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# EFFECT OF SOIL GENESIS ON FERTILITY STATUS OF SOME WADIS IN SOUTH SINAI

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## ABSTRACT

This study aims to find the effect of both geogenesis and pedogenesis on soil fertility status in south Sinai wadis (Sidri and Feiran). Nine soil profiles in different physiographic units characterizing the study area were selected to represent their associated parent rocks, which in turn related to different parent rocks (basement complex, sedimentary and mixed "sedimentary with igneous and metamorphic".

The obtained data reveal that the total content of soil nutrients P, K, Fe, Mn, Zn and Cu were markedly influenced by the type of parent rocks from which soils were derived. The highest values are associated with the soils of igneous and metamorphic parent rocks (wadi feiran and its delta) followed by the soils of mixed parent rocks (marine sediments). The lowest values were found in the soils of sedimentary parent rocks (wadi Sidri and its delta, piedmonts plain and bajada).

The values of available soil nutrients were affected by pedogenic processes and sedimentation regime. The soils in wadis of either igneous and metamorphic or sedimentary parent rocks include higher contents of available P, K, Fe, Mn, Zn and Cu than the soils in other units. This are related to the geomorphic process. The vertical distribution of available P, K, and Mn in vegetated soils (wadis) show a relative higher levels in soil surface (ecosystem).

According to Soltanpour evaluation, the nutrient rating are high to medium for P, K, Mn, Zn and Cu in the soils of wadis (Feiran and Sidri). Fe and Mn are adequate in all physiographic units while, K is medium in bajada. For each nutrient, the rest of physiographic units are suffering from the nutrient deficiency, which be needed as fertilizers for such soils.

The mineralogical examination of light and heavy minerals reveal that the nutrient bearing minerals assemblage are achieved in feldspars as the main source for K and Ca. A relatively high content of these minerals were found in the soils of wadis and coastal braided delta (either derived from igneous and metamorphic or sedimentary parent rocks), reflected their soil potentiality for these nutrients. As for heavy minerals, the studied soils were characterized by abundance of opaques (as a source of Fe). Pyroxenes and amphiboles (Ca, Mg and Fe), epidotes (Ca and Fe), biotite (K, Mg and Fe) and Apatite and monazite (P), comprise a relatively high portion of the non opaque minerals, especially for the soil derived from the igneous and metamorphic parent rocks. Thus these soils are potentially rich in these elements, comparing with the other soils.

**Keywords:** soil genesis, fertility status, south Sinai

## INTRODUCTION

Soil productivity is generally judged by it's capacity to supply plant nutrients through the occurrence of nutrient-bearing minerals ability to weather, which is greatly affected by the structural characteristics. Hence, the available data of nutrients status as related to soil development (Pedogenesis) and mineralogical constituent (geogenesis) are important knowledge and useful guide for the assessment of fertility management planning.

Soils in South Sinai have a wide variations in their origin. Soils of the northern part were derived from sedimentary rocks (El-Tih and El-Agma Plateaux), whereas those of southern part were mainly derived from igneous and metamorphic rocks (basement complex). Thus, it is expected that a wide variability in their mineralogical, physio-chemical and fertility properties occurred. The overall view of the promising areas in South Sinai was identified, using landsat image interpretation, superimposed with the geological map. The area of wadis Sidri and Feiran were selected for modeling their soil-landscape characteristics, being of prior utilization. Based on interpretation of the landsat TM5 images, several physiographic units characterizing the area which identified by El-Gammal (2004). There are mountains and escarpments, piedmonts, bajada, wadis, coastal braided delta and marine sediments.

The status of the micronutrients in the soil depends almost on the soil parent rock. Both geochemical and pedochemical weathering processes are responsible for forming soil material as final product (Mitchell, 1964). In this respect Swaine and Mitchell (1960) found that the content of trace elements in soils was more influenced by parent rocks than any other pedogenic factor. Krauskoph (1972) reported that micronutrients seem to be strongly related to parent rock composition in early stages of soil development more than this of the later stages. He added that Fe, Mn, Cu and Zn are more abundant in basaltic lavas than those in granites. In sedimentary rocks Mn is more abundant in limestone, while other trace elements are conspicuously abundant in shales. On the other hand sandstones are relatively poor except in Ti and B (Jenkins and Jones, 1980).

El-Demerdashe *et al.* (1971) reported that the most important factors controlling total trace elements content are those related to weathering processes, leaching of soluble constituents, moisture regime, plant absorption and surface enrichment (either due to size sorting or due to microbiological activity). In addition to geo and pedogenesis, Afify *et al.* (2005) stated that the presence of vegetation cover has somewhat effect for the redistribution of certain soil nutrients (recycling effect) such as P, K and Mn, he also, found that the soil N, P, Fe and Mn nutrient level were much affected by the redox condition in the poorly drained soils, which include more nutrients level of those elements more than in the well drained ones.

The current work aimed to evaluate the spatial distribution of some plant nutrients status and their genesis within the related physiographic units to assess the potential and current fertility status of these soils. The study also, aimed to identify the relation between the contents of this nutrients and soil mineral constituents, that influences soil fertility as a result of mineral weathering process in a cyclic sequences in the physiographic units in the studied area. This correlation would be helpful when extrapolation approach is applied for characterizing soils in the other scanned promising areas.

## MATERIALS AND METHODS

Nine soil profiles were selected to represent the physiographic units of wadi Sidri and wadi Feiran (Fig 1) that was established by El-Gammal (2004).

Soil samples were air dried, crushed and passed through a 2mm sieve, mixed thoroughly and stored in plastic jars and subjected to the following analyses:

**Mineralogical analysis of sand fractions:**

Separation of light and heavy minerals was performed on the 0.125-0.063 mm fraction after the ordinary treatments. The separation was carried out using the bromoform (sp.gr. 2.85 ± 0.02) according to Brewer (1964), then the minerals were mounted on glass slides following the method recommended by Brewer (1964). The systematic identification of the light and heavy minerals using the polarizing microscope was performed by counting an average of 500 grains (Milner, 1962).

**Total and chemically extractable soil nutrients:**

Extraction:

Total P, K, Fe, Mn, Zn and Cu in the soil were extracted by digestion with hydrofluoric acid, Jackson, (1967) and their available forms were extracted by DTPA and $NH_4HCO_3$ according to the method of Soltanpour (1985).

**Determination:**

Total and available P contents were determined spectrophotometerically according to the method of Olsen *et al.* (1954).

Total and available K contents were determined by flame-photometer.

Total and available content of Fe, Mn, Zn and Cu were determined by atomic absorption.

## RESULTS AND DISCUSSION

Afify (1999) stated that the drainage lines are important clues for tracing the parent rocks, considering this is importance for the nature of main sediments, that were previously deposited during the fluvial periods, or those of the minor sediments, that are being deposited by seasonal flush flooding. These drainage patterns are mediators between a certain mineralogical rock structure in the high land and a relative specified physiographic unit in the lowland.

According to this approach, the soil parent rocks in the studied wadis were traced, using TM5 Landsat to cover the overall view of the studied area. They are generally described as follows:

**Igneous and metamorphic parent rock (M1):**

These rocks are located in the eastern side of the study area. They are mainly composed either of banded hornblende-biotite, gneiss or of quartz-diorite and hornblende-granodiorite. From these rocks most the soils of wadi Feiran (upstream and downstream) and its delta were derived. They are represented by profiles 5, 8 and 9.

**Sedimentary parent rock (M2):**

These rocks are located in the north east of the basement complex escarpment, and mainly composed of limestones, sandstones, clays and marls, from which the wadi Sidri and its delta, piedmonts (colluvial alluvial footslope and alluvial fan) and bajada were derived (profiles 3, 1, 7, 2 and 6).

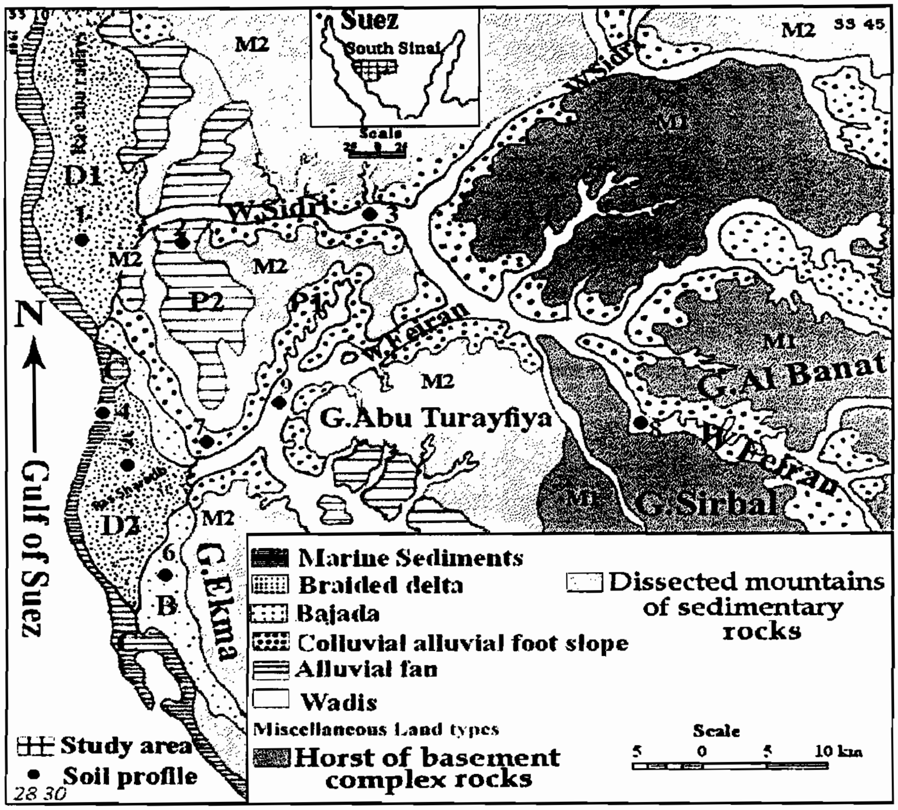

Fig. 1: Physiographic units of wadi Sidri and wadi Feiran.

**Parent rocks of mixed sedimentary and igneous rocks:**

These soils are located in the western side of the studied area (marine sediments), profile 4. The correlation between the total and available contents of soil nutrients and their parent rock mineralogical compositions were assessed as follows:

**The effect of parent rocks on soil fertility:**

**Soil nutrient status of the studied area:**

Data in Table 1 give the values of total and DTPA-extractable nutrients contents of the soil in different physiographic unit as well as the ratings of available nutrients:

**Phosphorus content:**

Data in Table 1 show that, the variation of the soil parent rocks influenced their content of P. The total P values in the soils of igneous and metamorphic parent rocks, ranged from 490 to 790 mg/kg with average of 695, 561 and 525 mg/kg for the upstream, downstream of wadi Feiran and its delta respectively. As for soils of mixed parent rock (marine sediments), the total P contents ranged from 480 to 515 mg/kg with an average value of 495 mg/kg. The total P contents in the soils of sedimentary parent rocks ranged from 310 to 480 mg/kg with average values of 408, 406, 322, 351 and 351 mg/kg for the soils of wadi Sidri and its delta, piedmont plain (colluvial alluvial foot slopes and alluvial fans) and bajada, respectively. Similar results were obtained by Kotb (1999), whose results showed that total P in some wadis of south Sinai ranged from 177 to 846 ppm.

The available P in the different wadis whether of igneous and metamorphic parent rocks "wadi Feiran", or of sedimentary parent rock "wadi Sidri" have soils with the highest P levels. The average contents were 10.66, 9.18 and 8.68 mg/kg for wadi Feiran (upstream and downstream) and wadi Sidri, respectively. According to Afify *et al.* (2005), these wadis represent a network of drainage lines, that receive periodical water runoff, and more dissolved constituents, that released from the eroded parent rocks. P nutrient is most probably accumulated in wadis as a result of geomorphic process. In these wadis, the soil surface layers include more available P contents as affected by the ecosystem of the present natural vegetation. In the soils of mixed parent rocks, marine sediments are affected by the anoxic condition, they include less available P, as affected by fine $CaCO_3$ fractions that were transported to the terminal depositional points (marine zone), as it ranged from 6.7 to 8.8 mg/kg with an average value 7.63 mg/kg. The available P values of the rest of other physiographic units in well drained soils are varied between 1.5 and 7.1 mg/kg. The average values were 6.33, 5.23, 2.47, 2.25 and 2.70 mg/kg for the soils of coastal braided delta of wadi Feiran and wadi Sidri, piedmont plain (colluvial alluvial foot slope and alluvial fan) and bajada, respectively. Abdel-Warth (2002), found that the available P (using Soltanpour method) in south Sinai soils were ranged from 5.25 to 15.52 mg/kg.

**Potassium content:**

Data in Table 1 reveal that, the soils of igneous and metamorphic parent rocks contain values of total K, that range from 4350 to 6800 mg/kg, with average values of 6060, 5225 and 4763 mg/kg for the soils of wadi Feiran (upstream and downstream) and its delta, respectively. Where, in the soils of sedimentary parent rocks, the total K contents range from 3000 to 4800 mg/kg with average values of 3710, 4025, 3083, 3775 and 3300 mg/kg for the soils of wadi Sidri and its delta, piedmont plain (colluvial alluvial foot slope and alluvial fan) and bajada, respectively.

As for the soils of mixed parent rocks (marine sediments), total K range from 4200 to 4900 mg/kg, with an average value of 4633 mg/kg. The highest values of total K were detected in the soils of igneous and metamorphic parent rocks followed by soils of mixed parent rocks. The soils of sedimentary parent rocks are the lowest values.

Data in Table 1 indicate that, the available K content varied widely between the different physiographic units. The average values of available K in the soils of igneous and metamorphic parent rocks were 198, 165 and 115 mg/kg for wadi Feiran (upstream and downstream) and the delta of wadi Feiran, respectively. Where, in the soils of sedimentary parent rock, the average values were 143, 107, 50, 58 and 78 for wadi Sidri and its delta, piedmont plain (colluvial alluvial foot slope and alluvial fan) and bajada, respectively. In the soils of marine sediments (mixed parent rocks), the average value of available K was 153 mg/kg.

Table (1): Total and available nutrients contents in the studied soils (mg/kg).

| Parent materials | Physiographic feature | | Profile No | Depth cm | P | | | K | | | Fe | | | Mn | | | Zn | | | Cu | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | units | sub units | | | Total | Available | | Total | Available | | Total | Available | | Total | Available | | Total | Available | | Total | Available | |
| | | | | | mg/kg | | | | | | | | | | | | | | | | | |
| Igneous and metamorphic | Wadies (W) | W2 (Wadi Feiran) upsteam | 8 | 0-10 | 790 | 14.30 | H | 6800 | 220 | H | 35800 | 10.80 | H | 380 | 4.10 | H | 280 | 4.56 | H | 55.30 | 1.55 | H |
| | | | | 10-30 | 670 | 12.20 | H | 5500 | 218 | H | 34500 | 10.10 | H | 365 | 2.80 | H | 250 | 3.65 | H | 60.20 | 1.30 | H |
| | | | | 30-50 | 620 | 9.80 | H | 5800 | 190 | H | 33600 | 8.90 | H | 280 | 3.71 | H | 200 | 3.70 | H | 45.11 | 1.50 | H |
| | | | | 50-90 | 718 | 8.60 | H | 6300 | 180 | H | 34000 | 10.20 | H | 200 | 2.18 | H | 252 | 2.94 | H | 50.30 | 0.80 | H |
| | | | | 90-150 | 677 | 8.40 | H | 5900 | 180 | H | 30500 | 10.50 | H | 315 | 2.98 | H | 220 | 3.10 | H | 62.80 | 0.95 | H |
| | | | | Mean | 695 | 10.66 | H | 6060 | 198 | H | 33680 | 10.10 | H | 308 | 3.15 | H | 240 | 3.62 | H | 54.74 | 1.22 | H |
| | | downstream | 9 | 0-20 | 650 | 10.13 | H | 5800 | 183 | H | 28600 | 6.80 | H | 310 | 2.80 | H | 258 | 3.40 | H | 45.10 | 0.85 | H |
| | | | | 20-35 | 533 | 9.80 | H | 4600 | 176 | H | 27500 | 8.10 | H | 290 | 1.60 | H | 230 | 3.66 | H | 46.80 | 0.60 | H |
| | | | | 35-80 | 560 | 8.90 | H | 5300 | 180 | H | 25800 | 7.30 | H | 285 | 1.55 | H | 225 | 2.95 | H | 44.20 | 0.65 | H |
| | | | | 80-150 | 501 | 7.90 | M | 5200 | 120 | M | 25350 | 5.60 | H | 211 | 2.97 | H | 200 | 2.11 | H | 51.30 | 0.70 | H |
| | | | | Mean | 561 | 9.18 | H | 5225 | 165 | H | 26813 | 6.95 | H | 274 | 2.23 | H | 228 | 2.87 | H | 46.85 | 0.70 | H |
| | Coastal braided delta (D) | D2 (delta wadi Feiran) | 5 | 0-30 | 520 | 7.10 | H | 5300 | 130 | H | 25800 | 7.00 | H | 270 | 1.70 | H | 212 | 2.85 | H | 39.30 | 0.56 | H |
| | | | | 30-65 | 500 | 6.10 | M | 4900 | 125 | H | 25350 | 6.92 | H | 260 | 1.58 | H | 185 | 2.65 | H | 35.80 | 0.50 | M |
| | | | | 65-80 | 590 | 5.30 | M | 4500 | 115 | M | 24380 | 7.34 | H | 220 | 2.28 | H | 204 | 2.90 | H | 30.10 | 0.58 | H |
| | | | | 80-150 | 490 | 6.80 | M | 4350 | 90 | M | 25535 | 6.80 | H | 200 | 1.92 | H | 215 | 2.95 | H | 38.20 | 0.50 | M |
| | | | | Mean | 525 | 6.33 | M | 4763 | 115 | M | 25266 | 7.02 | H | 238 | 1.87 | H | 204 | 2.84 | H | 35.85 | 0.54 | H |
| Sedimentary | Wadies (W) | W1 (Wadi Sidri) | 3 | 0-20 | 413 | 9.80 | H | 3500 | 190 | H | 16800 | 4.80 | M | 220 | 1.80 | H | 206 | 2.30 | H | 29.80 | 0.48 | M |
| | | | | 20-60 | 385 | 8.40 | H | 3780 | 170 | H | 15400 | 4.00 | M | 180 | 0.88 | M | 175 | 2.50 | H | 30.10 | 0.36 | M |
| | | | | 60-90 | 450 | 9.20 | H | 4560 | 120 | M | 13500 | 4.60 | M | 230 | 1.15 | H | 158 | 3.50 | H | 32.30 | 0.38 | M |
| | | | | 90-150 | 382 | 7.30 | H | 3000 | 90 | M | 14600 | 3.90 | M | 180 | 1.18 | H | 180 | 2.30 | H | 27.50 | 0.30 | M |
| | | | | Mean | 408 | 8.68 | H | 3710 | 143 | H | 15075 | 4.33 | M | 203 | 1.25 | H | 180 | 2.65 | H | 29.93 | 0.38 | M |
| | Coastal braided delta (D) | D1 (delta wadi Sidri) | 1 | 0-25 | 381 | 5.80 | M | 3800 | 138 | H | 11570 | 4.10 | M | 170 | 1.20 | H | 113 | 1.90 | H | 21.30 | 0.36 | M |
| | | | | 25-45 | 390 | 5.10 | M | 3300 | 130 | H | 11480 | 4.20 | M | 150 | 0.98 | M | 152 | 2.30 | H | 23.10 | 0.20 | L |
| | | | | 45-95 | 480 | 5.60 | M | 4800 | 85 | M | 12500 | 4.90 | M | 280 | 1.96 | H | 130 | 1.50 | M | 25.80 | 0.30 | M |
| | | | | 95-150 | 371 | 4.40 | M | 4200 | 75 | M | 10300 | 5.00 | M | 125 | 0.80 | M | 90 | 2.50 | H | 22.50 | 0.25 | L |
| | | | | Mean | 406 | 5.23 | M | 4025 | 107 | M | 11463 | 4.55 | M | 181 | 1.24 | H | 121 | 2.05 | H | 23.16 | 0.28 | L |
| | Piedmont plain (P) | P1 (Colluvial alluvial foot slope) | 7 | 0-20 | 330 | 2.80 | L | 3150 | 45 | L | 15500 | 4.80 | M | 170 | 0.70 | M | 111 | 0.60 | L | 27.30 | 0.16 | L |
| | | | | 20-50 | 310 | 3.10 | L | 3000 | 50 | L | 13300 | 3.80 | M | 160 | 0.48 | L | 109 | 0.80 | L | 31.20 | 0.18 | L |
| | | | | 50-75 | 325 | 1.50 | L | 3100 | 55 | L | 12800 | 4.00 | M | 270 | 0.92 | M | 113 | 0.90 | L | 25.30 | 0.15 | L |
| | | | | Mean | 322 | 2.47 | L | 3083 | 50 | L | 13867 | 4.20 | M | 200 | 0.70 | M | 111 | 0.77 | L | 27.93 | 0.16 | L |
| | | P2 (alluvial fan) | 2 | 0-25 | 320 | 2.10 | L | 3500 | 60 | L | 14300 | 4.13 | M | 180 | 0.80 | M | 180 | 0.65 | L | 25.50 | 0.12 | L |
| | | | | 25-55 | 365 | 2.00 | L | 3300 | 55 | L | 14720 | 4.80 | M | 150 | 0.88 | M | 175 | 0.77 | L | 23.10 | 0.30 | M |
| | | | | 55-85 | 385 | 3.00 | L | 4500 | 65 | M | 14800 | 4.90 | M | 140 | 0.60 | M | 200 | 1.30 | M | 22.90 | 0.20 | L |
| | | | | 85-150 | 335 | 1.90 | L | 3500 | 50 | L | 13200 | 4.15 | M | 160 | 0.70 | M | 160 | 0.80 | L | 20.30 | 0.22 | L |
| | | | | Mean | 351 | 2.25 | L | 3775 | 58 | L | 14255 | 4.50 | M | 158 | 0.75 | M | 179 | 0.88 | L | 22.95 | 0.21 | L |
| | Bajada (B) | — | 6 | 0-35 | 340 | 2.80 | L | 3200 | 62 | M | 16200 | 4.90 | M | 190 | 0.98 | M | 190 | 0.90 | M | 29.10 | 0.24 | L |
| | | | | 35-60 | 310 | 2.70 | L | 3400 | 80 | M | 12600 | 5.00 | M | 170 | 1.30 | H | 170 | 0.95 | M | 24.30 | 0.26 | L |
| | | | | 60-95 | 380 | 3.40 | L | 4800 | 100 | M | 13350 | 4.80 | M | 210 | 0.95 | M | 200 | 0.85 | L | 31.38 | 0.28 | L |
| | | | | 95-150 | 372 | 1.90 | L | 3800 | 70 | M | 15800 | 5.00 | M | 180 | 0.86 | M | 180 | 0.70 | L | 30.31 | 0.34 | M |
| | | | | Mean | 351 | 2.70 | L | 3800 | 78 | M | 14468 | 4.93 | M | 188 | 1.02 | H | 185 | 0.86 | L | 28.77 | 0.28 | L |
| Mixed (Sedimentary & igneous) | Coastal plain | C | 4 | 0-20 | 515 | 8.80 | H | 4900 | 180 | H | 26500 | 8.80 | H | 245 | 2.56 | H | 212 | 1.80 | H | 30.10 | 0.45 | M |
| | | | | 20-60 | 480 | 6.70 | M | 4800 | 170 | H | 21500 | 7.10 | H | 230 | 1.15 | H | 190 | 1.70 | H | 35.20 | 0.40 | M |
| | | | | 60-120 | 490 | 7.40 | H | 4200 | 110 | M | 23300 | 5.90 | H | 210 | 1.88 | H | 205 | 1.51 | H | 28.50 | 0.48 | M |
| | | | | Mean | 495 | 7.63 | H | 4633 | 153 | H | 23767 | 7.27 | H | 228 | 1.86 | H | 202 | 1.67 | H | 31.27 | 0.44 | M |

| | | P | K | Fe | Mn | Zn | Cu | |
|---|---|---|---|---|---|---|---|---|
| Low | (L) | < 3 | < 60 | < 3 | < 0.5 | < 0.9 | < 0.2 | mg/kg |
| Medium | (M) | 4 - 7 | 61 - 120 | 3.1 - 5 | 0.6 - 1 | 1 - 1.5 | 0.3 - 0.5 | mg/kg |
| High | (H) | > 8 | > 120 | > 5 | > 1 | > 1.5 | > 0.5 | mg/kg |

The vertical distributions of K element show relative higher levels in the upper parts of the soil profiles in the vegetated physiographic units (wadis). Jobbagy and Jackson (2001), reported that this distribution reflected the importance of vegetation to increase the available K in topsoil (ecosystem effect).

**Iron content:**

Table 1, show that the total Fe content in the soils are differed from soil to another, depending on their parent rocks, whereas, in the soils of igneous and metamorphic parent rocks have the highest values. The average values were 33680, 26813 and 25266 mg/kg for the soils of wadi Feiran (upstream and downstream) and its delta, respectively. The soils of sedimentary parent rocks have average values of total Fe content as 15075, 11463, 13867, 14255 and 14488 mg/kg for the soils of wadi Sidri and its delta, piedmont plain (colluvial alluvial foot slope and alluvial fan) and bajada, respectively. In soils of mixed parent rock (marine sediments), the average value was 23767 mg/kg.

Data in Table 1 reveal that the available Fe is markedly influenced by the parent rock of the soil. The high levels of available Fe were found in the soils of igneous and metamorphic parent rocks, which are ranged from 5.6 to 10.8 mg/kg with the average values of 10.10, 6.95 and 7.02 mg/kg for wadi Feiran (upstream and downstream) and its delta, respectively. While the medium levels were generally presented in the soils of sedimentary parent rocks. The average values were 4.33, 4.55, 4.20, 4.50 and 4.93 mg/kg for the soils of wadi Sidri and its delta, piedmont plain (colluvial and alluvial foot slope and alluvial fan) and bajada, respectively. As for soil of mixed parent rock (marine sediments) is generally high in the available Fe contents as it ranged from 5.9 to 8.8 mg/kg with an average value of 7.27 mg/kg. In these soils, wet conditions can increase Fe availability ($Fe^{+3} \rightarrow Fe^{+2}$) to be more soluble. According to Kabata-Pendias and Pendias (1992), iron availability is dependent on the soil-water status, in particular goethite ($Fe(OH)_3$) can be reduced to ferrous ($Fe^{+2}$) under that reducing conditions, which can occur in saturated soils.

**Manganese content:**

Data in Table 1 show that the variations in the soil parent rocks (soils of igneous and metamorphic parent rocks) affected significantly on the total Mn contents. These contents ranged from 200 to 380 mg/kg with the averages of 308, 274 and 238 mg/kg in wadi Feiran (upstream and downstream) and its delta, respectively. In the soils of sedimentary parent rock, the total values ranged from 125 to 280 mg/kg with the averages of 203, 181, 200, 158 and 188 mg/kg for wadi Sidri and its delta, piedmont plain (colluvial alluvial foot slope and alluvial fan) and bajada, respectively. The soils of mixed parent rocks (marine sediments), total Mn values were within the range of 210 to 245 mg/kg with an average value of 228 mg/kg. The results indicate that the variations in total Mn contents in different physiographic units mainly reflect the composition characteristics of the different parent rocks as well as the depositional and pedogenic processes, that acted on the soils.

Data in Table 1 show that DTPA-extractable of Mn contents in sedimentary and, igneous and metamorphic parent rocks ranged from 0.48 to 4.1 mg/kg. The highest values of available Mn content in both parent rocks were found in the physiographic unit of wadis. The average values were 3.15, 2.23 and 1.25 mg/kg for the soils of wadi Feiran (upstream and downstream) and wadi Sidri, respectively. These wadis receive frequent flush flooding, resulting in an action of moving fresh water that can act to regulate the dissolving process for Mn constituents. The soils of mixed parent rocks (marine sediments) affected by anoxic condition and halophytic natural vegetation. According to Schulte and Killing (2004) in wet soils, Mn oxides are reduced, so, these soils include relatively high contents of available Mn as ranged from 1.15 to 2.56 mg/kg with an average value of 1.86 mg/kg.

The vertical distribution of Mn in different units is somewhat following the same behavior of K nutrient in the vegetated areas (wadis), which the Mn cycling is increased toward the soil surface.

**Zinc content:**

Table 1 show that, the total Zn values in the soils of igneous and metamorphic parent rocks ranged from 185 to 280 mg/kg with the average values 240, 228 and 204 mg/kg for wadi Feiran (upstream and downstream) and its delta, respectively. In the sedimentary parent rocks the total Zn values varied between 90 to 206 mg/kg with the average values 180, 121, 111, 179 and 185 mg/kg for the soils of wadi Sidri and its delta, piedmont plain (colluvial and alluvial foot slope and alluvial fan) and bajada, respectively. Soils of mixed parent rocks (marine sediments) the total Zn ranged from 190 to 212 mg/kg with an average value 202 mg/kg.

Table 1 indicates that the highest values of available Zn are found in the soils of igneous and metamorphic parent rocks. The average values are 3.62, 2.87 and 2.84 mg/kg for the soils of wadi Feiran (upstream and downstream) and its delta, respectively, followed by the soils of mixed parent rocks (marine sediments), with an average of 1.67 mg/kg. The lowest values of available Zn are found in the soils of sedimentary parent rocks (colluvial alluvial foot slope), with an average of 0.77 mg/kg. The rest of physiographic units of sedimentary parent rocks have average values of available Zn ranged from 0.86 to 2.65 mg/kg.

The vertical distribution of available Zn decreased with the soil depth of vegetated units (wadis).

**Copper content:**

Table 1 show that Cu contents of the studied soils are markedly differed from soil to another depending on their parent rocks, where the total values of Cu in the igneous and metamorphic parent rocks ranged from 30.1 to 62.8 mg/kg, with the average values 54.74, 46.85 and 35.85 mg/kg for the (upstream and downstream of wadi Feiran) and its delta, respectively. The soils of sedimentary parent rocks ranged from 20.3 to 32.3 mg/kg with the average values 29.93, 23.18, 27.93, 22.95 and 28.77 mg/kg for wadi Sidri and its delta, piedmont (colluvial and alluvial fan) and bajada, respectively. Soils of mixed parent rocks (marine sediments), total Cu values varied between 28.5 to 35.2 mg/kg with an average value of 31.27 mg/kg. The results revealed that the soils of sedimentary and mixed parent rocks were contained the lowest values, while the highest values were detected in the soils of igneous and metamorphic parent rocks.

Table 1 show that the available Cu contents in the soils of igneous and metamorphic parent rocks ranged from 0.5 to 1.55 mg/kg with the average values 1.22, 0.7 and 0.54 mg/kg for wadi Feiran (upstream and downstream) and its delta, respectively. Available Cu contents in soils of sedimentary parent rocks were 0.12 to 0.48 mg/kg with the average values 0.38, 0.28, 0.16, 0.21 and 0.28 mg/kg for wadi Sidri and its delta, piedmont (colluvial alluvial foot slope and alluvial fan) and bajada, respectively. In the soil of mixed parent rocks (marine sediments), the average value of available Cu was 0.44 mg/kg.

According to Soltanpour evaluation, the nutrient rating are high to medium for P, K, Mn, Zn and Cu in the soils of wadis (Feiran and Sidri). Fe and Mn are adequate in all physiographic units while, K is medium in bajada. For each nutrients, the rest of physiographic units are suffering from the nutrient deficiency, which be needed as fertilizers for such soils.

## The effect of soil minerals on soil fertility:

### Light minerals:

Light mineral distributions are presented in Table 2. The results revealed that the quartz is the dominant mineral in all studied soils. However, it is occurred in descending order in the soils of sedimentary, mixed, igneous and metamorphic parent rocks. It is found that feldspars are the main sources for K (orthoclase and microcline) and Ca (plagioclase), which markedly differed from soil to another depending on their variance of parent rock as well as the depositional regime. The highest contents of total feldspars were found in the soils of igneous and metamorphic parent rocks. They ranged from 6 to 7.3%, 4.5 to 6% and 4 to 5% in the soils of wadi Feiran (upstream and downstream) and its delta, respectively, reflecting soil potentiality for K. While the relatively lowest values were recorded in the soils of sedimentary parent rocks as it ranged from 3 – 4%, 2.8 – 3.5%, 0.96 – 2%, 2.5 – 2.9% and 1.9 – 2.9% for the soils of wadi Sidri and its delta, piedmont plain (colluvial alluvial foot slope and alluvial fan) and bajada, respectively. In the soils of mixed parent rock, total content of feldspar ranged from 3 – 3.5%.

Released nutrients from light minerals are more influenced by chemical weathering, and vegetation cover, so they are expected to be in relatively light contents in Wadis (whether be derived from igneous and metamorphic or from sedimentary parent rock).

### Heavy minerals:

Data in Table 2 reveal that the opaque minerals (as a source of Fe) are dominated the mineral grains, ranging from 35.4 to 43.5%, 47.5 to 60.5% and 48.08 to 50.2% in the soils of igneous and metamorphic, sedimentary and mixed parent rocks, respectively.

Data of non-opaque minerals reveal that the less stable minerals, such as pyroxenes, amphiboles (as a source of Ca, Mg and Fe), epidotes (Ca and Fe) and biotite (K, Mg and Fe). These minerals dominate the non-opaque ones.

Table (2): Frequency distribution of light and heavy minerals in the sand fraction (0.125 – 0.063 mm) of soils in different physiographic units in the study area.

| Parent materials | Physio-graphic units | Profile No | Depth cm | Light minerals % | | | | | Heavy Minerals | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Quartz % | Feldspars % | | | | Opaques % | Non Opaques % | | | | | | | | | | | | | |
| | | | | | Ortho | Plagio. | Microcl | Total | Iron oxides | Pyroxines | Amphibole | Epidote | Biotite | Garnet | Kyanite | Staurolite | Sillimanite | Apatite | Monazite | Rutile | Tourmaline | Zircon | Total |
| Igneous and metamorphic | W2 | 8 | 0-10 | 92.70 | 3.20 | 2.30 | 1.80 | 7.30 | 36.90 | 11.90 | 21.00 | 2.50 | 5.80 | 3.10 | 2.90 | 2.90 | 1.21 | 5.70 | 2.60 | 0.79 | 0.80 | 1.90 | 63.10 |
| | | | 10-30 | 93.10 | 2.80 | 2.50 | 1.60 | 6.90 | 38.37 | 12.70 | 20.00 | 3.80 | 3.66 | 3.30 | 2.70 | 2.50 | 2.80 | 4.22 | 2.95 | 0.70 | 0.70 | 1.60 | 61.63 |
| | | | 30-50 | 93.70 | 2.50 | 2.10 | 1.70 | 6.30 | 35.40 | 10.00 | 23.00 | 5.20 | 5.00 | 4.20 | 2.00 | 3.18 | 1.30 | 3.66 | 2.00 | 1.30 | 1.10 | 2.66 | 64.60 |
| | | | 50-90 | 94.00 | 2.00 | 2.10 | 1.90 | 6.00 | 35.59 | 11.00 | 22.30 | 4.50 | 6.70 | 3.60 | 1.90 | 2.10 | 1.10 | 4.15 | 2.46 | 1.00 | 1.30 | 2.30 | 64.41 |
| | | | 90-150 | 92.90 | 2.30 | 2.20 | 2.60 | 7.10 | 35.71 | 10.30 | 20.50 | 3.10 | 5.90 | 3.39 | 2.20 | 3.75 | 1.80 | 4.85 | 3.80 | 0.85 | 0.90 | 2.95 | 64.29 |
| | W2 | 9 | 0-20 | 94.00 | 2.00 | 2.20 | 1.80 | 6.00 | 35.90 | 13.20 | 22.30 | 2.70 | 4.10 | 3.38 | 2.80 | 3.88 | 1.60 | 3.10 | 2.73 | 1.00 | 1.51 | 1.80 | 64.10 |
| | | | 20-35 | 94.10 | 2.20 | 2.30 | 1.40 | 5.90 | 40.54 | 10.10 | 23.20 | 2.80 | 5.10 | 2.31 | 1.70 | 2.31 | 1.65 | 3.90 | 1.95 | 1.20 | 1.43 | 1.81 | 59.46 |
| | | | 35-80 | 95.50 | 2.00 | 1.30 | 1.20 | 4.50 | 39.16 | 11.10 | 21.30 | 2.10 | 6.30 | 3.11 | 1.80 | 4.15 | 2.10 | 2.30 | 2.00 | 0.85 | 1.23 | 2.50 | 60.84 |
| | | | 80-150 | 95.00 | 2.10 | 1.80 | 1.10 | 5.00 | 37.12 | 9.80 | 24.10 | 3.20 | 4.20 | 4.12 | 2.91 | 3.30 | 2.30 | 2.35 | 1.65 | 1.00 | 1.15 | 2.80 | 62.88 |
| | D2 | 5 | 0-30 | 95.20 | 1.50 | 1.60 | 1.70 | 4.80 | 43.50 | 12.20 | 16.00 | 4.00 | 5.00 | 4.00 | 2.10 | 4.10 | 1.10 | 2.00 | 2.00 | 1.00 | 2.00 | 1.00 | 56.50 |
| | | | 30-65 | 95.50 | 2.50 | 1.00 | 1.00 | 4.50 | 40.10 | 11.00 | 18.19 | 4.20 | 4.30 | 3.90 | 2.50 | 5.30 | 1.95 | 2.70 | 2.00 | 1.00 | 1.75 | 1.11 | 59.90 |
| | | | 65-80 | 95.00 | 2.00 | 2.00 | 1.00 | 5.00 | 41.73 | 10.95 | 21.70 | 3.90 | 3.90 | 3.12 | 1.80 | 3.20 | 1.00 | 2.00 | 2.00 | 1.20 | 1.60 | 1.90 | 58.27 |
| | | | 80-150 | 96.00 | 2.00 | 1.00 | 1.00 | 4.00 | 40.50 | 13.43 | 18.38 | 3.20 | 4.10 | 4.44 | 1.90 | 4.10 | 1.90 | 2.15 | 1.90 | 1.30 | 1.20 | 1.50 | 59.50 |
| Sedimentary | W1 | 3 | 0-20 | 96.50 | 1.80 | 1.00 | 0.70 | 3.50 | 48.30 | 5.80 | 14.30 | 3.74 | 6.10 | 3.31 | 1.30 | 2.13 | 1.50 | 2.10 | 1.10 | 1.42 | 1.60 | 7.30 | 51.70 |
| | | | 20-60 | 96.00 | 1.80 | 1.20 | 1.00 | 4.00 | 47.50 | 7.20 | 16.10 | 2.80 | 6.40 | 2.80 | 1.10 | 2.15 | 1.30 | 2.35 | 1.90 | 1.80 | 1.10 | 5.50 | 52.50 |
| | | | 60-90 | 96.20 | 1.70 | 0.90 | 1.20 | 3.80 | 50.10 | 8.90 | 15.00 | 2.22 | 5.20 | 2.10 | 0.90 | 2.18 | 1.20 | 2.25 | 1.85 | 1.15 | 1.80 | 5.15 | 49.90 |
| | | | 90-150 | 97.00 | 1.50 | 0.80 | 0.70 | 3.00 | 48.90 | 9.10 | 16.10 | 2.11 | 6.30 | 2.07 | 0.80 | 2.10 | 1.57 | 1.00 | 1.10 | 1.02 | 1.70 | 6.13 | 51.10 |
| | D2 | 1 | 0-25 | 97.00 | 1.00 | 1.00 | 1.00 | 3.00 | 50.10 | 8.10 | 14.10 | 3.20 | 6.39 | 2.20 | 0.27 | 1.80 | 0.80 | 1.30 | 1.80 | 1.89 | 1.90 | 6.15 | 49.90 |
| | | | 25-45 | 97.20 | 1.02 | 1.08 | 0.70 | 2.80 | 50.30 | 9.40 | 13.57 | 2.80 | 6.00 | 2.90 | 0.60 | 1.90 | 0.77 | 1.60 | 1.90 | 1.13 | 1.00 | 6.13 | 49.70 |
| | | | 45-95 | 96.50 | 1.20 | 1.20 | 1.10 | 3.50 | 55.20 | 10.60 | 12.45 | 1.25 | 5.00 | 1.80 | 0.30 | 0.88 | 1.00 | 1.95 | 1.55 | 0.85 | 2.05 | 5.12 | 44.80 |
| | | | 95-150 | 96.70 | 1.02 | 2.00 | 0.28 | 3.30 | 58.50 | 8.80 | 12.19 | 1.59 | 6.10 | 1.50 | 0.20 | 0.75 | 0.50 | 1.30 | 0.65 | 0.97 | 1.80 | 5.15 | 41.50 |
| | P1 | 7 | 0-20 | 99.04 | 0.45 | 0.31 | 0.20 | 0.96 | 60.50 | 6.10 | 10.20 | 2.10 | 2.30 | 1.00 | 0.50 | 0.40 | 0.00 | 0.90 | 0.40 | 1.00 | 3.90 | 10.70 | 39.50 |
| | | | 20-50 | 98.00 | 1.20 | 0.60 | 0.20 | 2.00 | 59.20 | 7.94 | 11.10 | 2.80 | 2.00 | 1.10 | 0.60 | 0.30 | 0.46 | 0.85 | 0.30 | 0.95 | 3.10 | 9.30 | 40.80 |
| | | | 50-75 | 98.40 | 0.60 | 0.80 | 0.20 | 1.60 | 60.30 | 8.13 | 11.30 | 2.10 | 2.50 | 0.95 | 0.55 | 0.20 | 0.30 | 0.70 | 0.20 | 0.77 | 2.80 | 9.20 | 39.70 |
| | P2 | 2 | 0-25 | 97.20 | 1.00 | 1.30 | 0.50 | 2.80 | 55.30 | 8.50 | 10.30 | 3.10 | 6.46 | 1.80 | 1.10 | 1.80 | 0.47 | 1.24 | 1.40 | 1.90 | 1.50 | 5.13 | 44.70 |
| | | | 25-55 | 97.50 | 0.85 | 1.20 | 0.45 | 2.50 | 55.50 | 9.10 | 11.80 | 2.18 | 5.10 | 1.20 | 0.95 | 1.10 | 1.50 | 1.00 | 1.12 | 1.80 | 2.50 | 5.15 | 44.50 |
| | | | 55-85 | 97.30 | 1.05 | 1.10 | 0.55 | 2.70 | 55.30 | 8.30 | 13.30 | 3.10 | 3.20 | 1.10 | 0.75 | 1.05 | 0.85 | 0.88 | 0.85 | 1.70 | 3.50 | 6.12 | 44.70 |
| | | | 85-150 | 97.10 | 1.00 | 1.30 | 0.60 | 2.90 | 57.50 | 10.05 | 9.10 | 2.84 | 4.30 | 2.00 | 0.70 | 0.90 | 0.36 | 0.65 | 1.00 | 0.85 | 2.60 | 7.15 | 42.50 |
| | B | 6 | 0-35 | 97.50 | 1.00 | 0.80 | 0.70 | 2.50 | 55.30 | 7.30 | 11.58 | 2.80 | 3.88 | 2.37 | 1.15 | 0.55 | 0.79 | 1.30 | 1.80 | 1.60 | 3.48 | 6.10 | 44.70 |
| | | | 35-60 | 97.10 | 1.10 | 0.90 | 0.90 | 2.90 | 51.16 | 11.30 | 13.13 | 3.10 | 4.31 | 2.50 | 0.00 | 0.40 | 1.10 | 0.75 | 1.00 | 1.85 | 3.10 | 6.30 | 48.84 |
| | | | 60-95 | 98.00 | 0.60 | 0.80 | 0.60 | 2.00 | 50.37 | 8.10 | 14.25 | 2.45 | 6.12 | 1.90 | 0.00 | 0.76 | 0.55 | 0.80 | 0.95 | 1.85 | 3.80 | 8.10 | 49.63 |
| | | | 95-150 | 98.10 | 0.85 | 0.50 | 0.55 | 1.90 | 58.00 | 7.15 | 11.16 | 2.43 | 4.11 | 1.30 | 1.25 | 1.30 | 0.60 | 1.30 | 0.75 | 1.50 | 2.00 | 7.15 | 42.00 |
| Mixed (Sedimentary & igneous) | C | 4 | 0-20 | 96.50 | 1.50 | 0.50 | 1.50 | 3.50 | 48.08 | 10.30 | 16.00 | 3.20 | 5.00 | 3.10 | 1.00 | 2.10 | 1.10 | 2.00 | 1.00 | 2.10 | 1.90 | 3.12 | 51.92 |
| | | | 20-60 | 97.00 | 1.00 | 0.70 | 1.30 | 3.00 | 50.20 | 9.60 | 15.10 | 3.80 | 6.10 | 2.50 | 1.10 | 1.85 | 0.95 | 2.15 | 1.10 | 1.90 | 1.50 | 2.15 | 49.80 |
| | | | 60-120 | 97.00 | 1.00 | 0.50 | 1.50 | 3.00 | 49.10 | 11.10 | 17.50 | 3.00 | 6.00 | 2.00 | 0.90 | 1.20 | 0.80 | 2.10 | 1.40 | 0.70 | 2.10 | 2.10 | 50.90 |

The highest contents were found in the soils of igneous and metamorphic parent rock, reflecting their mineralogical structures ranging from 9.8 – 13.43%, 16.0 – 23.2%, 2.1 – 5.2%, 3.66 – 6.7% for pyroxenes, amphibole, epidote and biotite, respectively. As these minerals are rich in Ca, Mg, K and Fe, the soils in turn are potentially rich of them.

Soils of sedimentary parent rocks ranged from 5.8 – 11.3%, 9.10 – 16.1%, 1.25 – 3.74% and 2 – 6.40% for pyroxenes, amphibole, epidote and biotite, respectively. While the soils of mixed parent rocks (marine sediments) ranged from 9.6 – 11.10%, 15.1 – 17.5%, 3 – 3.8% and 5 – 6.11% for pyroxenes, amphibole, epidote and biotite, respectively.

Data of heavy mineral in minor amount, indicate that the distribution values are mainly related to nature of soil parent rocks. Soils of igneous and metamorphic parent rocks include higher contents of garnet, kyanite, staurolite and sillimanite, compared with those of sedimentary rock and mixed parent rocks. Apatite and monazite as a source of phosphorus are more related to the soils of igneous and metamorphic parent rocks. They ranged from 2 – 5.7% and 1.65 – 3.8% of the heavy minerals for apatite and monazite, respectively. Total P was generally high in these soils. In the soils of sedimentary parent rocks the amounts of apatite and monazite ranged from 0.65 – 2.35% and 0.2 – 1.9% of the heavy minerals, respectively. In the soils that of mixed parent rocks (marine sediments), the values of apatite varied between 2 – 2.15% and monazite 1.0 – 1.4% of the heavy minerals.

The amount of ultra stable minerals (zircon, rutile and tourmaline), show that the variation in the soils parent rocks caused a marked effect on their content. However, soils derived from sedimentary rocks include higher content of the ultra stable minerals compared with those derived from igneous and metamorphic rocks and soils of mixed parent rocks.

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## تأثير نشأة الأراضى على حالة الخصوبة لبعض أودية جنوب سيناء

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**معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة**

يهدف هذا البحث الى دراسة تأثير كلا من geogenesis (منشأ الأرض الجيولوجى) و pedogenesis (منشأ الأرض البيدولوجى) على خصوبة التربة لبعض أودية جنوب سيناء (وادى سدرى ووادى فيران). ولهذا أختيرت تسع قطاعات أرضية لوحدات فيزيوجرافية ناشئة من مواد أصل صخرية مختلفة (قاعدية - رسوبية -مختلطة "رسوبية، نارية، متحولة").

وقد أوضحت النتائج أن المحتوى الكلى لتلك العناصر الغذائية قد تأثرت بشدة بنوعية مادة الأصل الصخرية التى نشأت منها التربة، وكانت أعلى القيم لتلك العناصر فى الأراضى ذات الأصل النارى والمتحول (وادى فيران ودلتاه)، ويليه فى ذلك الأراضى ذات مواد الأصل المختلطة (الترسيبات البحرية) بينما وجدت أقل القيم من تلك العناصر فى الأراضى ذات الأصل الرسوبى.

أما الكمية الميسرة من العناصر فقد تأثرت بالعمليات البيدوجينية ونظام الترسيب. فقد أحتوت أراضى الأودية (سواء ذات أصل نارى ومتحول أو رسوبى) على أعلى القيم من العناصر

الميسرة للفسفور والبوتاسيوم والحديد والمنجنيز والزنك والنحاس مقارنة بالوحدات الفيزيوجرافية الأخرى ويرجع ذلك الى فعل العمليات الجيومورفولوجية. وقد أوضح التوزيع الرأسى للكمية الميسرة من الفوسفور والبوتاسيوم والمنجنيز فى الوحدات ذات الغطاء النباتى الطبيعى (الأودية) زيادة ملحوظة فى الطبقات السطحية للتربة (ecosystem).

وطبقا لتقيم Soltanpour فقد صنفت أراضى الأودية (فيران وسدرى) لعناصر الفوسفور والبوتاسيوم والمنجنيز والزنك والنحاس من متوسطة الى عالية الخصوبة. وعنصرى الحديد والمنجنيز فقد تواجدا بقدر كاف فى كل الوحدات الفيزيوجرافية بينما عنصر البوتاسيوم كان متوسطا فى اراضى الباجادا. وبالنسبة لكل عنصر من تلك العناصر فإن الأراضى فى الوحدات الفيزيوجرافية المتبقية تعانى من نقص لتلك العناصر حيث ينصح بإضافتها فى صورة أسمدة لتعويض هذا النقص.

ولقد وجد خلال الفحص المنرالوجى للمعادن الخفيفة والثقيلة أن أهم المعادن الحاملة للمغذيات تنحصر فى مجموعة الفلسبارات كمصدر للبوتاسيوم والكالسيوم كما وجد أن المحتوى المرتفع نسبيا من تلك المعادن يوجد فى أراضى الأودية والدلتا سواء الناشئة من أصل نارى ومتحول أو رسوبى ويعكس هذا قدرتها الامدادية لتلك العناصرً.

أما بالنسبة لمجموعة المعادن الثقيلة فقد وجد أن المعادن المعتمة Opaques (كمصدر للحديد) تمثل نسبة كبيرة لأراضى منطقة الدراسة. وتمثل معادن البيروكيسينات والأمفيبولات مصدر لعناصر (Ca, Mn, Fe) والإيبيدوت (Ca, Fe) والبيوتيت (K, Mn, Fe) والاباتيت والمونازيت (P) والتى تمثل جزءا كبيرا من تكوين المعادن الغير معتمة Non opaques وخاصة فى الأراضى الناشئة من أصل نارى ومتحول. ولذلك تعتبر هذه الأراضى ذات قدرة إمدادية عالية لغناها بهذه العناصر مقارنة بباقى الأراضى.