.09	2.66	2.66	1.00	38.40
3	0 - 35	60.39	20.80	18.81	Sandy loam	1.81	14.90	8.30	0.74	3.06	3.28	0.32	0.53	3.09	2.25	2.00	32.63
	35 - 55	68.91	9.85	21.24	Sandy clay loam	0.95	17.40	8.39	0.57	4.10	1.22	0.17	0.25	1.84	2.60	1.50	31.46
	55 - 70	86.41	2.68	10.91	Loamy sand	0.63	22.60	8.48	0.48	3.06	1.46	0.15	0.18	1.12	2.25	1.50	38.65
	70 - 150	87.49	4.11	8.40	Loamy sand	0.73	25.60	8.52	0.52	2.46	2.46	0.16	0.22	1.84	2.25	1.00	26.89
4	0 - 20	93.23	2.42	4.35	Sand	0.52	25.70	8.57	2.71	13.10	2.95	11.40	0.17	15.40	3.60	8.00	21.11
	20 - 35	74.49	10.10	15.41	Sandy loam	0.07	33.10	8.61	5.77	26.40	3.11	27.50	0.36	27.40	6.30	21.00	19.91
	35 - 150	43.64	51.06	5.30	Silt loam	0.87	29.00	8.17	1.44	10.70	2.64	1.29	0.18	8.82	2.25	3.50	21.16
5	0 - 20	40.07	37.76	22.17	Loam	2.36	2.48	8.15	0.98	5.88	3.34	0.37	0.37	5.33	2.66	2.00	33.66
	20 - 35	34.22	31.20	34.58	Clay loam	1.38	2.07	8.04	0.94	5.74	3.28	0.27	0.22	5.19	2.25	2.00	41.83
	35 - 65	40.46	34.58	24.96	Loam	1.34	1.66	8.14	0.57	2.44	2.46	0.60	0.12	2.55	1.80	1.50	34.14
6	0 - 45	40.5	29.77	29.73	Clay loam	2.42	2.07	8.29	0.99	4.28	4.88	0.70	0.09	4.12	3.60	2.00	37.10
	45 - 80	46.41	25.81	27.78	Sandy clay loam	1.76	2.48	8.24	0.88	4.88	3.28	0.51	0.18	3.09	4.05	1.50	37.35
7	0 - 40	40.97	28.74	30.29	Clay loam	2.75	3.48	7.81	1.27	7.84	4.10	0.54	0.21	6.39	3.60	3.00	36.25
	40 - 70	31.45	39.93	28.63	Clay loam	1.10	2.40	8.39	0.52	2.44	2.44	0.21	0.06	2.66	1.80	1.00	36.16
	70 - 120	42.43	34.04	23.53	Loam	1.81	4.97	8.26	0.95	5.56	3.28	0.27	0.08	3.12	4.05	2.00	34.01
	120 - 155	45.96	32.14	21.91	loam	2.34	1.66	8.30	0.81	6.72	1.22	0.24	0.10	3.09	4.50	1.00	37.12
8	0 - 50	62.80	6.63	30.57	Sandy clay loam	2.56	15.55	8.24	0.75	4.28	2.44	0.33	0.11	2.55	3.40	1.50	35.27
	50 - 70	84.85	2.24	12.91	Loamy sand	0.63	38.20	8.48	0.52	2.46	2.46	0.22	0.06	1.84	2.25	1.00	23.33
	70 - 85	91.57	3.25	5.18	Sand	0.42	41.40	8.55	0.91	5.44	2.46	1.02	0.10	3.49	3.45	2.00	23.97
	85 - 150	94.37	2.62	3.01	Sand	0.70	25.30	8.50	1.14	6.12	4.88	0.27	0.14	6.39	3.60	1.50	30.10
9	0 - 10	40.53	37.12	22.35	Loam	0.73	33.10	8.17	2.82	20.50	5.74	1.37	1.32	11.00	4.05	13.00	25.80
	10 - 35	93.05	2.35	4.61	Sand	0.59	45.60	8.09	3.61	29.50	4.10	1.24	1.47	5.49	3.60	26.00	19.24
	35 - 150	90.77	5.71	3.52	Sand	0.78	36.40	8.39	1.73	13.10	2.46	0.87	1.01	3.09	2.25	12.00	21.46

Table 2: Percentages of minerals in heavy and light fractions of the fine and very fine sand of the studied soils

Profile No.	Depth (cm)	Heavy Minerals (%)															Light Minerals (%)				
		Op-ques	Epi-dotes	Pyro-xenes	Amph-iboles	Aug-ite	Horn-blend	Sph-ene	Ru-tile	Gar-net	Zir-con	Tour-maline	Mon-azite	Stur-olite	Bio-tite	Apa-tite	Kya-nite	Qua-rtz	Feld-spars	Micro-cline	Cal-cite
1	0 - 15	46.47	17.1	11.15	7.43	8.18	5.58	2.23	0.74	0.74	0.37	0.37	1.12	1.12	9.29	1.49	0.37	95.77	4.11	0.55	0.12
	15 - 25	53.79	17.6	7.87	9.68	6.99	7.92	1.88	0.29	0.29	0.59	0.00	0.59	0.29	3.88	2.38	0.88	95.85	4.15	0.64	0.00
	25 - 35	50.67	8.97	14.8	11.66	11.66	6.73	2.24	0.90	0.90	0.90	0.45	1.35	0.90	4.04	1.35	0.90	93.24	6.76	1.17	0.00
	35 - 70	43.42	19.08	15.13	9.87	12.5	6.58	5.26	1.32	0.66	0.66	0.66	0.66	0.66	2.63	0.00	0.00	97.72	2.28	0.33	0.00
2	0 - 40	39.39	12.12	15.76	9.7	10.91	7.88	7.27	1.21	2.42	1.21	1.21	1.21	0.61	6.06	1.21	0.61	97.13	2.63	0.53	0.24
	40 - 70	53.13	7.81	7.81	7.81	3.91	5.47	2.34	1.56	1.17	1.17	1.56	1.17	0.78	11.72	1.56	0.39	98.52	1.48	0.25	0.00
	70 - 95	39.77	14.77	9.66	7.39	7.39	5.68	3.98	1.14	1.70	1.70	0.57	2.84	1.14	11.36	2.27	1.70	98.21	1.57	0.39	0.22
	95 - 195	47.3	13.51	9.46	10.14	7.43	6.76	3.38	1.35	1.35	0.68	0.68	2.03	0.68	6.76	2.03	0.68	96.15	3.85	0.64	0.00
	195-235	54.55	16.36	6.36	8.18	5.45	6.36	1.82	0.91	0.91	1.82	0.91	2.73	0.91	4.55	0.00	0.00	97.05	2.95	0.42	0.00
3	0 - 35	54.95	8.79	14.29	8.79	10.99	6.59	2.20	1.10	4.94	0.55	1.10	1.10	1.10	0.00	0.00	1.10	88.54	2.27	0.32	9.18
	35 - 55	58.39	9.49	14.6	10.22	8.76	5.84	0.73	2.19	0.73	0.73	0.00	0.73	0.73	0.00	0.73	0.00	84.91	1.10	0.37	13.99
	55 - 70	40.27	16.78	20.13	12.75	11.41	6.71	2.01	2.68	3.36	1.34	0.00	0.00	0.67	0.00	0.00	0.00	81.52	0.36	0.00	18.12
	70 - 150	41.24	13.4	16.49	17.53	7.22	10.31	3.09	2.06	3.09	2.06	0.00	1.03	0.00	0.00	0.00	0.00	82.10	1.48	0.00	16.42
4	0 - 20	62.83	7.85	9.42	10.47	8.38	6.28	2.09	0.52	1.57	2.62	1.05	0.00	1.05	0.00	0.00	0.52	67.02	0.80	0.27	32.17
	20 - 35	62.83	9.95	11.52	5.76	8.9	4.71	2.62	2.62	2.09	1.57	0.52	0.00	0.52	0.00	0.00	0.00	66.84	1.07	0.27	32.09
	35 - 150	54.64	9.84	14.21	13.11	10.93	9.29	1.09	1.09	0.55	2.73	1.09	0.55	0.55	0.00	0.55	0.00	55.28	0.75	0.25	43.97
5	0 - 20	34.48	21.67	16.75	17.73	12.32	14.78	2.46	0.99	0.49	0.49	0.49	0.99	0.49	1.97	0.49	0.49	95.00	4.75	0.25	0.25
	20 - 35	44.64	8.93	11.61	8.04	8.93	6.25	5.36	1.79	0.89	0.89	0.89	2.68	1.79	8.93	1.79	1.79	97.22	2.78	0.28	0.00
	35 - 65	42.25	18.59	15.49	11.55	12.68	8.45	1.69	0.56	0.28	0.56	0.00	0.56	0.28	5.63	1.69	0.85	96.62	3.14	0.24	0.24
6	0 - 45	46.15	15.38	16.54	9.23	11.54	7.69	1.92	0.38	0.77	1.54	0.00	0.77	0.38	5.77	0.38	0.77	98.04	1.96	0.33	0.00
	45 - 80	44.22	12.56	13.57	14.07	5.03	7.54	5.03	0.50	0.29	2.22	0.00	1.51	0.00	5.03	1.01	0.00	98.04	1.96	0.28	0.00
7	0 - 40	41.37	12.59	18.71	14.03	8.99	10.79	3.60	1.44	0.36	2.16	0.00	0.72	0.36	3.60	0.72	0.36	95.95	3.41	0.21	0.64
	40 - 70	47.7	13.16	13.49	11.51	10.86	9.87	3.29	0.99	0.33	1.97	0.66	1.64	0.99	2.63	0.99	0.66	95.99	4.01	0.35	0.00
	70 - 120	54.89	11.89	6.58	6.58	5.26	6.58	7.89	1.32	1.32	2.63	0.00	1.32	0.00	6.58	0.00	0.00	93.06	5.86	0.72	1.08
	120-155	50	9.38	9.38	12.5	6.25	9.38	3.75	1.25	0.63	2.50	0.00	0.63	0.63	9.38	0.00	0.00	97.40	1.95	0.32	0.65
8	0 - 50	62.21	9.22	12.9	6.45	11.52	5.99	2.76	1.84	0.00	2.30	0.46	0.00	0.00	0.92	0.92	0.00	82.52	1.29	0.32	16.18
	50 - 70	61.48	9.84	10.25	5.74	5.33	4.51	2.05	1.23	4.10	2.46	1.23	1.23	0.00	0.00	0.00	0.41	64.50	0.54	0.00	34.96
	70 - 85	50.00	7.00	19.00	3.00	11.00	3.00	7.00	4.00	7.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	65.07	0.88	0.00	34.05
	85 - 150	57.88	17.68	8.04	4.5	4.82	4.18	3.22	2.57	2.25	1.93	1.29	0.00	0.00	0.64	0.00	0.00	73.21	0.68	0.00	26.12
9	0 - 10	45.59	12.16	12.77	13.98	9.12	9.42	3.04	2.74	2.13	3.04	1.52	0.91	0.61	0.61	0.30	0.61	74.74	1.05	0.00	24.21
	10- 35	51.81	9.84	15.54	10.36	10.36	7.77	2.07	1.04	0.78	3.11	2.59	0.78	1.04	0.52	0.52	0.00	66.11	0.47	0.23	33.42
	35 -150	62.22	4.44	9.78	8.00	7.56	4.89	4.44	1.78	4.00	3.56	0.89	0.44	0.44	0.00	0.00	0.00	51.20	0.60	0.30	48.19

Table 3: Relative abundance of the identified minerals in the clay fraction of the studied soils

Profile No.	Depth (cm)	Smectites	Kaolinite	Mixed micas-sme	Vermiculite	Chlorite	Sepiolite	Palygorskite	Mixed micas-verm.	Micas	Pyrophyllite	Quartz	K-Feldspar	Calcite	Plagioclase
1	0 - 15	27.44	6.51	5.66	6.79	6.36	3.11	2.12	2.26	1.41	0.28	20.23	12.16	4.24	1.41
	15 - 25	35.28	6.24	2.99	7.46	6.11	2.71	2.04	1.90	0.54	0.41	12.08	15.06	4.48	2.71
	25 - 35	40.76	5.37	13.42	0.00	2.58	3.20	3.10	1.55	2.06	0.31	10.94	9.29	4.13	3.30
	35 - 70	33.76	7.77	12.41	0.00	1.94	2.37	3.45	1.40	3.34	0.65	12.94	11.87	4.31	3.78
2	0 - 40	25.72	6.24	11.11	4.99	5.87	2.00	3.12	1.87	2.75	1.25	16.48	13.48	3.50	1.62
	40 - 70	28.97	4.49	11.90	7.34	6.35	2.48	2.48	1.69	2.78	1.09	10.89	12.80	5.26	1.49
	70 - 95	29.74	7.03	12.25	5.72	4.58	2.29	0.98	1.14	1.96	0.65	14.05	13.07	4.90	1.63
	95 - 195	33.37	8.58	3.22	4.29	3.97	3.22	3.00	2.36	0.54	0.43	13.95	14.81	6.44	1.82
	195-235	40.63	8.34	2.94	8.34	3.34	3.93	2.36	2.75	2.06	0.98	10.60	7.75	4.51	1.47
3	0 - 35	31.50	6.76	2.71	5.31	4.64	2.90	3.86	2.22	0.97	0.48	12.56	5.80	18.36	1.93
	35 - 55	21.60	6.00	10.84	3.69	2.92	5.46	4.23	5.38	1.54	0.77	9.45	3.38	20.75	4.00
	55 - 70	25.81	5.60	2.55	3.90	4.58	1.70	2.72	1.70	0.85	0.85	9.00	3.40	35.65	1.70
	70 - 150	16.63	5.65	7.36	3.41	2.67	5.22	3.94	4.80	1.17	0.75	8.00	3.84	33.05	3.52
4	0 - 20	19.24	10.87	7.90	5.11	4.18	3.72	3.07	2.79	2.51	0.46	10.22	3.90	24.16	1.86
	20 - 35	21.61	10.59	14.15	4.83	3.98	3.22	2.54	5.68	0.85	0.68	10.59	3.22	16.53	1.53
	35 - 150	19.39	11.40	1.18	6.35	5.17	4.00	4.70	2.59	1.18	0.82	10.58	5.05	25.85	1.76
5	0 - 20	38.17	5.65	3.14	6.27	5.20	2.51	1.61	1.88	1.70	0.45	15.23	11.65	4.75	1.79
	20 - 35	36.35	6.04	1.89	5.41	4.15	3.27	2.14	2.52	2.77	0.63	16.35	9.06	7.17	2.26
	35 - 65	39.05	7.91	4.82	6.27	4.82	2.89	3.86	1.93	0.48	0.48	12.05	7.71	5.30	2.41
6	0 - 45	22.41	6.11	13.45	7.33	5.70	2.44	1.79	2.77	2.44	0.41	15.16	11.74	6.60	1.63
	45 - 80	31.62	5.78	8.83	6.42	4.82	2.73	2.89	4.09	2.65	0.64	14.85	8.83	4.25	1.61
7	0 - 40	30.76	4.66	2.00	5.99	4.79	1.86	1.33	1.60	1.60	0.67	19.44	14.65	7.99	2.66
	40 - 70	34.38	4.76	2.72	0.00	3.67	1.36	0.68	0.82	0.68	0.68	22.42	15.90	9.24	2.72
	70 - 120	23.51	6.97	11.06	7.71	6.32	3.35	2.23	2.79	3.07	0.56	15.80	10.32	4.37	1.95
	120-155	34.61	6.92	11.36	0.00	4.55	1.86	1.76	0.00	2.07	0.41	19.32	11.47	3.82	1.86
8	0 - 50	52.73	7.58	2.96	0.00	1.66	2.37	0.95	0.00	0.83	0.59	12.80	7.70	7.46	2.37
	50 - 70	40.86	5.69	3.49	6.50	4.55	3.09	2.27	2.60	2.19	0.41	7.72	3.01	14.46	3.17
	70 - 85	34.42	8.82	12.68	0.00	1.68	2.27	3.36	0.00	2.10	0.34	6.80	1.34	23.51	2.69
	85 - 150	26.47	8.60	10.02	4.73	3.78	1.98	1.89	3.78	0.95	0.38	6.43	1.89	27.41	1.70
9	0 - 10	24.53	7.95	1.69	3.55	2.88	3.38	2.20	3.05	1.35	0.68	17.94	5.41	22.84	2.54
	10 - 35	21.49	9.06	1.90	2.92	2.34	2.19	1.90	1.90	1.02	0.44	15.64	5.85	31.43	1.90
	35 - 150	14.79	10.17	9.52	4.16	3.70	2.59	4.34	2.22	1.66	0.74	13.40	4.53	25.97	2.22

RESULTS AND DISCUSSIONS:

I-Available nutrients:

1-Phosphorus:

The available phosphorus in the soil samples of the studied profiles is present in Table (4). The results indicated that the available phosphorus varies from 14.84 to 54.68 ppm. Most layers of the soils of recent and old Nile terraces show greater P concentrations than those of the terrace bench in the interference zone and those of the terrace rear suture in desert fringes on both Nile sides, indicating that Nile sediment-derived soils are characterized by high contents of phosphorus. In general, the soils of the oldest terraces on both Nile sides have higher values of available phosphorus than those of the youngest ones, particularly in the surface layers. This could be due to the surface applications of organic and inorganic phosphate fertilizers during cultivating the soils of the oldest terraces on both Nile sides.

In most cases, there are no consistent changes in the available phosphorus in the studied soils with depth as shown in Figure (2). This reflects the nature of sediments forming these soil profiles and their role in affecting its chemical composition.

All the studied soils of the recent and old Nile terraces show a very high level of phosphorus (>21ppm), according to Cook (1967). However, most soil layers of the terrace bench in the interference zone and of the terrace rear suture in desert fringes on both Nile sides exhibit moderate to high values of available P (13-20 ppm). For the oldest Nile terrace soils, the sediment nature as well as the application of mineral fertilizers and

the organic residues are possibly the cause for the very high available P values obtained. Phosphorus-bearing minerals in desert could be the source for the obtained P values. These results are in agreement with those of Farragallah (1995) and Abdel-Mawgoud and Faragallah (2004).

The relationships between soil available phosphorus and particle size distribution as well as some chemical properties have been statistically studied as correlation coefficients (r values) (Table 5). The highest positive correlation coefficient ($r=+0.755^{**}$) was recorded between the sum of silt+clay fractions and available phosphorus. However, the highest negative correlation coefficient ($r=-0.755^{**}$) occurred with sand fraction. Such results are in accordance with those of Amer *et al.* (1991), Eden and Parfitt (1992), Awadalla (1993) and Faragallah (1995).

Highly significant positive correlations were recorded between each of clay, silt, organic matter and CEC and available phosphorus. However, highly significant negative correlations were obtained between soil CaCO_3 as well as pH and available P (Table 5). Insignificant correlation was observed between salinity content (EC_e) of the studied soils and available P with very low negative correlation ($r=-0.130$). Most of these results agree with those reported by Awadalla (1993) and Faragallah (1995).

Concerning, the relationship between available phosphorus and its bearing-minerals in the studied soils, correlation coefficients between the concentration of available P and the percentages of apatite, monazite and apatite + monazite were calculated and are given in Table

(6). The results showed that significantly positive correlations are between the available phosphorus and both monazite ($r=+0.319^*$) and the sum of apatite+monazite ($r=+0.350^*$). However, low positive correlation is found between available P and the percentages of apatite ($r=+0.280$). These data suggest that monazite could be the possible source of available P in the uncultivated soils of the youngest Nile terraces on river border and the terrace rear suture in the desert fringes. Moreover, the phosphorus bearing minerals as well as the organic and inorganic fertilizers added through cultivation practices could be the main source of available P in the cultivated soils of the oldest Nile terraces.

2-Potassium:

The available potassium in the studied soil profiles is shown in Table (4) and graphically presented in Figure (3). The results generally indicated clear variations in the available K among various layers and sites. Most soil layers of the youngest Nile terraces show a greater K concentration than the oldest ones, but the surface layers of the oldest terraces have the highest amounts of available potassium. According to Metson (1961), most layers of youngest terrace soils show medium amounts of K (205.04 - 293.50 ppm) on both Nile sides. However, most layers of oldest terrace soils exhibit low to medium amounts of K (155.68 -256.50 ppm). The surface layer of the oldest terraces soils on eastern and western Nile sides show very high amounts of K (571.20 and 474.51 ppm, respectively). On the other hand, most soil layers of the terrace bench in the interference zone and the terrace rear

suture in desert fringes on both Nile sides have relatively low values of available K (48.71 - 186.50 ppm). No specific pattern of potassium distribution with depth is evident (Figure 3). The nature of sediments and the fertilizer applications could be the reason for enriching the surface soil with K^+ . Similar results were obtained by El-Hadedy (1976), Faragallah (1995) and Abdel-Mawgoud and Faragallah (2004).

The correlation coefficients between available potassium and some physical and chemical properties of the soils under study are given in Table (5). Highest positive correlation coefficients were recorded between clay and organic matter contents ($r=+0.643^{**}$ and $+0.673^{**}$, respectively) and the available potassium concentration. On the other hand, the available K showed a highest negative correlation ($r=-0.541^{**}$) with the sand fraction.

Highly significant, positive correlations were obtained between the available K and contents of silt, clay+silt and CEC ($r=+0.400^{**}$, $+0.565^{**}$ and $+0.421^{**}$, respectively). However, highly significant, negative correlations were recorded between the available K and both soil pH and $CaCO_3$ content ($r=-0.599^{**}$ and -0.510^{**} , respectively). Insignificant negative correlation coefficient was found between available K and soil salinity (Table 5). The same trends reported by Abou-El-Roos (1972), Kabata-Pendias and Pendias (1984) and Faghmi *et al.* (1985).

Regarding the relation between the available potassium and its bearing minerals, correlation coefficients between levels of available K and the percentages of microcline, feldspars and biotite in sand fraction as well as feldspars, smectites, and

micas in clay fraction were calculated and present in Table (6). A highly significant, positive correlation was only obtained between the available K and the k-feldspar content of the clay fraction ($r=+0.540^{**}$). In all cases, correlation values are positive and insignificant. Accordingly, the role of microcline and biotite (sand fraction) as well as smectites, and micas (clay fraction) in affecting available K is not clearly expressed. The relatively high K levels in the cultivated oldest Nile terrace soils could be attributed to agricultural practices rather than due to K-bearing minerals. The uncultivated soils of youngest Nile terraces on river border and the terrace rear suture in the desert fringes have relatively high values of available K due to the total native amounts that have not been yet used by cropping.

Table 4: Available phosphorus (P) and potassium (K) in soil samples of the studied Nile terraces

Profile No.	Depth (cm)	P	K	Profile No.	Depth (cm)	P	K
		(ppm)				(ppm)	
1	0 - 15	43.22	227.70	5	0 - 20	48.92	281.15
	15 - 25	48.29	256.50		20 - 35	43.6	272.92
	25 - 35	39.20	293.50		35 - 65	40.99	205.04
	35 - 70	49.97	412.80	6	0 - 45	38.25	192.70
2	0 - 40	54.68	571.20		45 - 80	42.57	180.36
	40 - 70	37.71	198.90	7	0 - 40	54.43	474.50
	70 - 95	28.04	256.50		40 - 70	51.32	155.68
	95 - 195	26.30	190.60		70 - 120	40.24	69.28
195- 235	48.79	221.50	120- 155		32.65	205.04	
3	0 -35	38.08	366.75	8	0 -50	25.18	295.55
	35 -55	39.83	166.00		50 -70	18.70	75.45
	55 -70	20.95	131.00		70 -85	13.84	56.94
	70 -150	20.20	178.30		85 -150	20.93	48.71
4	0 - 20	35.24	65.17	9	0 - 10	36.63	279.41
	20 - 35	36.94	186.50		10 - 35	20.04	114.54
	35 - 150	20.93	71.34		35 - 150	20.54	126.88

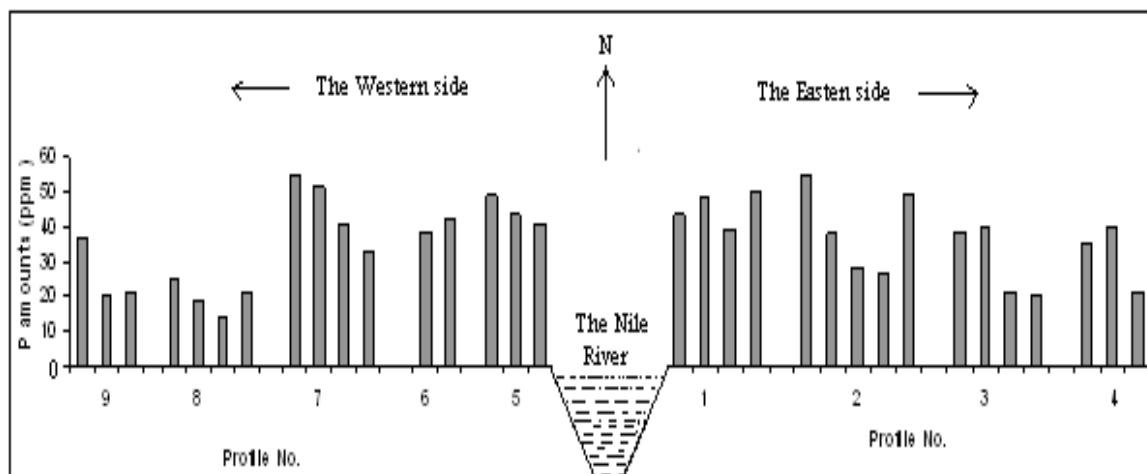


Fig. 2: Distribution of available phosphorus in the soil profiles with distance from the Nile border to the desert on both sides

Table 5: Correlation coefficients (r values) of available P and K and some soil properties

Soil property	r value	
	Phosphorus	Potassium
Sand (%)	-0.755**	-0.565**
Silt (%)	+0.655**	+0.400**
Clay (%)	+0.689**	+0.643**
Silt + Clay (%)	+0.755**	+0.565**
Organic matter (%)	+0.555**	+0.673**
CaCO ₃ (%)	-0.740**	-0.510**
pH (1:1)	-0.492**	-0.599**
EC _e (dsm ⁻¹)	-0.130	-0.157
CEC (Cmol ⁺ /kg)	+0.545**	+0.436**

Table 6: Correlation coefficients of available phosphorus and potassium and their bearing minerals of the studied soils

Nutrient (ppm)	Mineral (%)	"r" value
Phosphorus	Apatite	+0.280
	Monazite	+0.319*
	Apatite + Monazite	+0.350*
Potassium	Microcline	+0.278
	Biotite	+0.255
	K-feldspars (clay fraction)	+0.540**
	Smectites	+0.281
	Micas	+0.160

* Significant at the 5% level.

** Significant at the 1% level.

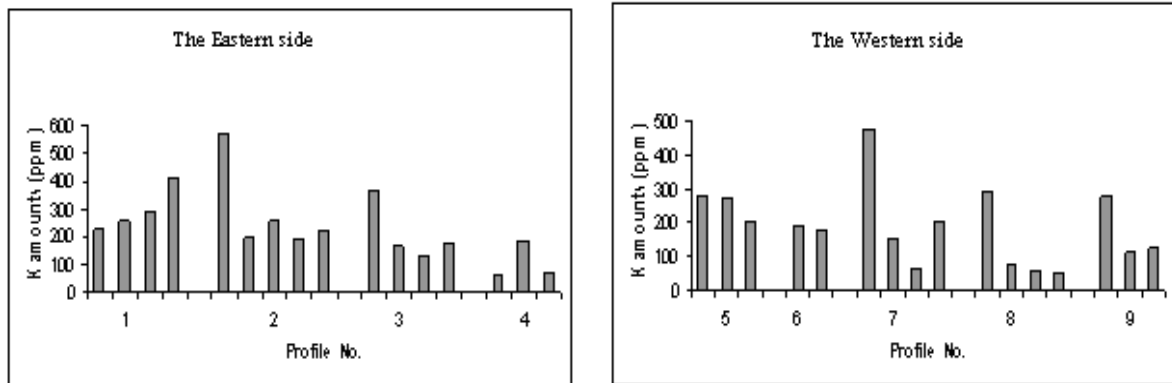


Fig. 3: Distribution of available potassium in the soil profiles with distance from the Nile border to the desert on both sides

3-Iron:

The DTPA-extractable Fe of the soil samples of the studied Nile terraces are present in Table (7) and graphically illustrated in Figure (4). Generally, it ranges between 1.33 and 36.72 ppm. In soil samples representing the youngest and oldest Nile terraces, the extractable Fe ranges from 19.91 to 36.72 ppm. The highest levels of DTPA-extractable Fe are obtained in the oldest Nile terraces soils. According to the limits of Viets and Lindsay (1973), all samples of the youngest and oldest Nile terraces soils and most soil layers of the terrace bench in the interference zone contain adequate amounts of available Fe (>4.5 ppm). However, most soil samples of the terrace rear suture in desert fringes on both Nile sides are deficient (<2.5 ppm) to marginal (2.5-4.5 ppm) with respect to the extractable Fe. Similar results were reported by Abdellah (1984), Amer *et al.* (1991), Faragallah (1995), Abdel-Mawgoud and Faragallah (2004) and Faragallah and Essa (2005).

No clear distribution pattern of the available Fe can be observed in all studied sites, especially in the case of youngest and oldest Nile terraces soils (Figure 4).

The correlation coefficients (*r* values) between the DTPA-extractable Fe and some soil properties of the studied samples are given in Table (8). The fine particles (clay and the sum of clay+ silt) showed the highest positive correlations with the extractable Fe ($r=+0.811^{**}$ and $+0.833^{**}$, respectively). On the other hand, the sand fraction was negatively correlated to the extractable Fe ($r=-0.833^{**}$). Highly significant,

positive correlations showed the relations between the organic matter content and CEC of the studied soil samples and the DTPA-extractable Fe ($r=+0.691^{**}$ and $+0.784^{**}$, respectively). However, highly significant negative correlations between both calcium carbonate content and soil pH and the DTPA-extractable Fe were obtained ($r=-0.858^{**}$ and -0.581^{**} , respectively). A significant negative correlation was recorded between the soil EC_e and the DTPA-extractable Fe (Table 8). Such trends were also found by Rabie *et al.* (1989), Amer *et al.* (1991), Awadalla (1993) and Faragallah (1995).

Respecting the relation between the DTPA-extractable iron and its bearing minerals (opaques, epidotes, amphiboles, pyroxenes, biotite and feldspars according to Wedepohl, 1974 and Dress and Wilding, 1978, as well as smectites, chlorite, sepiolite, palygorskite, micas and vermiculite according to Duane and Robert, 1989 and Velde, 1992), the correlation coefficients between them were calculated and listed in Table (9). The data reveal that highly significant positive correlations between the extractable Fe and biotite ($r=+0.817^{**}$) and feldspars of the sand fraction ($r=+0.615^{**}$) as well as feldspars of the clay fraction and smectites ($r=+0.749^{**}$ and $+0.425^{**}$, respectively). A significantly positive correlation is found between the extractable Fe and both epidotes ($r=+0.335^*$) and chlorite ($+0.375^*$), but low positive correlations were recorded with amphiboles ($r=+0.149$), micas ($+0.292$) and vermiculite ($+0.167$), indicating the role of these minerals as a source for iron in the studied soils.

Table 7: DTPA-extractable Fe, Mn, Cu and Zn in the soil samples of the studied Nile terraces

Profile No.	Depth (cm)	Fe	Mn	Cu	Zn	Profile No.	Depth (cm)	Fe	Mn	Cu	Zn
		(ppm)						(ppm)			
1	0 - 15	23.79	7.67	2.41	0.4	5	0 - 20	24.93	8.78	2.45	0.79
	15 - 25	21.71	8.54	2.39	0.39		20 - 35	25.79	8.57	2.89	1.43
	25 - 35	28.62	3.43	1.58	0.31		35 - 65	26.04	7.08	2.77	0.38
	35 - 70	23.08	4.16	2.56	0.45	6	0 - 45	31.10	4.46	2.84	1.69
2	0 - 40	19.91	4.73	1.96	0.66		45 - 80	29.81	6.44	2.45	0.52
	40 - 70	36.72	3.56	2.07	0.42	7	0 - 40	20.52	1.61	2.08	0.31
	70 - 95	29.33	3.61	3.20	0.4		40 - 70	26.67	1.74	2.10	0.38
	95 - 195	32.70	2.69	2.96	0.37		70 - 120	26.79	1.08	2.40	0.32
195-235	33.26	2.23	3.44	0.58	120-155		35.32	1.51	2.67	0.67	
3	0 - 35	13.37	5.84	1.44	1.19	8	0 - 50	12.41	4.25	1.88	0.46
	35 - 55	8.24	1.26	0.82	0.75		50 - 70	6.30	0.52	0.68	0.34
	55 - 70	8.41	1.16	0.93	1.20		70 - 85	3.76	1.93	0.41	0.18
	70 - 150	6.37	0.37	0.41	0.22		85 - 150	4.24	2.00	0.71	0.39
4	0 - 20	1.80	0.17	0.23	0.16	9	0 - 10	20.46	4.78	1.39	1.52
	20 - 35	9.01	0.97	0.72	0.47		10 - 35	3.68	3.12	0.21	0.19
	35 - 150	1.33	4.82	0.27	0.56		35 - 150	1.48	0.31	0.20	0.12

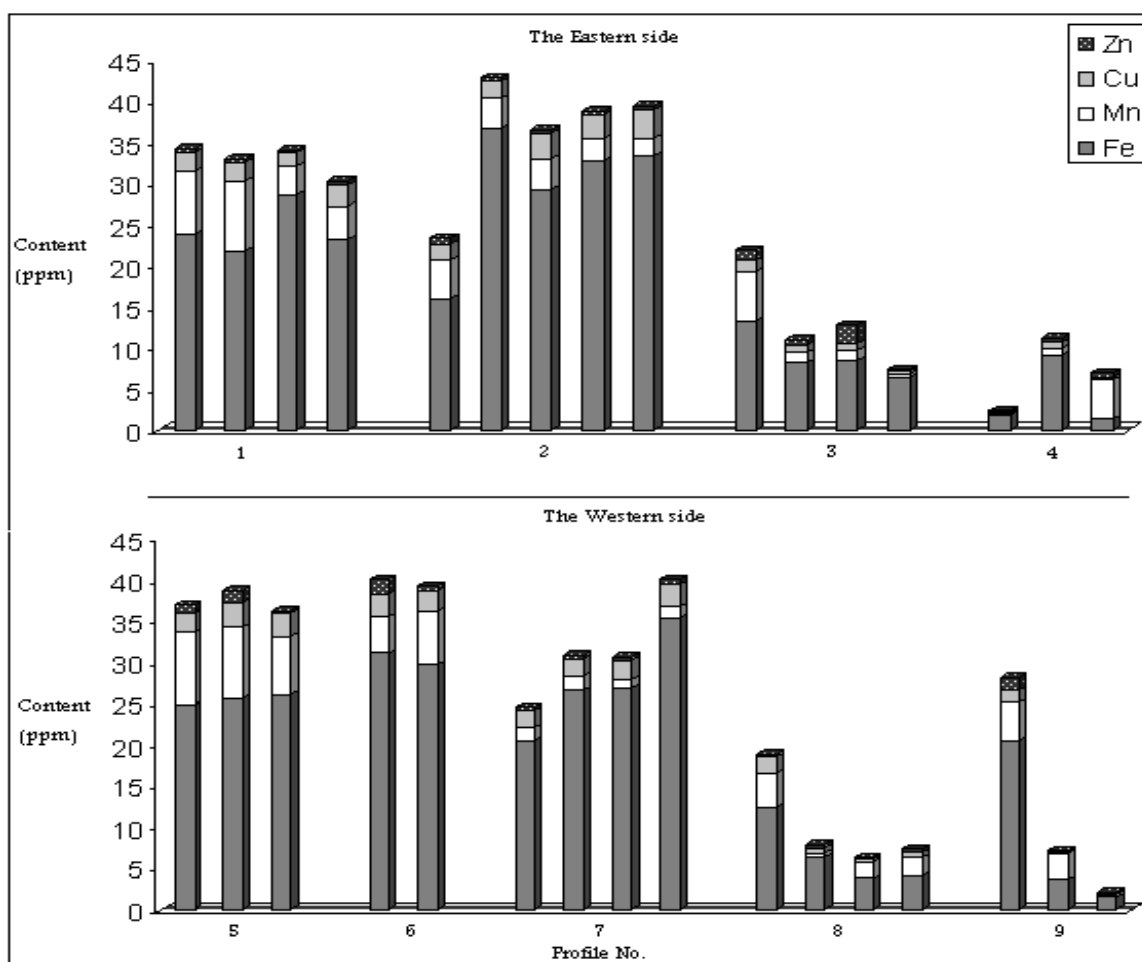


Fig. 4: Distribution of DTPA-extractable Fe, Mn, Cu and Zn in the soil profiles with distance from the Nile border to the desert on both sides

Table 8: Correlation coefficients (r values) of DTPA-extractable Fe, Mn, Cu and Zn and some soil properties

Soil property	r value			
	Fe	Mn	Cu	Zn
Sand (%)	-0.833**	-0.565**	-0.824**	-0.289
Silt (%)	+0.688**	+0.512**	+0.636**	+0.251
Clay (%)	+0.811**	+0.486**	+0.863**	+0.264
Silt + Clay (%)	+0.833**	+0.565**	+0.824**	+0.289
Organic matter (%)	+0.691**	+0.392*	+0.743**	+0.164
CaCO ₃ (%)	-0.858**	-0.463**	-0.877**	-0.176
pH (1:1)	-0.581**	-0.522**	-0.681**	-0.057
EC _e (dsm ⁻¹)	-0.338*	-0.190	-0.400**	-0.059
CEC (Cmol ⁺ /kg)	+0.784**	+0.424**	+0.830**	+0.318*

Table 9: Correlation coefficients of DTPA-extractable Fe, Mn, Cu and Zn and their bearing-minerals in the studied soils

Nutrient	Mineral	R Value	Nutrient	Mineral	R Value
Fe	Opauques	-0.453**	Mn	Chlorite	+0.339*
	Epidotes	+0.335*		Smectites	+0.357*
	Amphiboles	+0.149		Sepiolite	-0.103
	Pyroxenes	-0.256		Palygorskite	-0.103
	Biotite	+0.817**		Micas	-0.034
	Feldspars (Sand Fraction)	+0.615**	Cu	Opauques	-0.477**
	Feldspars (Clay Fraction)	+0.749**		Epidotes	+0.497**
	Chlorite	+0.375*		Hornblende	+0.224
	Smectites	+0.425**		Augite	-0.077
	Sepiolite	-0.211		Biotite	+0.766**
Palygorskite	-0.401**	Garnet		-0.517**	
Micas	+0.292	Rutile		-0.469**	
Vermiculite	+0.167	Sphene		+0.163	
Mn	Opauques	-0.430**		Feldspars (Sand Fraction)	+0.574**
	Epidotes	+0.425**		Feldspars (Clay Fraction)	+0.736**
	Hornblende	+0.315*	Zn	Opauques	-0.287
	Garnet	-0.362*		Hornblende	+0.190
	Rutile	-0.394**		Pyroxenes	+0.233
	Sphene	-0.058		Biotite	+0.073

* Significant at the 5% level.

** Significant at the 1% level.

4-Manganese:

Generally, the DTPA-extractable Mn of the studied soils ranges between 0.17 and 8.78 ppm (Table 7). For the soil samples of the youngest and oldest terraces, it varies between 1.08 and 8.78 ppm. According to DTPA-extractable Mn limits of Viets and Lindsay (1973), all these soils are Mn-sufficient. Moreover, the soils of the youngest terraces on both Nile sides contain higher DTPA-extractable Mn than those of the oldest ones. However, several soil samples of the terrace bench in the interference zone and the terrace rear suture in desert fringes on both sides have amounts of DTPA-extractable Mn less than 1.0 ppm. Therefore, these soils are considered Mn deficient. No specific pattern of extractable Mn distribution with depth can be shown (Figure 4). These results are in full accordance with those reported by Abd El-Razek *et al.* (1984) and Faragallah (1995), Abdel-Mawgoud and Faragallah (2004) and Faragallah and Essa (2005).

The correlation coefficients calculated to test the effect of some soil properties on the level of DTPA-extractable Mn, showed highly significant positive correlations with contents of silt, clay, silt+clay and CEC (Table 8). On the other hand, highly significant negative correlations were found in cases of sand, CaCO₃ and pH of the studied soils. A significant positive correlation ($r=+0.392^*$) was obtained between the soil organic matter content and the extractable Mn. Insignificant correlation resulted between soil EC_e and DTPA-extractable Mn ($r=-0.190$). Similar trends were reported by Attia (1988),

Rabie *et al.* (1989), El-Shazely *et al.* (1991) and Amer *et al.* (1991).

Manganese is present in magnetite (opaques), hornblende, epidote, garnet, rutile and sphene (Gladilovich and Sergeeva, 1971) as well as smectites, chlorite, sepiolite, palygorskite and micas (Duane and Robert, 1989 and Velde, 1992). To clear up the relationship between the DTPA-extractable Mn and its bearing minerals, the correlation coefficients are recorded in Table (9). The obtained data clearly show that there are a highly significant positive correlation value between extractable Mn with epidotes ($r=+0.425^{**}$) and slightly significant positive correlations with hornblende ($r=+0.315^*$), smectites ($r=+0.357^*$) and chlorite ($r=+0.339^*$). These suggest that epidote, hornblende, smectites and chlorite minerals are considered a source of manganese in the studied soils. However, there are highly significant negative correlation values between the extractable Mn and both opaques ($r=-0.430^{**}$) and rutile ($r=-0.394^{**}$). Moreover, a slightly significant negative correlation for the extractable Mn with garnet ($r=-0.362^*$). These relations are logic where rutile, opaques and garnet are considered the most stable minerals.

5-Copper:

Table (6) reveals that the DTPA-extractable Cu of the investigated soils falls in the range between 0.20 and 3.44 ppm. It can be stated that all these soils are considered Cu nondeficient according to the limits of Viets and Lindsay (1973), where they contain more than 0.2ppm. The youngest and oldest Nile terraces soil samples

have high levels of extractable Cu., Moreover, these levels were quite variable among these terraces. This suggests that metal content may be controlled by similar soil components. From the results in Table (7) and Figure (4), there is no clear trend in distribution of DTPA-extractable Cu with depth of the studied soils.

Highly significant correlations were found between the examined soil properties and the DTPA-extractable Cu (Table 8). The highest positive correlation coefficient (+0.863**) was obtained between the clay fraction and the DTPA-extractable Cu. On the other hand, the highest negative correlation coefficient (-0.877**) was recorded with the CaCO₃ content. These results well coincide with those obtained by Attia (1988), Rabie *et al.* (1989), Amer *et al.* (1991), Faragallah (1995) and Marto-Anez and Motto (2000).

With regard to the relation between the DTPA-extractable Cu and its bearing minerals, correlation coefficients were calculated between them, where copper occurs in hornblende, augite, biotite, feldspars, opaques (ilmenite & magnetite), epidotes, garnet, rutile and sphene (Mitchell, 1964; Gladilovich and Sergeeva, 1971). Data in Table (9) indicate that highly significant positive correlations were obtained between the extractable Cu and biotite ($r=+0.766^{**}$), feldspars of the clay fraction ($r=+0.736^{**}$), the feldspars of sand fraction ($r=+0.574^{**}$) and epidotes ($r=+0.497^{**}$). Moreover, low positive correlation with hornblende ($r=+0.224$). On the other hand, highly significant negative correlations were recorded between the extractable Cu and garnet ($r=-0.517^{**}$), rutile

($r=-0.469^{**}$) and opaques ($r=-0.477^{**}$). The minerals of biotite, feldspars, hornblende and epidotes are considered as a source of Cu in the investigated soils. These results are reliable since these minerals are unstable but the others i.e., rutile and garnet are ultrastable.

6-Zinc:

The DTPA-extractable Zn in the studied soils ranges from 0.12 to 1.69 ppm (Table 7). Soil samples representing the youngest Nile terraces show variable zinc concentrations, ranging from 0.31 to 1.69 ppm. According to the limits of Viets and Lindsay (1973), most of these soils are considered Zn deficient since they contain less than 0.5 ppm. Two samples (the surface sample of profiles 5 and the subsurface of profile 6 are Zn marginal. The surface layer of profile 6 and the subsurface one of profile 5 are only Zn nondeficient since they have more than 1.0 ppm. The DTPA-extractable Zn of the oldest Nile terraces soils falls between 0.31 and 0.67 ppm. Only, three samples (the surface and lower layers of profile 2 and the lower one of profile 7) are Zn marginal but the rest are Zn deficient. For soils of the terrace bench in the interference zone and the terrace rear suture in the desert fringes on both sides, most samples are considered Zn deficient. No regular distribution pattern is noticed for the extractable Zn throughout the studied profiles (Table 7 and Figure 4).

The results in Table (8) indicate that no significant correlations occurred between all the considered soil properties and the DTPA-extractable Zn, except of soil CEC ($r=+0.318^*$). Fine soil particle i.e., silt, clay and clay+silt showed low positive correlations with the

extractable Zn ($r=+0.251$, $+0.264$ and $+0.289$, respectively). However, a low negative correlation ($r=-0.289$) was recorded with the sand fraction. Very low negative correlations were found with both soil pH and EC_e ($r=-0.057$ and -0.059 , respectively). Similar relations were obtained by Khetawat and Vashishtha (1977), Ghoneim *et al.* (1984), Attia (1988) and Marto-Anez and Motto (2000).

Zinc is found mainly in pyroxenes, biotite, magnetite (opaques) and hornblende minerals (White, 1957 and Wiklander, 1958). Based on such information, correlation coefficients were calculated between these minerals and the DTPA-extractable Zn of the studied soils (Table 9). The obtained data clearly illustrate that there are low positive correlations between the extractable Zn and hornblende ($r=+0.190$) and pyroxenes ($r=+0.233$). Moreover, a very low positive correlation with biotite ($r=+0.073$). The only exception appears with opaques, which show a low negative correlation ($r=-0.287$). These data indicate that the role played by these suggested minerals in affecting the level of available Zn is not clearly expressed.

II-Heavy metals:

1-Nickel:

The DTPA-extractable Ni of the investigated soils is shown in Table (10). Generally, the extractable Ni is slightly higher in the youngest Nile terrace soils than in the oldest ones with a range of 0.38 to 1.52 ppm, without any clear trend of its distribution with depth (Table 10 and Figure 5). The lower values of the DTPA-extractable Ni are recorded in the terrace bench in the interference zone and the terrace rear suture in desert fringes on both sides, where they range from nil to 0.39 ppm. These soils do not have also any specific pattern of distribution with depth (Figure 5). These results agree with those of Abdel-Mawgoud and Faragallah (2004), Faragallah and Essa (2005) and Roshdy (2009).

Correlation coefficients calculated to test the relation between some soil properties and the DTPA-extractable Ni, are listed in Table (11). The results show highly positive significant correlations between the DTPA-extractable Ni and the soil contents of fine fractions (clay, silt and sum of silt + clay), organic matter, and CEC. On the other hand, the highest negative correlation coefficient ($r=-0.801^{**}$) was calculated for the $CaCO_3$ content, followed by the sand content ($r=-0.741^{**}$), soil pH ($r=-0.535^{**}$) and then soil EC_e ($r=-0.343^*$). These relations are in agreement with those obtained by Roshdy (2009).

Table 10: DTPA-extractable Ni, Pb and Cd in the soil samples of the studied Nile terraces

Profile No.	Depth (cm)	Ni	Pb	Cd	Profile No.	Depth (cm)	Ni	Pb	Cd
		(ppm)					(ppm)		
1	0 - 15	0.62	0.34	0.01	5	0 - 20	1.36	0.71	0.02
	15 - 25	0.78	0.36	0.02		20 - 35	1.04	0.74	0.02
	25 - 35	0.47	0.34	0.02		35 - 65	0.96	0.24	0.00
	35 - 70	0.67	0.44	0.02		6	0 - 45	1.52	0.75
2	0 - 40	0.72	0.43	0.02	45 - 80		1.07	0.24	0.00
	40 - 70	0.86	0.21	0.01	7	0 - 40	0.39	0.20	0.00
	70 - 95	0.75	0.30	0.01		40 - 70	0.52	0.27	0.02
	95 - 195	0.82	0.33	0.02		70 - 120	0.38	0.02	0.00
195-235	0.95	0.37	0.03	120-155		0.55	0.37	0.02	
3	0 - 35	0.39	0.63	0.01	8	0 - 50	0.27	0.00	0.00
	35 - 55	0.06	0.64	0.00		50 - 70	0.05	0.21	0.01
	55 - 70	0.11	0.61	0.04		70 - 85	0.00	0.04	0.00
	70 - 150	0.07	0.38	0.05		85 - 150	0.00	0.09	0.00
4	0 - 20	0.00	0.00	0.00	9	0 - 10	0.21	0.58	0.00
	20 - 35	0.07	0.37	0.02		10 - 35	0.00	0.11	0.00
	35 - 150	0.00	0.24	0.01		35 - 150	0.03	0.00	0.00

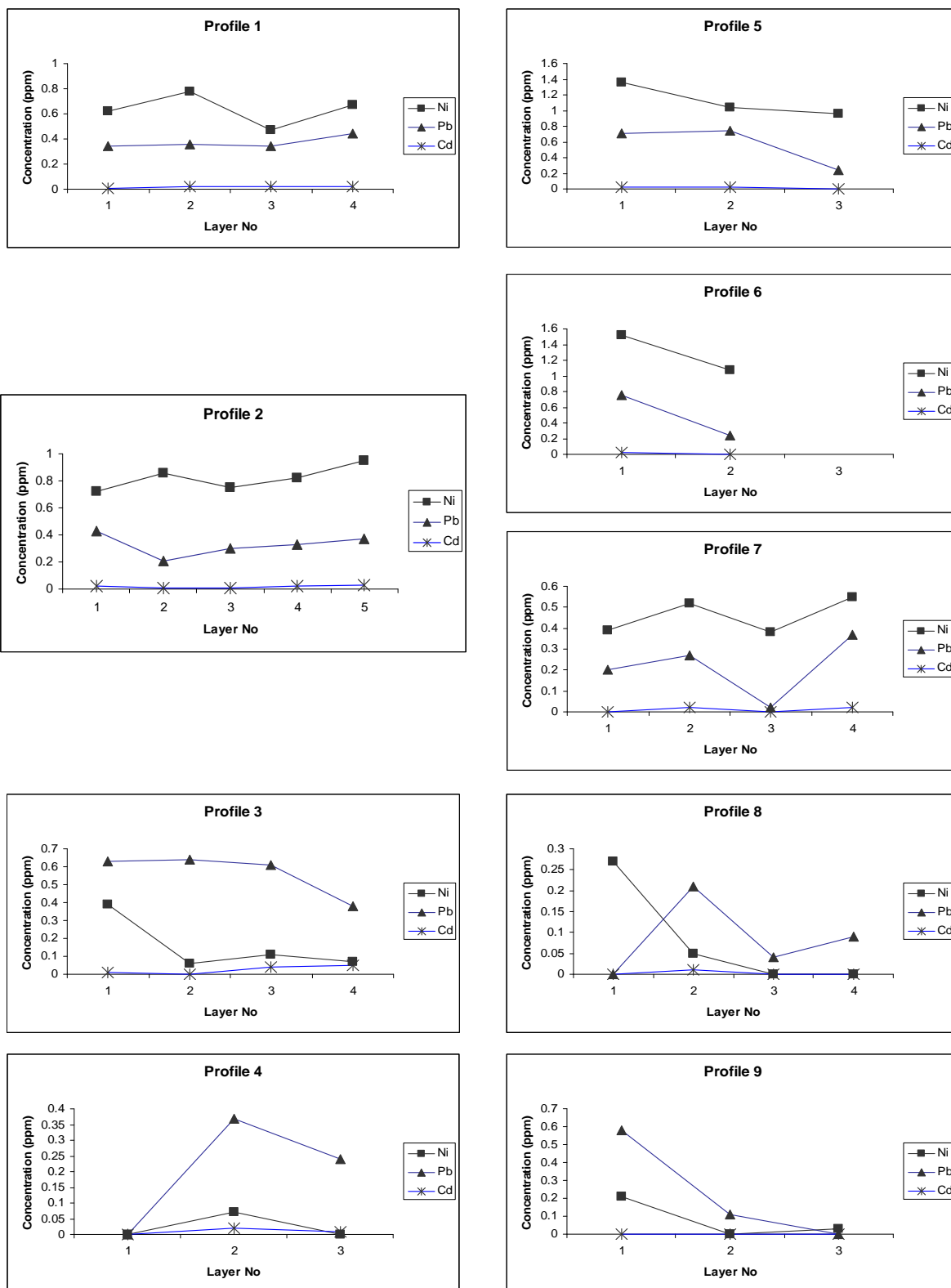


Fig. 5: Distribution of extractable Ni, Pb and Cd with depth in the soil profiles of the studied Nile terraces

Table 11: Correlation coefficients of DTPA-extractable Ni, Pb and Cd and some physical and chemical properties of the studied soils

Soil property	r value		
	Ni	Pb	Cd
Sand (%)	-0.741**	-0.381*	-0.143
Silt (%)	+0.605**	+0.321*	+0.132
Clay (%)	+0.729**	+0.362*	+0.120
Silt + Clay (%)	+0.741**	+0.381*	+0.143
Organic matter (%)	+0.675**	+0.199	+0.052
CaCO ₃ (%)	-0.801**	-0.332*	-0.229
pH (1:1)	-0.535**	-0.165	+0.029
EC _c (dsm ⁻¹)	-0.343*	-0.146	-0.212
CEC (Cmol ⁺ /kg)	+0.720**	+0.381*	+0.289

Table 12: Correlation coefficients between Ni and Pb and their bearing-minerals

Element	Mineral	r value	Element	Mineral	r value
Ni	Hornblende	+0.351*	Pb	Opaques	-0.484**
	Pyroxenes	-0.047		Amphiboles	+0.375*
	Botite	+0.648**		Botite	+0.117
	Grnet	-0.467**		Fldspars (sand fraction)	+0.131
	Clorite	+0.453**		Fldspars (clay fraction)	+0.172
	Spiolite	-0.193			

* Significant at the 5% level.

** Significant at the 1% level.

2-Lead:

Table (10) reveals that the DTPA-extractable Pb of the studied soils varies from 0.0 to 0.75 ppm. The youngest Nile terraces soils contain a higher concentration of the extractable Pb than the oldest ones, with a range of 0.24 to 0.75 ppm and 0.02 to 0.43 ppm, respectively. Although most soil samples of the terrace bench in the interference zone and the terrace rear suture in desert fringes on both sides have levels of the extractable Pb ranging from 0.0 to 0.38 ppm, the first three layers of profile 3 and the surface layer of profile 9 display values between 0.58 and 0.64 ppm. Like extractable Ni, extractable Pb concentrations show no trend of change with depth (Figure 5). Similar results were reported by Abdel-Mawgoud and Faragallah (2004), Faragallah and Essa (2005) and Roshdy (2009).

The correlation coefficients in Table (11) clearly indicate positive significant correlations between the DTPA-extractable Pb and the soil contents of silt ($r=+0.321^*$), clay ($r=+0.362^*$) and sum of silt+clay ($r=+0.381^*$) as well as CEC ($r=+0.381^*$). On the other hand, negative significant correlations were obtained between the DTPA-extractable Pb and both sand ($r=-0.381^*$) and CaCO_3 ($r=-0.332^*$) contents. The data also show low correlations between the extractable Pb and organic matter content ($r=+0.199$), soil pH ($r=-0.165$) and soil EC_e (-0.146). Similar relations were found by Marto-Anez and Motto (2000) and Roshdy (2009).

Lead occurs in feldspars, biotite, amphiboles, quartz and magnetite (Wedepohl,

1974). Accordingly, correlation coefficients were calculated between these minerals and the DTPA-extractable Pb (Table 12) to verify the source of lead in the investigated soil. The obtained results reveal a significant positive correlation between the extractable Pb and amphiboles ($r=+0.375^*$) as well as low positive correlations with biotite ($r=+0.117$), feldspars of the sand fraction ($r=+0.131$) and feldspars of the clay fraction ($r=+0.172$), suggesting these minerals are considered a source of the extractable Pb in the studied soils. A highly significant negative correlation between the extractable Pb and opaques ($r=-0.484^{**}$) was observed (Table 12).

3-Cadmium:

Compared to the above mentioned heavy metals, the DTPA-extractable Cd concentration is very much lower in all studied soils and ranges from 0.0 to 0.05 ppm (Table 10). The youngest and oldest Nile terrace soils contain similar amounts of the extractable Cd with a range of 0.0 to 0.03 ppm. Most soil samples of the terrace bench in the interference zone and the terrace rear suture in desert fringes on both sides do not have extractable Cd. Like extractable Ni and Pb, the distribution of Cd in all location under study with depth is unsystematic (Figure 5).

Table (11) shows that, in all cases, the correlation values between the concentration of the DTPA-extractable Cd and the considered soil properties are low and insignificant. The correlation coefficient values are positive with soil contents of silt, clay, silt + clay, organic

matter, pH and CEC. However, they are negative with soil contents of sand, CaCO₃ and EC_e. Most of these findings coincide with those obtained by Ghallab and Usman (2007) and Roshdy (2009).

Cadmium occurs in salirite mineral which is extremely rare in soils. Therefore very much lower of cadmium amounts that is detected in the studied Nile terraces due to anthropogenic contamination. This finding is in full agreement with those found by Zhou *et al.* (2004), Jjemba (2005) and Jinling *et al* (2009).

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حالة بعض العناصر الغذائية والعناصر الثقيلة و علاقاتها بالمعادن الحاملة لها
فى أراضى المدرجات النهرية بأسبوط - مصر

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تم اختيار تسع قطاعات تمثل أراضى المدرجات النهرية الحديثة و القديمة المتكونة فى منطقة جنوب قناطر أسبوط وذلك لدراسة مستويات و توزيع بعض العناصر الغذائية (P, K, Fe, Mn, Zn, Cu) و بعض العناصر الثقيلة (Ni, Pb, Cd) و علاقاتها ببعض الخواص الطبيعية و الكيميائية لهذه الأراضى، و كذلك لتقييم ارتباط هذه العناصر مع المعادن الحاملة لها فى هذه الأراضى.

و قد أظهرت النتائج المتحصل عليها أن قيم الفوسفور الميسر كان أعلى فى أراضى المدرجات النهرية القديمة منه فى المدرجات الحديثة على جانبى النيل، بينما محتوى البوتاسيوم الميسر أظهر العكس. وقد احتوت أراضى المدرجات النهرية الحديثة و القديمة على مستويات عالية من الفوسفور و مستويات متوسطة من البوتاسيوم . و لم يوجد تغير ثابت فى توزيع كل من الفوسفور و البوتاسيوم مع العمق فى معظم القطاعات. و قد وُجد ارتباطات موجبة معنوية جداً بين تركيزات كل من الفوسفور و البوتاسيوم مع محتوى هذه الأراضى من السلت و الطين و المادة العضوية و السعة التبادلية الكاتيونية، و لكن كان الارتباط سالباً مع محتوى التربة من الرمل و كربونات الكالسيوم و الـ pH. كما اتضح وجود ارتباطات موجبة معنوية بين محتوى الفوسفور الميسر مع كميات معدن المونازيت و مجموع معدنى الأباتيت و المونازيت. كما يوجد ارتباط موجب عالى بين البوتاسيوم و معادن الفلسبار التى فى حجم الطين لهذه الأراضى.

أوضحت النتائج أيضاً أن المستويات الأعلى من الحديد الميسر كانت فى أراضى المدرجات النهرية القديمة، بينما محتوى المنجنيز الميسر كان أعلى فى أراضى المدرجات الحديثة، و لم يُظهر عنصر النحاس تغيرات كبيرة بين أراضى المدرجات القديمة و الحديثة. و احتوت أراضى كل المدرجات النهرية على مستويات كافية من الحديد و المنجنيز و النحاس، بينما أظهرت كل الأراضى نقصاً فى الزنك الميسر. كما ظهرت ارتباطات موجبة عالية بين الحديد و المنجنيز و النحاس مع النسبة المئوية للحبيبات الناعمة خاصة الطين و نسبة المادة العضوية و السعة التبادلية الكاتيونية للأراضى، و أخرى سالبة مع محتوى التربة من الرمل و كربونات الكالسيوم و الـ pH، بينما لا توجد ارتباطات معنوية بين عنصر الزنك و أى من خواص التربة المدروسة. كما توجد ارتباطات موجبة عالية بين كل من الحديد و النحاس من جهة و المعادن الحاملة لها قليلة الثبات مثل الابدوت و البيوتيت و الفلسبار من جهة أخرى، و بين المنجنيز و معادن الابدوت و الهورنبلند و السمكتيت و الكلوريت. بينما توجد ارتباطات موجبة منخفضة بين عنصر الزنك و كل من الهورنبلند و البيروكسن.

بيّنت النتائج أن مستوى عنصرى النيكل و الرصاص كان أعلى قليلاً فى أراضى المدرجات النهرية القديمة منه فى المدرجات الحديثة على جانبى النيل و بدون تغير واضح مع العمق ، بينما كان مستوى عنصر الكادميوم متشابه و منخفض جداً فى كل من أراضى المدرجات النهرية الحديثة و القديمة. و قد وجد ارتباط موجب معنوى عالى بين كمية النيكل المستخلص مع النسبة المئوية للسلت و الطين و نسبة المادة العضوية و السعة التبادلية الكاتيونية للأراضى. و ظهر ارتباط موجب معنوى بين كمية الرصاص المستخلص مع النسبة المئوية للسلت و الطين و السعة التبادلية الكاتيونية، و آخر سالب مع محتوى التربة من الرمل و كربونات الكالسيوم. وقد اتضح وجود ارتباطات موجبة معنوية بدرجة منخفضة بين كل من عنصرى الرصاص و النيكل و معدن الهورنبلند بينما ارتباط موجب عالى بين عنصر النيكل و كل من معدنى البيوتيت و الكلوريت .