

Environmental Geochemistry of Some Western Desert Soils, Egypt

El-Sayed, M.I.¹, El-Kammar, A.M.², Abdel Ghaffar, M.K.³ and El-Shawadfi, T.M.³

¹Faculty of science, Beni-Suief Univ., ²Faculty of science, Cairo Univ., ³Soil, water and Environmental Inst., ARC.

Abstract. This paper discusses the geochemical characteristics of some soils in northeast Western Desert, Egypt. These characteristics include the soil paste extracts (saturation percent, pH, electrical conductivity and soluble ions), available macro- and micro- elements as well as total oxides and trace elements. The geochemical analyses were conducted on 76 soil samples representing 28 soil profiles in the study area.

The saturation percent (SP) values are generally low due to the coarse texture of the studied soils. pH varies considerably between neutral to moderately alkaline soil reaction. Most values of soil salinity (EC) indicate very strongly saline soils. The soluble cations are dominated by Na⁺ followed by Ca⁺⁺ and Mg⁺⁺; while K⁺ is the least abundant cations. On the other hand, Cl⁻ is the dominant anion followed by SO₄⁼, while HCO₃⁻ is the least abundant anion and CO₃⁼ is undetectable. The available macronutrients (nitrogen, phosphorous and potassium) and micronutrients (iron, zinc, manganese and copper) in the studied soil profiles are generally low compared with the standard levels. This is due to the coarse texture of soils, low contents of clay and organic matter.

The analysis of total major and trace elements include 9 major oxides and 11 trace elements. The major oxides include SiO₂, Al₂O₃, Fe₂O₃, MgO, CaO, Na₂O, K₂O, SO₃ and P₂O₅. The average chemical composition of the studied profiles is compared to data of the upper continental crust (UCC) as well as the data of world soils. This comparison suggests that there is notable depletion in the major oxides; Al₂O₃, Fe₂O₃, Na₂O, K₂O and P₂O₅ relative to the UCC and world soils, however MgO is depleted relative to UCC and within the world soils range. On the other hand, SiO₂ and CaO are relatively high when compared to the UCC and world soil. The following trend of trace elements concentration was established: Mn > Zn > Cr > Cu > Pb > Ni > B > Co > Mo > Cd > Se for the soil samples studied. The result from this study does not indicate any serious pollution or contamination for Mn, Cr, Ni, Zn, Pd, Co and B, since elements including metals cannot be degraded these tend to accumulate in soils and remain

available with subsequent accumulation in plants. However, Cd, Mo and Se are more toxic elements in the study soils. Contamination of soils and sediments by metals such as Cd, Cr and Pb is of concern for human health.

The factor component analysis shows that there is no relation between major elements with each other except for Na and K, also the relation between some of the major oxides and trace elements like Al and Co, Fe and Co and K and Cr. The relation is just about good 0.50, so there may be some correlation between these trace elements and the minerals carrying the major oxides like Al-oxides, Fe-oxides, Mn-oxides, Mg-rich clays. Even the factor analysis confirms these results too.

Keywords: Environmental geochemistry, Soil, Northeast Western Desert, Egypt.

1. Introduction

According to the definition of [1] the environmental geochemistry is the discipline that uses chemistry of solid earth, its aqueous and gaseous components, and life forms to assess metals contamination impacts on our planet's ecosystems.

Sediments conserve important environmental information [2] and are increasingly as both a carrier and a possible source of contaminants in aquatic systems [3]. The sediments act, therefore, as sink for transition metal contaminants, and risk increases with increasing metals leachability. Analysis of sediments indicates that pollution is confined to a local scale [4]. The impact of such transition metals abnormality may extend to involve the water quality and food web, hence the human health. [5] characterized the physical states of pollutants in soils and sediments as being present as particulates, liquid films, adsorbed ions, absorbed ions and liquid phases in pores. Nonetheless, high percentages of organic matter and/or small grains in sediment are generally associated with reduced heavy metals bioavailability and toxicity [6].

This paper discusses the geochemical characteristics which include the soil paste extracts (saturation percent, pH, electrical conductivity and soluble

ions), available macro- and micro-elements as well as total oxides and trace elements.

Location of the study area: The study area occupies a portion of the Western Desert of Egypt (Fig. 1). It is located north-east of Bahariya Depression between longitudes $^{\circ}28'58''19.2$ and $^{\circ}29'30''28.8$ E and latitudes $^{\circ}28'44''16.8$ and $^{\circ}29'1''22.8$ N and it extends in the direction -southwest northeast with total area of 945 km² (Fig. 1).

Geologically, the study area is covered by extensive exposures of sedimentary successions ranging in age from Eocene to Quaternary. The oldest sedimentary rocks are represented by late folded structure. The surface stratigraphic succession

includes sequences of Middle Eocene, Upper Eocene, Lower Miocene, Oligocene and Quaternary sediments.

Geomorphologically, landsat ETM⁺ image, triangulated irregular network (TIN map), digital elevation model (DEM map), geological map and data verification by in situ observation were used for delineating the main geomorphologic units. The study area can be divided into four units; namely, terraces, scarpment, structural platform and sand accumulation. The terraces can be distinguished into four subunits: high, medium, low and very low Terraces (Fig. 2).

Fig. (1): Location of the study area on Egypt image and on subset landsat ETM8 image (acquired in 2012).

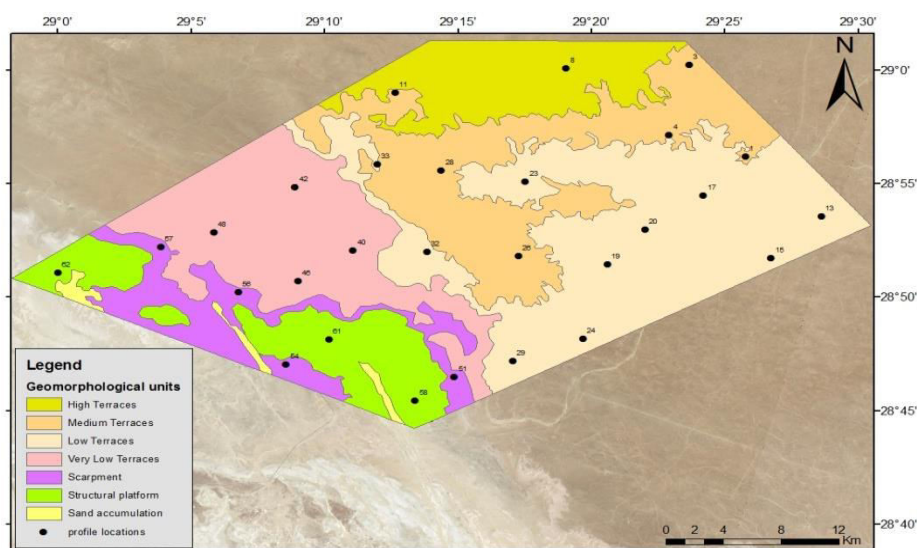
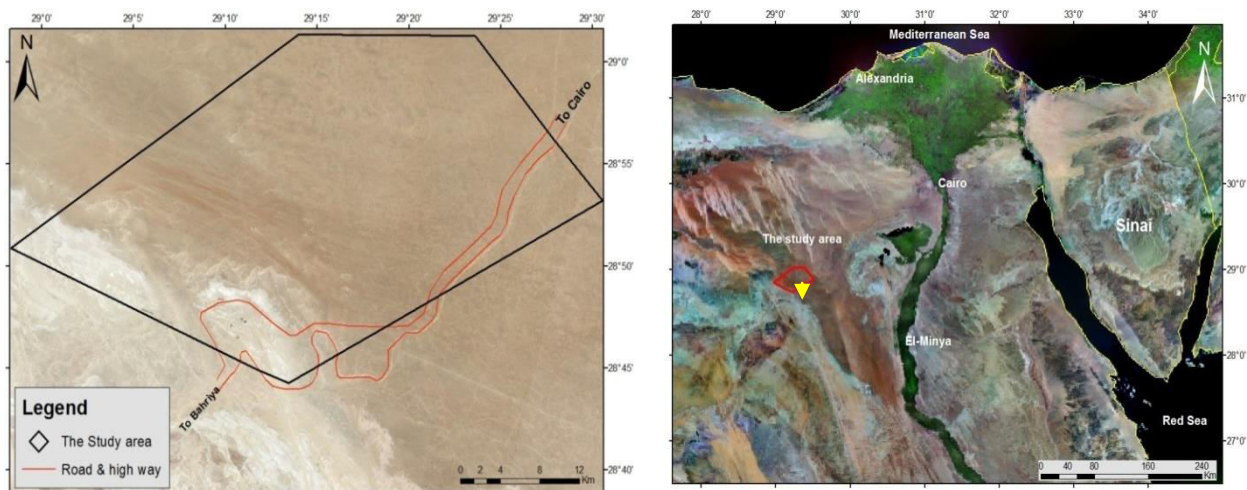


Fig. (2): Geomorphological units and soil profile locations in the study area.

2. Materials and Methods

Field investigations were carried out in the study area using geological map (1:100,000), topographic map (1:50,000) and landsat TM image. Different geomorphologic units were identified in the study area. Guided by the identified geomorphological units; 28 soil profiles (Fig. 2) were selected and allocated by the portable global positioning system (GPS). Representative 76 soil samples have been collected from these profiles according to the morphological variations. The depth of digging in the studied profiles was usually about 150 cm except when met bed rock to locate the type of boundaries and general lithology.

Soil samples were air dried, crushed and sieved through a 2 mm sieve for chemical analyses.

The grain size analysis was carried out for soil samples using the methods of [7]. The name of textural classes was based on [8].

The chemical analyses of soil paste extract as well as the determination of calcium carbonate and organic matter contents were carried out according to the methods described by [9] as follows:

1- Water saturation capacity or saturation percentage (SP) was determined by adding distilled water to a 100g dry soil and stirring with spatula until the saturation point is reached.

$SP = (\text{volume of distilled water/weight of air dry soil}) \times 100$.

2- The pH value was determined in saturated soil paste after 24 hours using pH meter by inserting the pH electrode repeatedly until a representative pH value is obtained.

3- Soil water extract was obtained using a vacuum to filtrate the soil paste.

4- The electrical conductivity (EC) was determined using the conductivity meter and the values were corrected at 25°C.

5- The soluble cations were determined for the soil paste extract as follow:

a- Determination of Ca^{2+} and Mg^{2+} was carried out by titration.

b- Determination of Na^+ and K^+ was carried out using flame photometer.

6- The soluble anions were determined for the soil paste extract as follow:

a- Carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) were carried out by titration with HCl acid using phenolphthalein as indicator for the former and methyl orange for the latter.

b- Chloride (Cl^-) was determined by titration against silver nitrate.

c- Sulphate (SO_4^{2-}) was determined by precipitation as barium sulphate using barium chloride.

7- Calcium carbonate content was determined volumetrically using Collin's calcimeter.

8- Organic matter content (O.M.) was determined using ferrion as indicator

Available and total macro and microelements:

1- Soil available nitrogen was determined by using KCl (2N) as extractable solution with the ratio of (5gm soil to 50 ml KCl), shaken for 30 min. and then filtered and the available $N-NH_4^+$ and $N-NO_3^-$ were determined by using Kjeldahl method according to [10].

2- Available P, K, Fe, Mn, Zn, Cu, Co, and Pb were extracted according to the method of [11] by mixture solution of Diethylenetriaminepenta-acetic acid 97% (DTPA) and ammonium bicarbonate with adjusting at pH 7.6. Soil sample (20 gm) were shaken with 40 ml from the mixture solution to about 15 minutes then filtered. Determination of P, K, Fe, Mn, Zn, and Cu was carried out in this extract using Inductively Coupled Plasma (ICP) Spectrometry (Ultima 2 JY Plasma), while Na and K was determined by flame photometer.

4 -Total Si, Al, Mg, Ca, P, K, Fe, Mn, Zn, Cu, S, pd, B, Cr, Co, Ni, Se, Br, Mo and Cd were determined in soil samples which digested by aqua regia (hydrochloric acid and nitric acid) according to [12]. The analysis was done by the Inductively Coupled Plasma-Mass Spectrometry (Ultima 2 JY Plasma) technique. This technique is suitable for determining trace elements because of its high sensitivity, rapidity, simplicity, multi-elemental and isotopic capability [13]. The data include 10 major oxides and 11 trace elements. The statistical treatment of the obtained data involves descriptive statistics, correlation matrix and data reduction by factor analysis using SPSS[®] program.

3. Results and Discussion

3.1. Soil paste and its extracts:

The data of weight average values for the soil paste and its extracts are shown in Table (1) and discussed hereafter:

3.1.1. Saturation percent (SP):

The weight average values of SP for the studied soil profiles are generally low and fluctuate between 18.3 and 28.6 with mean of 22.5%. Low SP values can be interpreted to the sandy coarse texture of these soils (Table 1).

3.1.2. Soil reaction (pH):

The pH value is one of the main factors affecting the physiochemical characteristics of the soil. The mobility and bioavailability of nutrients and toxic elements in soils depends principally on the pH value of the soil [14]. The weight average values of the investigated soils have pH range from 7.1 to 7.9 indicating neutral to moderately alkaline soil reaction. The high pH values are due to the abundance of $CaCO_3$ and presence of $MgCO_3$ or other carbonate phases.

3.1.3. Soil salinity and soluble ions:

Salinity is one of the main edaphic factors which limits the distribution of plant communities in their

natural habitats and which is causing increasingly severe agricultural problems. Electrical conductivity is a measure of the concentration of water-soluble salts in saturated soil paste.

Salt affected soils are widely spread in semi-arid and arid areas such as Egypt. It is a fact that saline soils distribution is closely related to environmental factors such as climate, geology, geochemical and hydrological conditions.

In the study area, soil salinity weight average values ranged widely between 5.7 and 87.8 dSm⁻¹, with mean of 28.2 dSm⁻¹. Most values of soil

salinity (EC) indicate very strongly saline soils (> 16 dSm⁻¹; Table 1). The low precipitation level and the high evaporation rate lead to the accumulation of soluble salt.

The soluble cations are dominated by Na⁺ followed by Ca⁺⁺ and Mg⁺⁺; while K⁺ is the least abundant cations (Fig. 3). On the other hand, Cl⁻ is the most dominant anion followed by SO₄⁼, while HCO₃⁻ is the least abundant anion and CO₃⁼ is undetectable (Fig. 3). Exceptional cases are found in some soil profiles, where SO₄⁼ exceeds Cl⁻.

Table (1): The weight average values of chemical analyses of soil paste extract as well as the textural classes and CaCO₃ content in the studied soil profiles.

Profile No	SP	pH	E.C ds/m	Anions (cmol _c kg ⁻¹)			Cations (cmol _c kg ⁻¹)				Texture class	CaCO ₃ %
				HCO ₃ ⁻	Cl ⁻	SO ₄ ⁼	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺		
High Terraces												
4	21.7	7.5	29.7	9.4	386.3	102.4	91.3	94.1	309.7	3.0	Loamy sand	11.8
Medium Terraces												
1	18.8	7.5	20.4	4.1	224.3	66.4	89.2	59.0	145.5	1.6	Sand	4.0
2	21.8	7.7	13.8	4.6	106.3	71.9	61.6	22.0	97.2	2.1	Sand	10.8
3	20.8	7.7	21.3	5.5	123.9	185.4	80.2	40.7	192.8	1.1	Sand	8.9
5	21.9	7.5	34.7	5.2	477.5	109.1	168.3	23.6	351.1	1.1	Sand	3.9
13	21.8	7.9	12.9	2.4	46.6	104.5	41.8	15.7	93.6	2.4	Sand	7.2
14	21.0	7.3	31.5	7.6	425.1	71.2	142.1	18.9	340.0	2.9	Loamy sand	9.3
Low Terraces												
6	21.16	7.8	39.25	7.06	518.0	99.34	94.2	57.9	469.4	2.7	Loamy sand	10.0
7	19.9	7.8	11.0	2.2	75.9	41.6	35.3	6.0	76.6	1.7	Sand	6.1
8	21.6	7.9	22.3	5.4	273.6	47.4	71.8	32.8	220.0	1.8	Loamy sand	7.6
9	21.2	7.8	40.9	5.2	471.2	42.5	190.6	138.5	186.9	2.9	Loamy sand	14.1
10	26.8	7.8	17.3	2.7	173.6	40.2	38.4	38.5	137.8	1.7	Sandy loam	6.6
11	21.6	7.9	18.9	3.9	210.4	55.8	71.1	42.5	154.4	2.1	Loamy sand	11.8
12	19.2	7.8	5.7	1.9	60.2	16.3	28.3	5.1	46.0	1.5	Sand	6.8
15	23.5	7.5	26.4	3.4	270.4	134.6	103.7	29.9	272.3	2.5	Loamy sand	8.2
16	21.4	7.9	17.1	5.7	156.4	145.7	49.0	11.3	159.3	2.1	Loamy sand	4.7
17	18.3	7.5	21.4	6.9	272.3	78.2	56.2	22.7	277.7	0.8	Sand	3.8
Very Low Terraces												
18	21.4	7.9	8.4	2.0	49.8	40.4	32.3	8.2	50.0	1.7	Sand	4.0
19	24.6	7.7	21.5	5.1	275.7	82.5	123.1	89.7	149.2	1.3	Sand	5.8
20	28.6	7.9	12.6	5.2	13.5	160.8	11.1	3.2	163.5	1.6	Sandy loam	45.4
21	22.8	7.7	43.4	8.1	1079.2	47.1	435.9	105.5	591.0	2.1	Loamy sand	7.9
Scarpment												
22	28.1	7.7	39.2	10.7	514.0	18.1	202.0	11.8	326.2	2.7	Sand	7.1
23	19.7	7.1	87.8	12.5	1401.6	158.1	553.4	299.3	688.3	2.4	Loamy sand	7.4
24	23.2	7.8	15.1	5.1	135.9	8.0	33.2	18.6	106.2	1.3	Sandy loam	32.8
25	20.8	7.9	23.4	5.5	211.1	49.8	52.4	18.2	196.3	2.1	Sand	7.0
Structural Platform												
26	20.9	7.9	34.7	11.2	371.1	49.9	75.3	4.3	351.7	1.0	Sand	14.0
27	21.5	7.6	16.3	4.1	173.8	16.2	58.7	29.3	104.8	1.3	Sand	15.9
28	21.6	7.9	9.2	2.3	82.6	27.1	28.1	22.2	61.2	0.5	Sand	33.0

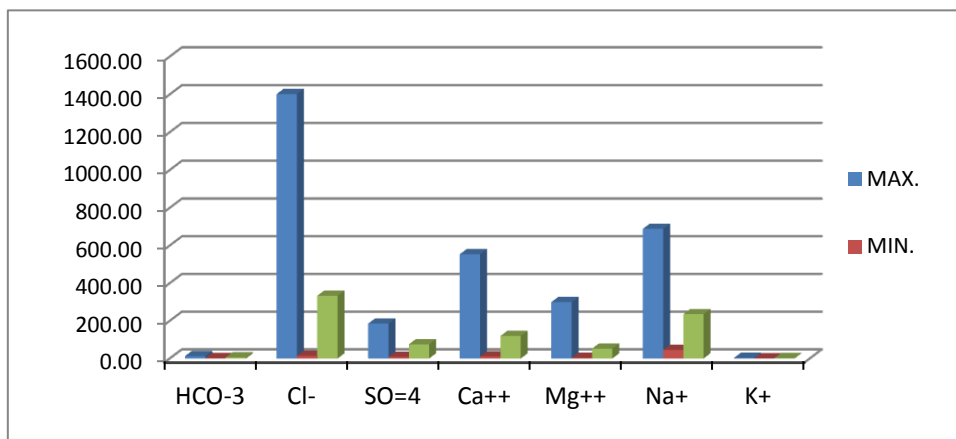


Fig. (3): Concentration of soluble ions in the study soil profiles.

3.2. Available macronutrients (NPK):

The primary nutrients for plant growth are nitrogen, phosphorus, and potassium (known collectively as NPK). When insufficient, these primary nutrients are most often responsible for limiting crop growth. The weight average of available values of NPK in the studied soil profiles are shown in Table 2). These values can be discussed as follows:

3.2.1. Available nitrogen:

Nitrogen is one of the basic plant nutrients and is essential for all life processes in plants; lack of N often limits plant growth in nature and in agriculture [15]. The principle forms of N in soils are NH₄⁺, nitrate NO₃⁻ and organic substances. The prevailing climate of the studied area is characterized by a long hot summer and low precipitation. Soils under such climatic conditions contain a low organic fraction. The weight average values of available nitrogen in the studied soil profiles range from 7.2 to 86.3 mg/kg with mean of 28.5 mg/kg (Table 2).

3.2.2. Available phosphorus:

Phosphorus in nature exists mainly as phosphate rocks. Phosphorus deficiencies retard plant growth and tillering and reduce product quality and storage properties. Effective management of P fertilizers is not only critical to

economics of crops production, but also to reduce the risk of eutrophication of surface waters [16]. The weight average values of available phosphorus in the studied soil profiles varies from 0.0 to 0.1 mg/kg with mean of 0.0 mg/kg. According to the critical levels: P > 11 mg/kg very high; 8-11 high; 4-7 medium and 0-3 low) stated by [17], all of the studied soil samples contain low amounts of available P (Table 2). These low results indicate that the values available P is affected by low contents of clay and carbonate in the studied soil profiles.

3.2.3. Available potassium:

Plant availability and utilization of K was partly related to clay content, but more closely to contain exchange surfaces associated with both mineral and organic constituents [18].

The weight average values of available K vary from 0.6 to 7.9 mg/kg with mean of 3.0 mg/kg. The relatively highest value of available K is accompanied by high amount of clay content. According to [17], the index values of available K in soils are as follow: low, 0-60 mg/kg; medium, 61-120 mg/kg; high > 120 mg/kg. Comparing these levels with the values of available K, it can be stated that all of the studied samples are belonging to low levels of available K (Table 2).

Table (2): The weight average values of available macro-and micronutrients in the soil profiles.

Profile No.	Available micronutrients (mg Kg-1)				Available macronutrients (mg Kg-1)		
	Zn	Mn	Cu	Fe	N	P	K
High Terraces							
4	0.66	0.24	0.00	3.45	37.71	0.03	1.80
Medium Terraces							
1	1.06	0.28	0.00	1.81	23.24	0.02	3.13
2	0.54	0.46	0.17	1.61	12.49	0.11	2.47
3	3.29	0.20	0.07	2.14	10.52	0.03	1.36

5	0.05	0.00	0.00	0.24	19.41	0.02	1.93
13	0.53	0.13	0.26	1.18	71.89	0.02	2.72
14	0.22	0.15	0.09	1.54	50.05	0.03	7.88
Low Terraces							
6	0.01	0.00	0.00	0.05	29.34	0.01	1.48
7	0.00	0.00	0.00	0.00	10.51	0.02	0.57
8	2.37	0.48	0.00	1.56	11.01	0.01	4.00
9	0.29	0.05	0.00	0.02	10.01	0.01	3.89
10	0.14	0.06	0.00	0.04	58.39	0.01	1.67
11	0.25	0.03	0.28	1.18	63.40	0.01	1.35
12	0.28	0.00	0.12	1.85	86.35	0.00	4.12
15	0.42	0.05	0.15	1.43	14.47	0.02	4.49
16	0.27	0.08	0.09	1.07	10.11	0.01	3.33
17	0.46	0.00	0.07	0.78	11.52	0.01	0.60
Very Low Terraces							
18	0.18	0.05	0.03	3.57	18.30	0.01	2.49
19	0.28	0.15	0.06	1.74	8.40	0.02	1.15
20	0.09	0.10	0.03	0.92	8.77	0.03	2.88
21	0.17	0.11	0.05	0.98	8.29	0.04	3.06
Scarpment							
22	0.08	0.03	0.08	1.26	7.23	0.04	5.12
23	0.11	0.16	0.00	1.68	43.47	0.01	3.43
24	0.08	0.03	0.01	0.30	22.84	0.02	4.84
25	0.02	0.02	0.00	0.00	9.55	0.04	3.21
Structural Platform							
26	0.00	0.13	2.06	0.00	46.54	0.03	2.09
27	4.10	0.01	1.22	4.10	23.86	0.03	1.42
28	6.90	0.05	1.13	6.90	15.08	0.04	0.84

3.3. Available micronutrients:

Undoubtedly, trace elements have their specific role in soil fertility and its relationship to plant growth. In this connection, chemically extractable levels of micronutrients could be considered as a reliable guide for the assessment of their availability [19].

3.3.1. Iron (Fe): The obtained data refer to amounts of available iron from the subsequent layers of the studied soil profiles. It is obvious that available iron

ranges from 0.00 to 6.9 mg/kg with mean of 1.61 mg/kg (Table 2).

Considering the critical levels (Table 3) suggested by [17], it is revealed that about 64.5, 23.5 and 12.0% of the studied soils are in low, marginal and adequate levels of Fe, respectively. [20] mentioned that the extractable Fe values are relatively high in the clay and silt fractions compared to its values in sand fraction.

Table (3): Critical levels of micronutrient according to [17].

Element Class	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
Adequate	> 4.0	> 1.80	>1.50	> 0.5
Marginal	2.1- 4.0	Not mentioned	1-1.50	Not mentioned
Low	< 2.0	1.8 or less	0.9 or less	0.5 or less
The study soils (weight average and mean)	0.0 – 6.9 (1.61)	0.0-0.48 (0.12)	0.0 - 6.9 (0.99)	0.0 - 2.06 (0.27)

3.3.2. Manganese (Mn): The amounts of DTPA-extractable Mn in the subsequent layers of the studied profiles vary widely between 0.0 and 0.48 mg/kg with mean of 0.12 mg/kg (Table 2).

According to the critical levels of Mn (Table 3); the majority of the studied soil samples contain low content of available Mn.

3.3.3. Zinc (Zn): The obtained data of DTPA extractable Zn in studied soil profiles range from 0.00 to 6.9 mg/kg with mean of 0.99 mg/kg (Table 2). Regarding, the critical levels (Table 3): about 70% of the subsequent layers of studied soils profiles contain low levels of Zn and about 10% of soil profiles have a marginal level while the rest of the layers have an adequate level.

3.3.4. Copper (Cu): The amounts and distribution of extractable Cu ranges from 0.00 to 2.06 mg/kg with an average of 0.27 mg/kg (Table 2). According to the critical levels of extractable Cu (Table 3); the majority of the studied layers contain low levels of available Cu.

Regarding the vertical distribution of the extractable micronutrients in the studied profiles, it is stated that their distribution is characterized by an irregular distribution with depth in most of the studied profiles.

3.4. Total elemental analysis:

The major elements in soils are those whose concentrations exceed 100 mg/kg, all others being termed trace elements. The chemical elements essential to plant growth in soil are: H, B, C, N, O,

Mg, P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, and Mo [21]. Of these elements, B, Cl, Mn, Fe, Cu, Zn, and Mo are micronutrients (absorbed in trace amounts) and Mg, S, and Ca are secondary nutrients (absorbed in small, but not trace amounts). The remaining six elements are macronutrients.

The analysis of major and trace elements was conducted on soil samples of the studied area. The data include 9 major oxides and 11 trace elements (Tables 4 and 5).

3.4.1. Total oxides:

A) Silica (SiO₂): Silicon is the most abundant element in the worldwide soil with an average of 54%, but in some soils the content is exceptionally higher. In soils, amorphous silicates apparently contribute to anion adsorption processes, and it has been suggested that silicate and phosphate ions compete for sites on mineral soil particles [22].

In the study soils, the weight average values of the silica(SiO₂) content ranges from 67.9 to 88.7% with an average of 81.3% (Table 4). It is also apparent that sandy textured soil profiles have higher content of SiO₂ where the sand fractions are composed mainly of quartz mineral (SiO₂).

T

able (4): The weight average values of major total elements analyses for soil profiles of the study area (Wt.%).

Profile No.	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	SO ₃	P ₂ O ₅	O.M.	moisture	L.O.I.
High Terraces												
4	81.2	2.0	2.2	1.0	6.3	0.6	0.2	0.6	0.1	0.2	1.8	3.7
Medium Terraces												
1	86.9	0.8	0.7	0.3	2.9	0.4	0.1	0.7	0.1	0.7	2.0	4.3
2	86.5	1.0	1.0	1.1	4.8	0.5	0.2	1.1	0.1	0.5	1.6	1.7
3	84.2	2.7	2.5	0.9	3.7	0.9	0.3	0.2	0.1	0.4	1.6	2.6
5	81.5	3.8	4.7	1.1	2.0	1.2	0.2	1.5	0.1	0.5	1.3	2.1
13	84.1	1.1	2.9	1.9	2.9	0.2	0.1	0.2	0.1	0.3	1.5	4.7
14	79.4	3.2	3.9	2.4	4.6	0.6	0.2	0.2	0.2	0.4	1.6	3.3
Low Terraces												
6	80.6	3.0	2.3	1.8	4.6	1.2	0.2	2.5	0.0	0.6	1.1	2.2
7	86.3	1.8	1.7	0.4	2.6	0.3	0.0	1.1	0.1	0.1	2.2	3.5
8	83.1	2.3	1.8	0.9	4.1	0.5	0.2	1.0	0.2	0.5	2.1	3.3
9	76.5	1.9	2.3	0.8	7.1	0.6	0.0	1.7	0.0	0.2	3.1	5.8
10	79.8	3.8	4.0	0.9	4.8	0.4	0.1	2.1	0.1	0.2	0.7	3.1
11	81.0	3.4	3.0	0.8	5.3	0.5	0.1	2.4	0.0	0.2	1.3	2.0
12	84.9	1.7	3.3	0.7	3.4	0.2	0.0	0.7	0.0	0.3	1.8	3.0
15	80.0	2.6	4.7	2.1	4.2	1.3	1.3	0.4	0.1	0.3	1.8	1.2
16	81.0	2.6	2.9	1.4	2.7	0.8	0.3	2.7	0.2	0.4	2.0	3.0
17	88.7	1.6	1.6	0.7	1.9	0.2	0.1	0.1	0.1	0.2	1.9	3.0
Very Low Terraces												
18	83.2	2.0	2.0	0.8	2.3	0.4	0.6	1.4	0.1	0.1	2.6	4.5
19	84.4	1.6	1.9	2.4	3.3	0.3	0.2	0.3	0.1	0.2	1.4	3.7
20	68.5	3.6	3.7	2.0	14.2	0.4	0.2	3.0	0.2	0.0	1.0	3.2
21	82.3	2.6	2.6	1.6	4.7	0.5	0.2	0.6	0.2	0.4	1.0	3.3

Scarpment												
22	82.8	3.0	3.6	2.5	2.2	0.8	0.3	0.5	0.1	0.1	1.0	3.0
23	80.5	2.6	4.2	2.8	3.4	1.1	0.4	0.1	0.1	0.3	0.4	4.0
24	67.9	4.1	3.4	2.1	14.9	1.2	0.3	0.3	0.1	0.2	2.0	3.6
25	84.5	1.6	2.0	1.4	3.4	0.6	0.2	0.2	0.2	0.3	1.4	4.3
Structural Platform												
26	82.6	0.8	2.0	0.8	7.3	0.4	0.1	0.2	0.1	0.2	1.3	4.4
27	82.5	1.1	2.2	1.6	6.7	0.4	0.1	0.1	0.2	0.2	1.6	3.2
28	77.0	1.0	2.1	1.0	13.6	0.6	0.1	0.2	0.1	0.1	1.2	3.0

Note: L.O.I.: Loss on ignition

O.M.: Organic matter

B) Alumina (Al_2O_3): In soils of the temperate zone, aluminium normally occurs in close association with silicon either in primary minerals, such as feldspars, phyllosilicates and clay minerals. Relatively small proportions of aluminium are found in active forms, although these can be of considerable importance in soil forming processes or in determining the impact of acidification on soils [23]. In the study soils, the weight average values of total Al_2O_3 ranges from 0.8% to 4.1% with mean of 2.3%. The lowest content of alumina in the study soil profiles is due to the sandy textured soils along the study area.

C) Iron (Fe_2O_3): Iron plays an important role in the pedogenesis of soils where its mobilisation and reprecipitation within the soil profile is used as an important diagnostic criterion in soil classification. In most soils, Fe is bound mainly to the clay and silt fractions [23]. Iron plays an important role in soil chemistry being involved in numerous reactions affecting the chemical and physical properties of soils. In the study soils, the weight average values of total Fe_2O_3 ranges from 0.7 to 4.7% with mean of 2.7.

D) Magnesium (MgO): Magnesium occurs in a wide range of silicate minerals, where it frequently substitutes for Fe^{2+} , and also in phyllosilicate minerals, such as biotite and chlorite. Magnesium is an essential element for both plant and animal health; in the former, it is the central metallic constituent of the porphyrin complex, chlorophyll, and, in the latter, it plays a key role in enzymatic reactions. The source of magnesium in soils is related to weathering products of biotite, dolomite, hornblende, olivine, chlorite, illite, montmorillonite and vermiculite [24]. In the study soils, the weight average values of MgO range between 0.3 and 2.8% with mean of 1.4%.

E) Calcium (CaO): Calcium is the fifth most abundant element in the Earth's crust and is an important constituent of many rock-forming minerals. Calcite which is the major source of calcium is a weathering product of rocks and Ca containing minerals such as calcite, apatite, dolomite, aragonite, feldspars and gypsum. In the

study soils, calcium weighted average values range between 1.9 and 14.9% with mean of 6.0%. The highest values of CaO are associated with high amounts of $CaCO_3$, while the lowest values characterize the coarse textured soils of the study area which are relatively low in the content of $CaCO_3$ (Table 1).

F) Sodium (Na_2O): Sodium has an average crustal abundance of 2.3% (23,000 mg/kg).

In parent rocks, most of the sodium is found in feldspars although it can also be found in amphibole and pyroxene. Sodium is also one of the four major cations found associated with cation exchange sites in soils. In the study soils, the weight average values of total Na_2O ranges from 0.2 to 1.3% with mean of 0.6. Sodium possibly accumulates in soils due to evaporation of capillary water under the prevailing arid climate.

G) Potassium (K_2O): Potassium occurs in soil at concentrations that are only slightly lower than those of magnesium and sodium. The availability of K_2O is based on the parent material; where the contents of K_2O in basaltic rocks are higher than in other materials, may be due to mica content of basaltic rocks [25]. The minerals that considered as original source of K are feldspars, orthoclase, microcline, muscovite, biotite and also secondary silicate clays like illite, vermiculite, glauconite and chlorite. Potassium is an essential element for both plant growth and animal health. In the study soils, the weight average values of K_2O are ranged from not detected to 1.3% with mean of 0.3%.

H) Sulfates (SO_3): The weight average values of SO_3 range between 0.1 and 3.0% with mean of 0.9%.

I) Phosphorus (P_2O_5): The average crustal abundance of phosphorus is 1050 mg/kg and apatite is the only phosphorus compound known to occur in natural systems. Thus, minerals such as apatite form a major source of phosphorus. In the study soils, the weighted average values of P_2O_5 are very low and range between not detected and 0.2% with mean of 0.1%. Most of the study area is markedly depleted in phosphorus, suggesting necessity for

remediation through addition of phosphate fertilizer.

3.4.2. Trace elements: The trace elements; B, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se and Zn, were determined in the studied soils (Table 5).

The abundance and distribution of these trace elements in the studied soils are controlled by many factors, including:

1- The parent rocks: The main factors for variation in the heavy metal contents are both the soil type and the lithology [26].

2- Stability of minerals, which host trace elements, versus the prevailing weathering activity. According to [27], the relative affinities for organic and mineral fractions play an important role in the distribution of trace metals during burial and diagenesis, and hence in the shape of their vertical profiles. The differential behavior of metals during diagenesis has further been emphasized by [28].

3- Maturity of the sediments: The sediment texture plays a controlling role on the concentrations and trace elements spatial distribution [29].

4- The physico-chemical conditions such as temperature, pH and composition of pore water. The most moderately acid fluids percolate through a multi-layer sedimentary filling, in near-surface conditions and in a temperate/warm climate [30]. pH level is one of the most important factors controls the sorption, hydrolysis and solubility of metallic cations such as zinc [31].

The following is a brief discussion on the analyzed trace elements.

A) Zinc (Zn): The Zn content of the lithosphere has been estimated to be about 80 mg/kg and in soils its total content reported usually ranges from 10 to 300 mg/kg with occasional lower and higher values [22]. According to [32], Zn is considered one of the elements enriched in worldwide soils and the weight average values of Zn in soil profiles range from 1.9 to 64.5 mg/kg with mean of 24.3 mg/kg. Zn deficiency is found in a wide range of soil

textures but most often in sandy soils. This may be due to the same reason as for many other trace elements, i.e. that most Zn containing rock and minerals are easily weathered and thus likely to form fine textured soils [22].

B) Manganese (Mn): Mn in soils originates primarily from the decomposition of ferromagnesian minerals. The average content in the lithosphere is 1000 mg/kg and the total quantities present in soils vary from less than 100 to several thousand mg/kg [22]. In the study soils, the weight average values of Mn in soil profiles range from 32.4 to 232.6 mg/kg with mean of 135.6 mg/kg.

C) Copper (Cu): The average occurrence of Cu in the earth's crust has been estimated to be 70 mg/kg and its total content in soils ranges usually from about 2 to 100 mg/kg [22]. In the study soils, the distribution of weight average values of Mn ranged from 4.5 to 31.0 mg/kg with mean of 17.6 mg/kg.

D) Nickel (Ni): In the Earth's crust, the mean Ni abundance has been estimated around 20 mg/kg, whereas in the soils it ranges from 10 to 50 mg/kg [22]. The Ni status in soils is highly dependent on its contents in parent material. In the study area, Ni contents are mostly in the range of the world soils and the weight average of Ni in soil profiles ranged from 4.1 to 39.9 mg/kg with mean of 11.3 mg/kg.

E) Lead(Pb): The average Pb content is the Earth's crust is estimated to be 15 mg/kg, whereas the overall mean value of total Pb for different soils is estimated as 27 mg/kg [22]. In the study soils, the weight average values of Pb in soil profiles range from 6.1 to 20.5 mg/kg with mean of 11.5 mg/kg. Pb content in the studied soil profiles is not indicative of pollution and it is within the global acceptable range for soils.

Table (5): Trace elements analysis of some soil samples of the study area (mg/kg).

Profile No.	B	Cd	Co	Cr	Cu	Mn	Mo	Ni	Pb	Se	Zn
High Terraces											
4	11.1	0.3	3.1	31.0	24.7	102.2	2.4	9.0	11.9	0.8	28.3
Medium Terraces											
1	6.3	0.4	1.0	9.9	18.6	150.4	5.1	4.1	8.2	0.4	15.4
2	12.9	2.1	3.7	34.5	10.4	103.4	3.1	10.8	15.0	1.2	2.8
3	11.4	0.9	4.6	43.0	26.1	159.1	2.4	10.6	7.6	1.0	27.7
5	15.0	1.5	9.8	26.6	23.2	128.9	1.8	24.0	11.6	1.0	64.5
13	9.4	0.5	2.5	27.3	24.4	133.5	3.1	9.7	15.3	0.8	28.7
14	5.1	0.9	10.8	36.4	31.0	168.6	5.4	39.9	6.9	0.8	20.5
Low Terraces											
6	13.3	0.4	4.1	37.3	4.5	217.9	1.4	14.7	8.7	1.1	28.8

7	7.7	0.2	1.9	9.2	14.8	105.4	3.2	28.0	7.2	0.6	23.7
8	4.3	1.3	5.3	41.8	17.4	131.0	2.7	6.7	17.8	0.6	27.4
9	6.6	1.4	3.4	16.0	19.2	62.9	3.6	5.7	16.2	1.1	17.8
10	7.1	1.0	4.1	38.0	29.5	70.6	4.0	6.6	19.9	1.4	31.9
11	9.2	0.6	4.8	21.3	22.7	75.0	2.5	6.6	20.5	0.9	16.7
12	9.0	1.0	3.0	10.5	23.8	146.3	4.1	13.7	10.9	1.0	5.5
15	10.0	0.9	5.9	18.6	11.6	172.9	4.0	13.0	10.4	1.1	29.1
16	12.4	0.7	3.3	18.0	5.7	88.0	2.8	9.2	7.7	1.0	27.6
17	5.1	0.3	1.5	6.1	10.3	32.4	1.8	7.8	9.9	1.0	23.6
Very Low Terraces											
18	6.8	0.4	3.7	12.3	6.7	59.5	3.3	7.3	14.5	0.9	12.5
19	5.9	0.5	1.7	13.8	14.1	164.8	3.3	12.3	10.0	1.0	16.6
20	9.6	1.1	3.8	11.0	17.9	211.1	1.0	8.2	10.3	1.1	19.5
21	3.9	1.1	2.8	17.8	12.7	165.0	0.5	6.8	11.3	1.0	30.3
Scarpment											
22	20.7	2.2	6.1	25.8	10.3	232.6	0.8	11.4	10.9	1.0	20.0
23	13.6	1.7	7.4	23.5	29.0	164.5	1.3	8.1	7.9	1.5	1.9
24	8.7	0.9	2.2	26.4	28.9	127.1	4.7	7.8	9.6	1.6	33.4
25	9.2	0.7	2.8	18.7	14.1	76.0	3.3	4.8	6.1	1.0	25.6
Structural Platform											
26	9.2	0.8	0.9	9.3	15.5	139.6	4.2	4.1	6.9	0.9	18.0
27	6.9	0.6	2.5	13.2	9.0	119.8	2.4	5.1	8.7	0.8	31.0
28	8.0	3.4	1.4	13.5	7.8	81.4	3.4	6.6	8.1	0.9	47.7

F) Cobalt (Co): Cobalt, in the Earth's crust, is highly concentrated in mafic rocks, up to 200 mg/kg, when compared to its content in acid igneous rocks, 1-15 mg/kg, and to its abundance in the upper continental crust, 10-12 mg/kg. The Co content of soils is inherited mainly from parent materials. The worldwide mean value of Co in surface soils is calculated as 10 mg/kg [22]. In the study soils, Co contents are in the range of the world soils and the weight average contents range from 0.9 to 10.8 mg/kg with mean of 4.0 mg/kg. The content and distribution of Co in soil profiles are dependent on soil-forming processes and therefore differ for soils of various climatic zones. Higher Co contents of surface soils are found in arid and semi-arid regions, for example, Egyptian soils contain Co from 16.5 to 26.8 mg/kg [33].

G) Boron (B): The average B content of the earth's crust has been estimated to be about 15 mg/kg, while in soils B range usually from about 2 to more than 100 mg/kg, averaging about 30-40 mg/kg [22]. In the study soils, B contents are in the range of world soils and the weight average contents range from 3.9 to 20.7 mg/kg with mean of 9.0 mg/kg.

H) Cadmium (Cd): The average Cd content for the Earth's crust is given as 0.1 mg/kg. Its abundance is fairly similar in both igneous and sedimentary rocks. The contents of Cd in soils lie between 0.2 and 1.1 mg/kg with an average of 0.41 mg/kg [22]. In the study soils, Cd contents are high compared to

the world soils and the weight average contents range from 0.2 to 3.4 mg/kg with mean of 1.1 mg/kg. The mean concentration of Cd in the study area is 2.7 times higher than the world soil average. This indicates that the study soils have high background of Cd which can be related to the influence of the source sedimentary rocks.

I) Chromium (Cr): The abundance of Cr in the Earth's upper crust averages 100 mg/kg. The world soil average content of Cr in soils has been established as 60 mg/kg [22]. In the study soils, Cr contents are in the range of the world soils and the weight average contents range from 6.1 to 43.0 mg/kg with mean of 21.8 mg/kg.

J) Molybdenum (Mo): The average content of Mo is given for the upper Earth's crust as 1.5 mg/kg and its concentration is elevated in granitic rocks and argillaceous sediments, up to 2.5 mg/kg [22]. The world-soil average content of Mo in soils has been established as 1.1 mg/kg (range 0.9-1.8 mg/kg) and is fairly similar to its crustal abundance. In the study soils, Mo contents are high compared to the world soils and the weight average contents of Mo range from 0.5 to 5.4 mg/kg with mean of 3.1 mg/kg. The mean concentration of Mo in the study area is 2.82 times higher than the average of world soils. The high content of Mo is due to that soils in arid and semi-arid regions generally have higher Mo contents. Also, Mo species may be bound to Fe

and Al oxides in soils and sediments, what may determine its behavior in the environment [22].

L) Selenium (Se): The average content of selenium in the Earth's crust is estimated as 0.05 mg/kg; however, a higher value, up to 0.5 mg/kg is also given. The mean total Se content in worldwide soils is estimated as 0.44 mg/kg. Its background contents of various soil groups range from 0.05 to 1.50 mg/kg [22]. In the study soils, Se contents are high compared to the world soils and the weight average contents range from 0.4 to 1.6 mg/kg with mean of 1.0 mg/kg. The mean concentration of Se in the study area is 2.27 times higher than the average of world soils. This indicates that the study soils have high background of Se which can be interpreted to influence of the source sedimentary rocks and the arid climate of the study area.

3.5. Comparison to Upper Continental Crust and world soils:

The geochemical records of clastic sediments have widely been implemented to realize the provenance, tectonics, climate and weathering conditions in their source region since a century [34] and continued to recently [35, 36]. Grain size plays a significant role in determining the elemental concentrations in

sediments [37]. Many research results reveal that geochemical composition of the sediment varies with grain size due to: (1) multiple sources contributing mineralogically and texturally distinct grain sizes; (2) mechanical weathering of rock fragments into finer components; (3) chemical weathering of labile grains into alteration products; and (4) sorting of compositionally distinct grains during transport [38 and 39]. [38] showed that there was considerable compositional variation from gravel or very coarse sand to very fine sand or mud.

3.5.1. Total Oxides:

The average chemical composition of the studied samples is compared to data of the Upper Continental Crust (UCC) as quoted by [40 and 41] as well as the data of world soils as obtained by [42, 43]. This comparison suggests that there is notable depletion in the major oxides; Al_2O_3 , Fe_2O_3 , Na_2O , K_2O and P_2O_5 relative to the UCC and world soils, however MgO is depleted relative to UCC and within the world soils range (Table 6). On the other hand, SiO_2 and CaO are relatively high when compared to the UCC and world soil.

Table (6): The obtained data compared to the Upper Continental Crust & normal soil.

Major oxides (Wt %)	This study			[40]	[41]	[42]	[43]
	Max.	Min.	Average	Upper continental crust		World soil	
				Average	Average	Average	Average
SiO_2	89.8	56.6	81.3	65.9	66.6	59.9	70.6
Al_2O_3	6.5	0.5	2.3	15.17	15.4	15.1	13.4
Fe_2O_3	8.0	0.5	2.7	4.5	5.02	5.0	5.7
MgO	6.7	0.1	1.5	2.2	2.5	1.5	0.8
CaO	23.7	0.2	5.3	4.2	3.6	2.0	2.1
Na_2O	1.5	ND	0.6	3.9	3.3	1.35	0.67
K_2O	1.6	ND	0.2	3.4	2.8	1.7	1.7
P_2O_5	0.5	ND	0.1	0.20	0.15	0.17	0.18
SO_3	4.2	0.1	0.9	-	-	-	-

ND: Not detected

3.5.2. Trace elements:

In this study the following trend of heavy metal average concentration was established: $Mn > Zn > Cr > Cu > Pb > Ni > B > Co > Mo > Cd > Se$ for the soil samples studied.

The result from this study does not indicate any serious pollution or contamination for Mn, Cr, Ni, Zn, Pd, Co and B, since these elements cannot be degraded and tend to accumulate in soils and remain available with subsequent accumulation in plants [44]. However, Cd, Mo and Se are more toxic elements in the study soils. Contamination of soils and sediments by metals such as Cd, Cr and Pb is of concern for human health [45].

3.6. Geochemical trends:

The concentration levels of the major and trace elements in the studied soils are represented in figures (5 and 6). The geochemistry of the major elements is mostly controlled by the mineral composition, which in turn, strongly affected by the physico-chemical conditions prevailed during deposition. The major oxides; CaO and MgO are the main constituents of the carbonate minerals; calcite, aragonite and dolomite. SiO_2 is mainly in the form of detrital quartz. Sometimes a high quotient of SiO_2 together with the oxides; Al_2O_3 , K_2O and partly of Na_2O and Fe_2O_3 are essentially allocated within the structure of the silicate minerals.

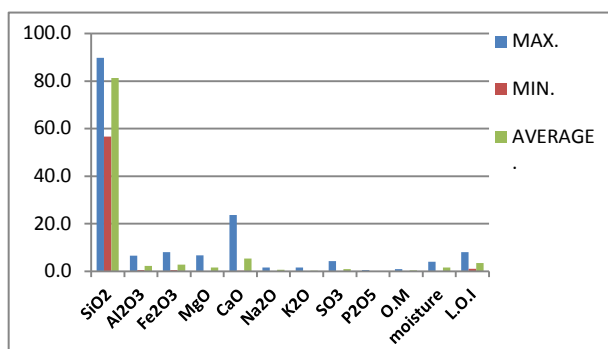


Fig. (5): The concentrations of major elements in the studied sediments(Wt.%).

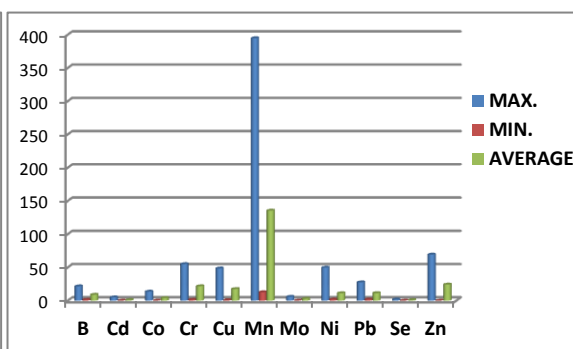


Fig.(6): The concentration of trace elements in the studied sediments (mg/kg).

The obtained data have been processed for factor analysis using the SPSS (Table 7). Most variables are loaded in six main factors, representing a

cumulative total variance 57.16 %, with the smallest “Eigenvalue” being 4.66.

Table (7): Summary of factor analysis of the analyzed soil sample.

Eigenvalue	3.29	2.07	2.01	1.99	1.97	1.82
% of Variance	14.32	9.00	8.74	8.66	8.55	7.90
Cumulative %	14.32	23.32	32.05	40.71	49.26	57.16
Factors	clay	silica	carbonate	Mg-Mn	5	6
Al ₂ O ₃	0.81	-0.22	0.13	-0.17	0.15	-0.06
SiO ₂	-0.48	0.56	-0.53	-0.07	-0.14	-0.30
CaO	0.08	-0.62	0.45	0.00	0.11	0.30
Fe ₂ O ₃	0.77	-0.19	0.14	0.29	0.07	-0.20
MgO	0.12	-0.03	0.18	0.75	0.14	-0.14
Na ₂ O	0.30	0.27	0.22	0.11	0.73	-0.08
K ₂ O	0.01	0.05	0.00	0.08	0.71	-0.07
P ₂ O ₅	0.24	-0.15	-0.36	0.14	0.17	0.18
SO ₃	0.22	-0.12	0.38	-0.52	0.09	-0.17
moisture	-0.20	-0.01	0.02	-0.36	-0.03	0.66
L.O.I.	-0.01	-0.22	0.15	-0.02	-0.45	0.54
O.M.	-0.06	0.70	0.10	0.02	0.14	0.15
B	0.23	0.00	0.15	0.04	0.36	-0.41
Cd	0.07	0.08	0.52	0.30	0.09	-0.09
Co	0.76	0.19	-0.04	0.08	-0.05	-0.03
Cr	0.32	0.69	0.19	0.04	0.20	-0.02
Cu	0.53	0.20	0.09	0.39	-0.26	0.12
Mn	0.07	-0.01	0.16	0.70	0.16	-0.13
Ni	0.51	0.16	-0.43	0.16	0.24	0.07
Pb	0.35	0.20	0.39	-0.30	-0.50	-0.13
Zn	0.36	0.05	0.15	-0.10	0.14	-0.16
Mo	0.02	0.08	-0.16	0.03	0.02	0.71
Se	0.14	0.01	0.60	0.14	0.05	-0.02

These six factors summarize the main geochemical controls affecting the abundance and distribution of the analyzed major and trace elements in the studied sediments. The factor analysis is a powerful tool for identifying relationships that are not readily evident from simple correlation analysis. The variances of each factor reflect the amount of the total data contained in it. The following are short notes on the six factors.

Factor 1: This factor is the most influential in the geochemistry of the studied sediments. It covers

about 14.32% of the total variance and about 3.3 of the eigenvalue. This factor has strong positive loadings for Al₂O₃, Fe₂O₃, Na₂O, Co, Cu, Ni, Zn and Pb while SiO₂ shows strong negative loading (Fig. 7). Therefore, this factor represents the prominent influence of the clayey material on the geochemistry of the studied sediments and its opposite distribution pattern with respect to carbonates. The loading of Al₂O₃, Fe₂O₃ and Na₂O with the main clay components confirms the statement that these clays are essentially structure.

Co, Cu and Ni show very intimate coherence to the clay components. in this factor as they coprecipitated with Al and Fe oxides or with clay minerals (Table 7). This can be considered as a clue for the detrital origin of the clays (possibly recycled from older sediments or from the parent rock).

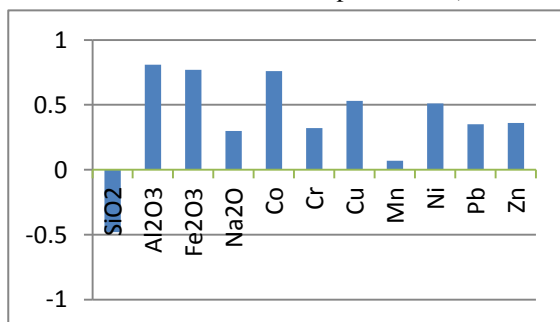


Fig. (7): The relationship between total oxides and clay fraction. and silicates.

Factor 2: This factor covers about 9% of the total variance with an eigenvalue about 2. It has positive loadings for SiO₂, OM and Cr (Fig. 8). The loading of to this factor indicates the prominent influence of the silicctes in the form of detrital quartz.

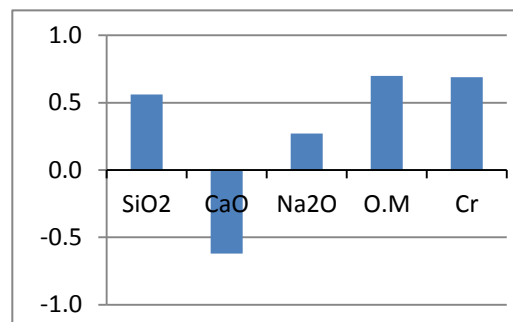


Fig. (8): The relationship between total oxides

Factor 3: This factor covers about 8.7% of the total variables with an eigenvalue about 2 and has positive loadings for CaO, SO₃, Cd, Se and Pb while SiO₂ show strong negative loading (Fig. 9). Therefore, this factor represents the prominent influence of the carbonates. The loading of Cd and Pb to this factor indicates their accumulation with Ca carbonate.

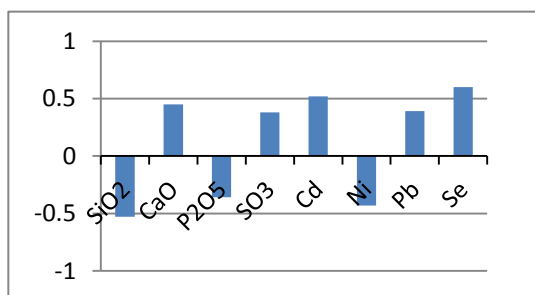


Fig. (9): The relationship between total oxides and carbonates

Factor 4: This factor loads for about 8.7% of the total variables with an eigenvalue about 2 and show clear positive loadings for MgO and Mn, while SO₃ shows strong negative loading (Fig. 10). Therefore, this factor represents the prominent influence of the Mg minerals, possibly such as dolomite.

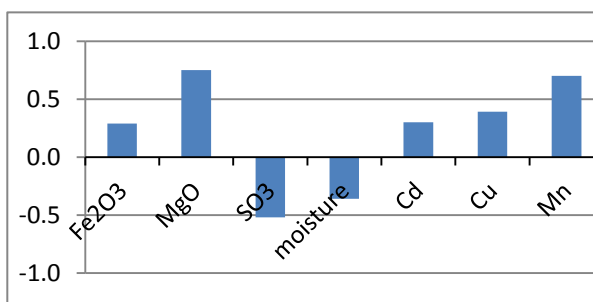
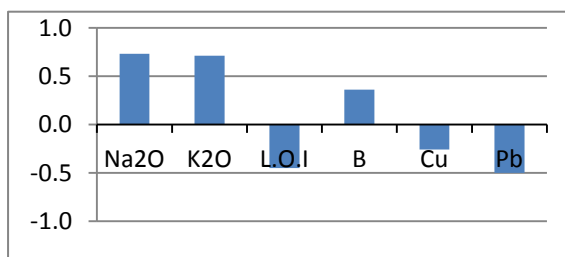


Fig. (10): The relationship between total Oxides and Mg-Mn.

Factor 5:

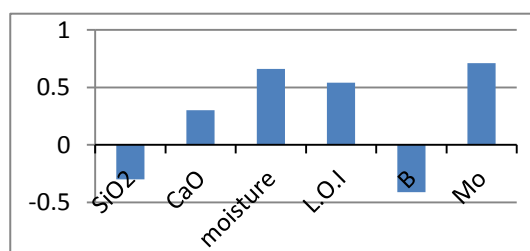
This factor loads for about 8.5% of the total variables with an eigenvalue about 2, and show clear positive loadings for Na₂O, K₂O and B, while Pb shows negative loading (Fig. 11). These constituents may reflect the evaporation tendency in the study area.

Fig. (11): The relationship between total oxides and B. elements and Mo.



Factor 6: This factor covers about 8% of the total variance with an eigenvalue about 1.8. It has positive loadings for Mo, CaO while B shows negative loading (Fig. 12). There is no clear relationship between Mo and other oxides and trace elements.

Fig. (12): The relationship between trace



However, in summary, the correlation matrix and factor component analysis shows that there is no relation between major elements with each other except for Na and K, also the relation between some of the major oxides and trace elements like Al and Co, Fe and Co and K and Cr. The relation is just about good 0.50, so there may be some correlation between these trace elements and the minerals carrying the major oxides like Al-oxides, Fe-oxides, Mn-oxides, Mg-rich clays. Even the factor analysis confirms these results too.

4. References

[1] Siegel, F. R. (2002) Environmental geochemistry of potentially toxic metals. Springer-Verlag, Berlin: 1-218.

[2] Vongunten, H. R., Sturm, M. and Moser, R. N. (1997) 200 - years record of metals in lake sediments and natural background concentrations, Environmental Series Technology, 31 (8): 193 –219.

[3] Tessier, A., Carignan, R. and Belzile, N. (1994) Processes occurring at the sediment-water interface: emphasis on trace elements. Chemical and Biological Regulation of Aquatic Processes: 137-175. Lewis Publishers, Chelsea.

[4] Frascari, F., Frignani, M., Guerzoni, S. and Ravaoli, M. (1988) Sediments and pollution in the Northern Adriatic Sea. Reprinted from Living in a Chemical World, Vol. 534.

[5] Rulkens, W. H., Grotenhuis, J. T. and Tichy, R. (1995) Methods of cleaning contaminated soils and sediments. Heavy metals. Berlin: Springer: 151–191.

[6] Ankley, G. T., Di Toro, D. M., Hansen, D. J. and Berry, W. J. (1996) Technical basis and proposal for deriving sediment quality criteria for metals. Journal of Environmental Toxicology and Chemistry, 15:2056–2066.

[7] Folk, R. L. (1980) Petrology of sedimentary rock; Sylabus, Hamphill's publishing company, Austin, Texas.

[8] USDA (United State Department of Agriculture, Natural Resources Conservation Service) (2010) Field Indicator of hydric soils for the United States, Version 7.0, USDA, NRCS, in cooperation with the Natural Technical Cmmittee for Hydric Soils.

[9] Issam, I. B. and Antoine, H. S. (2007) Methods of analysis for soils of arid and semi-arid regions, FAO, Rome, 128 pp.

[10] Chapman, H. D. and Pratt, P. F. (1961) Methods of analysis for soil, plants and waters. University of California, Riverside, CA.

[11] Soltanpour, P. N. (1991) Determination of nutrient availability element toxicity by AB-DTPA. Soil Test and ICPS Adv. Soil Sci., 16: 165- 190.

[12] Cottenie, A., Verloo, M., Kieken, L., Velgh, G. and Camerlynek, R. (1982) Chemical analysis of plant and soils, Lab. Agrochem., State Univ., Gent, Belgium.

[13] Itoh, A., Hamanaka, T., Rong, W., Ikeda, K., Sawatari, H., Chiba, K. and Haraguchi, H. (1999) Multi-element determination of rare earth elements in geochemical samples by Liquid Chromatography/Inductively Coupled Plasma Mass Spectrometry. Analytical Sciences, 15:17-22.

[14] Schroder, D., and Blum, W. H. (1992) Bodenkunde in Stichworten, 4th ed. Hirt, Berlin.

[15] Mortor-Gaudry, J. F. (1997) Aspects physiologique, biochimiqueetmoleculaire. National Institute de la Recherche, Paris.

[16] Ziardi, N., Simard, R. R., Trans, T. S. and Allard G. (2001) Soil available P as evaluated by description techniques and chemical extractions. Can. J. Soil Sci., 81: 167-174.

[17] Soltanpour, P. N. and Schwab, A. R. (1977) A new soil test for simultaneous extraction of macro- and micro-nutrients in alkaline soils. In Soil Sci. and Plant Anal. 8, 195 pp.

[18] Blake, L., Mercik S., Koerschens, M., Goulding, K. W., Stempen, A., Weigel, P. R., and Powlson, D. S. (1999) Potassium content in soil, uptake in plants and the potassium balance in three European long-term field experiments. Plant and Soil, 216: 1-14.

[19] El-Gundy, A. M. (1988) Pedochemical studies on the soils of East Owienat region. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Cairo, Egypt.

[20] Hafez, I. W., Abdel-Hamid, E. A., Hamra, A. M. and Kamb, R. N. (1992) Prediction of available zinc in some calcareous soils of Egypt. Egypt. J. Soil Sci., 31: 291-300.

[21] Singer, M. J. and Munns, D. N., 2002: Soils: An introduction, 5th ed. Upper Saddle River, NJ: Prentice. Hall, 429 pp.

- [22] Kabata-Pendias, A. (2011) Trace elements in soils and plants, 4th ed. London, New York.
- [23] Edward, P. (2011) Geochemical Atlas for Scottish Topsoils. The Macaulay Land Use Res. Ins. ISBN: 978-0-902701-00-7. 44pp.
- [24] El Bastawesy, M., Ali, R. R., and Nasr, A. H. (2008) The use of remote sensing and GIS for catchment delineation in northwestern coast of Egypt: an assessment of water resources and soil potential. *Egyptian Journal of Remote Sensing and Space Sciences*, 7: 3-16.
- [25] Irmak, S., Sürücü, A. K., Anac, D. and Martin-Prével, P. (1999) Effects of different parent materials on some plant nutrients and heavy metals in the arid regions of Turkey. In: I.C.Q.b.N. Management (Editor). *Developments in Plant and Soil Sciences*. Springer Netherlands: 289-291.
- [26] Navas, A. and Machín, J. (2002) Spatial distribution of heavy metals and arsenic in soils of Aragón (northeast Spain): controlling factors and environmental implications. *Applied Geochemistry*, 17: 961–973.
- [27] ElBilali, L., Rasmussen, P. E., Hall, G. E. and Fortin D. (2002) Role of sediment composition in trace metal distribution in lake sediment. *Appl. Geochem.* 17: 1171–1181.
- [28] Whiteley, J. D. and Pearce, N. J. (2003) Metal distribution during diagenesis in the contaminated sediments of Dulas Bay, Anglesey, N. Wales, UK. *Applied Geochemistry*, 18: 901-913.
- [29] Zhang, H., Davison, W., Mortimer, R. J., Krom, M. D., Hayes, P. J. and Davies, I. M. (2002) Localized remobilisation of metals in a marine sediment. *Science of the Total Environment*, 296: 175-185.
- [30] De Putter, T., Bernard, A., Perruchot, A., Yans, J., Ver-brugghe, F. and Dupuis, C. (2002) Neofomed mineral para-geneses in acid weathering systems: sedimentary vs volcanic environments. *Proceedings of the 12th International Clay Conference*, Elsevier, Oxford.
- [31] Fuller, C. C., Davis, J. A., Coston, J. A. and Dixon, E. (1996) Characterization of metal adsorption variability in a sand and gravel aquifer, Cape Cod, Massachusetts, USA, *J. Contam, Hydrol.*, 22: 165-187.
- [32] El-Kammar, A. M. and Basta, E. Z. (1983) Chemical weathering of the economic phosphate of Abu Tartor W. D. *Chemical Geology*, 38: 321–328.
- [33] Nasseem M. G. and Abdalla Y. H. (2003) Cobalt status in the north western coast soils of Egypt in relation to cobalt content of barley for ruminants. *16 Int. Symp. Environ. Biogeochem. Edinburgh*.
- [34] Gilbert, G. K. (1917) Hydraulic-mining debris in the Sierra Nevada. *US Geol. Surv. Prof. Pap.*, 105 pp.
- [35] Grunsky, E. C., Drew, L. J., David, M. and Sutphin, D. M. (2009) Process recognition in multi-element soil and stream-sediment geochemical data. *Appl. Geochem.*, 24: 1602-1616.
- [36] Young, S. M., Ishiga, H. and Pitawala, A. (2012) Geochemical assessment of upper Mahaweli River and Polgolla reservoir sediments, Sri Lanka. Conference paper. ICESD, Hong Kong. *RechercheGate, APCBEE Procedia*: 57- 62.
- [37] Szefer, P., Szefer, K., Glasby, G. P., Pempkowiak, J. and Kaliszczan, R. (1996) Heavy metal pollution in surficial sediments from the Southern Baltic Sea off Poland, *J. Environ. Sci. Heal. A*, 31(10): 2723–2754.
- [38] Whitmore, G. P., Keith A. W. Crook, K. A. and Johnson, D. P. (2004) Grain size control of mineralogy and geochemistry in modern river sediment, New Guinea collision, Papua New Guinea. *Sedimentary Geology*. 171: 129-157.
- [39] Lee, S. G. , Kim, J. K. , Yang, D. Y., and Kim, J. Y. (2008) Rare earth element geochemistry and Nd isotope composition of stream sediments, south Han River drainage basin, Korea. In *Quaternary international*; 176-177; 121-134; Symposium on terrestrial environmental changes in east Eurasia and adjacent areas; *Quaternary studies in Korea* by Elsevier.
- [40] Taylor S. R. and McLennan S. M. (1995) The geochemical evolution of the continental crust. *Rev. Geophys.* 33: 241–265.
- [41] Rudnick, R. L. and Gao, S. (2004) Composition of the Continental Crust. In: *Treatise on Geochemistry*. Holland, H.D. and Turekian, K.K. (Editors), Elsevier, Amsterdam. 3: 1-64.
- [42] Bowen, H. J. (1979) *Environmental Chemistry of the Elements*. Academic Press, London, 333pp.

[43] Koljonen, T. (1992) Geochemical Atlas of Finland, Part 2: Till, Geological Survey of Finland, Espoo, Finland, 218 pp.

[44] Allsopp, D., Seal, K. and Gaylarde, C. (2004) Introduction to biodeterioration. Cambridge Univ. Press, 237pp.

[45] Chibuikwe, G. U. and Obiora, S. C. (2014) "Heavy metal polluted soils: Effect on plants and bioremediation methods." *Applied and Environmental Soil Science*. doi: 10.1155/2014/752708.