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Vegetation Analysis and Chorological Affinities in WadiHagul, Northeastern Desert, Egypt

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Abstract: *The present study aims to investigate the ecological features, vegetation analysis and chorological affinities in WadiHagul at Northern part of the Eastern Desert of Egypt. The total number of the recorded plant species in this study was 57 species belonging to 50 genera and 19 flowering families. According to the life-span, these species were classified into 46 perennials, nine annuals and two biennials. The life-form spectrum of the recorded species comprise 24 species as chamaephytes, 13 hemicryptophytes, 11 therophytes, seven phanerophytes and twocryptophytes. Chorologically, the Saharo-Sindian element was the predominant chorotype comprising 51 species which distinguished into 25 Monoregional, 23 Biregional and threePluriregional elements. Based on the importance values, the classification of the recorded species in 36 sampled stands led to recognition of four vegetation groups (A – D). Ochradenusbaccatus community type dominated all the identified vegetation groups, but with different important and indicator species. The vegetation groups were clearly distinguished and showing a clear pattern of segregation on the ordination plane. It is also obvious that maximum water – holding capacity, sand fraction, pH value, electrical conductivity, lead, calcium and magnesium were the most controlling edaphic factors which exhibited high significant correlations with the first and second axes of CCA diagram.*

Keywords: *Wadi-Hagul, classification, ordination, soil analysis, chorotype.*

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I. Introduction

The desert vegetation in Egypt is the most significant and characteristic kind of natural plant life covering approximately 95% of the overall area of the country, mostly, it is composed of xerophytic shrubs and subshrubs [1]. [2]recognized two kinds of desert vegetation namely diffuse and contracted. Both kinds refer to persistent vegetation that can be accompanied by ephemeral plant growth relying on the quantity of rainfall in a particular year. A third kind named accidental vegetation was added by [3], where rainfall is little and falls so irregularly that no persistent vegetation occurs. As dry regions are usually specialized by minimal precipitation and frequent droughts [4], thus the availability of water is on of the serious agents prevailing the distribution of species [5]. The most important gradients in abiotic factors may be linked to water availability, in duding annual rainfall, soil characteristics and topography [6].

WadiHagul is one of the most notable and dry diverse wadis in the Eastern Desert. It is bordered by Suez Gulf from the east, Gebel Ataqa from the north, WadiBadaa from the south and Gebel El-Kahaliya from the west [7].

*Ochradenusbaccatus*Delile (Resedaceae) as one of the dominant community type is a deciduous shrub common in numerous stony wadis and along hilly slopes. It is distributed from Libya to Pakistan, Somalia and Ethiopia [8]. In Egypt, [9] described *Ochradenusbaccatus* as a yellow green large shrub with stout, spinescent branches and forming dense bushes in dry desert habitats. It is probably the dominant fleshy-fruited shrub throughout many hot desert regions in the Middle East [10; 11]. Recently, *Ochradenusbaccatus* in WadiHagulbecomes threatened species in this disturbedwadi due to intensive and excessive destruction by the unplanned human interferences. Therefore, the aim of the present study is to throw light on the ecological status, vegetation analysis and chorological affinities in WadiHagul area (Egypt) with particular reference to *Ochradenusbaccatus* community type.

II. The Study Area

WadiHagul occupies an area of approximately 350 km^3 representing about 0.16% of the total area of the Egyptian Eastern Desert and it is located at the North-west part of Gulf of Suez [12]. It is bounded by latitudes 29° 41 - 30° 01 N and longitudes 32° 08 - 32° 24 E. Its main channel extends for a distance of about 40 km with a width of 6 – 10 km and it runs to south and southest to debauch into the Gulf of Suez. It is bordered by Suez Gulf from the east, Gebel Ataqa from the north and Gebel El-Kahaliya from the west and WadiBadaa from the south (Fig. 1). WadiHagul is characterized by local physiognomic heterogeneity andphysiographic variations, and it is enriched with soft sediment deformation structures [13].The geologic and vegetation structures of WadiHagul bed led to the recognition of three main sections: upstream, middle stream and downstream sections [14]. WadiHagul lies within arid desert climate with very low rainfall, high temperature and high evaporation rate. Rainfall is scanty, patchy and usually falls during winter season, where the average annual rainfall is about 2.7 mm. However, the area may be subjected to occasional heavy rainstorms that causing dangerous flash flooding.

III. Materials and Methods

After regular field trips to the study area in WadiHagul, a number of stands were selected for sampling vegetation associated with *Ochradenusbaccatus* during spring 2016. Thirty six stands (area = 10 × 10m each) were chosen for sampling vegetation in the present study. These stands were selected to cover all physiographic variations to ensure sampling of wide range of vegetation diversity. The soil samples were collected from depth 0 – 50 cm from each sand, pooled together to form one composite sample, spread over sheets of paper, air dried, passed through 2 mm sieve, and packed wellto be ready for analysis. Physical and chemical analyses of soil samples were carried out according to [15; 16; 17].

The relative values of density and cover of each plant species were calculated in each stand. Density was determined by counting the number of individuals of the species within a series of randomly distributed stands [18]. Cover was measured by application of line intercept method [19]. The importance value (IV = out of 200) was calculated by the summation of the relative values of density and cover for each species [20]. The techniques of classification and ordination were applied in the present investigation. The classification applied here was the Two Way Indicator Species Analysis (TWINSPAN) according to [21]. The ordination techniques applied were the Detrended Correspondence Analysis (DCA) and the Canonical Correspondence Analysis (CCA) using CANOCO [22]. The identification, nomenclature and chorotypes of the recorded plant species in the current study were according to [9; 11; 23; 24; 25; 26; 27; 28].

IV. Results

4.1. Floristic Features

The floristic features of the plant species recorded in WadiHagul study area include the following items: floristic composition, vegetation analysis and soil-vegetation relationships.

4.1.1. Floristic list

The floristic composition of WadiHagul area is presented in Table (1). In total, 57 plant species belonging to 50 genera and 19 flowering families were recorded in 36 sampled stands in both sides of WadiHagul bed extending for about 30 km long.

4.1.2. Life – span

The longevity of the recorded species (57) showed that the majority were perennials attaining 46 species (80.70%), followed by annual (nine species = 16.79%) and biennials showing the lowest representation (two species = 3.51).

4.1.3. Life – form

The life – form spectrum of the recorded species comprise chamaephytes (24 species = 41.11%), hemicryptophytes (13 species = 22.81%), therophytes (11 species = 19.30%), phanerophytes (seven species = 12.28%) and cryptophytes (two species = 3.51%).

4.1.4. Chorological analysis

The chorological elemnts of the families in the study area is presented in Table (1). Asteraceae includes 15 species or about 26.32% of the total number of recorded species, followed by Poaceae which comprise five species (8.77%), then Asclepiadaceae, Brassicaceae, Fabaceae and Zygophyllaceae four species each (7.02%). These six leading families were attained collectively by 37 species (64.91%). Caryophylleaceae and Lamiaceae were represented by three species each. The other remaining families (11) were represented by either two or one species. The floristic elements in family Asteraceae include Monoregional (six species), Biregional (six species) Pluriregional (two species) and Cosmopolitan (one species). In family Poaceae, the chorotypes include Cosmopolitan (two species), Biregional (two species) and Monoregional (one species). In each of Asclepiadaceae and Brassicacecae the floristic categories comprise Biregional and Monoregional (two species each). Fabaceae includes Monoregional (three species) and Biregional (one species). Zygophyllaceae includes two species as Monoregional and one species as Biregional and Palaeotropical elements each.

The chorological analyses of the surveyed flora in the study area are presented in Tables (1 & 2). The Mediterranean taxa were represented by eight species as Biregional elements and three species asPluriregional elements. The Saharo – Sindianchorotype comprises 25 species Monoregional, 23 species Biregional and three species Pluriregional elements. The Sudano – Zambizanchorotype includes 11 species Biregional and one species Pluriregional elements. The Irano – Turanianchorotype was represented by seven species Biregional and two species Pluriregional. The world widechorotypes were represented by three species as Cosmopolitan and one species as Palaeotropied elements. In general as shown in Table (2), the Biregional andMonoregionalelements were represented by 25 species each (43.86%), the world wide elements by four species (7.02%) and the Pluriregional elements by three species (5.26%).

4.2. Vegetation Analysis

4.2.1. Classification of stands

The application of TWINSPAN classification based on the importance values (out of 200) of 57 plant species in 36 sampled stands in WadiHagul, led to the identification of four vegetation groups (A, B, C and D) as shown in Figure (2). The vegetation composition of these groups is presented in Table (3). *Ochradenusbaccatus* dominated all the identified vegetation groups, but with different important and indicator species.

Group A includes the smallest number of stands (two stands) dominated by *Ochradenusbaccatus* (IV = 25.43). The other important species which attain relatively high importance value comprise three perennials namely, *Lavandulacoronopifolia* (IV = 18.32), *Lotus herbanicus* (IV = 16.08) and *Calotropisprocera* (IV = 11.09), as well as one annual species namely, *Trigonellastellata*. In this vegetation group no any indicator species was detected.

Group B comprises eight stands dominated also by the same community of*Ochradenusbaccatus* (IV = 46.53). The important species in this group also include three perennials namely, *Tamarixnilotica* (IV = 14.83), *Iphionamucronata* (IV = 14.50) and *Zillaspinosa* (IV = 13.84), as well as one annual species namely, *Centaureaaegyptiaca* (IV = 10.36). The indicator species in this vegetation group were *Zygophyllumcoccineum* (IV = 9.43) and *Panicumturgidum* (IV = 6.55).

Group C comprises the largest number of stands (22) dominated by *Ochradenusbaccatus* (IV = 37.99). Three important perennial species were recorded in this group namely, *Lavandulacoronopifolia* (IV = 12.09), *Zillaspinosa* (IV = 11.06) and *Crotalaria aegyptiaca* (IV = 10.71). The indicator species in this group were numerous such as *Zygophyllumdecumbens* (IV = 9.36), *Lasiurusscindicus* (IV = 7.80), *Diplotaxisharra* (IV = 3.45), *Echinopsspinosus* (IV = 3.18), *Achilleafragrantissima* (IV = 1.70) and *Rumexvesicarius* (IV = 1.48).

Group D includes three stands dominated also by the target species *Ochradenusbaccatus* (IV = 42.12). Five important perennial species were identified in this vegetation group, these comprise *Zillaspinosa* (IV = 17.08), *Zygophyllumcoccineum* (IV = 16.95), *Zygophyllumdecumbens* (IV = 16.33), *Retamaraetam* (IV =11.16) and *Launaeaspinosa* (IV = 10.95). The annuals recorded in this group were three species namely, *Zygophyllum simplex* (IV = 3.42), *Rumexvesicarius* (IV = 2.54) and *Centaureaaegyptiaca* (IV = 1.20). The indicator species in this group such as in group A did not represented by any species.

4.2.2. Ordination of stands

The Detrended Correspondence Analysis (DCA) ordination plot of 36 stands on the first and second axes is shown in Figure (3). It is clear that the vegetation groups identified by TWINSPAN classification were markedly distinguishable and having a clear pattern of segregation on the ordination plane. Groups A and B were segregated at the right side of DCA-diagram, while groups C and D were separated at the left side of the diagram. It is also obvious that groups B and D were located at the lower part of DCA-diagram, whereas groups A and C were occupied the upper part of diagram.

4.3. Soil-Vegetation Relationships

4.3.1. Correlation between soil variables and vegetation groups

The variations in soil variables between four vegetation groups recognized by TWINSPAN classification in the study area are presented in Table (4). It is obvious that the soil variables of the four vegetation groups showed comparable contents.

The highest percentage of sand fraction (90.10%) was determined in group A, the highest percentage of silt fraction (11.19%) was obtained in group D and the highest percentage of clay fraction (5.20%) was determined in group B. In contrary, the lowest percentage of sand (84.19%) was determined in group D, silt (8.25%) and clay (1.65%) in group A. Soil porosity attained the highest percentage (39.40%) in group A, while the lowest percentage (29.05%) in group B. The maximum water – holding capacity exhibited the highest percentage (26.30%) in group B, whereas the lowest percentage (16.76%) in group D.

The chemical soil characteristics showed relatively variations from one vegetation group to another. The soil samples of group A attained the highest value (8.75) of pH, while the lowest value (7.74) in group B. In contrary, electrical conductivity attained the highest value (2.27 ms/cm) in group B, and the lowest value (0.07 ms/cm) in group A. Calcium carbonate content showed the highest percentage (6.35%) in group B, and the lowest value (3.96%) in group C. The highest values of organic carbon (0.75%), total dissolved phosphorus (6.83 mg.Kg^{-1}) and total nitrogen (33.64 mg.Kg^{-1}) were determined in group C. On the other hand, the lowest values of these variables (0.47%, 5.37 mg.Kg^{-1} and 30.54 mg.Kg^{-1}, respectively) were measured in group B. The highest contents of chlorides (10.58 mg/ 100 g dry soil), sulphates (3.49 mg/ 100 g dry soil), bicarbonates (3.64 mg/ 100 g dry soil), sodium cation (10.77 mg/ 100 g dry soil), potassium cation (0.81 mg/ 100 g dry soil), calcium cation (3.49 mg/ 100 g dry soil) and magnesium cation (2.64 mg/ 100 g dry soil) were determined in group B. On the other hand, the soil samples of group B showed the lowest values of the previous soil variables attaining values of 6.90, 2.09, 2.43, 7.07, 0.57 and 1.5/ mg/100 g dry soil, respectively in group C except calcium cation (0.23 mg/ 100 g dry soil) in group A.

Heavy metals exhibited also relatively comparable variations from one group to another, as well as from one metal to other. The soil samples of group C attained the highest contents of iron, manganese, zinc, cobalt and lead with values of 36.70, 12.37, 19.76, 2.69 and 7.72 $mg.Kg^{-1}$, respectively. On the other hand, the soil samples of group A showed the lowest contents of Mn, Zn, Cu, Co and Pb with values of 10.12, 16.65, 8.23, 1.18 and 6.19 $mg.Kg^{-1}$, respectively. Copper attained the highest content (9.07 $mg.Kg^{-1}$) in group B and iron showed the lowest value (32.23 $mg.Kg^{-1}$) in the same group.

4.3.2. Correlation coefficient (r) between the different soil parameters

The correlation coefficient (r) between the different soil variables in the sampled stands is presented in Table (5).

It is obvious that sand fraction showed high negative significant correlations with silt and clay fractions, as well as low positive significant correlation with pH value. Silt fraction exhibited a low positive significant correlation with clay fraction. The soil reaction (pH) showed moderate positive significant correlations with total dissolved phosphorus and total nitrogen, as well as low positive correlations with organic carbon and soluble bicarbonates. On the other hand, it exhibited moderate negative correlations with chlorides and sodium cation, as well as low negative correlations with calcium carbonates, potassium, calcium and magnesium cations. Calcium carbonate content showed high positive correlations with sulphates, bicarbonates, sodium, potassium, calcium and magnesium cations, and high negative correlations with total dissolved phosphorus, total nitrogen and chlorides. Organic carbon content exhibited high negative correlations with total nitrogen, chlorides, sulphates, bicarbonates, sodium, potassium, calcium and magnesium cations, whereas it showed a high positive correlation with total dissolved phosphorus. Total dissolved phosphorus showed high negative correlations with chlorides, sulphates, bicarbonates, sodium, potassium, calcium and magnesium cations, but it exhibited a high positive correlation with total nitrogen. Total nitrogen content showed high negative significant correlations with each of chlorides, sulphates, bicarbonates, sodium, potassium, calcium and magnesium cations.

On the other hand, chlorides exhibited high positive significant correlations with each of sulphates, bicarbonates, sodium, potassium, calcium and magnesium cations. Sulphates also showed high positive correlations with each of bicarbonates, sodium, potassium, calcium and magnesium cations. Soluble bicarbonates showed high positive correlations with all cations. Sodium cation exhibited high positive correlations with each of potassium, calcium and magnesium cations. Potassium cation also showed high positive correlations with calcium and magnesium cations, as well as calcium showed a high positive correlation with magnesium. It is clear that some soil variables such as clay fraction, soil porosity, maximum water-holding capacity and electrical conductivity did not show any correlation with any soil variables.

4.3.3. Relationship between soil factors and vegetation groups

The correlation between vegetation and soil variables is indicated on the ordination diagram produced by Canonical Correspondence Analysis (CCA) of the biplot of species and soil characteristics. The Canonical Correspondence Analysis (CCA) ordination of the sampled stands in study area is shown in Figure (3). It is clear that maximum water - holding capacity, sand fraction , pH value, electrical conductivity, lead, calcium and magnesium were the most controlling soil variables which exhibited high significant correlations with the first and second CCA diagram. In the upper right side of diagram, vegetation group A was located, and it did not show any correlation with any soil variable. On the other hand, vegetation group B was segregated at the lower right side of CCA-biplot, and it exhibited significant correlations with maximum water-holding capacity, electrical conductivity, magnesium, calcium and cupper. Group Cwas segregated in the upper left side of diagram, , and it exhibited significant relationships with pH value, cadmium and total dissolved phosphorus. On contrary, group D was segregated at the lower left side of CCA-biplot, and it exhibited significant correlations with many edaphic variables such as lead, silt, clay, zinc and porosity.

V. Discussion

The Egyptian Eastern Desert covers an area of about 223.500 sq. km, representing about 22.5% of total area of Egypt. It extends from Nile Valley eastward to the Red Sea coast. There are two groups of threats facing the wild vegetation of Egypt: 1- The natural environmental accidents such as flood streams, drought, fire, diseases, wild enemies (e.g. insects and rodents) and invasion of exotic plant species. 2- The man-mediated threats which have been distinguished in the Eastern Desert of Egypt such as over-grazing, over-cutting and collecting for fuel, power stations, urbanization, industrialization, military activity, etc. [29].

In the present study, the surveyed natural plant cover in WadiHagul was 57 species related to 50 genera and 19 flowering families which recorded in 36 sampled stands. These plant species were distinguished into 46 perennials, nine annuals and two biennials. Chronologically, the recorded species in the present study were classified into 25 species as Biregional and Monoregional elements each, 3 species as Pluriregional and Cosmopolitan elements each and one species as Palaeotropical element. Generally, the Saharo – Sindianchorotype comprises 51 species which distinguished as 25 Monoregional, 23 Biregional and threePluriregional elements. The predominance of Saharo – Sindian elements in the present investigationmay be due to the location of Egypt in the central part of Saharo – Sindianphytogeographicalarea which located between Morocco and Iraq [30]. The relative low records of other floristic categories such Sudano – Zambiezian,Mediterranean and Irano – Turanian proved the modifications which occurred in the desert wadis due to climatic changes andanthropogenic factors, and that provides the chance for some exotic species to migrate and inhabit nearby phytogeographicalregions [31].

Ochradenusbaccatus is one of dangered and / or threatened plant species in WadiHagul due to the intensive human activities and disturbance in this wadi during the last years. So, it is urgent to investigate the current status of the vegetation structure in WadiHagual, especially this shrubby species which is considered as one of the most dominant species along the streams of this wadi for long time ago. On the other hand and according to [10], the nutritional value of *Ochradenusbaccatus* fruits is similar to the nutritional profile for fruits of twenty seven species from Mediterranean areas. It attained low protein and lipid contents but high non – soluble carbohydrates. Also, its water content is relatively high (86%) therefore, this plant species is considered as an important and main water source for its numerous consumers in WadiHagul, as well as during the year – round and through out its range, its fruits may be the single most important food for many desert frugivores [32].

The TWINSPAN application classified the vegetation structure associated with *Ochradenusbaccatus* in WadiHagul into four vegetation groups. It has been found that *Ochradenusbaccatus*dominated all identified groups, but with different important and indicator species. Group A was represented by the smallest number of stands (two stands) while, group C was represented by the largest number of stands (22 stands). The floristic composition of the identified vegetation groups was obviously similar to those reported by [33; 3; 34; 35; 7; 36; 37; 38; 39; 40; 41; 12]

The DCA diagram exhibited that the vegetation groups (A - D) identified by TWINSPAN classification were clearly separated on the positive side on the I and II ordination axes. It is also showed that group A and group B were separated at the right side of DCA diagram, whilegroup C and group D were segregated at the left side of DCA diagram, this may be attributed to relative similarities in the floristic features of each pair of groups. These results were in agreement with the studies of [1; 12].

The application of Canonical Correspondence Analysis (CCA-biplot) proved that the maximum water-holding capacity, sand fraction, pH value, electrical conductivity, lead, calcium and magnesium were the most controlling edaphic factors that exhibited relatively high significant correlations with the I and II CCA-biplot diagram. Vegetation – soil gradient relationship in the current investigation were more or less comparablewith the studies by [7; 36; 42].

According to the ecological studies carried out by [43; 7; 12] and the present study that carried out in WadiHagul, it has been found that many obvious significant correlations were done in the vegetation composition of this wadi ecosystem. The detected alterations in WadiHagul include decrease in the number of wild species, change in community composition and dominance, as well as change in the indicator and diagnostic plant species. This could be attributed to the local destruction and / or to the variation in the environmental conditions prevailing in the study area, as well as to the intensive human interference and grazing animals in this wadi ecosystem [7]. The obtained results are also agreed with some evidences detected in other desert wadis in the EgyptianEastern Desert where decrease in biodiversity may be due toover – grazing,over – collecting, climatic aridity, as well as urbanization [37; 38; 41; 12].

VI. Conclusion

The vegetation structure of WadiHagul becomes threatened this may be due to the local destruction, variation in the prevailing environmental conditions, intensive human interference, over-cutting and over-grazing in this wadi ecosystem. The natural plant cover in WadiHagul was 57 species related to 50 genera and 19 families. These plant species were distinguished into 46 perennials, nine annuals and two biennials. TWINSPAN application classified the plant cover in WadiHagul into four vegetation groups. *Ochradenusbaccatus* was dominated all of the identified four groups. The application of CCA-biplot proved that the maximum water-holding capacity, sand fraction, pH value, electrical conductivity, lead, calcium and magnesium were the most controlling edaphic factors affecting the abundance and distribution of vegetation structure in WadiHagul.

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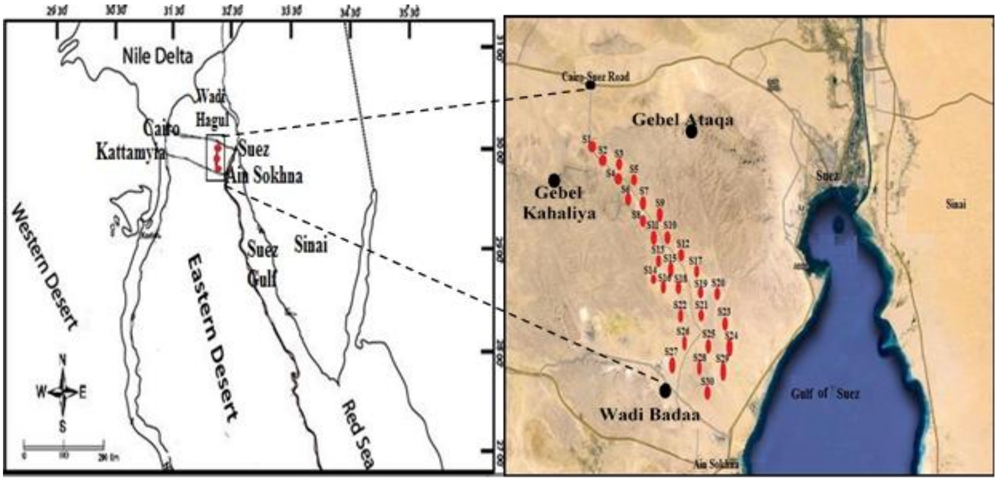


Figure (1): Map showing the location of WadiHagul, Northeast of the Eastern Desert, Egypt. (After Abd El-Aal, 2016).

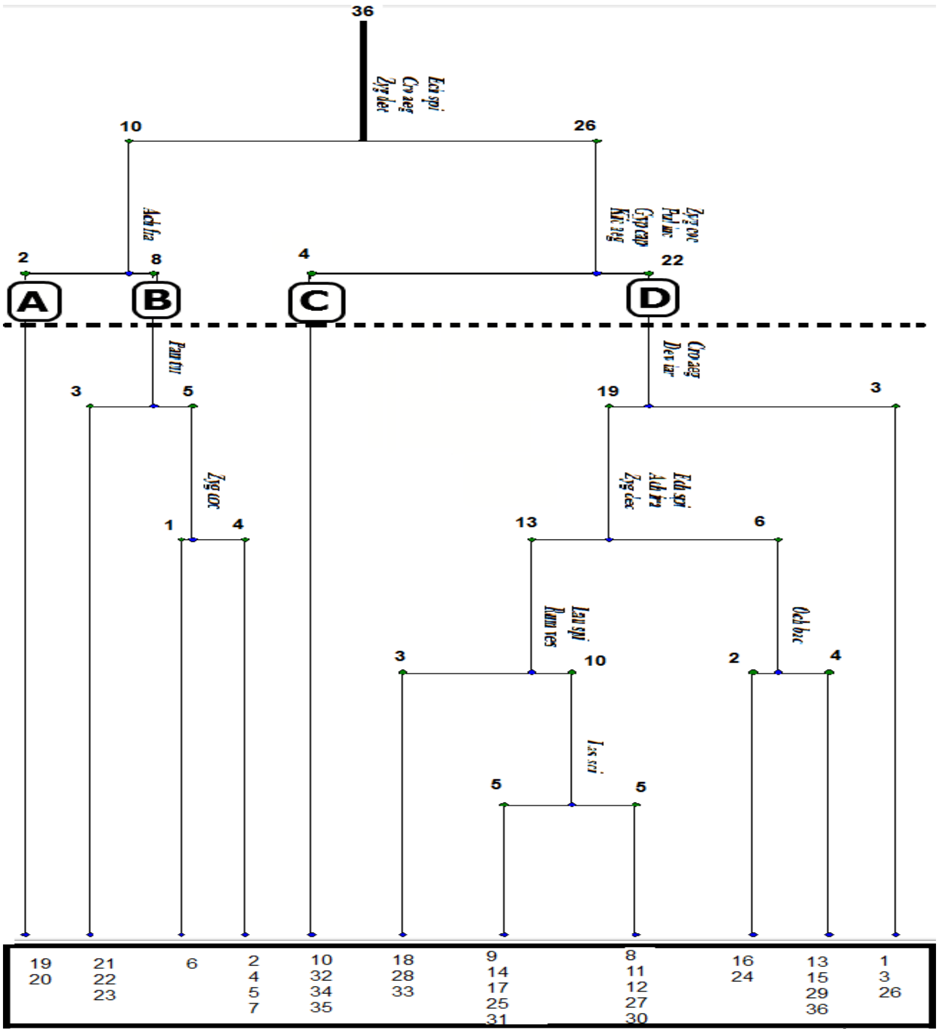
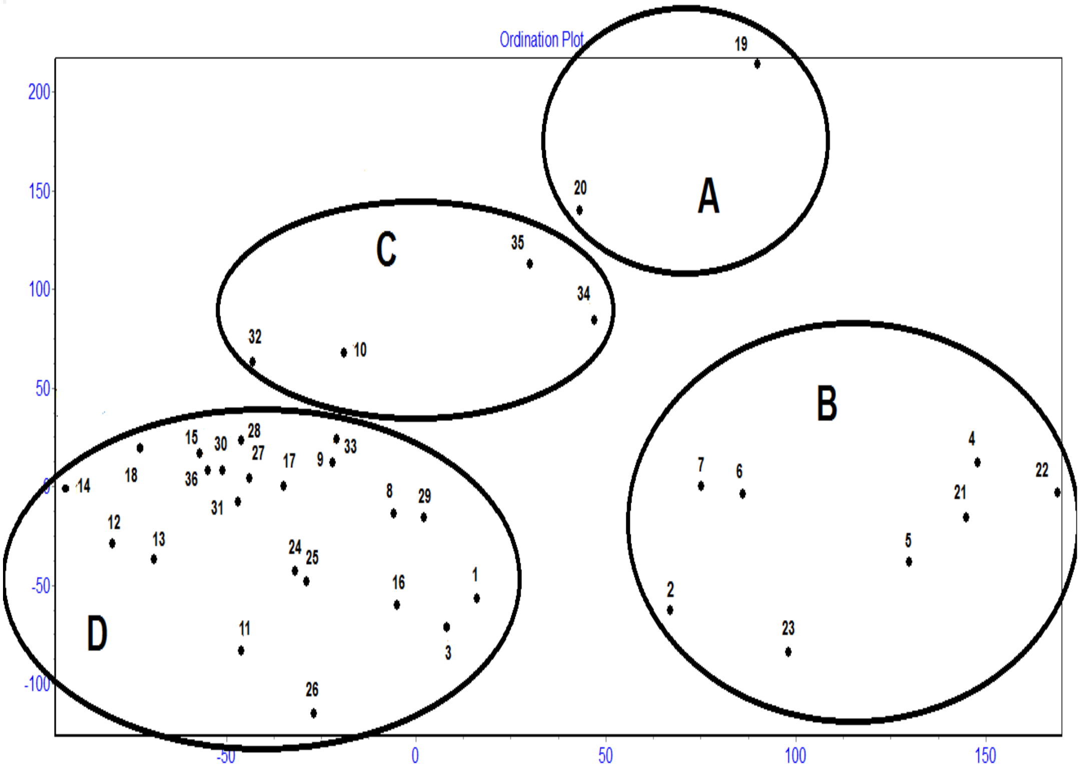


Figure (2). TWINSPAN dendrogram displaying the four groups (A, B, C and D) at the 3rd level. Dashed line illustrates the level of classification. The indicator species are abbreviated by the first three letters of genus and species, respectively. The indicators species were coded as follow: *Ech. spi.:Echinopsspinosus; Cro. aeg.:Crotalaria aegyptiaca*; *Ach. fra.:Achilleafragrantissima*; *Zyg. dec.*: *Zygophyllumdecumbens*;*Zyg. coc.:Zygophyllumcoccineum*; *Pul. inc.*: *Pulicariaincisa*; *Gyp. cap.*: *Gypsophila capillars*; *Kic. aeg.:Kichxiaaegyptiaca*; *Pan. tur.: Panicumturgidum*; *Dev. tar.:Deverratortuosa*;*Och. bac.:Ochradenusbaccatus*; *Lau. spi.:Launaeaspinosa*; *Rum.* ***ves.:Rumexvesicaus; Las. sci.: Lasiurusscindicus.***

Figure (3). DCA ordination diagram of the four vegetation groups, identified by TWINSPAN classification.



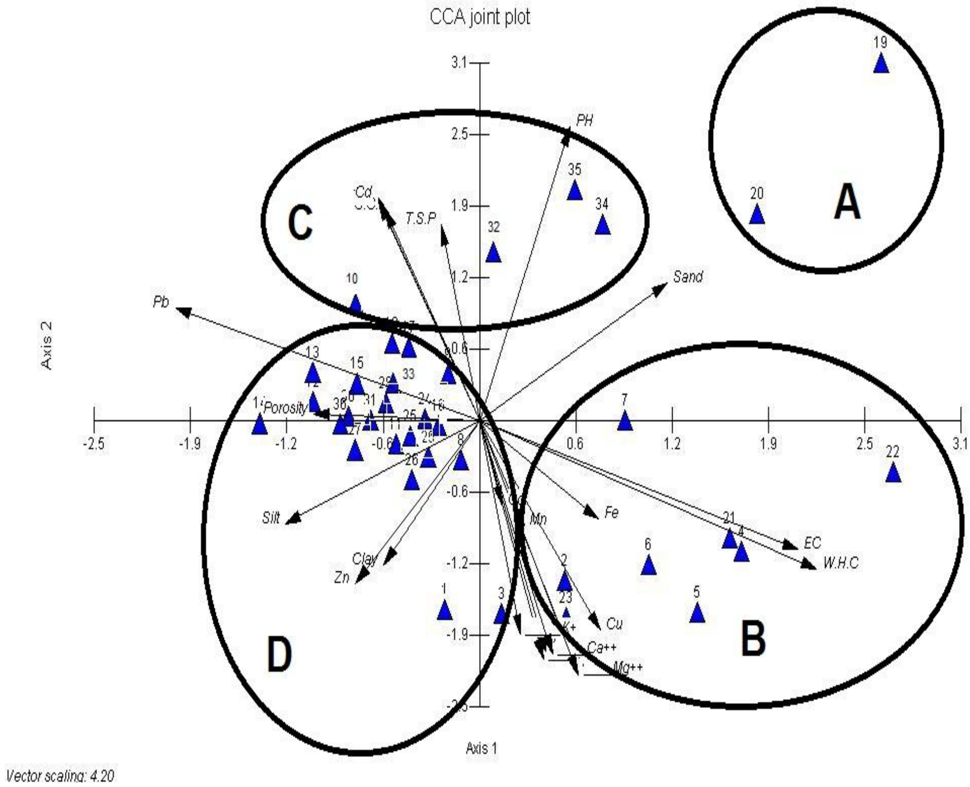


Figure (4). CCA-ordination biplot of the characteristics species and soil factors in the present study.

Table (1) Species composition of the study area with their families, life- span, life- form, and chorotypes. Ann = Annuals, Bie = Biennials, Per = Perennials, Th = Therophytes, Cr = Cryptophytes, H = Hemicryptophytes, Ch = Chamaephytes,Ph = Phanerophytes, COSM = Cosmopolitan, PAL = Palaeotropical, , ME = Mediterranean, SA-SI = Sahro-Sindian, S-Z = Sudano-Zambezian, IR-TR = Irano-Turanian, ER-SR- Euro-Siberian.

Family and species	Life span	Life form	Chorotype
Apiaceae			
Deverratortuosa (Desf.) DC.	Per	Ch	SA-SI
Asclepiadaceae			
Calotropisprocera (Aiton) W.T. Aiton	Per	Ph	S-Z+SA-SI
Cynanchumacutum L.	Per	H	ME+IR-TR
Leptadeniapyrotechnica (Forssk.) Decne.	Per	Ph	SA-SI
Pergulariatomentosa L.	Per	Ch	SA-SI
Asteraceae			
Achilleafragrantissima (Forssk.) Sch.Bip.	Per	Ch	SA-SI+IR-TR
Artemisia judaica L.	Per	Ch	SA-SI
Atractyliscarduus (Forssk.) C.Ch.	Per	H	ME+SA-SI
Centaureaaegyptiaca L.	Bie	Th	SA-SI
Echinopsspinosus L.	Per	H	ME+SA-SI
Iphionamucrona ta (Forssk.) Asch. exSchwenf.	Per	Ch	SA-SI
Launaeamucronata (Forssk.) Muschl.	Per	H	SA-SI
Launaeanudicaulis (L.) Hook.f.	Per	H	ME+SA-SI
Launaeaspinosa (Forssk.) Sch.Bip. ex Kuntze	Per	Ch	SA-SI
Plucheadioscoridis (L.) DC.	Per	Ph	SA-SI+S-Z
Pulicariaincisa (Lam.) DC.	Per	Ch	SA-SI
Pulicariaundulata (L.) C.A.Mey.subsp.*undalata*	Per	Ch	SA-SI+S-Z
Reichardiatingitana (L.) Roth	Ann	Th	ME+SA-SI+IR-TR
Senecioglaucus L.	Ann	Th	ME+SA-SI+IR-TR
Sonchusoleraceus L.	Ann	Th	COSM
Boraginaceae			
Heliotropiumdigynum (Forssk.) Asch.exc.Chr.	Per	Ch	SA-SI
Trichodesmaafricanum (L.) R.Br.	Bie	Ch	SA-SI+S-Z
Brassicaceae			
Anastaticahierochuntica L.	Ann	Th	SA-SI
Diplotaxisharra (Forssk.) Boiss.	Per	H	ME+SA-SI
*Farsetiaaegyptia*Turra	Per	Ch	SA-SI+S-Z
Zillaspinosa (L.) Prantl	Per	Ch	SA-SI

Table (1) continue

Family and species	Life span	Life form	Chorotype
Caryophyllaceae			
*Gymnocarposdecandrus*Forssk.	Per	Ch	SA-SI
Gypsophila capillaris (Forssk.) C.Chr.	Per	H	SA-SI+IR-TR
*Herniariahemistemon*J.Gay	Per	H	ME+SA-SI
Chenopodiaceae			
*Anabasis setifera*Moq.	Per	Ch	SA-SI+IR-TR
Haloxylonsalicornicum (Moq.) Bunge ex Boiss.	Per	Ch	SA-SI
Cucurbitaceae			
Citrulluscolocynthis (L.) Schrad.	Per	H	SA-SI
Fabaceae			
*Crotalaria aegyptiaca*Benth.	Per	Ch	SA-SI
*Lotus hebranicus*Hochst.ex Brand	Per	H	SA-SI
Retamaraetam(Forssk.) Webb &Berthel.	Per	Ph	SA-SI
*Trigonellastellata*Forssk.	Ann	Th	SA-SI+IR-TR
Geraniaceae			
Erodiumglaucophyllum (L.) L,Her.	Per	H	SA-SI+IR-TR
Lamiaceae			
*Lavandulacoronopifolia*Poir.	Per	Ch	SA-SI
Salvia aegyptiaca L.	Per	Ch	SA-SI+S-Z
*Salvia deserti*Decne.	Per	Ch	SA-SI
Plumbaginaceae			
Limoniumpruinosum (L.) Chaz.	Per	Ch	SA-SI
Poaceae			
Imperatacylindrica (L.) Raeusch.	Per	H	PAL+ME
*Lasiurusscindicus*Henrard	Per	Cr	SA-SI+S-Z
*Panicumturgidum*Forssk.	Per	H	SA-SI
Phragmitesaustralis (Cav.)Trin.exSteud.	Per	Cr	COSM
Polypogonmonspeliensis (L.) Desf.	Ann	Th	COSM
Polygonaceae			
Rumexvesicarius L.	Ann	Th	SA-SI+ME+S-Z
Resedaceae			
Cayluseahexagyna (Forssk.) M.L.Green	Ann	Th	S-Z+SA-SI
*Ochradenusbaccatus*Delile	Per	Ph	SA-SI
Scrophulariaceae			
Kickxiaaegyptiaca (L.) Nabelelc	Per	Ch	ME+SA-SI

Table (1) continue

Family and species	Life span	Life form	Chorotype
Solanaceae			
*Lyciumshawii*Roem. &Schult.	Per	Ph	SA-SI+S-Z
Tamaricaceae			
*Reaumuriahirtella*Jaub .&spach	Per	Ch	SA-SI+IR-TR
Tamarixnilotica(Ehrenb.) Bunge	Per	ph	SA-SI+S-Z
Zygophyllaceae			
*Fagoniaarabica*L.	Per	Ch	SA-SI
Zygophyllumcoccineum L.	Per	Ch	SA-SI+S-Z
*Zygophyllumdecumbens*Delile	Per	Ch	SA-SI
Zygophyllum simplex L.	Ann	Th	PAL

Table **(2)**

Chorotyoe	No.	%	Geographical Distribution
COSM	3	5.26	World wide element
PAL	1	1.75	
Sup Total	**4**	**7.02**	
ME+SA-SI+IR-TR	2	3.51	Pluriregional element
SA-SI+ME+S-Z	1	1.75	
Sup Total	**3**	**5.26**	
S-Z+SA-SI	11	19.30	Biregional element
ME+SA-SI	6	10.53	
SA-SI+IR-TR	6	10.53	
ME+IR-TR	1	1.75	
PAL+ME	1	1.75	
Sup Total	**25**	**43.86**	
SA-SI	25	43.86	Monoregional element
SabTotal	**27**	**42.11**	
Total	**57**	**100**	

Summrized chorological analysis of the recorded flora in the study area.

Table(3): Mean value and coefficient of variation (CV) of the importance value (out of 200) of the recorded species in the different vegetation groups resulting from TWINSPAN classification of stands in the study area.

No.	Plant species	Vegetation group			
		A	B	C	D
1	*Achilleafragrantissima*	8.63 (0.29)	-	1.70 (3.39)	5.88 (7.78)
2	*Anabasis setifera*	-	-	-	0.36 (1.68)
3	*Anastaticahierochuntica*	-	-	-	0.48 (2.27)
4	*Artemisia judaica*	-	-	3.90 (7.80)	-
5	*Atractyliscarduus*	-	1.84 (3.98)	-	-
6	*Calotropisprocera*	11.09 (0.01)	3.04 (6.67)	-	-
7	*Cayluseahexagyna*	-	2.49 (4.66)	-	-
8	*Centaureaaegyptiaca*	-	10.36 (9.15)	0.74 (1.48)	1.20 (4.43)
9	*Citrulluscolocynthis*	-	-	6.32 (12.64)	-
10	*Crotalaria aegyptiaca*	3.99 (5.64)	-	10.71 (2.73)	8.58 (7.78)
11	*Cynanchumacutum*	-	1.06 (2.98)	-	0.18 (0.85)
12	*Deveratortuosa*	-	6.20 (9.23)	-	3.50 (7.91)
13	*Diplotaxisharra*	2.72 (3.85)	1.13 (3.18)	3.45 (4.73)	4.84 (6.13)
14	*Echinopsspinosus*	4.03 (5.69)	-	3.18 (3.88)	8.31 (7.26)
15	*Erodiumglaucophyllum*	-	-	0.96 (1.91)	0.24 (1.11)
16	*Fagoniaarabica*	1.52 (2.15)	0.17 (0.48)	9.12 (12.85)	1.17 (2.56)
17	*Farsetiaaegyptia*	-	8.75 (8.31)	-	3.27 (6.21)
18	*Gymncarposdecandris*	-	0.93 (2.62)	2.04 (2.37)	0.33 (1.56)
19	*Gypsophila capillaris*	-	-	8.52 (6.46)	0.29 (1.35)
20	*Haloxylonsalicornicum*	-	-	4.86 (5.61)	5.03 (7.86)
21	*Heliotropiumdignum*	2.80 (3.95)	-	-	0.50 (2.35)
22	*Herniariahemistemon*	-	3.16 (3.54)	-	-
23	*Imperatacylindrica*	5.96 (8.43)	3.49 (6.61)	1.15 (2.30)	-

24	*Iphionamucronata*	4.05 (5.73)	14.50 (12.72)	8.06 (3.56)	9.59 (5.94)
25	*Kickxiaaegyptiaca*	6.62 (1.09)	4.47 (6.21)	6.93 (5.42)	-
26	*Launaeamucronata*	-	0.70 (1.98)	-	0.26 (1.24)
27	*Launaeanudicaulis*	2.26 (3.20)	4.15 (4.77)	1.31 (2.62)	0.55 (1.81)
28	*Launaeaspinosa*	6.52 (9.21)	7.81 (9.96)	5.59 (6.54)	10.95 (9.33)
29	*Lasiurusscindicus*	-	5.81 (7.75)	7.80 (7.75)	3.47 (5.81)
30	*Lavandulacoronopifolia*	18.32 (1.27)	-	12.09 (13.99)	3.52 (9.34)
31	*Leptadeniapyrotechnica*	-	-	6.53 (7.54)	1.57 (7.35)
32	*Limoniumpruinosum*	-	0.82 (2.32)	-	-

Table(3): Continued.

No.	Plant species	Vegetation group			
		A	B	C	D
33	*Lotus herbanicus*	16.08 (1.22)	0.86 (2.43)	4.61 (9.22)	-
34	*Lyciumshawii*	-	-	-	6.05 (10.38)
35	***Ochradenusbaccatus***	**25.43 (2.84)**	**46.53 (13.01)**	**37.99 (10.85)**	**42.12 (18.07)**
36	*Panicumturgidum*	-	6.55 (10.32)	-	0.73 (3.43)
37	*Pergulariatomentosa*	-	1.56 (4.40)	-	-
38	*Phragmitesaustralis*	7.13 (10.08)	1.67 (4.71)	-	-
39	*Plucheadioscoridis*	-	9.22 (10.96)	-	-
40	*Polypogonmonspeliensis*	2.19 (3.09)	-	-	-
41	*Pulicariaincisa*	9.22 (2.03)	-	4.19 (2.89)	1.39 (4.82)
42	*Pulicariaundulata*	5.07 (7.16)	3.10 (6.26)	2.25 (4.50)	-
43	*Reichardiatingitana*	4.80 (2.47)	0.82 (2.31)	-	-
44	*Reaumuriahirtella*	-	2.25 (4.25)	-	0.32 (1.48)
45	*Retamaraetam*	-	0.94 (2.62)	-	11.16 (11.96)
46	*Rumexvesicarius*	-	-	1.48 (2.96)	2.54 (4.95)
47	*Salvia aegyptiaca*	-	-	0.93 (1.86)	-
48	*Salvia deserti*	4.79 (0.72)	1.69 (4.77)	-	-
49	*Senecioglaucus*	1.14 (1.61)	-	0.96 (1.92)	-
50	*Sonchusoleraceus*	2.33 (3.30)	-	-	-
51	*Tamarixnilotica*	3.16 (4.46)	14.83 (13.68)	5.43 (6.77)	2.07 (6.70)
52	*Trichodemsaafricanum*	2.35 (3.32)	0.44 (1.24)	3.25 (3.76)	0.61 (2.03)
53	*Trigonellastellata*	10.56 (0.23)	1.75 (4.95)	1.78 (3.56)	-
54	*Zillaspinosa*	-	13.84 (13.35)	11.06 (12.94)	17.08 (9.51)
55	*Zygophyllumcoccineum*	4.68 (6.61)	9.43 (5.71)	8.35 (8.86)	16.95 (7.42)
56	*Zygophyllumdecumbens*	-	-	9.36 (6.71)	16.33 (9.08)
57	*Zygophyllum simplex*	-	-	3.49 (4.27)	3.42 (6.60)

Table(4): Mean value and standard error of the different soil variables at depth (0 – 50 cm) in the sampled stands representing different vegetation groups obtained by TWINSPAN classification in the study area. MWHC= Maximum water-holding capacity, EC= Electrical conductivity, OC= Organic carbon, TDP= Total dissolved phosphorus, TN= Total nitrogen.

Soil variables		Vegetation group			
		A	B	C	D
Sand	(%)	90.10 ±2.60	85.04 ±2.47	88.68 ±2.61	84.19 ±2.18
Slit		8.25 ±3.65	9.79 ±2.11	9.30 ±2.02	11.19 ±1.65
Clay		1.65 ±1.05	5.20 ±1.98	2.03 ±0.64	4.62 ±0.66
Porosity		39.40 ±6.60	29.05 ±2.33	35.00 ±3.48	38.11 ±2.33
MWHC		23.00 ±1.00	26.30 ±3.84	18.48 ±2.46	16.76. ±1.70
pH		8.75 ±0.25	7.74 ±0.06	8.35 ±0.14	8.00 ±0.09
EC	(ms/cm)	0.07 ±0.01	2.27 ±1.20	0.21 ±0.03	0.42 ±0.08
$CaCO_3$	(%)	4.67 ±0.26	6.35 ±0.48	3.96 ±1.45	5.33 ±0.46
OC	(%)	0.59 ±0.05	0.47 ±0.05	0.75 ±0.14	0.59 ±0.04
TDP	(mg.kg^{-1})	6.05 ±0.39	5.37 ±0.32	6.83 ±0.69	5.83 ±0.23

TN	(mg.kg^{-1})	31.85 ±0.73	30.54 ±0.61	33.64 ±1.39	31.91 ±0.45
Cl^-	(mg/100 g dry soil)	7.65 ±0.27	10.58 ±0.83	6.90 ±6.62	9.11 ±0.79
SO_4^{--}		2.64 ±0.21	3.49 ±0.21	2.09 ±0.84	2.96 ±0.26
HCO_3^-		2.72 ±0.09	3.64 ±0.29	2.43 ±0.85	3.18 ±0.26
Na^+		7.85 ±0.26	10.77 ±0.82	7.07 ±2.63	9.29 ±0.79
K^+		0.63 ±0.06	0.81 ±0.05	0.57 ±0.21	0.73 ±0.06
Ca^{++}		0.23 ±0.16	3.49 ±0.27	2.27 ±0.84	3.01 ±0.25
Mg^{++}		1.96 ±0.09	2.64 ±0.19	1.51 ±0.62	2.23 ±0.20
Fe	(mg.kg^{-1})	34.98 ±0.39	32.23 ±4.22	36.70 ±1.02	35.68 ±0.40
Mn		10.12 ±0.25	11.97 ±0.50	12.37 ±0.49	11.35 ±0.34
Zn		16.65 ±0.32	19.10 ±0.66	19.76 ±0.54	19.41 ±0.29
Cu		8.23 ±0.21	9.07 ±0.23	8.48 ±0.63	8.61 ±0.24
Co		1.18 ±0.03	1.41 ±0.06	2.68 ±0.14	2.50 ±0.05
Pb		6.19 ±0.11	6.74 ±0.15	7.72 ±0.14	7.14 ±0.10

Table (5). Pearson-moment correlation (r) between the soil variables.

	Sand	Silt	Clay	Porosity	MWHC	pH	EC	$CaCo_3$	O.C	TSP	TDN	Cl^-	So_4^{--}	HCo_3^-	Na^+	K^+	Ca^{++}	Mg^{++}	S.P %	W.P %	T.S.S
Sand	1																				
Silt	-0.922***	1																			
Clay	-0.701***	0.370*	1																		
Porosity	-0.241	0.165	0.272	1																	
MWHC	0.055	-0.074	0.005	-0.180	1																
pH	0.329	-0.280	-0.274	0.265	-0.226	1															
EC	0.163	-0.081	-0.243	-0.265	0.233	-0.213	1														
$CaCo_3$	-0.067	-0.035	0.226	0.123	0.209	-0.414*	-0.001	1													
O.C.	0.076	-0.005	-0.175	-0.094	-0.113	0.394*	0.040	-0.019	1												
TSP	0.091	-0.031	-0.101	-0.086	-0.034	0.439**	0.117	-0.795***	0.872***	1											
TDN	0.126	-0.047	-0.217	-0.067	-0.142	0.422**	0.064	-0.876***	-0.985***	0.851***	1										
Cl^-	-0.104	0.00	0.251	0.146	0.160	-0.427**	-0.014	0.994***	-0.912***	-0.793***	-0.867***	1									
So_4^{--}	0.010	-0.091	0.145	0.121	0.204	-0.321	0.027	0.985***	-0.895***	-0.761***	-0.837***	0.972***	1								
HCo_3^-	-0.053	-0.053	0.225	0.130	0.154	0.403*	-0.030	0.995***	-0.913***	-0.800***	-0.864***	0.996***	0.979***	1							
Na^+	-0.102	-0.002	0.248	0.144	0.159	-0.427**	-0.011	0.944***	-0.913***	-0.793***	-0.867***	1.00***	0.973***	0.996***	1						
K^+	-0.015	-0.069	0.165	0.141	0.143	-0.342*	-0.001	0.980***	-0.879***	-0.749***	-0.817***	0.983***	0.984***	0.988***	0.984***	1					
Ca^{++}	-0.047	-0.056	0.218	0.123	0.160	-0.399*	-0.014	0.996***	-0.914***	-0.794***	-0.864***	0.996***	0.983***	0.999***	0.996***	0.990***	1				
Mg^{++}	0.004	-0.094	0.165	0.125	0.214	-0.334*	0.003	0.985***	-0.895***	-0.765***	-0.840***	0.971***	0.997***	0.979***	0.971***	0.978***	0.982***	1			

Abbreviations:
EC: Electrical conductivity OC: Organic carbon TDP: Total dissolved phosphorus TN: Total nitrogen
* Significant at 0.05 ** Significant at 0.01 *** Significant at 0.001

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