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Physical and chemical characteristics of mangrove soil under marine influence. A case study on the Mangrove Forests at Egyptian-African Red Sea Coast.

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ABSTRACT

The present study provides an analysis the growth performance of mangrove forests (*Avicennia marina* and *Rhizophora mucronata*) and the concentrates on the environmental factors (soil) that affect on the mangroves along Egyptian-African Red Sea coast. The growth performance of *R. mucronata* was higher in association with *A. marina* than in pure stands. Moreover, *A. marina* trees growing in association with *R. mucronata* were taller than plants growing in pure community. Plants growing (size index) at high tide attained the highest values of growth attributes. In comparison, *A. marina* growth attributes differed between the three locations of the three tide levels. The highest values of the growth parameters were recorded for *A. marina* growing at the medium tide in pure stands. However, the growth values of *A. marina* growing in mixture with *R. mucronata* were higher at low tide than those at either high or medium tides. The total mean of Soil Bulk Density (SBD) of the *A. marina* (1.24 g cm^3) was higher than that of the *R. mucronata* (1.16 g cm^3) and mixed stands (1.12 g cm^3). The results shows that both ordination techniques clearly indicated that electric conductivity, CaCO3, K+, Ca++, Cl-, Na+ and Mg++ were the most important parameters determining the current distribution of mangrove pattern in the Egyptian Red Sea coast. The results showed that there is a similarity between the soil samples in different of the study locations as whole area is a coastal. In the current study the variability of ecosystem structure and function is generally a product of interactions between its different components. In the extreme arid environmental conditions of arid lands these interactions are of high significance, so that slight irregularities in one component of the ecosystem are likely to lead to substantial variations in others, so creating distinct micro habitats.

INTRODUCTION

Mangrove forests are tropical trees and woody shrubsgrowing at the intertidal zone of highly productive ecosystem of the tropical and subtropical regions (Kathiresan and Bingham, 2001; Giri *et al.*, 2011). Mangrove forests cover approximately 137,760 km^2 worldwide (Giri*et al.* 2011) and are more productive in terms of net primary production than most other types of forests.

These ecosystems provide coastal protection, habitat, shelter, nursery and breeding grounds for many fish and crustacea, and other sea and terrestrial fauna (Alongi *et al.*, 2004; FAO, 2005). *R. mucronata* is a small to medium size evergreen tree growing to a height of about 10 or 15 metres as average on the fringes of the sea. The tallest trees are closest to the water and shorter trees are further inland. The tree has a large number of aerial stilt roots buttressing the trunk. The leaves are elliptical and usually about 12 cm long and 6 cm wide. They have elongated tips but these often break off. There are corky warts on the pale undersides of the leaves. The flowers develop in axillary clusters on the twigs. Each has a hard cream-coloured calyx with four sepals and four white, hairy petals. The seeds are viviparous and start to develop whilst still attached to the tree (Gillikin and Verheyden, 2005). Where, the *A. marina* is a small shrub/tree with long creeping roots which give out at intervals narrow negatively geotrophic pneumatophores / respiratory roots. Leaves opposite, entire, ovate to oblanceolate, glabrous. Flowers small, yellow, sessile, in axillary and terminal cymes. Fruit a compressed ovoid capsule, dehiscing by 2 leathery valves (Gamble, 1921).

The mangroves in Egypt occupy about 525 hectares distributed in 28 different locations along Egyptian Red Sea coasts. One large discontinuous stand along the Gulf of Aqaba in Nabq Protected Area and one small stand at the most southern part of Gulf of Suez at Ras Mohammed National Park (Zahran and Willis, 2009). Mangroves in Egypt are predominantly mono-specific, consisting only of *Avicennia marina* (grey mangroves; Avicenniaceae), except for a few locations near the Egyptian-Sudanese border area, where *Rhizophora mucronata* (loop-root mangrove; Rhizophoraceae) coexists along with *A. marina*. From a geographical point of view, the Egyptian mangroves can be divided into the Sinai mangroves, and mangroves growing on the Egyptian-African Red Sea coast (PERSGA, 2004). *A. marina* is relatively more tolerant and adapted to salinity, low rainfall and extreme temperature conditions than *R. mucronata*. This explains the larger global and local (in Egypt) distribution of *A. marina* than *R. mucronata.*

R. mucronata exists in Egypt onlyin few localities around the Egyptian-Sudanese border area (Particularly in MarsaSha'ab and Marsa Abu Fassi), the distribution of mangroves in the southern Red Sea is more continuous than in the northern Red Sea (Aqaba Gulf) where mangroves are confined to a very restricted favorable habitats (Zahran and Willis, 2009). The mangroves export organic nutrients whereas saltmarsh and fringe communities act as nutrient sinks (Clarke, 1985). The above ground mangrove biomass correlated significantly with soil factors (Boto and Wellington, 1984). Many marsh soils contain large amount of sulphur which is oxidized to sulphate when exposed to air (Cotnoir, 1974*).* Mangrove soils generally were high in clay, organic matter, cation exchange capacity, Al, SO4 , Fe and exchangeable bases than non- mangrove soils. On the basis of exchangeable Na percentage and electrical conductivity, mangrove soils are classified as saline sodic and the non-mangrove soil, nonsaline sodic (Naidoo and Raiman, 1982*).* Studies of mineral elements in the mangroves from saline and non-saline localities reveal that potassium uptake is considerably reduced which results in increased uptake of calcium. Potassium and calcium ions build up salt tolerance in mangroves. However sodium concentration affects calcium uptake much more than that of potassium (Joshi and Jamale, 1975*).* Zahran and Al-Kaf (1996) reportd that, the halophytes were grouped under 6 types: seagrasses, mangroves, salt marshes, sand dunes, reed swamps and palm groves. Climate is arid, hot and dry soil is sandy, saline and contains more calcium carbonates. In an estuarine mangrove swamp in Africa, Ukpong (1998) reported high soil cation exchange capacity (21.8 to 53.6 me times 100g super (-^{1}), with Mg and Ca as the predominant cations. Soil nutrient content was related to tidal inundation, physiography, climate and soil drainage. The depth distribution of total Al, Fe, Mn, Zn, Cu, Cd, Pb, Ca, Mg and nitrogen were determined in sediment cores from a series of stations in the Tudor, Makupa and Gazi creeks of the Kenyan coast of the Indian ocean (Oteko, 1987).

The objective of the present study is analysis the growth performance of mangrove forests (*Avicennia marina* and *Rhizophora mucronata*) with the concentration of the environmental factors (physical and chemical analysis of the soil) that affect on the mangroves in Elba Protected Area along Egyptian-African Red Sea coast.

MATERIALS AND METHODS

STUDY AREA

Gebel Elba Protected Area is located between the longitudes 22°00'N - 23°50'N, and thelatitudes 35°00'E - 37°00'E, with a totalarea of about 35,600 km². It is the largest declared protected area in Egypt. Gebel Elba is a part of the Egyptian deserts that is considered as one of the most extremely arid areas of the world. The recorded mean minimum temperature is 11.4C° during January, while, the recorded maximum temperature is 38.7C° in July. The area is almost rainless, with a mean annual precipitation of 27.8 mm. The relative humidity shows that the atmosphere is dry throughout the year (RH=47.2% to 60%) (GEPA, 2008). Field sites were located at the south of Shalateencity to the north of Abu Ramad village. Sampling was carried out in three main mangrove locations to represent the mangrove forests along the Egyptian Red Sea Coast (Figure 1). Sharm El Madfaa (9.2km^{2}), MarsaSha'ab (15.8 km^{2}) and Marsa Abu Fassi (0.7km^{2}) (ITTO, 2006). Mangrove species composition at each location was determined (either *A. marina* or *R. mucronata*) (Table 1).

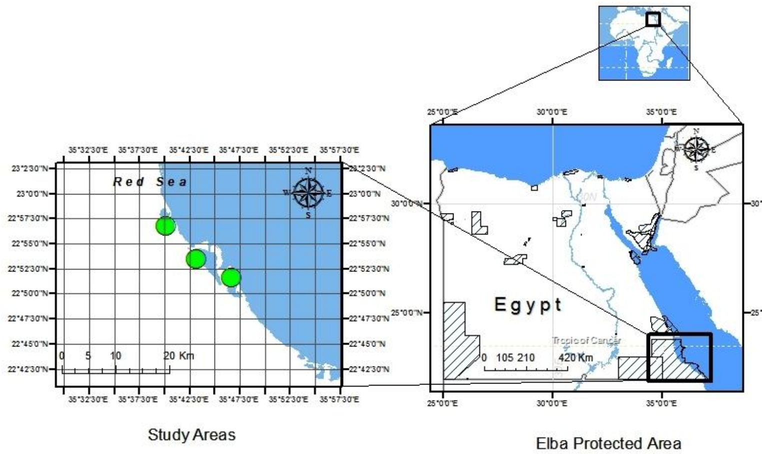

Fig. 1. Map of Egypt and the Elba Protected Area showing the study sites.

THE STUDY SPECIES

The mangrove stands along the Gulf of Aqaba and the Egyptian Red Sea coastlines cover a total area exceeding 525 hectares (Zahran and Willis, 2009). They are predominantly mono specific, consisting only of *Avicennia marina*, except for a few stands in the southern Sudanese border area where *Rhizophora mucronata* coexists along with *Avicennia marina*. From a geographical point of view, the

Egyptian mangroves may be divided into the Sinai mangroves and mangroves growing on the Egyptian-African Red Sea coast (PERSGA, 2004).

Table 1: The study samples collected within the study area.

Site No.	Species	Study site	Lat	Long
1	*A.marina*	Sharm EL Madfaa	22.94527	35.66717
2	*A.marina*	Sharm EL Madfaa	22.94519	35.66753
3	*A.marina*	Sharm EL Madfaa	22.94474	35.66766
4	*A.marina+ R.mucronata*	MarsaSha'ab	22.89105	35.71787
5	*A.marina+ R.mucronata*	MarsaSha'ab	22.89001	35.71856
6	*A.marina + R.mucronata*	MarsaSha'ab	22.89004	35.71353
7	*R.mucronata*	MarsaSha'ab	22.89048	35.7182
8	*R.mucronata*	MarsaSha'ab	22.88851	35.72582
9	*R.mucronata*	MarsaSha'ab	22.88859	35.72579
10	*A.marina*	MarsaSha'ab	22.88118	35.72708
11	*A.marina*	MarsaSha'ab	22.88105	35.72723
12	*A.marina*	MarsaSha'ab	22.88319	35.72695
13	*A.marina*	MarsaSha'ab	22.85823	35.77554
14	*A.marina*	MarsaSha'ab	22.85873	35.77548
15	*A.marina*	MarsaSha'ab	22.85829	35.77619
16	*R.mucronata*	Marsa Abu Fassi	22.85175	35.77638
17	*R.mucronata*	Marsa Abu Fassi	22.85181	35.77695
18	*R.mucronata*	Marsa Abu Fassi	22.85174	35.77639
19	*A.marina+ R.mucronata*	Marsa Abu Fassi	22.85184	35.77658
20	*A.marina+ R.mucronata*	Marsa Abu Fassi	22.85184	35.7766
21	*A.marina+ R.mucronata*	Marsa Abu Fassi	22.85183	35.77661
22	*A.marina*	Marsa Abu Fassi	22.84961	35.7797
23	*A.marina*	Marsa Abu Fassi	22.85008	35.78002
24	*A.marina*	Marsa Abu Fassi	22.85068	35.78026

MANGROVE VEGETATION ANALYSIS

Mangrove stands was observed at this sites during June, 2016 to June, 2017. Sampling was carried out in three main locations (Sharm EL Madfaa, Marsa Sha'ab and Marsa Abu Fassi) included 24 study site in Elba Protected Area to represent the mangrove forests along the Egyptian-African Red Sea Coast. The sampled stations were classified to mangrove *A. marina* and *R. mucronata*.

In each stand three random plots (10×10 m) were selected for each mangrove type. A plot location was arranged randomly within each strata, plots are picked at random to increase the likelihood of capturing the true variation within and across forest strata (terrestrial side/ middle/ sea side) (Howard *et. el.,* 2014). In each plot, species density, frequency and canopy cover were calculated according to Muller-Dombois and Ellenberg (1974). The main lateral branches per tree, tree circumference (at d.b.h) and leaf area are measured. Moreover, plant height (H) and diameter (D) of each individual of certain species in the sampled plots were measured and its size index was calculated as follows. [H+D)/2 (Crisp and Lange, 1976).

Soil Samples and Analysis.

The soil samples were collected during the work from all the plots of the study. From each plot three soil samples were collected and mixed to form a composite sample for the determination of their physical and chemical characteristics. The surface samples (excluding the surface crust) were taken to the depth of 25 cm.

Soil Bulk Density (SBD): In each of the main locations, 5 soil samples were collected randomly making a total 120 soil cores to assure representative samples to each of the mangrove species, and to determine SBD. Soil samples were collected with a 7 cm diameter hand sediment corer, which provides a core without compaction, distortion and disturbance (Tan, 2005). The corer was carefully inserted into the soil and pushed down to 50 cm depth. The soil core was removed from the corer slowly, and it was immediately sectioned with a blade into samples each of 10 cm thick (0–10, 10–20, 20–30, 30–40 cm and 40-50 cm) and packed in plastic containers. Each soil sample was oven-dry at 105 °C for three days, cooled down to room temperature in a desiccator, and weighed to determine the SBD (Soil Bulk Density) (g cm^{-3}) as follows (Wilke, 2005).

$$\rho_{sj} = \frac{m_j}{v_j}$$

Where ρ_{sj} is SBD (g cm^{-3}) of the j^{th} layer, m_j is mass of soil sample (g) of the j^{th} layer dried at 105 °C and v_j is volume of soil sample (cm^3) of the j^{th} layer. Dry samples will ground and sieve to pass through 2 mm particle size.

Surface soil samples (at depth of 25 cm, excluding the surface crust) were randomly collected at different stands to determine their physical and chemical characteristics.

Physical analysis: soil texture was determined using a series of sieves. Soil samples were air-dried and passed manually through a 2-mm sieve to evaluate gravel percent. Particle size analysis was accomplished according to Piper (1950) to calculate the percentages of sand, silt, and clay and the classification of the soil texture type was accomplished according to the USDA soil texture triangle (USDA, 1993).

Chemical analysis: Calcium carbonate was measured by titration against 1.0 N HCl following Allen *et al*. (1976). Oxidizable organic carbon (as an indication of the total organic matter content) was measured according to (Black, 1965). Soil reaction (pH value), electrical conductivity, sulphates and chlorides were measured according to Jackson (1967). Bicarbonate was determined by titration using 0.1 N HCl (Allen *et al*., 1976). Extractable cations (Ca^{++} and Mg^{++}) were determined (meq/L) by titration following Richard (1954); while, sodium and potassium ions (meq/L) were measured from air-dried soil using ammonium acetate solution at pH=7 (Allen *et al*., 1976).

Statistical Analysis.

One-way analysis of variance (ANOVA-1) was used to identify statistically significant differences in SOC contents and SBD among the two species of mangrove in pure and mixed stands and five soil depths. Significant differences between means among the five soil depths were identified using the least significant difference (LSD) test at $P < 0.05$. Statistical analyses were performed using SPSS 15.0 software (SPSS, 2006).

All ordinations were performed using the CANOCO program (version 4.5); Canoco 4.51 is one of the most popular programs for multivariate statistical analysis using ordination methods in the field of ecology and several related fields. (Ter Braak, 1998; Hejcmanovā-Neźerková and Hejcman, 2006).

RESULTS

Floristic relations

In the present study, the growth performance of *R. mucronata* was higher in association with *A. marina* than in pure stands and *A. marina* trees growing in association with *R. mucronata* were taller than that growing in pure community. Moreover, the growth attributes (size index) of *R. mucronata* in association with *A. marina* at high tide attained the highest values of growth attributes than of pure community. In comparison, the growth attributes (size index) of *A. marina* in association with *R. mucronata* at low tide attained the highest values of growth attributes then of pure community.

The highest values of the growth parameters were recorded for *A. marina* growing at the medium tide in mixture with *R. mucronata*. However, the mean comparison of growth performance at the different tides for *A. marina* and *R. mucronata* can be explainedclearly as shown in Tables 2, 3 and Figure 2.

Table 2: Mean comparison of growth performance of *Avicennia marina* growing alone (pure) and with *Rhizophora mucronata* (mixed) at low, medium and high tides

Character	Pure			Mixed					
	Low	Medium	High	Low	Medium	High	Mean	P-value	F-value
Height (cm)	253	419	224	546	493	280	352.57	.001	1.931
Size index	130.80	218.26	116.46	282.39	255.10	150.19	183.43	.001	2.080
Trunk circumf. (cm)	8.60	17.52	8.92	18.79	17.20	20.38	14.29	.001	5.391
No. main branches	5	6	3	13	17	7	8	.012	6.373
No. lateral branches	23	20	13	24	77	20	28.57	.028	1.356
Leaf number	1032	2744	607	1976	8462	7100	3279	.043	4.445
No aerial roots	1832	2472	958	1205	1938	762	1571.29	.002	.660
No seedlings	12	29	7	2	5	8	10.71	.045	2.556
Trees/ha	500	166	700	300	150	100	345.14	.021	2.654

Table 3: Mean comparison of growth performance of *Rhizophora mucronata* growing alone (pure) and with *Avicennia marina* (mixed) at low, medium and high tides

Character	Pure			Mixed					
	Low	Medium	High	Low	Medium	High	Mean	P-value	F-value
Height (cm)	325	275	151	431	413	450	338.57	.001	11.746
Size index	167.44	142.12	79.00	221.07	212.55	232.32	174.56	.001	11.803
Trunk circumf. (cm)	9.87	9.24	7.01	11.15	12.10	14.65	10.56	.000	8.358
No. main branches	7	5	8	10	5	3	6.43	.002	0.087
No. lateral branches	38	39	17	39	34	21	32.29	.001	1.02
Leaf number	1716	798	734	1023	796	708	1070.14	.002	0.528
No aerial roots	8	9	6	180	33	12	36.57	.017	4.469
No seedlings	8	4	14	1	9	2	6.57	.025	1.474
Trees/ha	650	500	400	150	300	300	421.43	.003	9.143

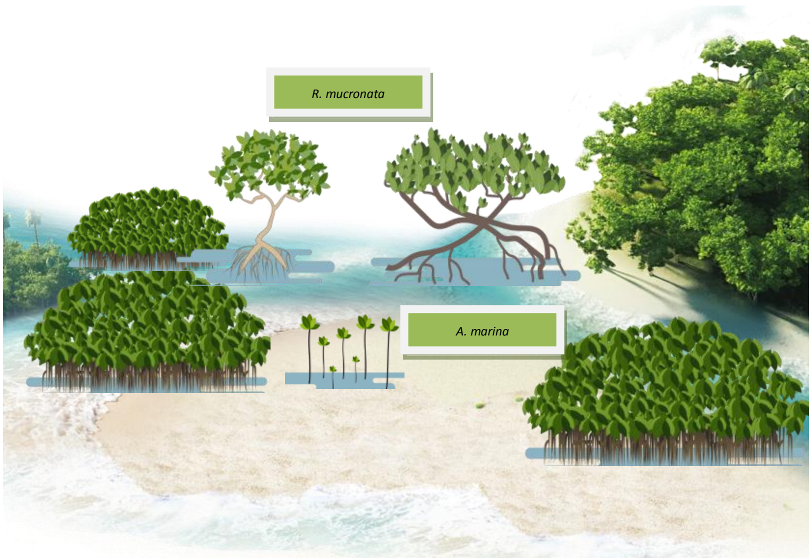

Fig. 2: Diagram showing the common distribution of mangrove trees in mixed communities growing on an extensive inter-tidal flat at the study area.

Multivariate analysis

Classification

The total mean of Soil Bulk Density (SBD) of the *A. marina* stands (1.24 g cm^{-3}) was higher than that of the *R. mucronata* stands (1.16 g cm^{-3}) and mix stands (1.12 g cm^{-3}) (Table 4). The ANOVA test showed significant variation between soil depth layers. For instance, at low depth layer (0-10 cm) *A. marina* was significant higher (1.20 g cm^{-3}) than *R. mucronata* and mixed stands (1.14 g cm^{-3} and 1.10 g cm^{-3} respectively) with F-value= 4.16 and $p < 0.047$ and $p < 0.019$ respectively (Figure 3). Moreover, at the depth layer (10-20 cm) *A. marina* was significant higher (1.23 g cm^{-3}) than *R. mucronata* and mixed stands (1.09 g cm^{-3} and 1.09 g cm^{-3} respectively) with F-value= 5.404 and $p < 0.013$ and $p < 0.016$ for *R. mucronata* and mixed stands respectively.

On the other hand, the distribution of SBD in the *A. marina* stands recorded 1.24g cm^{-3} at depth 20–30 cm and recorded 1.34 g cm^{-3} at depth 40–50 cm. While, the distribution of SBD in the *R. mucronata* stands from 1.12 cm^{-3} at depth 20–30 cm up to 1.21 g cm^{-3} at depth 30–40 cm to 1.25 g cm^{-3} at depth 40–50 cm. However, the range of SBD for mangrove (the two species) in the study area was between 0.95 – 1.55 g cm^{-3}.

Table 4: The total means of Soil Bulk Density (SBD) of *A. marina*, *R. mucronata* and mixed stands at different soil depth layers.

Species	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-50 cm	Total Mean
A. marina	1.20	1.23	1.24	1.21	1.34	1.24
R. mucronata	1.14	1.09	1.12	1.21	1.25	1.16
Mixed stands	1.10	1.09	1.15	1.12	1.15	1.12

Depth Layer	F –value
0-10 cm	2.255
10-20 cm	3.641
20-30 cm	0.839
30-40 cm	2.26
40-50 cm	0.112

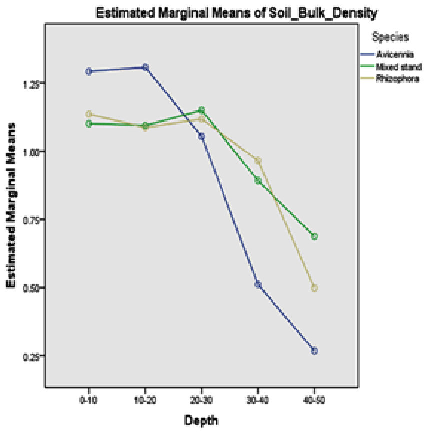

Fig. 3: The ANOVA-1 estimated marginal means of Soil Bulk Density (SBD) of *A. marina*, *R. mucronata* and mixed stands at different soil depth layers.

The soil of mangrove sites was made up of silt and clay particles. This type of soil shows high water holding capacity, soil aeration and supply of available nutrients (Sheela, 2007). The mean values of percentage of soil particles sand, silt and clay of all the study sites are given in Table 5. The textural study revealed that sand and clay were the predominant fractions at all the sites. The results clearly showed that, the saturation percentage (SP) of soil in the studied areas ranged between 42% (Sharm EL Madfaa) for *A. marina* to 55% (Marsa Abu Fassi) for *R. mucronata* and 52% (Marsa Abu Fassi) for *A. marina* / *R. mucronata* mixed stands with an average of 48.42 % (Table 5).

Table 5. Descriptive statistics for physical prosperities.

Character	Sharm El Madfaa	Marsa Sha'ab			Marsa Abu Fassi			Mean
	A. marina	***A. marina***	***R. mucronata***	**Mixed stands**	***A. marina***	***R. mucronata***	**Mixed stands**	
	Pure	**Pure**	**Pure**		**Pure**	**Pure**		
Coarse Sand (%)	11.5	11.5	18	16	15	12	12.5	13.79
Fine Sand (%)	38	38	34	35	37	38	36.5	36.64
Silt (%)	14.5	14.5	9	11.5	10.5	13.1	10.8	11.99
Clay (%)	36	36	39	37.5	37.5	36.9	36.2	37.01
SP	42	45	49	48	48	55	52	48.43

The analyses of the chemical properties of the soil showed that it was slightly alkaline (ranged between 7.7 "Marsa Abu Fassi" for *A. marina* / *R. mucronata* mix stands to 7.93 "Marsa Sha'ab" for *R. mucronata*). The EC values of soil extract show variation ranging between 27.9 ds/m (Sharm EL Madfaa) for *A. marina* to 51.5 ds/m (Marsa Sha'ab) for *A. marina*, the mean value was 39.79. However, mean differences in the soil chemical and physical characters were found in Table 6.

Table 6: Descriptive statistics for Chemical and physical prosperities.

Character	**Sharm EL Madfaa**	**Marsa Sha'ab**			**Marsa Abu Fassi**		
	A. marina	***A. marina***	***R. mucrona***	**Mixed stands**	***A. marina***	***R. mucronata***	**Mixed stands**
	Pure	Pure	Pure	Mixed	Pure	Pure	Mixed
Coarse Sand (%)	11.5	11.5	18	6	15	12	12.5
Fine Sand (%)	38	38	34	5	37	38	36.5
Silt (%)	14.5	14.5	9	5	10.5	13.1	10.8
Clay (%)	36	36	39	7.5	37.5	36.9	36.2
pH	7.89	7.88	7.93	91	7.9	7.83	7.7
EC (ds/m)	27.9	51.5	40.3	38.2	36.6	44.5	39.5
Na (meq/L)	142.5	264.6	206.6	194.5	185.8	229	205
K (meq/L)	1.9	2.7	2.8	2.5	2.8	3	2.9
Ca (meq/L)	70.1	130.5	102.2	97.2	92.2	113.5	103
Mg (meq/L)	63.5	116.2	88.4	85.8	84.2	98.5	92
Cl (meq/L)	256.4	492.1	375.4	341.2	310.1	403.1	357
SO4 (meq/L)	19.7	18.9	22.3	36.8	52.3	38.1	45.2
HCO3 (meq/L)	1.9	3	2.3	2	2.6	2.8	2.6
CaCO (%)	8.91	22.1	23.7	16.3	29.7	30.3	29.8
Organic carbon (%)	5.2	4.8	4.4	2.9	3.2	3.1	3.1
SP	42	45	49	48	48	55	52

The total SOC content was statistically higher in the *A. marina* stands (39.7 g C kg^{-1}) than in the *R. mucronata* stands (33.15g C kg^{-1}) and (32, 93g C kg^{-1}) for Mixed stands. However, the organic carbon content ranges of *A. marina* and *R. mucronata* ranged from 0.3% to 2.2% (Table 5).

Soil carbonate content showed great variation among the studied stands and ranged between 8.91 % (Sharm EL Madfaa) for *A. marina* to 30.3 % (Marsa Abu Fassi) for *R. mucronata*, the mean value is 22.97 %. Soil calcium contents ranged between 70.1 meq/L (Sharm EL Madfaa) for *A. marina* to 130.5 meq/L (Marsa Sha'ab) for *A. marina*. Soil magnesium contents showed a range from 63.5 meq/L (Sharm EL Madfaa) for *A. marina* to 116.5 meq/L (Marsa Sha'ab) for *A. marina*. Soil sodium contents ranged between 142.5 meq/L (Sharm EL Madfaa) for *A. marina* to 264.6 meq/L (Marsa Sha'ab) for A. *marina*. Soil potassium contents ranged between 1.9 meq/L (Sharm EL Madfaa) for *A. marina* to 3 meq/L (Marsa Abu Fassi) for *R. mucronata*, with the mean value was 2.66 meq/L.

The data indicate that Marsa Sha'ab stands for *A. marina* recorded the highest value of bicarbonate content (3 meq/L), but the lowest values were recorded for soil of Sharm EL Madfaa stands for *A. marina* (1.9 meq/L). The soil collected from Marsa Sha'ab stands for *A. marina* recorded the highest value of chloride content (492.1 meq/L) while the lowest values were recorded in soil of Sharm EL Madfaa stands (256.4 meq/L). Soil sulphate contents showed that the highest value was recorded in soil of (Marsa Abu Fassi) stands for *A. marina* (52.3 meq/L) and the lowest value was recorded in soil of Marsa Sha'ab stands for *A. marina* (18.9 meq/L).

Ordination

Detrended Correspondence Analysis (DCA) was used to detect the length of the environmental gradient (Lepŝ and milauer, 2003). Where the DCA analysis reveals information about the range of variation among the stands at the Elba mangrove coastal area (Table 7 and Figure 4).

Table 7. Environmental parameters used in the DCA and their eigenvalues.

Axes	1	2	3	4	Total inertia
Eigenvalues .	0.709	0	0	0	0.709
Lengths of gradient .	1.414	1.414	0	0	
Species-environment correlations .	1	0	0	0	
Cumulative percentage variance					
of species data .	100	100.1	0	0	
of species-environment relation .	100	0	0	0	
Sum of all eigenvalues					0.709
Sum of all canonical eigenvalues					0.709

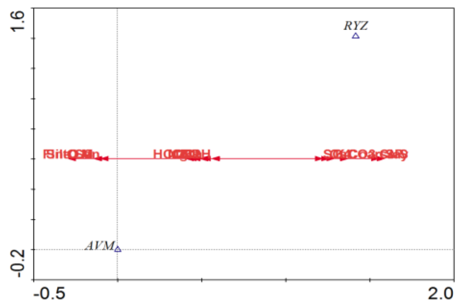

Fig. 4: The species-environment (triangles and circles, respectively) biplot of the DCA of the whole data set in the lower diagram, and retrospective projection of the environmental variables in the upper diagram.

The first gradient is by far the longest one, explaining about 100 % of the total species variability, whereas the second and higher axes explain much less (Table 7, Figure 4). Also, the first axis is very well correlated with the environmental data (r=1), and the correlation for the other axis is considerably lower. All this suggests that the whole data set is governed by a single dominant gradient. The sum of all canonical eigenvalues in the printout corresponds to the sum of all canonical eigenvalues in the corresponding canonical analysis. The percentage variance of the species-environment relationship values represents percentages of this value. The number of axis scores calculated for a species-environmental variable biplot is restricted in a DCA, by default, to one. This is why the explained variability for the second, third and fourth axis is shown as 0. The projection of environmental variables reveals that the first axis is negatively correlated with organic matter and carbon and soil contents (fine sand, silt and clay), with the increasing concentration of (Mg++, electrical conductivity, pH gradient, Na+, Ca++, Cl- and Hco3-), positively correlated with ($CaCO_3$, K+ and So4--), and with the increasing concentration of soil contents (coarse sand) and The saturation percentage. A closer inspection of the correlation matrix in the CANOCO Log View shows that the variables are indeed correlated, but in some cases the correlation is not very great. The correlation matrix also confirms that the correlation of all the measured variables with the second axis is rather weak (Figure 4). Modeling species response curves is used to describe the relationship between a quantity of a particular species and the environmental gradients or gradients of community variation. There is a similarity between the soil samples in different of the study locations as whole area is a coastal. As shown in Figure 5.

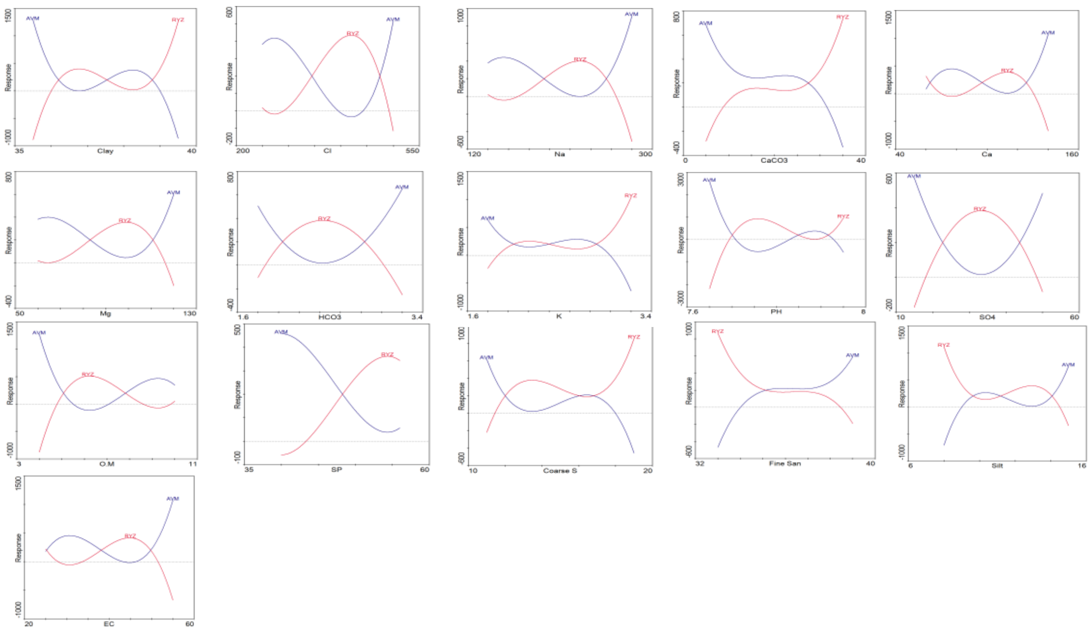

Fig. 5: Important value index of mangrove species in study area against soil parameters.

The current study results showed that both ordination techniques clearly indicated that electric conductivity, $CaCO_3$, K^+, Ca^{++}, C l^-, Na^+ and Mg^{++} were the most important parameters for the distribution of the mangrove pattern in the present study.

DISCUSSION

A. marina usually grows in pure stands, *R. mucronata* may be mixed with *A. marina* as a co-dominant or as an abundant associate, or it may form pure stands. Where both species grow together *R. mucronata* forms an open layer higher than the thick and almost continuous bushy canopy of *A. marina* (Zahran and Willis, 2009). Mangrove forests are a characteristic feature of the shorelines of the tropical and subtropical seas and oceans, however, their optimum density, diversity and cover is in the wet tropics. Some mangrove swamps occur in the coastlines of the arid areas like those of the Red Sea and Arabian Peninsula's coastal belts (Zahran, 2007).

Through review the literatures, we found that, the mangrove forests distributed along tropical and subtropical coasts are an important ecosystem because of their high net ecosystem production and carbon reserves (Komiyama *et al*., 2008; Poungparn *et al.*, 2012). Among *A. marina* tolerates a wider range of salinities (Ball and Farquhar, 1984a, b) and is distributed widely in Africa, Asia, South America, Australia, and Polynesia (Giesen *et al*., 2006). *A. marina* trees secrete excessive salt through glands on their leaves (Scholander *et al*., 1962), and can maintain a higher salinity in xylem sap and leaves than non-secreting mangroves, which enhances hydraulic conductivity and reduces osmotic potential (Lopez-Portillo *et al.*, 2005).

To compare the results of the present study with other study in Egyptain Red Sea Mnagrove, EEAA (2009) recorded that, the growth performance of *R. mucronata* was significantly higher in pure stands than in association with *A. marina*. *R. mucronata* growing in pure population grew twice taller, had more main and lateral branches and attained nearly 4 times the total number of leaves compared with its performance in mixed population with *A. marina*. However, *A. marina* trees growing in association with *R. mucronata* were taller than plants growing in pure communities *R. mucronata* stands have the lowest salinity, silt, pH and Na, but highest of sand and CaCo3. *A. marina* had the highest values of silt, clay, pH, K and Na. *R. mucrorata* contained higher ash. Content (28.2%) than *A. marina* (18.8%). The higher values were associated Cl, Mg, Ca, and Na.

The Similar results were reported in El-Khouly and Khedr (2007) that, the distribution of both species is subjected to varying condition of salinity concentrations, nutrient levels, substrate structure and tidal movement; however the influence of other environmental factors needs to be analyzed before the current zonation pattern can be properly understood.

We agree with (Thom, 1967; Brooks and Bell, 2005) that, the zonation pattern of the mangroves along the Red Sea coast of Egypt also relates to tidal inundation and morphological characteristics of the species. *Rhizophora* with extensive prop roots can withstand wave action along the main tidal channels, *Avicennia* fringe in the less dynamic parts of shores. This confirms that zonation is also a function of habitat change which may be induced by process of landscape evolution. *Avicennia* cover was greater in the mudflat, with a higher salinity this being a most important factor, along with substrate type and extreme hydrological and oceanographic regimes

Under optimal environmental conditions, *A. marina* trees form multi-cambia simultaneously at different positions around the stem circumference (Schmitz *et al*., 2008). This patchy growth mechanism is advantageous in the fluctuating environmental conditions that are driven mainly by climatic and tidal cycles. Due to such physiological and morphological adaptations, *A. marina* trees growing in inlandwards of a mangrove forests are often dwarfed, whereas those on shoreline fringes are tall and are occasionally highly productive (Naidoo, 2006, 2010).

The study agree with Yoshikawa *et al*., (2011) as most previous studies have been conducted in tropical areas with a rainy season or in subtropical areas, the water-use characteristics of *A. marina* in per-arid areas remain unknown. Monospecific stands of *A. marina* are found on the Red Sea coast where fresh water is less supplied from inland areas with extremely low rainfall (<70 mm/yr^{1}) *A. marina* trees in this area have short stems. And lateral branches with attached adventitious roots. This unique morphology is likely related to the water-use habits of leaves in per-arid areas. Carbon isotope compositions of leaf organic matter is a powerful tool for assessment of intrinsic water-use efficiency (Farquhar *et al*., 1989) relating to salinity (Ball and Farquhar, 1984a, b; Ball, 1988b; Naidoo, 2010). Vivipary Propagules of certain genera contain viviparous seeds which germinate while still attached to the parent tree. When the ripe propagules fall from the parent plant, the seedlings germinate rapidly. Air spaces in the propagules or germinating seedlings are modified to facilitate floating for dispersal by water. These can be found in *Rhizophora and Avicennia*. The propagules of all mangroves are buoyant and are able to disperse by water (Tomlinson, 1986; Aksornkoae, 1993).

The soil of *A. marina* mangrove contains 4.5–19.5% calcium carbonate whereas that of *R. mucronata* is highly calcareous, containing up to 80% of its weight of calcium carbonate. The tidal mud of the mangrove vegetation of the Red Sea coast is usually grey or black, and often foul-smelling (Kassas and Zahran, 1967). The total water-soluble salt content ranges from 1.2 to 4.3%. The pH from 8.5 to 9.0. A notable difference between the tidal mud colonized by *A. marina* and that by *R. mucronata* is the low content of calcium carbonate in the former (4.5–19.5%) as compared with the calcareous mud (80%) in the latter. (Zahran and Willis, 2009).

However, the study agree with El-Khouly and Khedr (2007) who stated that, the habitat of of *R. mucronata* is characterized by low soil salinity, silt and pH values, compared with that of *A. marina* that grow in more saline habitats and had the highest value of silt. Plots of the association growth of *R. mucronata* and *A. marina* showed an intermediate values for most of the studied soil variables. The results suggest that while abiotic environmental conditions may account for the absence of *R. mucronata* in high saline mud soils along the Red Sea coast of Egypt, but also the tolerance of each species to each particular is more important in the formation of mixed growth of both species. Moreover, El-Khouly and Khedr (2007) reported that, the distribution pattern and the overlap occurrences of *A. marina* and *R. mucronata* along the Red Sea coast of Egypt indicate overlap in environmental requirements or tolerance of environmental stress. The mangroves are not restricted to specific soil conditions although each community tends to show niche relation to certain soil variable. Hence, several soil properties could serve as indicators for community type differentiation (Ukpong, 1995). For example, higher acidity (pH-values) prevails in soils associated with *Rhizophora* communities than *Avicennia* communities. *Rhizophora* has extensive fibrous root system which form thick peat-like mud, which lower the pH after decomposition (Hart, 1962).

In present study, we suggest that, the environmental aspects of mangrove growth in Egypt can be divided into four groups as follows.

I. Climatic conditions.

2. Geomorphological aspects of Red Sea lagoons, bays and islands

3. Water characteristics.

4. Man-made modifications.

Mangroves are sound ecosystems that act as buffer zones to maintain biodiversity along sea-line. The predatory activity of man endangers the inherent fragile nature of this buffer zone. This study taken up against this background along Elba Protected Area shoreline has attempted an in-depth study of mangrove productivity in conjunction with a detailed analysis of water and soil. Mangrove is a tropical formation and its best growth occurs in high temperatures. It seems that individual trees and shrubs, especially of the salt excreting species like *A. marina,* withstand to some extent dry and hot climate. Mangrove formations along this shoreline are formed mainly of *A. marina,* a salt-excreting species. Mean maximum temperature 32.2 ° C yearly and 37.5 °C in summer months (Paramaraj, 2004). Similar observations were reported by Scholander *et al.* (1962) along the Red Sea coast.

CONCLUSION

The current study agrees with Zahran and Willis (2009), that the variability of ecosystem structure and function is generally a product of interactions between its different components. In the extreme environmental conditions of arid lands these interactions are of high significance, so that slight irregularities in one component of the ecosystem are likely to lead to substantial variations in others, so creating distinct micro habitats. In arid lands, the interrelationships between soils, vegetation and atmosphere are so interconnected that, in an ecological perspective, they can hardly be considered as separate entities.

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