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Vegetation-Soil Relationship in Sidi Abd El-Rahman Sector, Western Mediterranean Coast, Egypt

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THIS STUDY assesses the plant communities and edaphic factors that govern species distribution on the coastal Land of Sidi Abd El-Rahman sector, Western Mediterranean Coast of Egypt. A survey of soil and vegetation was conducted to clarify the relationship between the edaphic factors and the vegetation types of this sector. The application of TWINSPAN classification program on the study area, led to the recognition of four vegetation groups inhabiting three different habitats namely: coastal sand dune habitat supports two groups: group (A) co-dominated by *Ammophila arenaria* and *Elymus farctus*, and group (B) dominated by *Euphorbia paralias*. Group (C) inhabits the dry saline depression habitat co-dominated by *Nitraria retusa* and *Arthrocnemum macrostachiyum*. The wet saline depressions (salt marshes) habitat supports group (D) co-dominated by *Juncus acutus* and *Juncus rigidus*. The distribution pattern of the dominant species along the gradient of edaphic factors was examined using CCA ordination program. The result showed that the coastal sand dune habitat is characterized by a relatively high calcium carbonate contents being the most effective soil variables on the species distribution. Generally, the total dissolved salts and soil moisture contents were relatively high in the salt marsh habitat, indicating that this area was directly affected by seawater. The floristic composition in this coastal area shows that, the chamaephyte attained the highest percentage (30%), and Poaceae the highly represented family (30%). Finally, the Mediterranean elements have the highest contribution of the total species (37.5%).

Keywords: Mediterranean coastal Land, Sidi Abd El-Rahman sector, Vegetation types, Edaphic factors, Floristic composition.

The Western Mediterranean Coastal Land is by far the richest part of Egypt in its floristic composition owing to its relatively high rainfall. The number of species in this belt makes up about 50% of the total of the Egyptian flora which is estimated to be about 2000 by Oliver (1938), 2080 species by Täckholm (1974), 2094 species as Boulos (1995). However, Boulos (1999, 2000, 2002 and 2005) recorded a total of 2121 species of which 50 species are cultivated. Most of these species are therophytes that flourish during the rainy season, giving the coastal belt a temporary showy grassland desert.

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The northern extremities of the Western Desert along the Mediterranean Coast represent the so-called northwestern coastal zone, which extends from Alexandria in the east for 520 km to El-Salloum on the Libyan border in the west. The average width of the zone varies between 30 and 50 km overlapping with the limestone plateau of the Western Desert in the south by El-Miniawy *et al*. (1992); Von Rabenau (1994); Ayyad (1995) and Abdel-Kader (1998). Based on geomorphological and land use considerations most of plant community classifications are based on soil characteristics, nature of soil surface and landform types according to El-Ghareeb and Shabana (1990).

The Mediterranean Coastal Land of Egypt, in general, belongs to the dry arid climatic zone of Koppen (1931) classification system as quoted by Trewartha (1954), and the Mediterranean bioclimatic zone of Emberger (1955). The bioclimatic map of UNESCO/FAO (1963) indicates that it is of a subdesertic warm climate.

The rainfall of the study coastal Land is limited, unpredictable, and localized. Vegetation is too sparse to allow meaningful socio-economic activity. Thus, the small number of population in the neighborhood is nomadic, supported economically by breeding and grazing small herds, camels in particular. The environmental factors and vegetation changes are important for both of local and regional management proposals as Zahran and Willis (2009).

The aim of this study was to throw light on the vegetation types of the Mediterranean Coastal Land at Sidi Abd El-Rahman sector. It assesses the plant communities and edaphic factors that govern species distribution, and investigate the floristic elements in terms of species composition in Sidi Abd El-Rahman sector.

Material and Methods

Study area

The Mediterranean Coastal Land of Sidi Abd El-Rahman sector situated directly on the sea shore at about 112 km west of Alexandria (150 km east of Mersa Matrouh city) at the latitudes 30º 58' 21" N and the longitudes 28º 44' 36"E (Fig. 1). The prevailing climate is qualified as "arid Mediterranean" with mild winter in UNISCO (1977). Geomorphologically, the study area can be divided into: coastal plain, piedmont, table lands and drainage basins as Taha (1973). The main habitats of this coastal belt are: Coastal sand dunes, saline depressions, none saline depressions, rocky ridges and inland plateau.

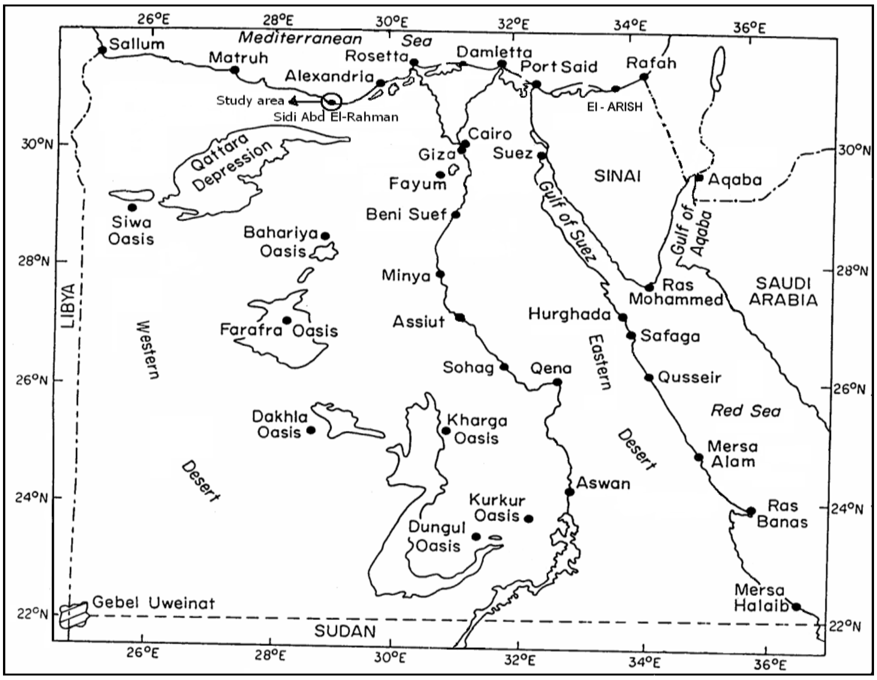

Fig. 1. Map of Egypt showing the study area.

Vegetation analysis

Seven stands were sampled representing the habitat and community variations in the study area during 2011. These stands were studied qualitatively and quantitatively using line intercept transect (50 m long) and quadrate methods. The species in each stand were listed and the number of individuals of each species was counted. The absolute density was assessed per unit area as Muller-Dombois and Ellenberg (1974); frequency was calculated as Raunkair (1934). The plant cover estimated as percentage of ground surface as Canfield (1941). The relative density (R.D.), the relative frequency (R.F.) and the relative cover (R.C.) were calculated for each species and summed up to give an estimate for its importance value (IV) in each stand which is out of 300 using the equation IV= (R.D.) + (R.F.) + (R.C.) according to Ludwig and Reynolds (1988). Life forms and chorotypes were calculated as Raunkair (1937) and Raven (1971).

Soil analysis

Soil samples were collected at two depths surface (0-20 cm) and subsurface (20-40 cm) from a profile dug in each habitat. Physical (soil texture and moisture content) and chemical analyses (pH, E.C, Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, SO_4^{--} and O.C) were estimated according to Piper (1950) and Rayan *et al*. (2001).

Data analysis

The initial classification was made by Two-way Indicator species Analysis (TWINSPAN) using Community Analysis package (CAP)version 3.1 according to Hill and Ŝmilauer (2005). Ordination was applied using Canonical Corresponding Analysis (CCA) implemented by (CANOCO for windows program version 4.8) according to Ter-Braak (1997).

Results

Classification

The application of TWINSPAN classification on the importance values led to the recognition of four vegetation groups (Fig. 2 and Table 1&2). Each group consists of one or two stands with greater homogeneity of vegetation.

Group A

It comprises two stands containing 13 species. The indicator species was *A. arenaria*. The co-dominant species was *A. arenaria* (IV=72.5) and *E. farctus* (IV=64.2). The soil supporting this group showed a wide range of variance in $CaCO_3$ and medium sand represent as the highest mean value of (93.5% and 57.8%, respectively).

Group B

This group comprises one stand containing 7 species. The indicator species was *L. shawii*. The dominant species was *E. paralias* (IV=99.7). The common species was *A. macrostachyum* (IV=41.2). Soil supporting this group is characterized by the relatively highest mean value of SO_4, Ca^{++} and Mg^{++} (22.4 m.eq/L, 36 m.eq/L and 28.4 m.eq/L, respectively).

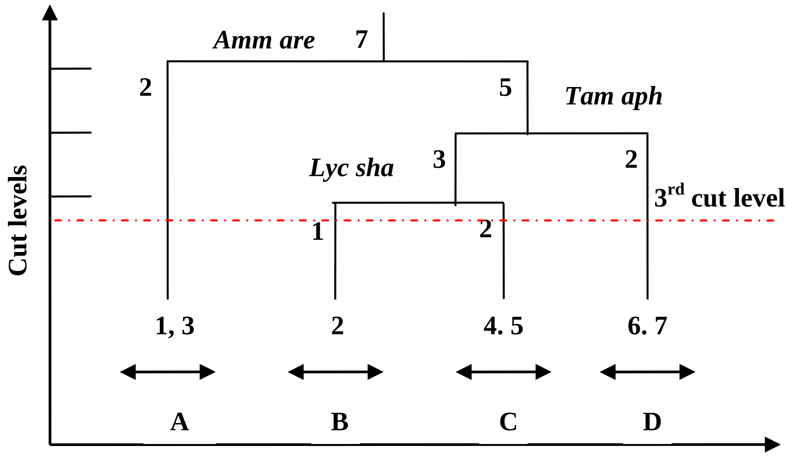

Fig. 2. Two Way Indicator Species Analysis (TWINSPAN) dendrogram of 7 sampled stands based on the importance values of 24 plant species. The indicator species are abbreviated by the first three letters of genus and species, respectively.

TABLE 1. Mean and standard deviation of importance values (out of 300) of plant species.

Species	Group A	Group B	Group C	Group D
Aeluropus lagopoides (L.) Trin.	0	0	0	14.4±20.3
Alhagi graecorum Boiss.	0	0	18.4±26	48.4±0.78
Ammophila arenaria (L.) Link.	72.5±1.91	0	0	0
Arthrocnemum macrostachyum Moric.	0	41.2	56.8±66.2	49.1±10.4
Cakile maritima Scop.	3.35±4.74	0	0	0
Cressa cretica L.	0	28.1	4.85±6.86	18.0±8.49
Echium sericeum Vahl.	4.60±6.51	0	0	0
Elymus farctus Viv.	64.2±44.6	0	0	0
Euphorbia paralias Forssk.	7.9±11.2	99.7	21.6±30.5	0
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	0	0	3.95±5.59	0
Hyoseris radiata L.	4.3±6.08	0	0	0
Juncus acutus L.	0	0	0	89±125.9
Juncus rigidus (Desf.) Fl. Atlant.	0	0	0	82.1±116.1
Limoniastrum monopetalum (L.) Boiss.	0	37.7	25.3±35.8	0
Lotus polyphyllus L.	8.45±12	0	0	0
Lycium shawii Roem. & Schult.	0	33.5	51.2±1.77	0
Nitraria retusa (Forssk.) Ach.	0	35.7	63.4±0.35	38±53.7
Otanthus maritimus L.	3.65±5.16	0	0	0
Pancratium maritimum L.	15.7±22.2	0	0	0
Retama raetam (Forssk.) Webb.	9.8±13.9	0	0	0
Sporobolus pungens (Schreb.) Kunth.	61.1±16.5	0	0	0
Tamarix aphylla (L.) Karst.	0	0	0	43.8±6.43
Thymelaea hirsuta (L.) Endl.	30.0±7.21	0	0	0
Zygophyllum album L.	12.7±17.9	24.1	20.1±28.4	0

Group C

The two stands in this group were represented by 9 species. The indicator species was *L. shawii* and the co-dominant species was *N. retusa* (IV=63.4) and *L. shawii* (IV=51.2). Soil of this group has relatively highest mean values of coarse sand, organic carbon and silt (0.25 m.eq/L and 12.1 m.eq/L, respectively).

Group D

The two stands in this group were characterized by 12 species. The indicator species was *Tamarix aphylla*. The co-dominant species were *J. acutus* (IV=89) and *J. rigidus* (IV=82.1). Clay, Moisture, Na^+, K^+, Cl^-, pH and E.C represent the highest mean values (37.5%, 14.9%, 95.1 m.eq/ L, 3.5 m.eq/ L, 142.8 m.eq/L, 7.75 and 16.2 ds^{-1}/cm, respectively).

TABLE 2. Physical and Chemical characteristics of soil samples.

Edaphic factors	Group A	Group B	Group C	Group D
Coarse sand (%)	1.08±0.74	1.7±0.11	5.73±3.64	4.27±0.54
Medium sand (%)	57.8±0.78	55.6±0.14	37.4±3.46	25.3±0.85
Fine sand (%)	39.4±0.21	38.7±0.28	35.0±3.75	24.5±2.62
Silt (%)	0.9±0.21	3.05±0.19	12.1±6.72	8.52±1.14
Clay (%)	0.88±0.53	0.95±0.13	9.83±3.50	37.5±1.77
Moisture (%)	1.66±0.59	1.13±0.01	3.72±0.23	14.9±0.71
pH	7.55±0.06	7.48±0.02	7.65±0.20	7.75±0.01
E.C (ds^{-1}/cm)	1.35±0.23	0.96±0.01	12.6±10.8	16.2±0.64
Na^+ (m.eq/ L)	5.96±5.61	1.45±0.01	68±38.5	95.1±1.20
K^+ (m.eq/ L)	0.56±0.07	0.33±0.01	4.4±4.31	3.50±0.04
Ca^{++} (m.eq/ L)	2.77±0.39	6.63±0.01	36.0±11.4	2.595±0.06
Mg^{++} (m.eq/ L)	2.23±0.40	3.38±0.01	28.4±19.3	3.43±0.16
Cl^- (m.eq/ L)	9.6±3.68	4.0±0.07	107.2±107.3	142.8±0.99
SO_4^{--}(m.eq/ L)	0.91±0.01	2.17±0.01	22.4±30.1	0.93±0.03
$CaCO_3$ (%)	93.5±0.71	91.8±0.21	13.7±1.91	9.71±0.13
Organic carbon (m.eq/ L)	0.03±0.01	0.15±0.01	0.25±0.24	0.1±0.0

Ordination

The biplot ordination diagram produced by CCA shown in Fig. 3 represents the relation between the edaphic factors and distribution of plant species. The decisive factors controlling the distribution of plant species are the medium sand, fine sand and $CaCO_3$ which are positively correlated with axis 1, while salinity, silt, clay and moisture content are strongly correlated with axis 2. the position of the dominant and associated species are clear along the gradient of 10 environmental variables. The community dominated by *A. arenaria* showed clear association with fine, medium sand and $CaCO_3$. *E. paralias* community showed a highly association with Ca^{++}, Mg^{++} and Sulphat. On the other hand, the community dominated by *N. retusa* is mainly affected by silt and organic carbon. The effective edaphic factors on the community dominated by *J. acutus* are moisture, pH, E.C, Na^+, Cl^- and Clay.

Floristic Composition

Families

Table 3 shows that twenty four species belonging to sixteen families were recorded in the study area. Fig. 4 shows that Poaceae is the most characteristic family as it is represented by four species (30%) namely: *A. arenaria*, *Aeluropus lagopoides*, *E. farctus* and *Sporobolus pungens*. Fabaceae (21%) contained three species (*Alhagi graecorum*, *Lotus polyphyllus* and *Retama raetam*), whereas each of Chenopodiaceae, Juncaceae and Asteraceae (14%) is represented by two species. Each of the remaining eleven families is represented with only one species (7% each).

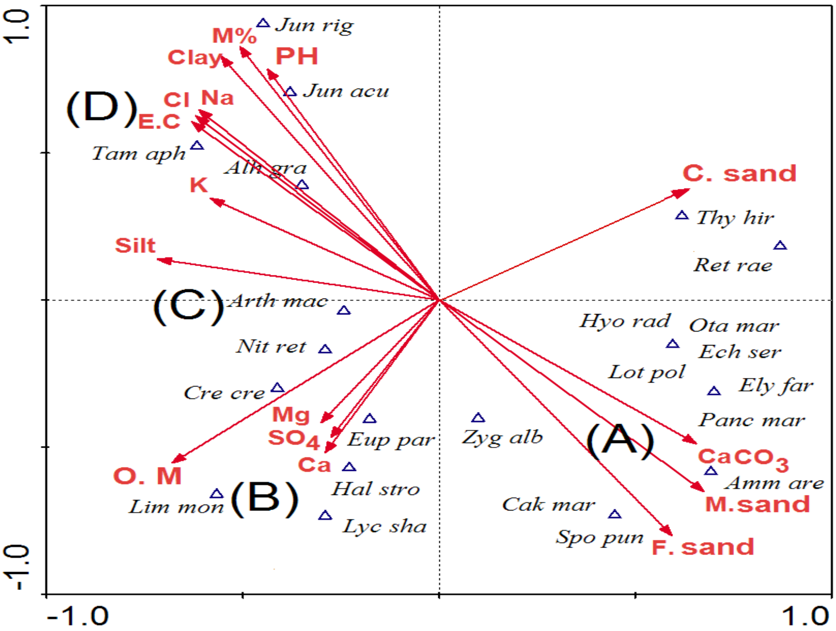

Fig. 3. Canonical Correspondence Analysis (CCA) ordination diagram of plant species along the gradient of environmental variables (arrows). The indicator and preferential species are indicated by three first letters of genus and species, respectively.

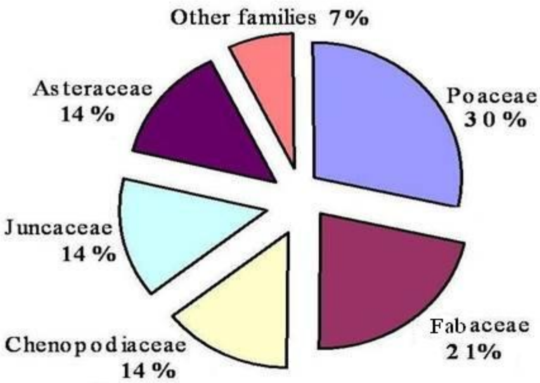

Fig. 4. Different families in the study area.

TABLE 3. Floristic composition of the study area. Where: Sudanian = S, Saharo-Arabian = SA, Mediterranean = M, Irano-Turanian = IT and Euro-Siberian = ES.

Species	Family	Chorology	Life form
Aeluropus lagopoides (L.) Trin.	Poaceae	SA	Chamaephyte
Alhagi graecorum Boiss.	Fabaceae	M-IT	Hemicryptophyte
Ammophila arenaria (L.) Link.	Poaceae	M	Chamaephyte
Arthrocnemum macrostachyum Moric.	Chenopodiaceae	M-SA	Chamaephyte
Cakile maritima Scop.	Brassicaceae	M-ES	Therophyte
Cressa cretica L.	Convolvolaceae	M-IT	Hemicryptophyte
Echium sericeum Vahl.	Boraginaceae	M	Chamaephyte
Elymus farctus Viv.	Poaceae	M	Hemicryptophyte
Euphorbia paralias Forssk.	Euphorbiaceae	M	Chamaephyte
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	Chenopodiaceae	S	Chamaephyte
Hyoseris radiata L.	Asteraceae	M	Chamaephyte
Juncus acutus L.	Juncaceae	M-IT	Hemicryptophyte
Juncus rigidus (Desf.) Fl. Atlant.	Juncaceae	M-IT	Hemicryptophyte
Limoniastrum monopetalum (L.) Boiss.	Plumbaginaceae	M	Chamaephyte
Lotus polyphyllus L.	Fabaceae	SA	Chamaephyte
Lycium shawii Roem. & Schult.	Solanaceae	SA-S	Phanerophyte
Nitraria retusa (Forssk.) Ach.	Nitrariaceae	SA	Phanerophyte
Otanthus maritimus L.	Asteraceae	M	Chamaephyte
Pancratium maritimum L.	Amaryllidaceae	M	Geophyte
Retama raetam (Forssk.) Webb.	Fabaceae	SA	Phanerophyte
Sporobolus pungens (Schreb.) Kunth.	Poaceae	M	Chamaephyte
Tamarix aphylla (L.) Karst.	Tamaricaceae	S	Phanerophyte
Thymelaea hirsuta (L.) Endl.	Thymeleaceae	M-SA	Phanerophyte
Zygophyllum album L.	Zygophyllaceae	SA	Chamaephyte

Life forms

Figure 5 shows that five life forms could be determined in the flora of the study area. Chamaephytes was the highest one with value (50%) followed by Phanerophytes and Hemicryptophytes with value (21% each) and the lowest was Geophytes and Therophytes (4% each).

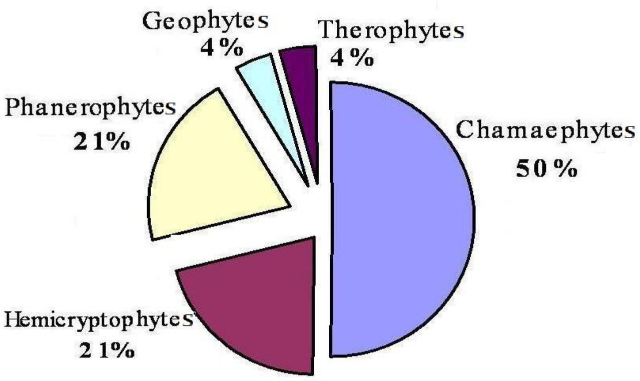

Fig. 5. The life forms of species in the study area.

Chorology

Figure 6 shows that chrologically the highest value was that of the Mediterranean elements (37.5%). Saharo-Arabian elements were (20.8%). The elements of Mediterranean-Irano-Turanian were (16.7%). Each of the Mediterranean-Saharo-Arabian and Sudanian were (8.33%). The lowest elements were these of Saharo-Arabian-, Sudanian and Mediterranean, Euro-Siberian each with value (4.17%).

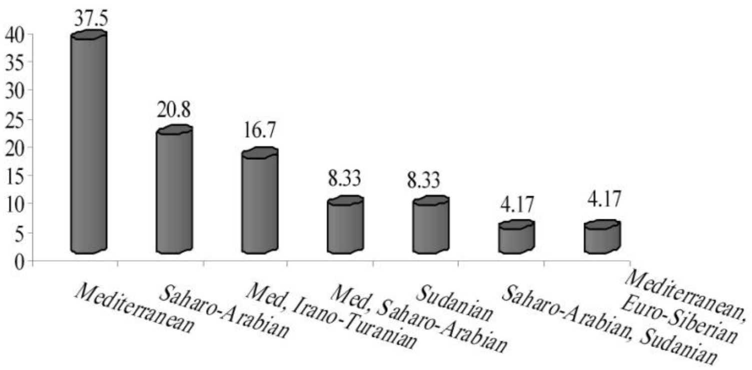

Fig. 6. The chorology of species in the study area.

Discussion

The classification and ordination analyses split the vegetation based on indicator species and their correlation with the edaphic factors. The community types derived from TWINSPAN are corroborated by CCA, although there is a certain degree of overlap in the ordination space between the different groups according to Abd EI-Ghani (1998). The results of the present study clarified that the communities are classified into four groups dominated by *A. arenaria* inhabiting the coastal sand dunes habitat, *J. acutus* and *J. rigidus* inhabiting the highly saline sabkhas whereas *A. macrostachyum* dominates the saline depression and *N. retusa* dominates the salt affected coastal sand dunes. These habitats showed clear salinity gradient. These differences reflect variation in soil properties.

The CCA analysis suggests that the two main compositional gradients represent soil salinity and texture. The correlation analysis demonstrated that sand fractions, Ca, Mg, So_4 and $CaCO_3$ have high significant correlation with the first axis; while moisture, pH, chloride, silt and clay showed significant correlations with the second axis according to Wasiel (1972) and Ayyad and El-Ghareeb (1982).

The floristic elements of the Western Mediterranean coastal belt enjoy better climatic conditions than those of the other parts of Egypt as Zahran and Willis (2009), habitats and community types are formed and become manifested in the coastal vegetation. The casual factor or factors behind the change of vegetation is of primary concern. Variations in the environmental gradients may be caused by variations in texture, organic carbon, pH and salinity of soil that might be of direct or indirect influence on plant life and existence. In trying to account on the distribution of community types in Sidi Abd El-Rahman coastal land, several edaphic differences concerned in the present study may be considered as solely responsible. The vegetation of the study area occupy the highly saline depressions or coastal sand dunes habitats, these habitats have a limited number of species which act as stress tolerators to adverse conditions as Grime (1979) and El-Shourbagy *et al.* (1979) and have a high plant cover.

Twenty-four species belonging to 13 families were recorded in the habitats of Sidi Abd El-Rahman coastal land. The life form spectra provide information which may help in assessing the response of vegetation to variations in environmental factors as Ayyad and El-Ghareeb (1982). The present study demonstrated that chamaephytes were represented by 50% of the total recorded species due to the Mediterranean climate was designated as Raunkair (1937) and Raven (1971), twenty one percent was phanerophytes and hemicryptophytes while therophytes and geophytes have the lowest value due to the limit proportion of rainfall in the study area, also adapted to drought and salinity as Ayyad and El-Ghareeb (1982). The highest values of chamaephytes may be attributed to the ability of species belonging to these life forms to salinity, sand accumulation and grazing as Danin (1996). The floristic categories of the recorded species showed that the Mediterranean elements have the highest contribution of the total species, followed by the Sahro-Arabian, and Med., Irano-Turanian, while the lowest was Saharo-Arabian, Sudanian taxa according to Zohary (1973), the Mediterranean territory of the Middle East occupies a narrow belt along the Mediterranean Sea.

The presence of the phytogeographical elements other than the Mediterranean, in the study area is believed to be a reflection of intense climatic changes and/or the degradation of the Mediterranean ecosystem which facilitated the invasion of some elements from the adjacent regions as Madi *et al*. (2002).

The distribution of species composition in specific ecologically defined habitats would substantiate the fact that such community types are useful as indicators for their habitat characters as Batanouny (1979), even under adverse conditions of disturbance agencies encountered in these habitats.

The present study shows that certain species have wide ecological ranges of distribution, e.g. *A. macrostachyium*, *J. rigidus* and *J. acutus*. On the other hand *A. arenarea* and *E. farctus* are moderately distributed. It worth to state that the understanding of relationships between edaphic factors and vegetation distribution helps us to apply these findings in management, reclamation, and development of arid and semi-arid grassland ecosystems.

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علاقة التربة بالغطاء النباتى فى قطاع سيدى عبد الرحمن، الساحل الشمالى الغربى للبحر المتوسط، مصر

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تقيم هذه الدراسة المجتمعات النباتية وعوامل التربة التى تتحكم فى انتشار الانواع النباتية فى الصحراء الساحلية لقطاع سيدى عبد الرحمن، الساحل الشمالى الغربى لمصر. تم مسح التربة والغطاء النباتى لتقييم العلاقة بين خصائص التربة والغطاء النباتى لهذه المنطقة. تطبيق برنامج الـ TWINSPAN على البيانات التى سجلت ادى الى تمييز اربع مجموعات نباتية تشمل ثلاثة بيئات وهى كالتالى: بيئة الكثبان الرملية الساحلية تحتوى على مجموعتين: المجموعة الاولى (A) يسودها مجتمعى الـ *Ammophila arenaria* و*Elymus farctus*، المجموعة الثانية (B) يسودها مجتمع الـ *Euphorbia paralias* . بينما وجدت مجموعة واحدة (C) فى بيئة المنخفضات الملحية يسودها مجتمعى الـ *Nitraria retusa* و *Arthrocnemum macrostachiyum*. وايضا بيئة المستنقعات الملحية وجدت بها مجموعة واحدة (D) يسودها مجتمعى الـ *Juncus acutus* و*Juncus rigidus*. الشكل التوزيعى للانواع النباتية السائدة مع عوامل التربة فتمت دراسته باستخدام برنامج الـ CCA . اوضحت النتائج ان بيئة الكثبان الرملية الساحلية تميزت بوجود نسبة عالية من كربونات الكالسيوم وهى عامل التربة المؤثر فى انتشار الانواع النباتية فى هذه البيئة. وعامة، تركيز الاملاح الذائبة ورطوبة التربة وصل الى درجة عالية فى بيئة المستنقعات الملحية دليلا على ان هذه البيئة اكثر تأثرا بمياه البحر. الازدهار النباتى فى هذه المنطقة اشار الى ان الانواع النباتية التى تنتمى الى الـ chamaephyte اكثر نسبة من غيرها (30%)، وان اكثر العائلات تواجدا هى النجيلية (30%). واخيرا، الانواع النباتية التى تنتمى لبيئة البحر المتوسط هى الاكثر تواجدا (37.5%).