Impacts of Anthropogenic Disturbance on Vegetation Structure of El-Maktala Coastal land, Egypt

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Article

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Abstract

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. 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%). Perennial, chamaephyte 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. Recently, the violation and destruction of wildlife have increased, therefore, preserving it along with general biodiversity has become an urgent necessity.

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 number of 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 are important landscapes in terms of environmental heterogeneity, species diversity, and habitat variability [2]; [3]. Furthermore, well-preserved dunes are the first natural barrier of defense against coastal erosion and 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]; [6].

The vegetation is the most important component in the desert ecosystems is the vegetation, as its structure and dynamics control the provision of ecosystem services [7]; [8]. The role which 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 an 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 aims at studying the vegetation composition and its relation to soil drivers also, vegetation quality along El-Maktala coastal land.

Study area

El- Maktala region is located between latitude $31^{\circ} 33'$ North and longitude $26^{\circ} 10'$ East. It lies 140 km after Matrouh and 90 km before El-Sallum in the North Western Coast. Geomorphologically, Sedi Barrani area is located near the Mediterranean Sea about 95 km east of the border with Libya, and about 420 km west of Alexandria (Fig. 1). El-Maktala sector comprises a vast area of fertile land (about 80 square km) with a more or less relatively dense cover of natural vegetation [9] (Migahid et al., 1974).

Materials And Methods

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 (quadrante area = $10 \text{ m} \times 10 \text{ m} = 100 \text{ m}^2$). Vegetation cover was measured using visual estimation. Recorded plant species in all localities were identified, and life span was documented according to [10]. Life form and floristic category were recognized after [11]; [12] and [13]. Shannon-Wiener diversity index (H'), Relative equitability or evenness (E) and Simpson indices was calculated following formula of [14]; [15]. Similarity Sorenson index was calculated following [16]; [17]. The vegetation quality index is valuable in determining the sensitivity of an area to desertification, it assessed according to [18]; [19] in terms of four indicators namely: Vegetation cover, Drought resistance plants, Plant species which tolerate erosion and grazing risk [20]; [21].

Soil Analyses

Many soil factors were examined in order 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, carbonate, sulfate, and organic carbon content. Soil texture was determined according to Estefan et al. [22] using a pipette method. Digital portable pH and EC meters were used to calculate pH and electrical conductivity (E.C.). Magnesium and calcium were determined using a titration method according to Page et al. [23]. A flame photometer at wavelengths of 589 and 767 nm was used to determine sodium and potassium, respectively [22]. Chlorides, bicarbonates, and carbonates were determined using a titration method [24]. Sulfates were determined after Estefan et al. [22] using the turbid metric method. Organic carbon was determined using a titration method [25].

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 of them. Thirteen families (Amaryllidaceae, Apiaceae, Boraginaceae, Cistaceae, Brassicaceae, Euphorbiaceae, Nitrariaceae, Polygonaceae, Rubiaceae, Solanaceae, Thymeleaceae and Zygophyllaceae) were represented by one species (Appendix and Figure 2).

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 (Table 1 and Figure 3). With respect to a phytogeographical region, Mediterranean geoelements 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-Turanaian and Mediterranean, Irano-Turanean. were represented by one species, respectively (Table 1 and Figure 4).

Classification:

A data of 12 stands of vegetation occupying El-Maktal coastal land was analyzed using TWINSpan to classify the stands at the fourth level into five groups labelled (A-E) in (Figure 5) 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 crismides*, whereas, the dominant one was *Ononis vaginalis* (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 (4)** 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)** 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) (Table.1).

Table 1

The list of species recorded in El-Maktala coastal land with their plant families, Vegetation groups, life form, floristic category, and abbreviations. Where: ME =Mediterranean, IT = Irano-Turanian, SA = Saharo-Arabian, S = Sudanian and EU = Euro-Siberian.

Families	Species	Vegetation groups				Life form	Floristic categories	Abbreviations	
		A	B	C	D				E
Amaryllidaceae	<i>Pancratium maritimum</i> (L.)					17.8	Geophyte	ME	<i>Pan mar</i>
Apiaceae	<i>Pituranthus tortuosus</i> (Desf.) Bnth	26.3±0.83					Chamaephyte	SA	<i>Pit tor</i>
Asteraceae	<i>Echinops spinosissimus</i> (Turra)				16.3±0.91	22.5	Hemicryptophyte	ME	<i>Ech spi</i>
	<i>Hyoseris radiata</i> (L.)	27.0±6.26					Chamaephyte	ME	<i>Hyo rad</i>
	<i>Inula crithmoides</i> (L.)			35.6±1.01			Hemicryptophyte	ME	<i>Inu cri</i>
	<i>Otanthus maritimus</i> (L.) Hoffmanns. & Link		23.8±13.3	73.7±7.72			Chamaephyte	ME	<i>Ota mar</i>
Boraginaceae	<i>Echium angustifolium</i> (Mill.)		55.8±1.13	34.0±6.93			Chamaephyte	ME	<i>Ech ang</i>
Chenopodiaceae	<i>Atriplex halimus</i> (L.)	29.80.57±					Chamaephyte	ME+SA	<i>Atr hal</i>
	<i>Salsola tetrandra</i> forssk.		80.8±7.43			13.3	Chamaephyte	SA+IT	<i>Sal tet</i>
	<i>Suaeda vera</i> (Forssk. ex J.F. Gmel.)			25.7±4.45			Chamaephyte	SA	<i>Sua ver</i>
Cistaceae	<i>Helianthemum lippii</i> (L.) Pers.	48.0±6.01					Chamaephyte	SA+S	<i>Hel lip</i>
Brassicaceae	<i>Cakile maritima</i> (Scop.)		55.5±11.1	25.7±4.45			Therophyte	ME+EU	<i>Cak mar</i>
Euphorbiaceae	<i>Euphorbia paralias</i> (L.)			17.7±3.06	5.55±11.1	44.50	Chamaephyte	ME	<i>Eup par</i>
Fabaceae	<i>Lotus polyphyllus</i> (E.D.) Clarke.	23.0±2.25			27.8±1.49		Chamaephyte	SA	<i>Lot pol</i>
	<i>Ononis vaginalis</i> (Vahl.)	66.7±1.15					Chamaephyte	ME	<i>Ono vag</i>
	<i>Retama raetam</i> (Forssk.) Webb & Berthel				15.2±1.55	22.4	Phanerophyte	SA	<i>Ret rae</i>
Nitrariaceae	<i>Nitraria retusa</i> (Forssk.) Asch.				63.7±3.11		Phanerophyte	SA	<i>Nit ret</i>
Poaceae	<i>Aeluropus lagopoides</i> (L.)				38.5±1.31		Chamaephyte	SA	<i>Ael lag</i>
	<i>Ammophila arenaria</i> (L.)			96.7±12.0	21.0±2.46		Chamaephyte	ME	<i>Amm are</i>
	<i>Elymus farctus</i> (Viv.)		53.0±6.65	61.7±1.15			Hemicryptophyte	ME	<i>Ely far</i>

Families	Species	Vegetation groups				Life form	Floristic categories	Abbreviations	
		A	B	C	D				E
	<i>Lygeum spartum</i> (L.)	18.0±1.39					Geophyte	ME	<i>Lyg spa</i>
	<i>Sporobolus pungens</i> (Schreb.)	15.3±2.25	71.5±8.27	16.2±3.31			Chamaephyte	ME	<i>Spo pun</i>
Polygonaceae	<i>Polygonum aviculare</i> (L.)		33.8±6.75	17.1±18.1	17.8±3.55		Hemicryptophyte	ME+IT	<i>Poly avi</i>
Rubiaceae	<i>Crucianella maritima</i> (L.)	19.5±0.67					Chamaephyte	ME	<i>Cru mar</i>
Solanaceae	<i>Lycium shawii</i> (Roem.)		3.23±6.45	62.3±10.8	18.8±2.17		Phanerophyte	SA+S	<i>Lyc sha</i>
Thymeleaceae	<i>Thymelaea hirsuta</i> (L.)		15.7±22.2	18.7±16.4	32.3±4.48		Chamaephyte	ME+SA	<i>Thy hir</i>
Zygophyllaceae	<i>Zygophyllum album</i> (L.)					14.8	Chamaephyte	ME+SA	<i>Zyg alb</i>

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 (Table 2). The studied showed that coastal land is highly sensitive to desertification each has vegetation quality index (VQI) of 1.38 (Table 2).

Table 2
Descriptive statistical analysis of Diversity indices in the study area. Where: VQI = vegetation quality index

Diversity Indices	Rang (Max-Min)	Standard deviation	Mean+Standard Error	Median	Interquartile Range (IQR)
Richness	-	-	4	-	-
Shannon Index (H)	0.83(2.15-1.32)	0.27	0.07	1.78	1.6
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)	0.1	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

Soil Characteristics

Soil samples were taken at a depth of 0 to 30 cm in the studied localities, and 14 soil factors were analyzed. Moisture, Soil pH and EC values ranged 1.17 to 3.91, 7.5 to 7.72 and 0.027 to 1.3 dS/m, respectively. Calcium, magnesium, sodium and potassium contents ranged 1.2 to 3.9 meq/L, 0.72 to 2.5 meq/L, 1.11 to 3.3 meq/L and 0.2 to 0.66 meq/L, respectively. Chloride, sulfate and calcium carbonate contents ranged between 2 to 11 meq/L, 0.23 to 0.96 meq/L and 53 to 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% (Table 3).

Table 3

Descriptive statistical analysis of soil factors associated with plant species in the study area. Where: VQI = vegetation quality index, pH = soil reaction, E.C. = electrical conductivity, Ca^{+2} = calcium, Mg^{+2} = magnesium, Na^{+} = sodium, K^{+} = potassium, CaCO_3 = calcium carbonates, Cl^{-} = chlorides, SO_4 = sulfates, dS/m = deciSiemens per meter and meq/L = milliequivalents per liter.

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 (%)	25.4(46.8-72.2)	6.93	56+2.1	54.5	51.8
Silt (%)	50.5(27.1-51.2)	6.46	41.6+1.98	42.9	37.8
Clay (%)	4.55(0.75-5.3)	1.23	2.39+0.34	2.3	1.84
pH	0.22(7.72-7.5)	0.06	7.61+0.02	7.62	7.59
E.C. (ds/m)	1.03(0.27-1.3)	0.31	0.59+0.09	0.53	0.33
Ca^{+2} (meq/L)	2.7(1.2-3.9)	0.86	2.21+0.24	1.92	1.6
Mg^{+2} (meq/L)	1.78(0.72-2.5)	0.95	1.6+0.27	1.21	1.07
Na^{+1} (meq/L)	2.19(1.11-3.3)	0.8	1.96+0.23	1.71	1.31
K^{+2} (meq/L)	0.46(0.2-0.66)	0.13	0.34+0.039	0.32	0.26
Cl^{-1} (meq/L)	9(2-11)	2.93	5.08+0.83	3.8	3.2
SO_4^{-2} (meq/L)	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(53-95)	11.6	88.2+3.24	91	89.9

Effect 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 (Figure 6). CCA biplot showed, the relations between vegetation structure and environmental variables along EL-Maktala coastal land. These arrows of environmental variables point in 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.

Biplot of the species revealed that several species showed a close association with CaCO_3 and sand, among them were *Lotus polyphyllus*, *Ammophylla arenaria*, *Euphorbia paralias* and *Elymus farctus* (Figure 6). Other species showed clear association with SO_4^{-2} and organic carbon, of these species were *Helianthemum lippi*, *Ononis vaginalis*, *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.

Discussion

The present study provides an insight into the floristic composition, life-form, chorotype and community structure in relation to edaphic variables of El-Maktal 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 which may help in assessing the response of vegetation to variations in environmental factors [26]. The present study demonstrated that the dominancy was for chamaephytes over the other life forms which coincided with the study [27] 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 [26] and forming 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 a number of species). This may be due to the presence of a very dominant species in a community causes the less competitive species to be suppressed [28]. Shannon index depends strongly on species richness [29]. Simpson index is not a very intuitive measure of diversity since higher values indicate lower diversity [30]. The average of vegetation quality index is measured on scale of 1-2 [19].

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 the coastal lands in general being not constant; varying from year to year, depending upon the moisture level [31]. The establishment, growth, regeneration and distribution of plant communities in the coastal lands controlled by many factors such as geographical position, physiographic features and human impacts [32]; [33]; [34]. 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 being one of the overriding factors controlling sedimentation and water redistribution with the local landscape [35].

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 [36]; 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 [37]; [36]. 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 since a long time [38]; [39]. The high concentration of organic matter, particularly in stabilized dunes, is evidence of the soil development, which is the main cause of the plant succession in addition to its main role as a reservoir for the essential elements [40]; [41]; 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 [41]. In addition to the environmental variables considered in this study, there are also other environmental factors that 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 [42]; [43].

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Appendix

Appendix 1 is not available with this version

Figures

Figure 1
Map showing the study area

Figure 2
Number of species distributed across different families recorded in El-Maktal coastal lands

Figure 3

Chorotypes of the species recorded in El-Maktala coastal land

Figure 4

Life forms of species recorded in El-Maktala coastal land

Figure 5

Figure 6

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 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