MANSOURA JOURNAL OF BIOLOGY
Official Journal of Faculty of Science, Mansoura University, Egypt
E-mail: scimag@mans.edu.eg ISSN: 1687-5087

Ecology of Six Halopytic Species and Associated Flora

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Received: 24/8/2020
Accepted:10/10/2020

Abstract: This study aimed to describe floristic composition and ecological chracteristics of six species of halophytes (*Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Juncus rigidus*, *Phragmites australis*, *Suaeda vera* and *Zygophyllum aegyptium*) in north part of Nile Delta of Egypt. Eighty-two species (40 annuals, one biennial and 41 perennials) of 73 genera and 24 families. Asteraceae, Poaceae, and Chenopodiaceae were the largest represented families.. Therophytes and chamaephytes were the dominat life forms. The widespread chorotype were Mediterranean taxa (82 species or about 73.18%). TWINSPAN segregated four groups. Group A codominated by *J. rigidus* and *P. australis***,** group B by *P. australis* and *Z. aegyptium*, group C by *Rumex pictus* and *Erodium laciniatum* and group D by *Zygophyllum album* and *H. strobilaceum*. Soil salinity, soil texture and human activities were the key drivers fordistribution of the studied halophytes in the study area. The Deltaic Mediterranean coast should be protected against excessive human activities

keywords: Vegetation, halophytes, edaphic factors, Nile Delta, costal desert**.**

Introduction

Coastal areas are characterized by their ecological diversity and natural resources that offer numerous opportunities such as tourism, farming, fisheries, oil and gas extraction, and marine transport. Moreover, coastal areas represent major pooling areas, which attract large number of immigrants, who have increasing demand for housing, energy, goods and services [1, 2].

In Egypt, the Mediterranean coastal zone has a narrow coastal strip that extends for c. 970 km from Sallum at the west of Egypt to Rafah at the east [3]. The Mediterranean coast of Egypt is distinguished into three sectors, the Mareotis coast (western coast), Deltaic sector (Nile Delta coast) and the Sinai sector (eastern coast) [4]. The coastal areas of Egypt are exposed to number of threats such as urbanization, salt water intervention, erosion and ecosystem degradation.

The north Nile Delta zone of Egypt is segregated into different habitats: fertile lands, reed swamps, sand dunes, salt marshes and wetlands. The sand formations of siliceous deposits are divided into three sub-habitats: sand dunes, sand mounds, and sand sheets. Sand mounds are located at the front with different sand grain sizes while sand sheets are either saline or non-saline flats and distributed between salt marshes and sand dunes. The well-conserved sand dunes include three morphological types, mobile, partial-stabilized and stabilized dunes, and represent the greatest part of the Deltaic coastal area [3]. The reed swamps habitats are created by accumulation of salt water in depressed areas and they are abundant in the Mediterranean coast. [3].

Salt affected lands are important natural resources because of many environmental and economic benefits that they provide, for example, fisheries, agriculture, timber, ecotourism, transport and water supply [5, 6]. Wetland provides a suitable environment for biological and chemical processes and also constitutes a critical role in nutrient and element cycle. [7].

Approximately, 2% of the earth plants are halophytes. Halophytes are plants that can survive and tolerate salinity up to 1M NaCl. Halophytes are used in different purposes such as forage, fuel, medicinal, building materials, land restoration, etc. [10, 11].

The different habitats and vegetation in the Deltaic Mediterranean coastal desert have been studied by many authors such as: Zahran *et al*. [12]; El-Demerdash *et al*. [13]; El-Kady and Sharaf El-Din [14]; Shaltout *et al*. [15]; El-Halawany [16]; El-Amier *et al*. [17]. The halophytes of the Nile Delta coastal desert were also studied by many workers such as: Zahran *et al*. [18]; Serag [19]; Zahran and El-Amier [20]; El-Amier *et al*. [21]. Thus, the main objective of this research was to study the floral composition and vegetation types of some halophytes in north Nile Delta and to evaluate the various edaphic factors that support the growth of the studied halophytes.

2. Materials and methods

1. Study Area

The Deltaic Mediterranean coast is a narrow belt through north of the Nile Delta and that affected by the sea water (Fig. 1). It extends from Abu-Qir (in the west, Long. 32°19' E) to Port-Said (in the east Long.31°19' E) with c. 180 km length, and c. 15 km width [22, 3]**.** Climatically, the Nile Delta is located in the arid province where mild winters and hot summer. The mean annual temperature ranged from 19.6 in Damietta to 20.5 in Baltim and mean annual rainfall fluctuates from 0 to 16.6 mm per year (Anonymous 19

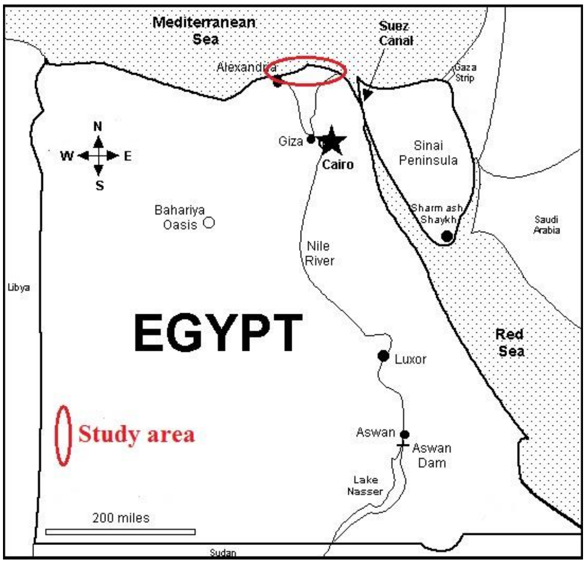

Figure 1. Location map of Egypt showing the location of the study area.

2. Vegetation analysis

The sampled stands are distributed in four governorates of Egypt, namely: Damietta, El-Dakahlia, and Kafr El-Sheikh. After regular visits to the study area, 63 stands (area = 20 × 20 m each) were selected for sampling vegetation as follows: 13 in Damietta, 23 in El-Dakahlia and 27 in Kafr El-Sheikh.

In each stand, the density of each plant was measured by counting the numbers of individuals of the species within a series of randomly distributed plots [25]. For each species the plant cover was measured using the line intercept method [26]. Finally, importance values (IV) were calculated for each species by sum of density and cover values (out of 200). During each field trip, plant specimens were collected from different sites for identification. The Raunkiaer classification for life-forms was followed in this study [27, 28]. The classification, identification and floristic categories were carried out as mentioned by Täckholm [29] and Boulos [30].

3. Soil sampling and analysis

Three soil samples were collected as a composite sample from the depth 0-20 cm in each stand. Physical and chemical analyses of soil samples were carried out according to Piper [31], Pierce *et al*. [32], Jackson [33] and Allen *et al*. [34].

4. Data analysis

TWINSPAN (CAP, community analysis package, version 2.3) was applied to classify the associated species of the studied halophytes [35]**.** The relationships between vegetation groups and edaphic variables were performed using CCA-biplot (Canonical-Correspondence Analysis) by the software-MVSP Program version 3.2 [36]. The soil variables for each group were tested for significance by using one-way ANOVA with equal replication at the 0.05 probability (Duncan's test) using software-COSTAT 6.3 program.

3. Results and Discussion

1. Floristic analysis

Eighty-two species were recorded in the study area. These species belonging to 73 genera and 24 families. Table (1) indicated that, family Asteraceae comprises 16 species (19.51%) of the total listed floral species, followed by family Poaceae 15 species (18.29%), Chenopodiaceae 10 species

(12.19%), Fabaceae comprise 6 species (7.31%), Boraginaceae, Brassicaceae & Caryophyllaceae comprise 4 species each (4.87%), Polygonaceae comprises 3 species (3.65%); These families represent the greatest frequent in the Mediterranean strip of North African flora [37, 38]. Poaceae are the fifth-largest family following the Asteraceae and Fabaceae in the world [39, 38]**.**

The records of plant species are classified as shown in Figure (2) into three major groups: 40 annual species (48.78 %), one biennial species (1.22%) and 41 perennial species (50%). The dominance of perennial species (≥ 50%) provides the permanent shape of the plant cover in each area and habitat. On the other hand, the appearance of high number of annuals is closely associated with the rainy season. Moreover, annuals can resist high levels of disturbance and agricultural practices by its reproductive performance, adaptation, morphological and genetic plasticity [40,41]. This finding is not agree with the studies of El-Kady *et al.* [42], El-Halwany [43], El-Amier *et al.* [17], El-Amier [44], but corresponds to El-Amier & Abd El-Gawad [45].

Table 2. Distribution, life span, life forms, chorotype and P% of the listed floral species in the north sector of the Nile Delta.

Species	Family	Life-span	Life-form	Chorotype	P%
Aegilops bicornis (Forssk.) Jaub. & Spach	Poaceae	Ann.	Th	ME+SA-SI	14.29
A. kotschyi Boiss.	Poaceae	Ann.	Th	IR-TR+SA-SI	3.17
Aetheorhiza bulbosa (L)Cass	Asteraceae	Per.	G	ME	1.59
Alhagi graecorum Boiss.	Fabaceae	Per.	H	PAL	6.35
Anchusa humilis (Desf.) I. M. Johnst.	Boraginaceae	Ann.	Th	ME+SA-SI	12.70
Arthrocnemum macrostachyum (Moric.) K. Koch	Chenopodiaceae	Per.	Ch	ME+SA-SI	36.51
Asparagus stipularis Forssk.	Asparagaceae	Per.	G	ME+ SA-SI	1.59
A. fruticosus Forssk.	Fabaceae	Per.	Ch	SA-SI	4.76
Atractylis carduus (Forssk.) C. Chr.	Asteraceae	Per.	H	ME+SA-SI	11.11
Atriplex portulacoides L.	Chenopodiaceae	Per.	Ch.	ME+IR-TR+ER-SR	4.76
Bassia indica (Wight) A. J. Scott	Chenopodiaceae	Ann.	Th	IR-TR+S-Z	7.94
Beta vulgaris L.	Chenopodiaceae	Ann.	Th	ME+IR-TR+ER-SR	1.59
Brassica tournefortii Gouan	Brassicaceae	Ann.	Th	ME+IR-TR+SA-SI	1.59
Bromus diandrus Roth	Poaceae	Ann.	Th	ME	11.11
Cakile maritima Scop.	Brassicaceae	Ann.	Th	ME+ER-SR	46.03
Calligonum polygonoides L.	Polygonaceae	Per.	Nph	IR-TR+SA-SI	25.40
Carduus getulus Pomel.	Asteraceae	Ann.	Th	SA-SI	7.94
Carthamus tenuis (Boiss. & Blanche) Bornm.	Asteraceae	Ann.	Th	ME	12.70
Carduus pycnocephalus L.	Asteraceae	Ann.	Th	SA-SI	3.17
Centaurium pulchellum (Swartz) Druce.	Gentianaceae	Ann.	Th	ME+IR-TR+ER-SR	3.17
Chenopodium murale L.	Chenopodiaceae	Ann.	Th	COSM	17.46
Cistanche phelypaea (L.) Cout.	Orobanchaceae	Per.	P, G	ME+SA-SI	7.94
Cressa cretica L.	Convolvulaceae	Per.	H	ME+IR-TR	1.59
Cutandia memphitica (Spreng.) Benth.	Asteraceae	Ann.	Th	ME+IR-TR+SA-SI	14.29
Cynanchum acutum L.	Asclepiadaceae	Per.	H	ME+IR-TR	7.94
Cynodon dactylon (L.) Pers.	Poaceae	Per.	G	PAN	6.35
Cyperus capitatus Vand.	Cyperaceae	Per.	G	ME	12.70
Daucus litoralis Sm.	Apiaceae	Ann.	Th	ME	9.52
Echinopus spinosus L.	Asteraceae	Per.	H	ME+SA-SI	12.70
Echium angustifolium Mill.	Boraginaceae	Per.	H	ME	4.76
Elymus farctus (Viv.) Runem.ex Melderis.	Poaceae	Per.	G	ME	7.94
Emex spinosa (L.) Campd.	Polygonaceae	Ann.	Th	ME+SA-SI	1.59
Erodium laciniatm (Cav.) Willd.	Poaceae	Ann.	Th	ME	22.22
Frankenia hirsuta L.	Frankeniaceae	Per.	H	ME+IR-TR+SA-SI	6.35
Halocnemum strobilaceum (Pall.) M. Bieb.	Chenopodiaceae	Per.	Ch	ME+IR-TR+SA-SI	31.75

Heliotropium curassavicum L.	Boraginaceae	Per.	Ch	NEO	1.59
Hordium marinum Huds.	Poaceae	Ann.	Th	ME+IR-TR	25.40
Ifloga spicata (Forssk.) Sch. Bip.	Asteraceae	Ann.	Th	SA-SI	31.75
Imperata cylindica (L.) Raeusch.	Poaceae	Per.	H	ME+PAL	4.76
Inula crithmoides. L	Asteraceae	Per.	Ch	ME+ER-SR+SA-SI	7.94
Juncus acutus L.	Juncaceae	Per.	He	ME+IR-TR+ER-SR	14.29
J. rigidus Desf.	Juncaceae	Per.	G, He	ME+IR-TR+ER-SR	20.63
Launaea mucronata (Forssk.) Muschl.	Asteraceae	Per.	H	ME+SA-SI	9.52
L. nudicaulis (L.) HOOK.f.	Asteraceae	Per.	H	SA-SI	3.17
Limoniastrum monopetalum (L) Boiss	Plumbaginaceae	Per.	Ch	ME	4.76
Limonium pruinosum (L.) Chaz.	Plumbaginaceae	Per.	H	SA-SI	9.52
Lolium perenne L.	Poaceae	Per.	Th	ME+IR-TR+ER-SR	6.35
Lotus halophilus Boiss.	Fabaceae	Ann.	Th	ME+SA-SI	12.70
Malva parviflora L.	Malvaceae	Ann.	Th	ME+IR-TR	23.81
Melilotus indicus (L.) All.	Fabaceae	Ann.	Th	ME+IR-TR+SA-SI	1.59
Mesembryanthemum crystallinum L.	Aizoaceae	Ann.	Th	ME+ER-SR	31.75
M. nodiflorum L.	Aizoaceae	Ann.	Th	ME+ER-SR+SA-SI	14.29
Moltkiopsis ciliata (Forssk.) I. M.Johnst.	Boraginaceae	Per.	Ch	ME+SA-SI+S-Z	4.76
Ononis serrata Forssk.	Fabaceae	Ann.	Th	ME+SA-SI	6.35
Pancratium maritimum L.	Amaryllidaceae	Per.	G	ME	12.70
Parapholis incurva (L.) C.E. Hubb	Poaceae	Ann.	Th	ME+IR-TR+ER-SR	6.35
Paronychia arabica (L.) DC.	Caryophyllaceae	Ann.	Th	ME+SA-SI+S-Z	11.11
Phalaris minor Retz.	Poaceae	Ann.	Th	ME+IR-TR	1.59
Phragmites australis (Cav.) Trin .ex Steud	Poaceae	Per.	G, He	COSM	42.86
Plantago squarrosa Murray	Plantaginaceae	Ann.	Th	ME	4.76
Poa annua L.	Poaceae	Ann.	Th	COSM	1.59
Raphanus raphanistrum L.	Brassicaceae	Ann.	Th	ME+ER-SR	1.59
Reichardia tingitana (L.) Roth	Asteraceae	Ann.	Th	ME+IR-TR	26.98
Retama raetam (Forssk.) Webb& Berthel.	Fabaceae	Per.	Nph	ME+IR-TR+SA-SI	1.59
Rumex pictus Forssk.	Polygonaceae	Ann.	Th	ME+SA-SI	63.49
Salsola kali L.	Chenopodiaceae	Ann.	Th	COSM	4.76
Senecio glaucus L.	Brassicaceae	Ann.	Th	ME+IR-TR+ER-SR	84.13
Silene succulenta Forssk.	Caryophyllaceae	Per.	H	ME	6.35
S. vivianii Steud.	Caryophyllaceae	Ann.	Th	SA-SI	12.70
Silybum marianum (L.) Gaertn.	Asteraceae	Per.	H	ME+IR-TR+ER-SR	1.59
Sonchus oleraceus L.	Asteraceae	Ann.	Th	COSM	6.35
Spergularia marina (L.) Griseb.	Caryophyllaceae	Bi.	Th	ME+IR-TR+ER-SR	4.76
Sphenopus divaricatus (Gouan) Rchb.	Poaceae	Ann.	Th	ME+IR-TR+SA-SI	14.29
Stipagrostis lanata (Forssk.) De Winter	Poaceae	Per.	G	SA-SI	9.52
Suaeda maritima (L.) Dumort.	Chenopodiaceae	Ann.	Th	COSM	6.35
S. pruinosa Lange	Chenopodiaceae	Per.	Ch	ME	1.59
S. vera Forssk.ex J.F. GMEL.	Chenopodiaceae	Per.	Ch	ME+SA-SI+ER-SR	26.98
Symphyotrichum squamatum (Asch.) Dandy	Asteraceae	Per.	Ch	NEO	1.59
Tamarix nilotica (Ehrenb.) Boiss.	Tamaricaceae	Per.	Nph	SA-SI+S-Z	11.11
Urospermum picroides (L.) F.W.Schmidt	Asteraceae	Ann.	Th	ME+IR-TR	3.17
Zygophyllum aegyptium Hosny	Zygophyllaceae	Per.	Ch	ME	26.98
Z. album L.	Zygophyllaceae	Per.	Ch	ME+SA-SI	26.98

According to Raunkier life-forms [25], the surveyed species are categorized under seven types (Figure 3). Therophytes are the dominant (49.41%), followed by chamaephytes (15.29%), hemicryptophytes (15.29%), geophytes (11.76%), helophytes (3.53%) and nanophanerophytes (3.53%). The lowest value of life-forms is recorded as parasites which attained value of 1.18 %. The appearance of therophytes is mainly depending on the rainy season and therefore, they are equally less acclimated to drought and salinity [46]. Moreover, the relative high frequencies of both of chamaephytes and hemicryptophytes may be due to the morphological habit of the plant species and the climatic and edaphic conditions prevailing in the study areas, the adaptability of the recorded plant species which characterized by these life- forms used as defence agent against the physiological stresses [47, 48, 17].

2. Chorological affinities of the associated species

Table (3) reveals that, 82 species or about 73.18% of the recorded species were Mediterranean taxa. These taxa were either Plurioregional (22 species =26.84%), Biregional (24 species =29.27 %) or Monoregional (14 species = 17.07 %). On the other hand, eight species or about 9.76 % of the recorded species are Saharo-Sindian and six species or about 7.32% are Cosmopolitan. Similar findings had been reported by El-Demerdash *et al.* [49, 50], El-Halawany [51], El-Amier *et al*. [17] and El-Amier & Abd El-Gawad [45]. Generally, the present investigation favors that, the flora of north Nile Delta is mainly belonging to the Mediterranean chorotype.

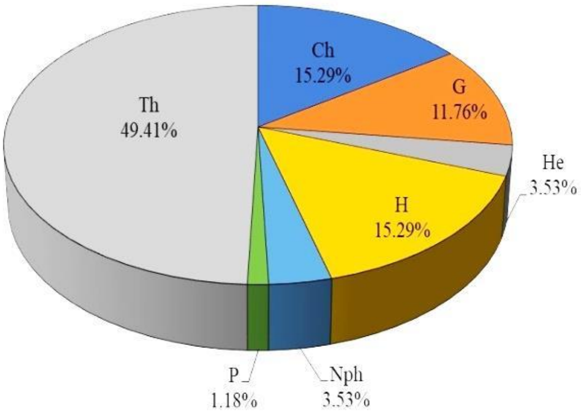

Figure 2. Life-span of the recorded species

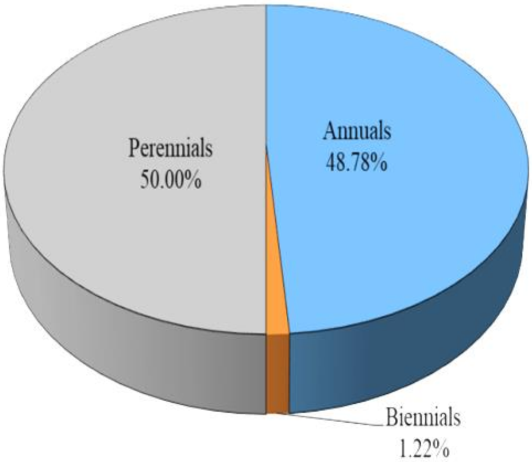

Figure 3. Life-form of the recorded species

Table3. Chorotype of plant species

Floristic category	Number of species	%	Geographical distribution
COSM	6	7.32	World wide
NEO	2	2.44	
PAL	1	1.22	
PAN	1	1.22	
ME+ER-SR+SA-SI	2	2.44	Pluriregional elements
ME+IR-TR+ER-SR	10	12.20	
ME+IR-TR+SA-SI	7	8.54	
ME+SA-SI+ER-SR	1	1.22	
ME+SA-SI+S-Z	2	2.44	
IR-TR+SA-SI	2	2.44	Biregional elements
IR-TR+S-Z	1	1.22	
ME+ SA-SI	1	1.22	
ME+ER-SR	3	3.66	
ME+IR-TR	7	8.54	
ME+PAL	1	1.22	
ME+SA-SI	12	14.63	
SA-SI+S-Z	1	1.22	
ME	14	17.07	Mono-regional elements
SA-SI	8	9.76	
Total	82	100	

3. Vegetation analysis

The application of TWINSPAN classification based on the importance values of 82 plant species distributed in 63 stands in the study area, led to the recognition of four vegetation groups (Figure 4 and Table 4).

Group A comprises 7 stands and codominated by *J. rigidus* (IV=30) and *P. australis* (IV=29.26). The other important species with high importance values in this group were *H. strobilaceum* (IV=18.55), *J. acutus* (IV=17.24) and *A. macrostachyum* (IV=15.88). The indicator species include *Inula crithmoides* (IV=13.19) and *Senecio glaucus* (IV=9.04). Stands of this group were found on soil rich in fine sand and silt, pH, CaCO3, Cl^-, SO_4^{--} and lowest in most soil variables (Table 5). Group B includes 23 stands codominated by *P. australis* (IV=44.36) and *Z. aegyptium* (IV=42.81). The other important species with high importance values in this group were *A. macrostachyum* (IV=20.29), *S. vera* (IV=12.84) and *S. glaucus* (IV=11.41). In this group, the indicator species were *H. strobilaceum* (IV = 10.62) and *Cakile maritima* (IV= 8.29). The sampled sites/stands of this group were characterized by high percentages of porosity, EC, cations, OC and moderate contents of HCO_3, and WHC (Table 5).

Group C comprises 15 stands codominated by *R. pictus* (IV=13.44) and *E. laciniatm* (IV=13.20). The other important species were *P. australis* (IV=11.35), *A. bicornis* (IV=10.29), and *C. maritima* (IV=10.12). The indicator species are *Z. album* (IV = 9.34) and *S. glaucus* (IV = 8.78). Most of the examined soil variables attained their highest levels in the stands of this group (Table 5). Group D comprises 18 stands codominated by *Z. album* (IV=16.44) and *H. strobilaceum* (IV=16.21). The other important species are *Calligonum polygonoides* (IV=15.45), *R. pictus* (IV=14.35), *S. glaucus* (IV=13.95) and *I. spicata* (IV=13.71). The indicator species in this group is *Cutandia memphitica* (IV=9.49). The stands were found to have the highest levels of fine silt and clay, WHC, and $CaCO_3$ as well as moderate contents of HCO_3, SO_4^{--} and cations (Table 5).

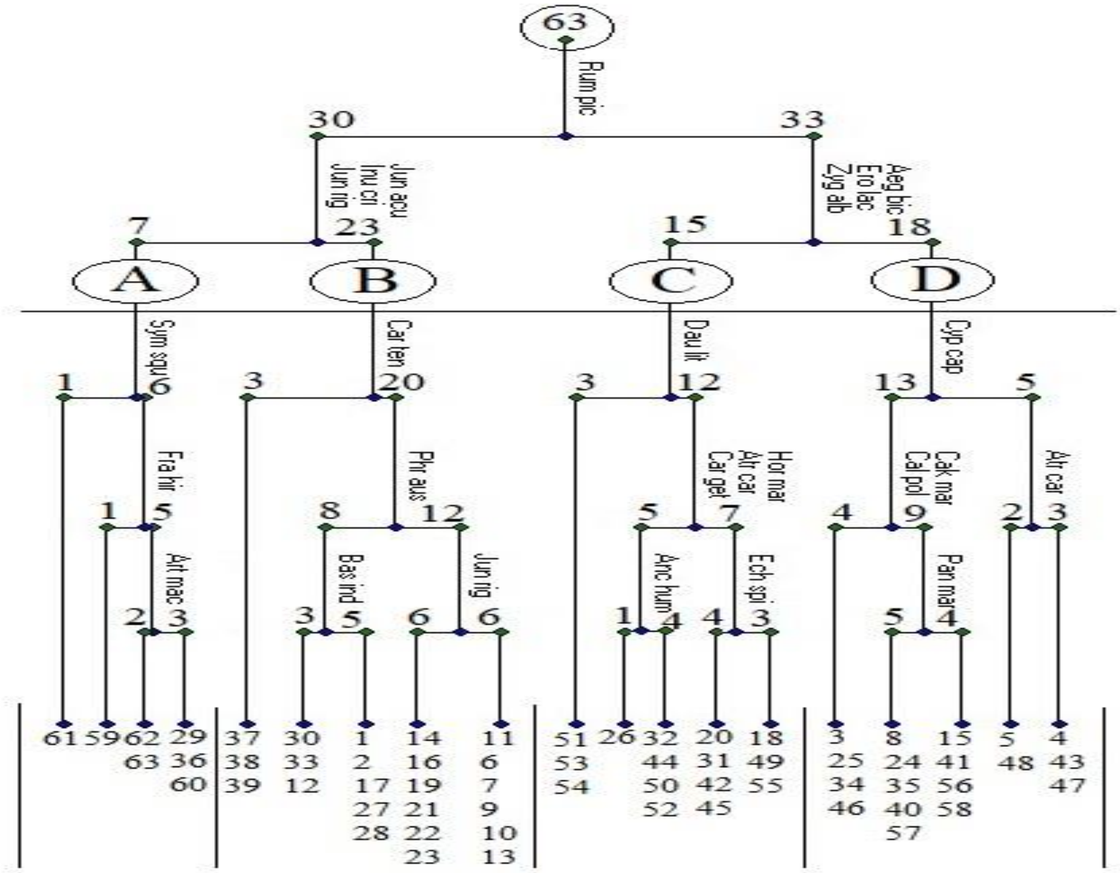

Figure 4. Two-Way Indicator Species Analysis (TWINSPAN) dendrogram of the 63 stands based on the importance values of the 82 plant species

Table 4. Importance value (IV) and coefficient variation (CV) of recorded plant species within different groups resulting from TWINSPAN classification

Species	Vegetation group							
	A		B		C		D	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Aegilops kotschyi Boiss.	-	-	-	-	0.92	3.87	0.78	4.24
Aegilops bicornis (Forssk.) Jaub. & Spach	-	-	-	-	10.29	1.16	-	-
Aetheorhiza bulbosa (L) Cass	1.38	2.65	-	-	-	-	-	-
Alhagi graecorum Boiss.	-	-	-	-	1.97	2.16	0.51	4.24
Anchusa humilis (Desf.) I. M.Johnst.	-	-	-	-	2.86	1.34	1.09	2.91
Arthrocnemum macrostachyum (Moric.) K.Koch	15.88	0.72	20.29	1.53	4. 3 .80	3.26	8.53	1.73
Asparagus stipularis Forssk.	-	-	-	-	4.43	3.87	-	-
Astragalus fruticosus Forssk.	-	-	-	-	2.31	2.27	-	-
Atractylis carduus (Forssk.) C.Chr.	-	-	-	-	2.52	1.65	0.38	3.07

Atriplex portulacoides L.	5.24	1.80	0.35	4.80	-	-	-	-
Bassia indica (Wight) A . J. Scott	-	-	2.18	4.80	0.28	3.87	1.90	2.43
Beta vulgaris L.	-	-	0.37	4.80	-	-	-	--
Brassica tournefortii Gouan	-	-	-	-	-	-	0.83	4.24
Bromus diandrus Roth	-	-	-	-	5.73	1.12	-	-
Cakile maritima Scop.	-	-	8.29	0.95	10.12	1.05	5.13	1.76
Calligonum polygonoides L.	-	-	-	-	7.45	1.85	15.45	0.94
Carduus getulus Pomel.	-	-	-	-	4.16	1.55	-	-
Carduus pycnocephalus L.	-	-	-	-	1.62	2.69	-	-
Carthamus tenuis (Boiss. & Blanche) Bornm.	-	--	1.99	2.75	1.85	1.82	0.83	4.24
Centaurium pulchellum(L)Fritsch	5.95	1.74	-	-	-	-	-	-
Chenopodium murale L.	2.09	2.65	5.83	1.88	1.13	3.87	-	-
Cistanche phelypaea (L.)Cout.	-	-	-	-	-	-	4.24	3.23
Cressa cretica L.	0.85	2.65	-	-	-	-	-	-
Cutandia memphitica (Spreng.) Benth.	-	-	-	-	0.82	3.87	9.49	1.67
Cynanchum acutum L.	2.34	2.65	-	-	3.76	1.73	-	-
Cynodon dactylon (L.) Pers.	6.29	1.71	-	-	2.17	2.71	-	-
Cyperus capitatus Vand.	-	-	-	-	2.64	2.10	2.62	1.78
Daucus litoralis Sm.	-	-	-	-	1.79	2.23	0.85	2.44
Echinopus spinosus L.	-	-	-	-	6.15	1.20	0.61	4.24
Echium angustifolium Mill.	-	-	2.99	2.64	-	-	-	-
Elymus farctus (Viv.) Runem.ex Melderis.	-	-	-	-	1.36	2.07	1.23	2.94
Emex spinosa (L.) Campd.	-	-	0.47	4.80	0.00	-	-	-
Erodium laciniatm (Cav.) Willd.	-	-	-	-	13.20	0.62	2.51	2.95
Frankenia hirsuta L.	1.97	2.65	-	-	-	-	2.43	2.65
Halocnemum strobilaceum (Pall.) M. Bieb.	18.55	0.73	10.62	2.76	5.40	3.87	16.21	1.04
Heliotropium curassavicum L.	-	-	-	-	1.22	3.87	-	-
Hordium marinum Huds.	4.60	1.71	-	-	4.13	1.55	6.15	1.32
Ifloga spicata (Forssk.) Sch. Bip.	-	-	0.55	4.80	5.50	1.38	13.71	0.81
Imperata cylindica (L.) Raeusch.	1.93	2.65	-	-	1.81	2.64	-	-
Inula crithmoides. L	13.19	0.72	-	-	-	-	-	-
Juncus acutus L.	17.24	0.78	3.39	3.58	0.34	3.87	0.32	4.24
Juncus rigidus Desf.	30.00	0.32	7.01	2.42	3.18	3.87	0.95	4.24
Launaea mucronata (Forssk.) Muschl.	-	-	-	-	0.82	2.75	2.19	2.22
Launaea nudicaulis (L.) HOOK.f.	-	-	-	-	-	-	0.99	2.92
Limoniastrum monopetalum(L) Boiss	-	-	-	-	-	-	7.36	2.30
Limonium pruinosum (L.) Chaz.	-	-	-	-	-	-	7.03	1.55
Lolium perenne L.	-	-	-	-	4.37	1.80	-	-
Lotus halophilus Boiss.	-	-	-	-	0.61	3.87	4.54	1.34
Malva parviflora L.	1.18	2.65	7.26	1.05	0.47	3.87	-	-
Melilotus indicus (L.) All.	-	-	-	-	0.74	3.87	-	-
Mesembryanthemum crystallinum L.	2.60	2.65	4.01	1.96	4.37	1.47	0.51	2.33
Mesembryanthemum nodiflorum L.	2.07	2.65	-	-	0.53	2.26	1.82	2.08
Moltkiopsis ciliata (Forssk.) I. M.Johnst.	-	-	-	-	2.52	2.10	-	-
Ononis serrata Forssk.	-	-	-	-	2.64	2.10	-	-

Pancratium maritimum L.	-	-	-	-	1.65	2.17	3.33	1.92
Parapholis incurva (L.) C.E. Hubb	8.17	1.28	0.37	4.80	-	-	-	-
Paronychia arabica (L.) DC.	-	-	-	-	0.71	2.69	1.75	2.18
Phragmites australis (Cav.) Trin .ex Steud	29.26	0.69	44.36	1.15	11.35	1.45	3.22	4.24
Plantago squarrosa Murray	-	-	-	-	1.90	2.11	-	-
Poa annua L.	-	-	-	-	-	-	0.24	4.24
Raphanus raphanistrum L.	-	-	0.26	4.80	-	-	-	-
Reichardia tingitana (L.) Roth	-	-	0.55	4.80	4.93	0.94	4.64	1.49
Phalaris minor Retz.	-	-	0.77	4.80	-	-	-	-
Retama raetam (Forssk.) Webb& Berthel.	-	-	-	-	0.60	3.87	-	-
Rumex pictus Forssk.	-	-	5.19	1.67	13.44	0.62	14.35	0.42
Salsola kali L.	-	-	-	-	0.68	2.17	-	-
Suaeda maritima (L.) Dumort.	-	-	-	-	-	-	2.14	2.17
Senecio glaucus L.	9.04	0.74	11.41	0.81	8.78	0.77	13.95	0.44
Silene vivianii Steud.	-	-	-	-	0.64	3.87	2.45	1.36
Silene succulenta Forssk.	-	-	-	-	0.52	3.87	0.56	2.35
Silybum marianum (L.) Gaertn.	-	-	0.76	4.80	-	-	-	-
Sonchus oleraceus L.	-	-	0.64	3.36	0.96	2.65	-	-
Spergularia marina (L.) Griseb.	3.09	1.71	-	-	1.43	3.87	-	-
Sphenopus divaricatus (Gouan) Rchb.	8.35	1.36	-	-	-	-	5.79	1.53
Stipagrostis lanata (Forssk.) De Winter	-	-	-	-	2.35	2.09	3.78	2.31
Suaeda pruinosa Lange	-	-	0.67	4.80	-	-	-	-
Suaeda vera Forssk.ex J.F.GMEL.	5.31	2.65	12.84	1.31	0.37	3.87	0.73	3.22
Symphyotrichum squamatum (Asch.) Dandy	1.51	2.65	-	-	-	-	-	-
Tamarix nilotica (Ehrenb.) Boiss.	1.93	2.65	3.78	4.80	-	-	5.43	1.83
Urospermum picroides (L.) F.W.Schmidt	-	-	-	-	1.00	2.71	-	-
Zygophyllum album L.	-	-	-	-	9.34	2.64	16.44	0.70
Zygophyllum aegyptium Hosny	-	-	42.81	1.09	7.36	2.30	-	-

Table 5. Soil analyses (Mean ± standard error) in the stands represent the different vegetation groups in the study area.

Edaphic factors		**Vegetation groups**			
		A	**B**	**C**	**D**
Sand	%	95.33±0.26	95.91±0.09	94.29±0.35	93.54±0.15
Silt		3.42±0.26	2.53±0.06	3.56±0.20	4.48±0.16
Clay		1.26±0.08	1.55±0.06	2.15±0.17	1.97±0.07
Porosity		41.93±1.03	45.25±0.29	42.65±0.55	40.40±0.28
WHC		30.25±0.61	37.74±0.22	33.74±0.28	42.62±2.49
$CaCO_3$		3.25±0.06	2.42±0.04	3.07±0.08	3.21±6.48
OC		0.57±0.02	0.66±0.01	0.68±0.02	0.58±0.02
pH		8.44±0.06	7.79±0.03	7.94±0.05	7.82±0.03
EC µmoh/cm-		597.86±23.59	1070.71±22.74	1262.33±69.21	895.56±36.96
Cl^-	%	2.04±0.08	1.41±0.04	1.43±0.05	1.07±0.05
SO_4^{--}		1.39±0.05	0.96±0.03	0.98±0.04	0.74±0.03
HCO_3^-		0.05±0.00	0.08±0.00	0.11±0.00	0.08±0.00
Na^+	mg/100g dry soil	62.69±1.81	100.97±1.69	115.00±5.33	85.47±2.97
K^+		8.82±0.27	12.77±0.21	15.29±0.75	11.62±0.38
Ca^{++}		13.49±0.46	22.46±0.51	25.18±1.43	20.08±0.74
Mg^{++}		5.84±0.27	8.89±0.19	10.70±0.46	8.22±0.26
SAR		20.19±0.32	25.07±0.21	26.43±0.55	22.34±0.34
PAR		2.83±0.04	3.18±0.02	3.53±0.07	3.03±0.04

4 Ordination of stands

DCA axes. Both group A and B were isolated at the right side of the DCA diagram, while group C was separated at the upper left side of the DCA diagram. Finally, group D was segregated at the lower left side of the diagram. clear that, the vegetation groups obtained by TWINSPAN are distinguishable and having a clear pattern of segregation on the 1st and 2nd The Detrended Correspondence Analysis (DCA) is shown in Figure 5. It is

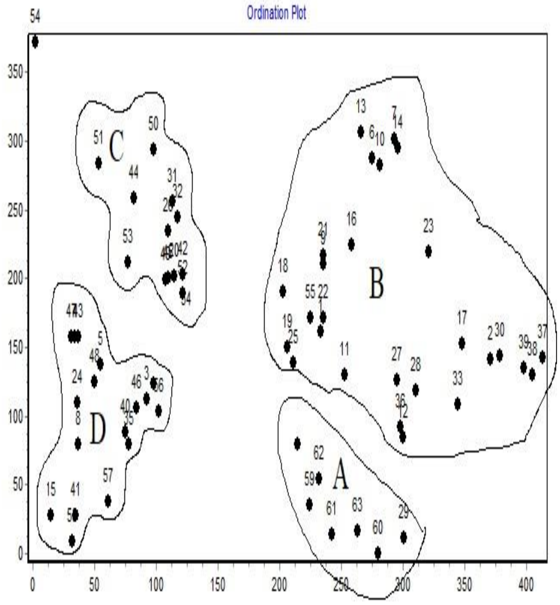

Figure 5. Detrended Correspondence Analysis (DCA) diagram of 63 stands of the study area.

5. Vegetation-soil relationships

5.1. Relationship between soil variables

The correlation coefficients (r) between the different soil variables in the sampled stands are shown in Table (6). It was found, there is a positive coorelation among soil variables, such as soil texture, electrical conductivity, pH, HCO_3, cations, SAR and PAR. On the other hand, the other edaphic variables e.g. porosity, water-holding capacity, calcium carbonate, chloride, sulphates and organic carbon were either negatively correlated or have no any correlations.

5.2. Correlation between soil variables and vegetational gradients

The correlation between plant species and soil variables is displayed on the axes of CCA program (Figure 6). It is clear that, EC, sodium, potassium, magnesium, sulphate and calcium cations, porosity, potassium adsorption ratio (PAR), sodium adsorption ratio (SAR) chlorides and bicarbonates were the most effective soil variables with high significant correlations with the 1st and 2nd axes. In the upper right side of CCA diagram, *R. pictus* and *Z. album* which are codominant species, *S. glaucus* and *I. spicata* which were important species in group D, *C. maritima* which was important species in group C and *C. memphitica* which was an indicator species in group D are collectively showed close relationships with Mg, Ca, HCO_3 and $CaCO_3$ (Figure 6). While, in the upper left side of the diagram *P. australis* and *E. laciniatm* which are codominant species in groups A, B and C respectively, *C. maritima* which was an indicator species in group B, *A. bicornis* which are important species in group C showed a close relationships with electrical conductivity, sodium, potassium, sulphate, chloride, potassium adsorption ratio (PAR) and sodium adsorption ratio (SAR). In the lower right side, *Z. aegyptium* and *H. strobilaceum* which are codominant species in groups B and D respectively and *S. vera* which was the important species in group B, showed a close relationship with pH value. In the lower left side, *J. rigidus* which are codominant in group, *A. macrostachyum* and *J. acutus* which were the important species in group A, *I. crithmoides* was the indicator species in group A, showed a relationship with sand fractions only (Figure 6).

Conclusion

6. From the current work, it is concluded that the coastal areas of the Nile Delta were rich in their plant diversity. However, different types of human activities, including urbanization, agriculture, mining and quarrying, and over cutting wild plants threaten the biodiversity of the Egyptian coastal line. Therefore, the protection of these natural habitats of this desert is urgent. Eighty-two registered plant species in the Deltaic coast can be acclimatized, and play a vital role in socio-economic and medical purposes Table 1

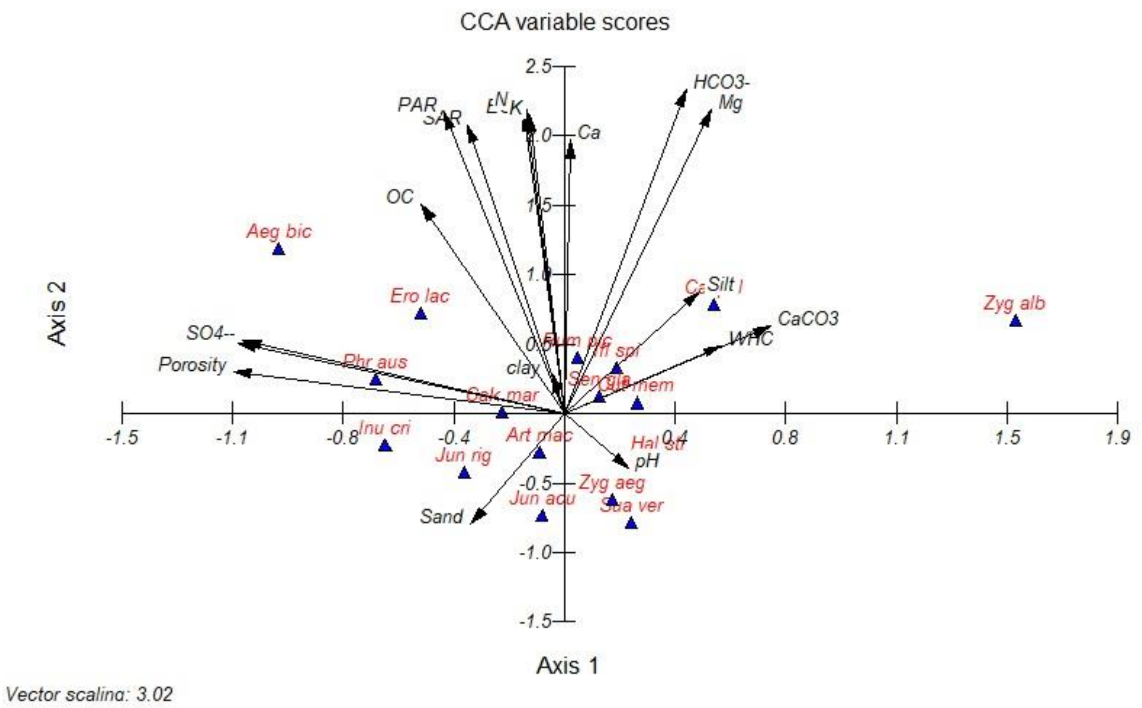

Figure 6. CCA-program ordination diagram of plant species with soil variables. The dominant species are abbreviated and see **Table 6**. **Correlation matrix (r) between the estimated soil factors in the study area.**

Soil variables	Sand	Silt	Clay	Por.	WHC	$CaCO_3$	OC	pH	EC	Cl^-	SO_4^{--}	HCO_3	Na^+	K^+	Ca^{++}	Mg^{++}	SAR	PAR
Sand	1																	
Silt	.886**	1																
Clay	.715**	.310*	1															
Por.	254*	0.196	0.225	1														
WHC	0.035	0.12	0.111	0.14	1													
$CaCO_3$	0.019	0.016	0.014	0.076	0.04	1												
OC	.298*	.331**	0.112	.054	0.095	0.031	1											
pH	0.074	0.102	0.002	0.127	0.094	0.022	0.125	1										
EC	383**	.282*	.360**	0.228	0.201	0.008	0.212	0.047	1									
Cl^-	.277*	353**	0.037	0.216	0.146	0.159	0.013	.263*	0.053	1								
SO_4^{--}	.279*	348**	0.048	0.217	0.147	0.159	0.04	.269*	0.046	0.199	1							
HCO_3	.380**	.342**	.264*	0.205	0.189	0.025	0.235	0.038	.882**	0.095	0.091	1						
Na^+	.365**	.252*	.370**	0.21	0.194	0.012	0.149	-.03	.990**	0.064	0.055	.854**	1					
K^+	.437**	.327**	.404**	0.218	0.183	0.019	0.195	0.034	.981**	0.002	0.011	.876**	.977**	1				
Ca^{++}	.380**	.292*	.339**	0.231	0.211	0.007	0.219	0.072	.980**	0.041	0.037	.888**	.959**	.970**	1			
Mg^{++}	.369**	.294*	.315*	0.181	0.189	0.02	0.211	0.008	.933**	0.002	0.006	.949**	.917**	.933**	.942**	1		
SAR	.252*	0.122	.332**	0.159	0.172	0.022	0.011	0.06	.903**	0.151	0.137	.697**	.943**	.881**	.826**	.784**	1	
PAR	.394**	.280*	.385**	0.17	0.157	0.041	0.082	0.044	.910**	0.041	0.029	.764**	.924**	.950**	.869**	.837**	.907**	1

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