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Research Article

Impact of Anthropogenic Disturbance on Vegetation Structure of El-Maktala Coastal Land, Egypt

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Abstract

Background and Objective: The anthropogenic disturbance on vegetation in El-Maktala coastal land, an unprotected area in the North Western coast of the Egypt. That has recently been subjected to blatant encroachments of vegetation, were studied. **Materials and Methods:** To estimate the vegetation structure in EL-Maktala coastal land, 12 stands were chosen to represent different plant habitats. A total of 12 stands were selected for the study of the vegetation composition and its relation to soil drivers using vegetation and soil analyses. Also, the vegetation quality was determined. **Results:** The most important of these threats is the construction of the road and grazing, 27 species are reported in this study, the most represented plant families are Poaceae (18.5%) and Asteraceae (14.8%). Perennials, chamaephytes and Mediterranean species were recorded in the highest percentage. Canonical correspondence analysis showed that silt, clay, sand contents, pH, EC and $CaCO_3$ content are the factors that have the highest effect on vegetation distribution in the studied stands. The diversity indices in the studied area was moderate. According to Sorenson's coefficient, these communities have quite a bit of overlap or similarity. The vegetation quality index indicated that coastal land is highly sensitive to desertification, as decrease in plant cover. **Conclusion:** Recently, the violation and destruction of wildlife have increased, therefore, preserving it along with general biodiversity has become an urgent necessity.

Key words: Plant diversity, vegetation structure, El-Maktala, CCA, similarity index and VQI

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The Northwestern Mediterranean coast of Egypt extends from Sallum eastward to Alexandria westward, the coastal climate is warm, temperate and arid, with some winter rainfall. The western coastal region can be distinguished into two main provinces: An eastern province from Alexandria to Ras El Hekma. The coastal plains are vast, with several depressions and ridges running parallel to the coast. The western province runs from Ras El Hekma to Sallum with a narrow coastal plain[1].

Coastal lands Basin is an important landscape in terms of environmental heterogeneity, species diversity and habitat variability[2,3]. Furthermore, well-preserved dunes are the first natural barrier of defence against coastal erosion and the destructive effects of wind and stormy waves[4].

Overgrazing, road building, overharvesting, solid wastes, salinization, industrialization, urbanization and military activities are considered to be the main anthropogenic activities that lead to changes and transformation of vegetation and natural habitat loss in arid and semi-arid environments[5].

The vegetation is a most important component in the desert ecosystems is the vegetation, as its structure and dynamics control the provision of ecosystem services[6,7]. The role that analysis can play in classifying sites depended on the purpose of the classification and the size of the area to be studied. It is well known that the natural vegetation is found always in equilibrium with the dominant ecological conditions in the locations such as climatic, edaphic and biological factors. Needs to study these reactions is more important for planning to manage the way for improving the productivity of such areas. The present study aimed at studying the vegetation composition and its relation to soil drivers also, as vegetation quality along with El-Maktala coastal land.

MATERIALS AND METHODS

Study area: El-Maktala region is located between latitude 31°33'North and longitude 26°10'East. It lies 140 km after Matrouh and 90 km before El-Sallum in the North Western Coast. Geomorphologically, the Sidi Barrani area is located near the Mediterranean Sea about 95 km east of the border with Libya and about 420 km west of Alexandria. El-Maktala sector comprises a vast area of fertile land (about 80 km^2) with a more or less relatively dense cover of natural vegetation[8].

Vegetation analysis: To estimate the vegetation structure in EL-Maktala coastal land, 12 stands were chosen to represent different plant habitats. A total of 12 stands were selected for the study of the vegetation of EL-Maktala coastal land during the summer season of 2018. In each stand, three quadrates were chosen (quadrate area = 10×10 m = 100 m^2). Vegetation cover was measured using visual estimation. Recorded plant species in all localities were identified and life span was documented according to Boulos[9]. Life form and floristic category were recognized[9,10]. Shannon-Wiener diversity index (H'), Relative equitability or evenness (E) and Simpson indices were calculated[11]. Similarity Sorenson index was calculated[12]. The vegetation quality index is valuable in determining the sensitivity of an area to desertification[13,14] in terms of four indicators namely: Vegetation cover, drought resistance plants, plant species that tolerate erosion and grazing risk[15].

Soil analysis: Many soil factors were examined to determine the characteristics of the soil in the study area. From each stand, three soil samples were collected and merged to form a homogeneous and representative sample of a single locality. Fourteen soil factors were analyzed: Soil texture (sand, silt and clay), pH, electrical conductivity, magnesium, calcium, sodium, potassium, chloride, calcium carbonate, sulfate and organic carbon content. Soil texture was determined[16] using a pipette method. Digital portable pH and EC meters were used to calculate pH and electrical conductivity (EC). Magnesium and calcium were determined using a titration method[17]. A flame photometer at wavelengths of 589 and 767 nm was used to determine sodium and potassium, respectively[16]. Chlorides and calcium carbonates were determined using a titration method[17]. Sulfates were determined[16] using the turbid metric method. Organic carbon was determined using a titration method[17].

RESULTS

Floristic composition: A collection of 27 plant taxa, belonging to 16 families, was recorded in El-Maktala coastal land. The most represented plant families were Poaceae, with 5 (18.5%), Asteraceae with 4 (14.8%), Fabaceae and Chenopodiaceae with 3 (11.1%), each them. Thirteen families (Amaryllidaceae, Apiaceae, Boraginaceae, Cistaceae, Brassicaceae, Euphorbiaceae, Nitrariaceae, Polygonaceae, Rubiaceae, Solanaceae, Thymelaeaceae and Zygophyllaceae) were represented by one species shown in Appendix 1 and Fig. 1.

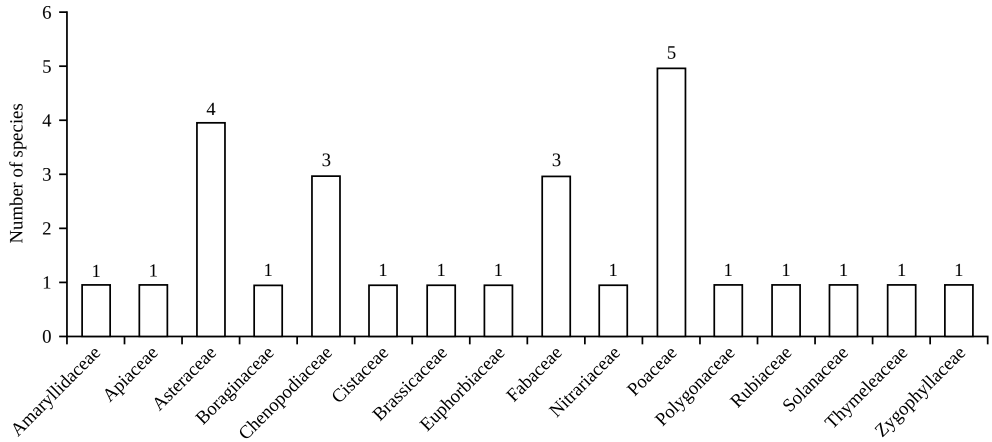

Fig. 1: Number of species distributed across different families recorded in El-Maktala coastal lands

Appendix 1: List of species recorded in El-Maktala coastal land with their plant families, vegetation groups, life form, floristic category and abbreviations

		Vegetation groups							
Families	Species	A	B	C	D	E	Life form	Floristic categories	Abbreviations
Amaryllidaceae	*Pancratium maritimum* (L.)					17.8	Geophyte	ME	*Pan mar*
Apiaceae	*Pituranthus tortuosus* (Desf.) Bnth	26.3±0.83					Chamaephytes	SA	*Pit tor*
Asteraceae	*Echinops spinosissimus* (Turra)				16.3±0.91	22.5	Hemicryptophytes	ME	*Ech spi*
	Hyoseris radiata (L.)	27.0±6.26					Chamaephytes	ME	*Hyo rad*
	Inula crithmoides (L.)			35.6±1.01			Hemicryptophytes	ME	*Inu cri*
	Otanthus maritimus (L.) Hoffmann's. and link		23.8±13.3	73.7±7.72			Chamaephytes	ME	*Ota mar*
Boraginaceae	*Echium angustifolium* (Mill.)		55.8±1.13	34.0±6.93			Chamaephytes	ME	*Ech ang*
Chenopodiaceae	*Atriplex halimus* (L.)	29.8±0.57					Chamaephytes	ME+SA	*Atr hal*
	Salsola tetrandra forssk.		80.8±7.43			13.3	Chamaephytes	SA+IT	*Sal tet*
	Suaeda vera (Forssk. ex J.F. Gmel.)			25.7±4.45			Chamaephytes	SA	*Sua ver*
Cistaceae	*Helianthemum lippii* (L.) Pers.	48.0±6.01					Chamaephytes	SA+S	*Hel lip*
Brassicaceae	*Cakile maritima* (Scop.)		55.5±11.1	25.7±4.45			Therophyte	ME+EU	*Cak mar*
Euphorbiaceae	*Euphorbia paralias* (L.)			17.7±3.06	5.55±11.1	44.50	Chamaephytes	ME	*Eup par*
Fabaceae	*Lotus polyphyllus* (E.D.) Clarke.	23.0±2.25			27.8±1.49		Chamaephytes	SA	*Lot pol*
	Ononis vaginales (Vahl.)	66.7±1.15					Chamaephytes	ME	*Ono vag*
	Retama raetam (Forssk.) Webb and Berthel				15.2±1.55	22.4	Phanerophytes	SA	*Ret rae*
Nitrariaceae	*Nitraria retusa* (Forssk.) Asch.				63.7+3.11		Phanerophytes	SA	*Nit ret*
Poaceae	*Aeluropus lagopoides* (L.)				38.5±1.31		Chamaephytes	SA	*Ael lag*
	Ammophila arenaria (L.)			96.7±12.0	21.0±2.46		Chamaephytes	ME	*Amm are*
	Elymus farctus (Viv.)		53.0±6.65	61.7±1.15			Hemicryptophytes	ME	*Ely far*
	Lygeum spartum (L.)	18.0±1.39					Geophyte	ME	*Lyg spa*
	Sporobolus pungens (Schreb.)	15.3±2.25	71.5±8.27	16.2+3.31			Chamaephytes	ME	*Spo pun*
Polygonaceae	*Polygonum aviculare* (L.)		33.8±6.75	17.1±18.1	17.8±3.55		Hemicryptophytes	ME+IT	*Poly avi*
Rubiaceae	*Crucianella maritima* (L.)	19.5±0.67					Chamaephytes	ME	*Cru mar*
Solanaceae	*Lycium shawii* (Roem.)		3.23±6.45	62.3±10.8	18.8±2.17		Phanerophytes	SA+S	*Lyc sha*
Thymelaeaceae	*Thymelaea hirsuta* (L.)		15.7±22.2	18.7±16.4	32.3±4.48		Chamaephytes	ME+SA	*Thy hir*
Zygophyllaceae	*Zygophyllum album* (L.)					14.8	Chamaephytes	ME+SA	*Zyg alb*

ME: Mediterranean, IT: Irano-Turanian, SA: Saharo-Arabian, S: Sudanian and EU: Euro-Siberian

Regarding the life span of the listed species, most of them are perennials (26 species) and one annuals species (Appendix 1). Comparing species according to their life form, we found approximately 63% chamaephytes, 15% hemicryptophytes, 11% phanerophytes, 7% geophyte and 4% therophyte in Appendix 1 and Fig. 2. Concerning a phytogeographical region, Mediterranean geo elements was the most common floristic category (13 species, 48%), followed by Saharo-Arabian (6 species, 22.2%), Mediterranean, Saharo-Arabian (3 species, 11.1%) and Saharo-Arabian, Sudanian (2 species, 7%). Mediterranean-Eurosiberian, Saharo-Arabian, Irano-Turanian and Mediterranean, Irano-Turanian. were represented by one species, respectively in Appendix 1 and Fig. 3.

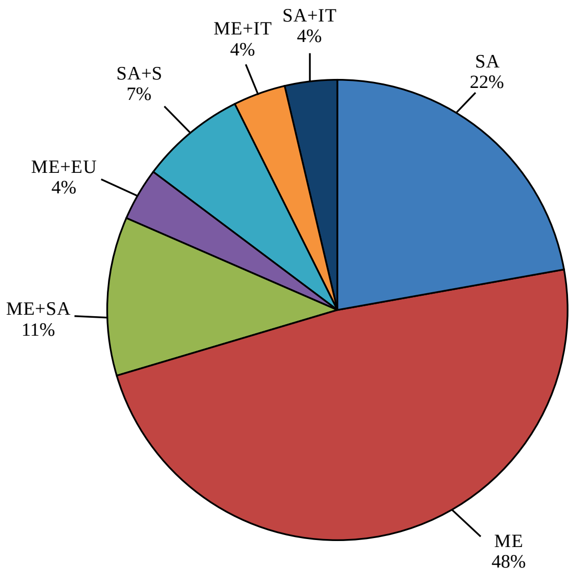

Fig. 2: Chorotypes of the species recorded In El-Maktala coastal land

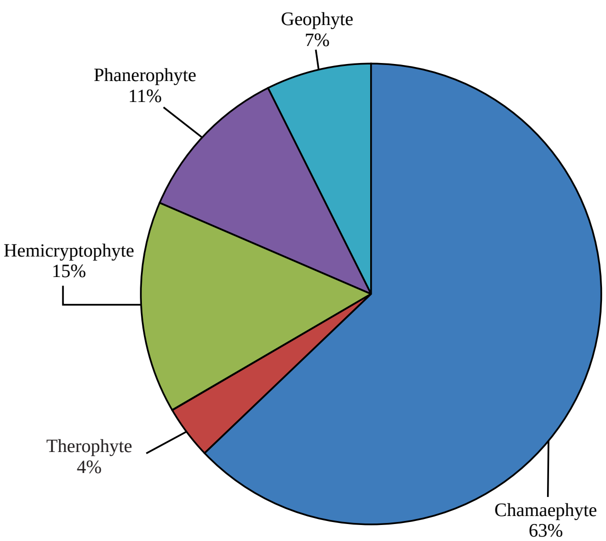

Fig. 3: Life forms of species recorded in El-Maktala coastal land

Classification: A data of 12 stands of vegetation occupying El-Maktala coastal land was analyzed using TWINSPAN to classify the stands at the fourth level into five groups labelled (A-E) in Fig. 4 with-set each sample group comprising a set of stands with greater homogeneity of vegetation, each group being characterized by indicator species, identified by TWINSPAN for each group at each level of hierarchical classification.

Group (A) consisted of three stands with twelve species. The indicator species of this group was *Inula crithmoides*, whereas, the dominant one was *Ononis vaginales* (I.V. = 66.7). Group (B) comprised three stands with nine species, the indicator species of this group was *Suaeda vera*, whereas, the dominant one was *Salsola tetrandra* (I.V. = 80.8). Group (C) has three stands with twelve species. The indicator species of this group was *Euphorbia paralias* whereas, the dominant one was *Ammophila arenaria* (I.V. = 96.7). Group (D) encompassed two stands with ten species. The indicator species of this group was *Pancratium maritimum* whereas, and the dominant one was *Nitraria retusa* (I.V. = 63.7). Group (5) is represented by one stand with five species. The indicator species of this group was *Pancratium maritimum*, whereas, the dominant one was *Euphorbia paralias* (I.V. = 44.5) (Appendix 1).

Diversity and vegetation quality index: The average of species richness, Shannon index (H), Shannon index (E) and Sampson Index (D) were 4, 0.07, 0.02 and 0.02, respectively. Sorenson's coefficient (CC) was 0.44. The vegetation quality index (VQI) is valuable in determining the sensitivity to desertification (Appendix 1). The study showed that coastal land is highly sensitive to desertification each has a vegetation quality index (VQI) of 1.38 in Table 1.

Soil characteristics: Soil samples were taken at a depth of 0-30 cm in the studied localities and 14 soil factors were analyzed. Moisture, pH and EC values ranged between 1.17-3.91, 7.5-7.72 and 0.027-1.3 dS m^{-1}, respectively. Calcium, magnesium, sodium and potassium contents ranged between 1.2-3.9, 0.72-2.5, 1.11-3.3 and 0.2-0.66 meq L^{-1}, respectively. Chloride, sulfate and calcium carbonate contents ranged between 2-11 meq L^{-1}, 0.23-0.96 meq $L^{-1}$and 53-95%, respectively. Organic carbon, clay and silt contents in all soil samples were less than 0.04, 4.55 and 50.5%, respectively. In addition, sand contribution in all soil samples was more than 25.4% in Table 2.

Impacts of environmental factors on the distribution of plant communities in the studied localities: The distribution of the studied localities and recorded plant species and their relationships to environmental factors are illustrated in Fig. 5. CCA bio lot showed the relations between vegetation structure and environmental variables along with EL-Maktala coastal land. These arrows of environmental variables point to the maximum change of that environmental variable across the diagram. Its length is proportional to the rate of change in this direction, environmental variables with long arrows are most strongly correlated with the ordination than those of short arrows and so more closely related to the pattern of variation in species distribution in the ordination diagram.

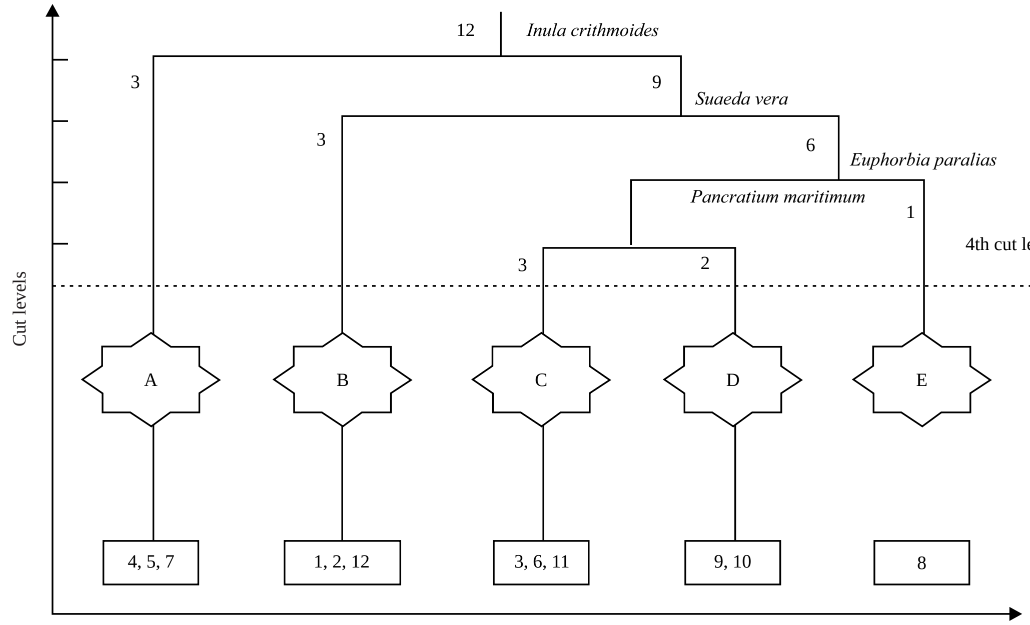

Fig. 4: Two Way Indicator Species Analysis (TWINSPAN) dendrogram of 12 stands based on the importance values of 27 perennial plant species in the study area

Table 1: Descriptive statistical analysis of diversity indices

Diversity indices	Rang (max-min)	Standard deviation	Mean+standard error	Median	Interquartile range (IQR)
Richness	-	-	4.00	-	-
Shannon index (H)	0.83 (2.15-1.32)	0.27	0.07	1.78	1.60
Shannon index (E)	0.25 (0.65-0.40)	0.08	0.02	0.58	0.54
Sampson index (D)	0.33 (0.81-0.48)	0.10	0.02	0.67	0.61
Sorenson's coefficient (CC)			0.44	-	-
VQI	0.8 (1.8-1)	0.33	1.38	0.09	1.00

Table 2: Descriptive statistical analysis of soil factors associated with plant species.

Factors	Rang (max-min)	Standard deviation	Mean+standard error	Median	Interquartile range (IQR)
Moisture (%)	2.74 (1.17-3.91)	0.95	2.34+0.26	2.19	1.68
Sand (%)	25.40 (46.8-72.2)	6.93	56.00+2.1	54.50	51.80
Silt (%)	50.50 (27.1-51.2)	6.46	41.60+1.98	42.90	37.80
Clay (%)	4.55 (0.75-5.3)	1.23	2.39+0.34	2.30	1.84
pH	0.22 (7.72-7.5)	0.06	7.61+0.02	7.62	7.59
EC (ds m^{-1})	1.03 (0.27-1.3)	0.31	0.59+0.09	0.53	0.33
Ca^{+2} (meq L^{-1})	2.70 (1.2-3.9)	0.86	2.21+0.24	1.92	1.60
Mg^{+2} (meq L^{-1})	1.78 (0.72-2.5)	0.95	1.60+0.27	1.21	1.07
Na^{+1} (meq L^{-1})	2.19 (1.11-3.3)	0.80	1.96+0.23	1.71	1.31
K^{+2} (meq L^{-1})	0.46 (0.2-0.66)	0.13	0.34+0.039	0.32	0.26
Cl^{-1} (meq L^{-1})	9.00 (2-11)	2.93	5.08+0.83	3.80	3.20
SO_4^{-2} (meq L^{-1})	0.73 (0.23-0.96)	0.25	0.49+0.07	0.41	0.31
Organic carbon (%)	0.04 (0.01-0.05)	0.01	0.03+0.01	0.03	0.02
$CaCO_3$ (%)	42.00 (53-95)	11.6	88.20+3.24	91.00	89.90

VQI: Vegetation quality index, pH: Soil reaction, EC: Electrical conductivity, Ca^{+2}: Calcium, Mg^{+2}: Magnesium, Na^{+}: Sodium, K^{+}: Potassium, $CaCO_3$: Calcium carbonates, Cl: Chlorides, SO_4^{-2}: Sulfates, dS m^{-1}: DeciSiemens per meter and meq L^{-1}: Milliequivalents per liter

Biplot of the species revealed that several species showed a close association with $CaCO_3$ and sand, among them were *Lotus polyphyllus*, *Ammophila arenaria*, *Euphorbia paralias* and *Elymus farctus*. Other species showed a clear association with SO_4^{-2} and organic carbon, of these species were *Helianthemum lippii*, *Ononis vaginales*, *Hyoseris radiata* and *Retama raetam*. However, *Nitraria retusa*, *Zygophyllum album*, *Lycium shawii*, *Aeluropus lagopoides* were found to be related to Ca^{+2}, Mg^{+2}, Na^{+}, Cl^{-} and moisture content. Meanwhile, *Thymelaea hirsuta*, *Atriplex halimus* and *Suaeda vera* were affected with EC, K^{+}, silt and clay.

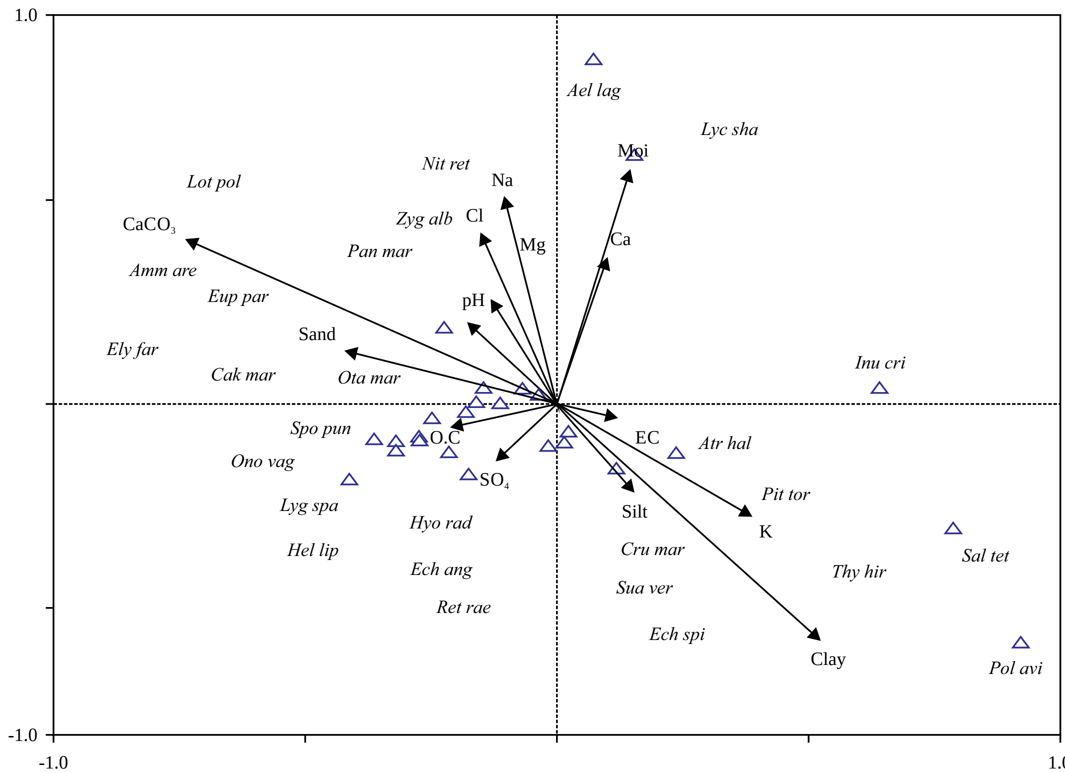

Fig. 5: CCA biplot showing the distribution of the studied localities and the recorded plant species as well as their relationships to environmental factors

The triangles represent species and the arrows represent environmental variables. Arrow length expresses the relative importance of an environmental variable. Dropping perpendicular to the arrows from each of the species indicates the species' relative position along the ecological gradient represented.

DISCUSSION

The present study provides an insight into the floristic composition, life-form, chorotype and community structure concerning edaphic variables of El-Maktala coastal land, Egypt. In El-Maktala coastal land, 27 plant species belonging to 16 families were recorded. Among them, Asteraceae, Poaceae and Fabaceae were the most frequent families. The vegetation of the study area exhibited the characteristics of the Mediterranean chorotype. The life form spectra provide information that may help in assessing the response of vegetation to variations in environmental factors[8]. The present study demonstrated that the dominancy was for chamaephytes over the other life forms which coincided with the study[18] which seems to be a response to the hot-dry climate, topographic variation and biotic influence. Chamaephytes was the abundant life forms in the studied area coincided with[8] and formed about 70% of the vegetation.

Species richness, which refers to the number of various plant species in the stands, is one of the most important indices of species diversity. In the studied stands, the average of species richness recorded three species, which is a low number. This could be due to a variety of factors, including the severe environment and climate that characterize the study area, which may be an obstacle to the growth of some plant species. Species evenness is a description of the distribution of species abundance in a community. The average of species evenness was 0.7. Species evenness is measured on a scale of 0 to 1, with 0 representing the lowest evenness (one species has 100% coverage) and 1 representing the highest evenness (coverage is evenly spread among some species). This may be due to the presence of a very dominant species in a community causing the less competitive species to be suppressed[19]. Shannon index depends strongly on species richness[10]. Simpson index is not a very intuitive measure of diversity since higher values indicate lower diversity[20].

Classification of the vegetation resulted in 5 vegetation groups associated with edaphic factors, which play a significant role in the distribution of the different vegetation groups. Vegetation along with the coastal lands, in general, is not constant; varying from year to year, depending upon the moisture level[8]. The establishment, growth, regeneration and distribution of plant communities in the coastal lands are controlled by many factors such as geographical position, physiographic features and human impacts[21-23]. The differences between the recorded vegetation groups and diversity may reflect the correlation with the environmental gradients. Under conditions of low and irregular rainfall prevailing in the study area, local topography is one of the overriding factors controlling sedimentation and water redistribution with the local landscape[24].

In this study, CCA results highlighted that soil chemical features (organic matter and $CaCO_3$ content), distance from the coastline and anthropogenic factors (overgrazing, trampling and urbanization) are the main significant explanatory variables that govern the floristic composition and patterns in the study area. In general, topographic and soil factors are complementary to and/or consequences of anthropogenic activities[25], nonetheless, plants that occur only in specific environments, such as the Mediterranean coastal lands, are more prone to suffer as a result of human-related disturbances than those with a wide distribution and ecological range[25,26]. By increasing the distance from the coastline, the content of soil organic matter increases and $CaCO_3$ content decreases; these general relationships along dune types are well known for a long time[27]. The high concentration of organic matter, particularly in stabilized dunes, is evidence of soil development, which is the main cause of the plant succession in addition to its main role as a reservoir for the essential elements[28,29] also, high concentrations of $CaCO_3$ in foredunes confirm its role in the establishment of pioneer communities in addition to being considered as a predictor for the development of stabilized inland dunes[29]. In addition to the environmental variables considered in this study, other environmental factors have significantly contributed to the explanation of coastal vegetation and should be considered for further studies, such as pH, electric conductivity, salinity, sorting, mean grain size, shoreline trend, erosion and wind-related variables[30].

CONCLUSION

The violation and destruction of wildlife have increased, therefore, preserving it along with general biodiversity has become an urgent necessity. Current results highlighted the importance of soil variables (e.g., organic matter and $CaCO_3$ content) and human impacts (constructions of roads and urbanization) on vegetation structure and quality, also life forms plant species composition in coastal land.

SIGNIFICANCE STATEMENT

By increasing the intensity of destruction, the number of species would be decreased and the community structure and species composition would be changed. Also, anthropogenic disturbance decreased the amount of organic matter (carbon and nitrogen) according to the degree of man-made disturbances. Therefore, a comprehensive program should be considered for coastal lands.

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