Egyptian Journal of Biology, 2004, Vol. 6, pp 39-51
© Printed in Egypt. . Egyptian British Biological Society (EBB Soc)

Spatial distribution of mangal-algal association in some sites along the Egyptian Red Sea coast by remote sensing technology

Ashraf M. Youssef[1], Adel F. Hamed[1*] & Boshra B. Salem[2]

1. Department of Botany, Faculty of Science , Ain Shams University, Abbassia , Cairo, Egypt
2. Environmental Sciences Department, Faculty of Science, Alexandria University, Alexandria

ABSTRACT

To extend the technology of remote sensing for detecting mangrove – algal environments of the Red Sea coastal ecosystem, two Landsat-TM images were integrated with ground observations along the Red Sea coast south of Hurghada and Safaga Island. Investigated sites were monospecific stands of *Avicennia marina*, occurring as small trees about 5m high scattered along the arid coastline of Safaga Island and south of Hurghada. The distribution of mangroves was investigated in relation to the physico-chemical chrarcteristics of the associated soils. Ground-truthing of the algal study in relation to the mangrove and its surroundings indicated the presence of 23 algal taxa along the different studied sites. Algal distribution associated with the mangrove canopy was mainly of the rhodophytic type, while the sublittoral fringe of the coral reef was inhabited by intermingled taxa of red, green and brown algae. Image processing of the satellite image classified the study area into five major five classes: deep sea, coral reef, algae associated with corals, mangroves and terrestrials.

Keywords: Mangrove, coastal habitats, algae, Red Sea, remote sensing.

INTRODUCTION

Since the launching of the first high resolution satellite in 1986, the mapping of mangroves and its associated communities has become more widespread in most tropical and subtropical countries. Previous literatures and studies dealing specifically with the Egyptian Red Sea mentioned the localities where mangrove and its associated habitats could be found (Zahran 1965; Kassas & Zahran 1962, 1967, 1971), but no detailed cartographic products mapping the coastal ecosystem have been published. Nevertheless, Zahran (1977) and UNEP (1993) mentioned that the mangrove vegetation along the length of sheltered areas of the Red Sea coast consists of *Avicennia marina* (Forssk.) Vierh. growing in shallow water lagoons, bays, corals and some bars parallel to the shore.

Mangrove-algal environments have been intensively studied by several authors in different parts of the world. Algal communities are closely associated either with pneumatophores of the mangrove (Rathindranath *et al*. 1994 ; Dawes *et al*. 1999; Proches & Marshall 2002) or attached to the mangrove sediment substrate (Wee 1986; Sarpedanti & Sasekumar 1996; Neera *et al*. 2002). Although intensive studies on the algal flora of the Red Sea have been carried out by several authors (Allem 1948, 1978, 1980, 1981; Farghaly 1980; Hegazy 1992; El-Manawy & Gab-Allah 2000), no attempts dealing with mangrove-algal association have used remote sensing.

Remote sensing technology is an efficient tool to study marine botany (Lehmann & Lachavanne 1997), depending on differences in the spectral reflectances of the communities of the ecosystem. The Red Sea is an elongate trough extending NW-SE from Sinai (Lat. 29° 50' N) to Bab El-Mandab Strait (Lat. 12° 33' N, Long. 43° 3' E), separating the Arabian Peninsula from the African continent (Zahran 1977). The Red Sea coastal

* Address for Correspondence

land of Egypt extends from Suez (Lat. 30^o N) to Mersa Halaib (Lat. 22^o N) at the Sudano-Egyptian border (Fig.1).

The aim of this study is to assess the vegetation cover of the mangrove and its associated algae inhabiting the coastal zones of the south part of Hurghada and along the coast of Safaga Island using remote sensing.

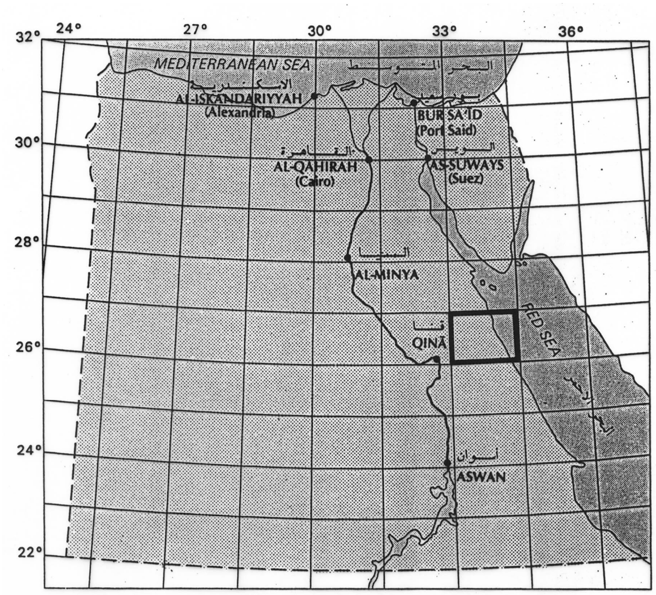

Fig. 1: Location map of study sites a long the Red Sea coast

MATERIALS AND METHODS

Field surveys for the sites of the present study of the south part of Hurghada and along the coast of Safaga Island were carried out during the period of October-November 2003 (Fig. 2). The ground-truth data collected from the selected field sites was undertaken using the line intercept method in sampling as carried out by Saenger & Snedaker (1993). Heights were determined on a minimum of 72 randomly selected *Avicennia marina* plants at each site, and densities were measured by the distance to the sixth nearest neighbor of randomly selected reference plants. Four field sites were investigated to represent the two coastal areas under study. The first area comprised three sites of geographic zones along the coast of Safaga Island in the Red Sea: Site IA at 26^o 30.744 N , 33^o 30.190 E; Site IB at 26^o 30.742 N , 33^o 30.192 E; Site IC at 26^o 30.737 N , 33^o 30.199 E. The second area is along the south part of Hurghada (Site II at 26^o 30.770 N , 33^o 30.190 E). The geographical localities were determined by Global Positioning System (Garmin, 12 XL).

Two soil samples of 0-10 cm depth were collected from the two studied areas. The percentage of gravel, coarse sand, fine sand, silt and clay were carried out using a hydrometer according to the procedures followed by Day (1965). Soil water extractions (1: 5) was used for the various determinations, following Richards (1954). The soil reaction was determined in saturated soil paste using Fisher's pH meter (Jackson 1962). Total soluble salts (TSS) were determined as described by Jackson (1967) and Wilde *et al.* (!979). Calcium carbonate (Ca CO_3) and organic carbon (OC) were determined following Piper (1950). The mean values of the physical and chemical characteristics of the soil samples were analyzed with a one–way ANOVA using the SigmaStat (1994) statistical package.

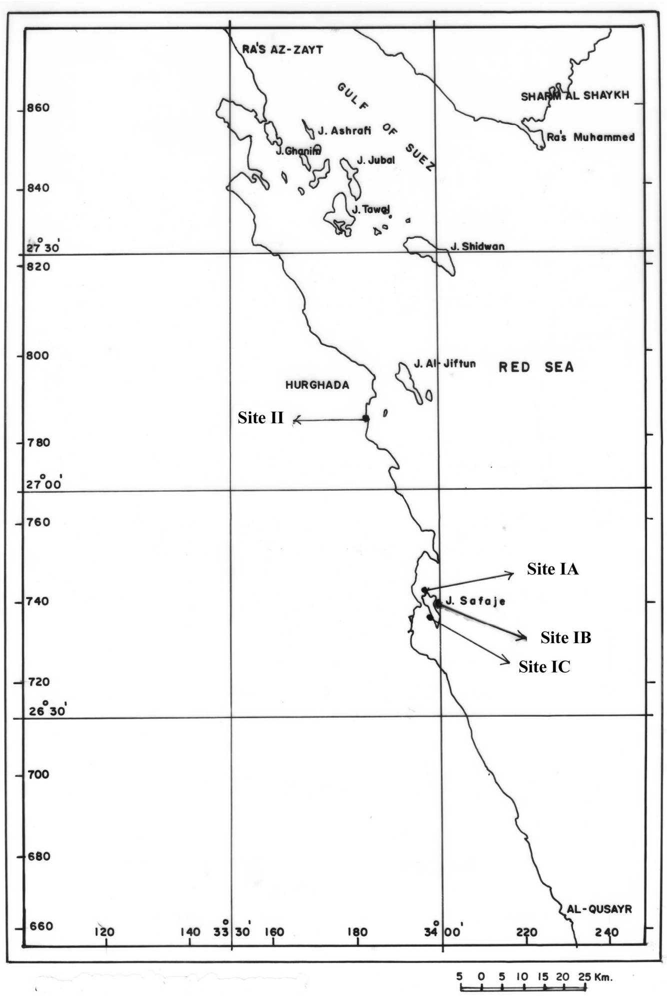

Fig. 2: Location map of the study sites showed its geographical localities

Collection of algal samples were easily carried out by hand from the study area covering the littoral fringe (spray zone = Z1) and eulittoral intertidal zones (Z2) where the mangrove canopy was present: algal samples associated with the mangrove substrate and pneumatophores were also collected. In addition, algae inhabiting the sub-littoral fringe (Z3) of the coral reef were collected by snorkelling. The samples were preserved in 4 % formalin-seawater solution for identification. Identification of species under investigation was performed using the keys of Smith (1969) and Aleem (1993).

In order to assess the environmental conditions in the area under study, multi-spectral (seven bands) satellite imagery of relatively high resolution (30 x 30 m) were acquired for analysis from the American satellite Landsat5, dated November 1998. The Landsat5 data used were acquired from the Thematic Mapper (TM5) sensor for 1998. The satellite images was projected using UTM and the earth model WGS84. The satellite images were downloaded to the computers of the Remote Sensing and GIS Laboratory of the Department of Environmental sciences, Faculty of Science, University of Alexandria where the image preprocessing/processing work was carried out using ERDAS/Imagine version 8.5.

A color-composite image was produced using the spectral Landsat-TM bands 2, 4, 7 (Green, Near Infrared , Middle Infrared) to differentiate visually the prevailing features in the scene. To assess the environmental status of these habitats, images were subjected to image processing analysis and classification. Classification is a process of dividing the multispectral satellite image to produce automatically an image (one layer) containing the major cover classes, referred to as "thematic images". The Unsupervised classification process was selected mainly because it does not need *a priori* detailed ground-truth information, and suits images that contain both water bodies and terrestrial features in the same subscene. Unsupervised classification was performed using an algorithm called ISODATA. This procedure classifies all band images using a user-specified number of clusters to process. The procedure starts by training sites based on statistical parameters produced throughout the algorithm that characterize individual classes. It results in a classification that includes not only these specific classes, but also significant (but unknown) mixtures that might exist. The end result has much of the character of the unsupervised approach described above. The ISODATA algorithm uses spectral distance as in the sequential method, but iteratively classifies the pixels, redefines the criteria for each class, and classifies again, so that the spectral distance patterns in the data gradually emerge (ERDAS 1997).

The classification process was necessary for separating the mangrove-aquatic vegetations from other land-use background. Classification trials with different number of classes were done, starting from 2 through 5 classes. For every trial, spectral signatures of classes were examined to determine class overlap and separation. The best results that yield complete separable classes with zero overlap i.e. best accuracy, were achieved using 5 classes. With this decision, the satellite image was fed into the ISODATA classifier with a convergence threshold equal to 0.95 to produce 4 major land cover classes using 6 iterations. Classification accuracy assessment allows evaluation of the classified image (thematic raster layer). It was performed here using the Cell Array utility, which lists two sets of class values for randomly selected points in the classified image file. One set of class values is automatically assigned to these random points as they are selected, and the other set of class values (reference values) is input by the user. These reference values used are based on ground truth data. The Accuracy Assessment Cell Array is an organized way of comparing the classification with ground truth data. The data for the random points in the Cell Array can be saved in the classified image file for further reference or to refine past evaluations.

RESULTS AND DISCUSSION

Figure 3 shows the false-color composite (bands 7:4:2) produced. The red colour in this subscene indicates algal cover associated with corals in shallow clear water areas; the black colour indicates water bodies; the grayish colour indicates urban structures; while the dark grey colour is the background deserts in the hinterlands. With increasing band numbers (1 through 7 except 6), the spectral reflectance values of water body decrease, i.e. bij1>bij2>bij3>bij4>bij5>bij7 and those of the desert areas increase. In this subscene the least minimum DN value is 0.00 and is attained by the infrared band (band 7). The minimum value is an indication of the reflections of deep, clear and unpolluted water reflections of the Red Sea.

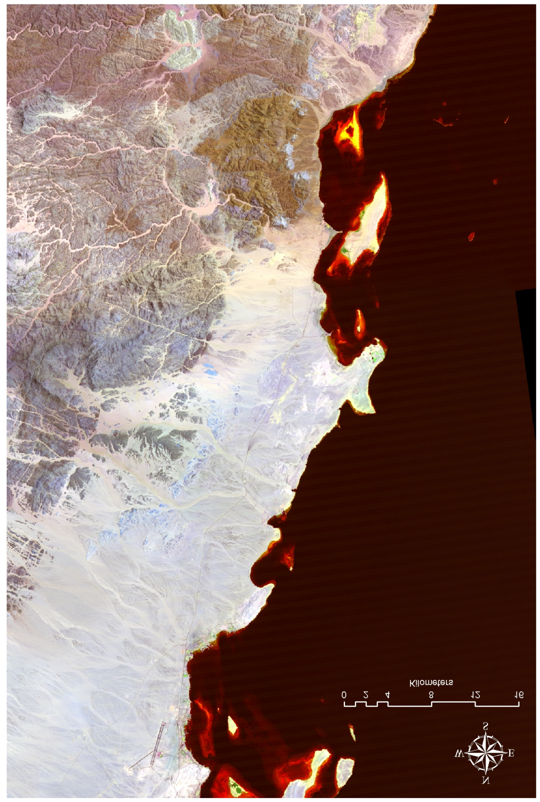

Fig. 3: False color composite of the study area along the Red Sea coast

The average height of *A. marina* plants ranged between 0.5-2 m. The size class 0.5-2 m class dominates most of the undisturbed sites (such as Safaga Island), with a small number of relatively tall trees attaining heights of about 5m (Table 1). The ground cover of the *A. marina* trees showed variable distribution throughout the different studied sites. Some parts of the investigated sites showed clumped pattern of distribution (i.e., dense mangroves), while there were regular patterns (i.e., open mangroves) on other parts. The survey of the different sites indicated that the vegetation structure is monospecific *Avicennia marina*, which grows on whitish intertidal sand flats (eulittoral zone) mainly around the margins of the lagoons that are submerged by sea water at high tide.

The average tidal amplitude varies from 0.5 to 1.5m Mangroves are limited by aridity but also by coastal stability: wherever there is natural shelter or where constructed protective measures are in place, mangroves can establish. These observations are supported by Kogo (1988) and Saenger *et al*. (2002).

Table 1: Main mangrove classes of the study sites along the Red Sea

Average height of *A. marina* trees	Average ground coverage (density)		
	70-100 %	25-70 %	< 25 %
2-5 m	1- Low dense mangrove forest	4- Low open mangrove forest	7- Low mangrove woodland
0.5 – 2m	2- Dense mangrove thicket	5- Open mangrove thicket	8- Scattered mangrove shrubs
< 0.5 m	3- Low dense mangrove thicket	6- Low discontinuous mangrove thicket	9- Scattered mangrove undershrub
	Dense *A. marina* mangroves	Open *A. marina* mangroves	Not discriminated from space

Abo Al-Izz (1971) indicated that the offshore islands of the Red Sea are close to the shoreline. The vegetation of these islands is represented by pure thickets of *Avicennia marina*, well developed within creeks where cover is 80-90 %. The mangrove area is fringed inland by salt-marsh vegetation dominated by *Arthrocnemum glaucum* (Zahran & Willis 1992). Vegetation characteristics of the coastal salt marshes (including mangroves) along the Red Sea is influenced by the physiographic attributes which limit these marshes to a narrow strip along the coastal area (Meigs 1966). Zahran (1965) and Kassas & Zahran (1977) studied the vegetation of the Red Sea coast and indicated that the structure of the Egyptian Red Sea coast is simple and usually dominated by a single layer of *Avicennia marina* from Hurghada southwards.

Table 2. Granulometric analysis, pH, total soluble salts (TSS), field capacity, calcium carbonates ($CaCO_3$) and organic carbon contents of the soil profiles associated with *Avicennia marina* along the Red Sea coast (south of Hurghada and Safaga Island).

Site	Granulometric analysis (%)				pH	T.S.S. (ppm)	Field capacity (%)	Ca Co_3 (%)	Organic carbon (%)
	Gravel	Coarse sand	Fine sand	Silt and clay					
Red Sea coast (south of Hurghada)	2.8	18.5	75.2	3.5	7.44	2600	19.5	23.7	0.11
	± 0.1	± 0.18	± 0.16	± 0.2	± 0.05	± 80	± 0.1	± 0.1	± 0.05
Safaga Island	1.7	13.9	79.8	4.6	7.80	5210	11.4	26.2	0.23
	± 0.1	± 0.18	± 0.15	± 0.16	± 0.05	± 80	± 0.1	± 0.1	± 0.05

The structure of the mangrove vegetation on the Red Sea coast is mainly influnced by the physical and chemical characteristics of the supporting sediment. The soil of the mangal vegetation is generally foul-smelling, perhaps due to its high organic-matter content relevant to the presence of aquatic fauna and flora. Soil texture of the associated subsurface layer samples of *Avicennia marina* was formed mainly of a fine-sand fraction (75.2 % south of Hurghada and 79.8 % along Safaga Island (Table 2).

The soil reaction was weakly alkaline (pH 7.44 – 7.8) and the total soluble salts attained a maximum value of 5210 ppm in the soil sample of Safaga Island. The field capacity of the soil samples were relatively high, ranging between 11.4 and 19.5 %. The total carbonate and organic carbon content had higher percentages in the sediment of Safaga Island (26.2 % and 0.23 % respectively) compared with those of south of Hurghada (23.7 % and 0.11%, respectively). Soil conditions, tidal movement, sea water spray, seawater seepage, waves, land relief and local and microclimate are the main factors that limit the distribution and extent of mangroves and the associated coastal habitats (Batanouny & Baeshin 1982; Kassas & Zahran, 1962, 1965, 1967, 1971; Zahran 1977; Zahran & Willis, 1992; Morsy 2002; Youssef *et al*. 2003).

Concerning the algal study relevant to the mangal vegetation, a list of 23 algal taxa and their distribution along the zones of the investigated sites was recorded (Table 3). The floristic composition emphasized the different percentages of taxonomic groups (Fig. 2). Rhodophytes constitute 56.5 % of the total number of species, whereas Cyanophyta, Chlorophyta and Phaeophyta were the poorest taxonomic groups. This finding is supported the observations by the studies of Reed (1990) and Karsten *et al*. (1995, 1996). These authors state that red algae are commonly associated with mangrove forests in tropical and subtropical coastal regions around the world. This may be due to their physiological capability to resist the osmotic stress of salinity by restoring normal turgor pressure, and their ability to occupy a wider range of irradiance environments (Graham & Wilcox 2000).

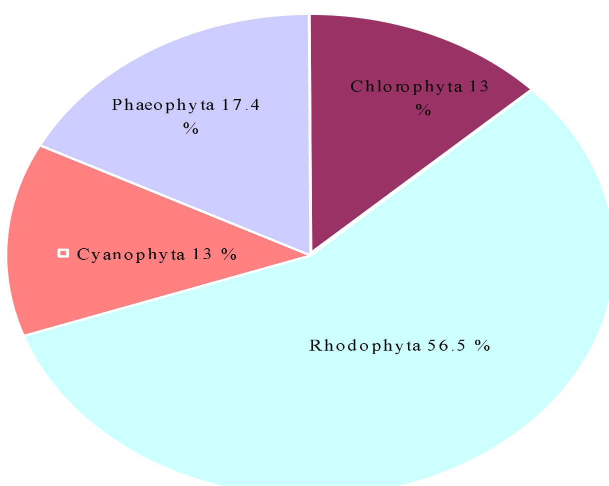

Fig. 4: Percentages of the different taxonomic algal groups of the investigated areas along the Red Sea Coast

Concerning the distribution of taxa along the investigated sites, *Jania rubens, Hypnea cornuta, Laurencia papilosa* and *Padina pavonica* were the most dominated taxa in this study. The spray zone (Z1) inhabited by some pneumatophores of the mangroves had some epiphytic blue-green algae (i.e. cyanobacteria) such as *Lyngbya confervoides, Lyngbya semiplena* and *Trichdesmium erythraeum* in Safaga Island sites. Dawes *et* *al.*(1999) and Proches & Marshall (2002) emphasized in their investigations that cyanophytes are common inhabitants on pneumatophores of mangrove forests.

In the eulittoral zone (i.e. inter-tidal zone: Z2), the mangrove sediment substrate favors the growth of 7 taxa of red algae of tubular (*Liagora fragilis, Galaxura oblongata*), turf-forming structure (*Gelidium latifolium*) , articulate coralline (*Jania rubens*), intestinal (*Gracilaria arcuata*), cartilaginous (*Hypnea cornuta*) and filamentous (*Ceramium diaphanum*) structures and forms. Graham & Wilcox (2000) also found red algae are dominant inhabitants in high-intertidal mangroves habitats that are subjected to long periods of full sunlight.

The sub-littoral fringe of reef flat (Z3), with cliffs, gullies and ledges, were mainly inhabited by the intermingled taxa of red, green and brown algae (i.e. highly diversified in comparison with the algal flora of the other zones). Most of the diversified algal species recorded in zone 3 were previously recorded in the work of El-Manawy & Gab-Allah (2000) on the coral reefs of Shalateen and Halaib sector of the Red Sea.

Image processing and GIS techniques together with the ground-truthing studies revealed the spatial distribution of mangroves – algal associations in the study area. Figure 3 shows the results of the unsupervised classification of the Landsat-TM satellite image used, and the estimated percent cover for each class is in Table 4. These classes are conspicuous and essential since they interact with each other, due to their dominancy in coastal landscapes and because they constitute the main features when mapping coastal ecological condition and vegetation. The accuracy of the classified map product is closely related to the spatial resolution acquisition and to the appropriate image processing method. Accuracy assessment was performed on the subscene comparing the resulted classified images with corresponding true color composites image, and the reference points from the ground observations. For the post-classification approach, individual single-date error matrices were generated made up of 128 points, 32 points for each of the four classes. The overall accuracy reached was about 93%, which is considered satisfactory

The image information and its analysis are useful, at least for the discrimination of the five main classes, but its spatial resolution does not enable us solely to discriminate the mangrove canopy from the algae. For this reason, the ground reference results are integrated with remote-sensing information in the processing of the image. In general, applications of satellite data for mapping coastal habitats seems to be an effective tool in a number of countries (Blasco *et al*. 1997; Mumby *et al*. 1999; Blasco *et al*. 2001; Murray *et al*. 2003 and Saito *et al*. 2003).

Table 3. Distribution of algal species along the different zones of the investigated sites of Red Sea Coast. (Z1 = Spray zone , Z2 = Eulittoral zone , Z3 = Sublittoral zone)

Species	Safaga Island (Site I)									Red Sea coast, south of Hurghada (Site II)		
	Site I A			Site I B			Site I C					
	Z1	Z 2	Z3	Z 1	Z2	Z 3	Z 1	Z2	Z 3	Z1	Z2	Z3
Division Cyanophyta												
Lyngbya confervoides C. Agardh ex Gomont	+											
Lyngbya semiplena (C. Agardh) J. Agardh ex Gomont	+											
Trichdesmium erythraeum Ehr. ex Gomont				+			+					
Division Rhodophyta												
Nemalionales												
Liagora fragilis Zanadini					+	+		+	+			+
Liagora rugosa Zanardini						+			+			+
Galaxura oblongata (Ellis et Solander) Lomouroux					+				+		+	
Gelidiales												
Gelidium latifolium kütz.			+		+	+					+	+
Gelidium pusillum (Strackhouse) Le Jolis		+										
Cryptonemaliales												
Jania rubens (Linnaeus) Lomouroux		+	+		+	+		+	+		+	+
Gigartinales												
Gracilaria arcuata Zanardini			+		+	+			+			+
Hypnea cornuta (kütz.) J. Agardh		+	+		+			+	+		+	+
Ceramiales												
Ceramium diaphanum (Lightfoot) Roth		+			+			+				
Digenea simplex (Wuffen) C. Agardh												+

Laurencia obtuse (Hudson) Lomouroux			+					+	+		+	
Laurencia papilosa (C. Agardh) Greville		+				+		+	+		+	+
Polysiphonia figariana Zanardini			+									
Division Chlorophyta												
Cladophorales												
Chaetomorpha indica (kütz.) kütz.						+			+			
Cladophora crystalline (Roth) kütz.			+									
Caulerpales												
Caulerpa racemosa (Forsskal) J. Agardh												+
Division Phaeophyta												
Dictyotales												
Dictyota indica (Sander) ex kütz.			+			+			+			
Padina pavonica (Linnaeus) Thivy			+			+			+			+
Dictosiphonales												
Colpomenia sinuosa (Derbes) et Solier			+									
Hydroclathrus clathratus (C. Agardh) Howe			+			+			+			
Total species	2	5	11	1	7	10	1	6	12	0	6	10

Table 4: Provisional quantitative results of the different classes of the scene.

Class	Total Surface Area (%)	Number of pixels / image
Class 1 (Deep Sea)	69 %	7801398
Class 2 (Coral Reef)	12 %	1297809
Class 3 (Algae associated with corals)	6%	666387
Class 4 (Mangrove)	2 %	198639
Class 5 (Terrestrials)	11 %	1224675

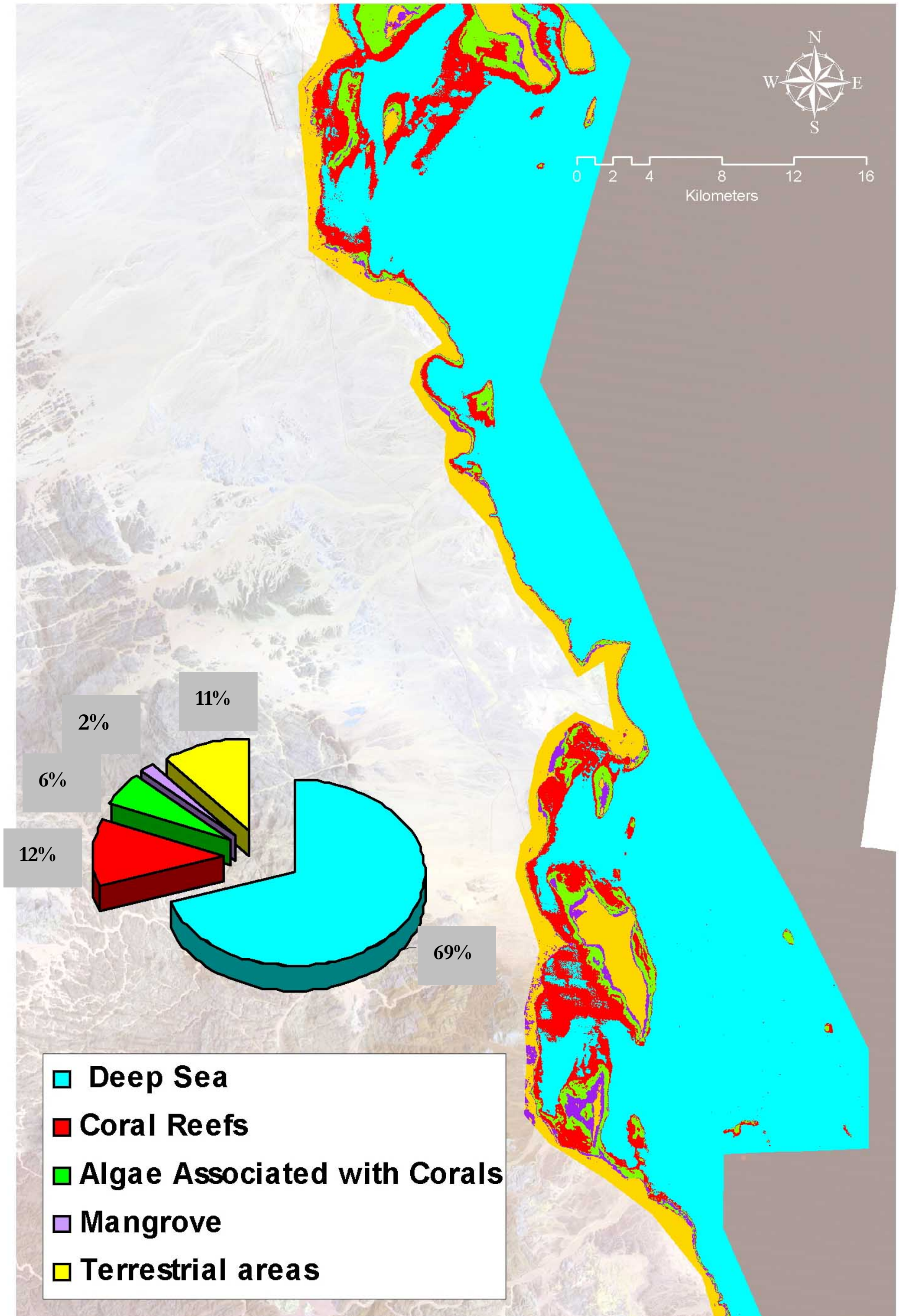

Fig. 5 Classified map of the different classes of the studied areas

ACKNOWLEDGMENTS: We greatly appreciate the assistance of Mrs Nihad Al-Nogomy, sector manager in ERSS, for her support and for supplementing the SPOT images for the study area.

REFERENCES

Abo Al-Izz MS (1971) *Landforms of Egypt*. Translated by Dr. Yusuf A. Fayid. The American Univ. in Cairo Press, Cairo, Egypt, 281.

Aleem AA (1948) The recent migration of certain Indo-Pacific algae from the Red Sea into the Mediterranean. *The New Phytol*., 47: 88-94.

Aleem AA (1978) Contribution to the study of the marine algae of the Red Sea . III- Marine algae from Obhor, in the vicinity of Jeddah. *Bull. Fac. of Sci. K. Abdle Aziz Univ., Jeddah*, 2: 99-118.

Aleem AA (1980) Contribution to the study of the marine algae of the Red Sea. IV- The algae and seagrasses inhabiting the Suez Canal. *Bull. Fac. of Sci. K. Abdle Aziz Univ., Jeddah*, 4: 31-89.

Aleem AA (1981) Contribution to the study of the marine algae of the Red Sea. V- New or little known algae from the west coast of Saudi Arabia. *Bull. Fac. of Sci. K. Abdle Aziz Univ., Jeddah*, 5: 1-49.

Aleem AA (1993) *The marine algae of the Alexandria, Egypt*. Ed. Univ. of Alex., Egypt, 138-155.

Batanouny KH & Baeshin NA (1982) Studies on the flora of Arabia. II. The Medina-Badr Road, Saudi Arabia, *Bull. Fac. Sci. King Abdle Aziz Univ., Jeddah*, Saudi Arabia, 6: 1-26.

Blasco F, Gauquelin T, Rasolofoharinoro M, Denis J, Aizpuru M & Calderou V (1997) Recent advances in mangrove studies using remote sensing data. *Australian Journal of Marine and Fresh Water Research*, 49: 287-296.

Blasco F, Aizpuru M & Din N (2001) Mangrove: Remote Sensing. In M. Schwartz Eds. Coastal Encyclopedia, Kluwer Academic Publishers, Dordrecht.

Dawes C, Siar K & Marlett D (1999) Mangrove structure, litter and macroalgal productivity in a northern most forest of Florida. *Mangrove and Salt marshes* 3(4): 259-267.

El-Manawy IM & Gab-Allah AAF (2000) Distribution and diversity of seaweeds on coral reef at Shalateen and Halaib sector (Red Sea , Egypt). *Proc. 1st Int. Con. Bio. Sci., Fac. Sci. Tanta Univ.,* 1: 45-60.

ERDAS Field Guide (1997) *Fourth edition, ERDAS, Inc. Atlanta, Georgia,* 639 pp.

Farghaly MS (1980) *de la Mer Algues Benthiques Rouge et du Basin Occidentale de l'Ocean Indian*. These Doc. Sci. U. S. L. France.

Graham LE & Wilcox LW (2000) *Algae ,* Prentice Hall, 640 pp.

Hassanein RA, Youssef AM, Hassanein AA & Morsy AA (2003) Lipid composition and phytohormonal contents of some halophytes in relation to soil characteristics of the Red Sea and Sinai Peninsula, *Egypt. J. Environ. Sci*. (25): 207-236.

Hegazy MM (1992) *Ecological studies on the seaweeds of south Sinai*. M. Sc. Fac. of Sci. Suez. Canal Univ.

Jackson ML (1962) *Soil Chemical Analysis* . Constable and Co. Ltd. London.

Jackson ML (1967) *Soil Chemical Analysis*. Printice Hall, New Delhi, India.

Karsten U, Bock C & West JA (1995) ^{13}C-NMR spectroscopes as a tool to study organic osmolytes in the mangrove red algal genera *Bostrychia* and *Stichosiphonia* (Ceramiales). *Phycological Research* 43: 241-247.

Karsten U, Mostert AS, King RJ, Kamiya M & Hara Y (1996) Osmoprotctors in some species of Japanese mangrove macroalgae. *Phycological Research* 44: 109-112.

Kassas M & Zahran MA (1962) Studies on the ecology of the Red Sea coastal land. I. The district of Gebel Ataqa and El-Galala El-Bahariya. *Bull. Soc. Geog. d'Egypte*, XXXV: 129-175.

Kassas M & Zahran MA (1965) Studies on the ecology of the Red Sea coastal land. II. The district from El-Galala El-Qibliya to Hurghada. *Bull. Soc. Geog. d'Egypte*, 38: 155-193.

Kassas M & Zahran MA (1967) On the ecology of the Red Sea littoral salt marsh, *Egypt. Ecol. Mong*., 37(4): 287-316.

Kassas M & Zahran MA (1971) Plant life on the coastal mountains of the Red Sea, Egypt. *Ind. Bot. Soc*. Golden Jubilee 50A: 571-589.

Kogo M (1988). Natural environmental factors affecting mangrove growth in the early stages, a study from the experimental cultivation in Saudi Arabia, Abu Dhabi and Pakistan. UNDP/UNESCO Regional Mangrove Project Conference, 11-14 November, 1986, Colombo,165-179.

Lehmann A & Lachavanne JB (1997) Geographic Information systems and remote sensing in aquatic botany. *Aquatic botany*, 58: 195-207.

Meigs P (1966) Geography of coastal desert. *Arid Zone Res*., UNESCO, 28: 140.

Morsy AA (2002) *Ecophysiological studies on certain wild plants grown in different habitats in the Egyptian Deserts*. Ph. D. Thesis, Fac. Sci., Ain Shams Univ., Cairo, Egypt.

Mumby PJ, Green EP, Edwards AJ & Clark CD (1999) The coast effectiveness of remote sensing for tropical coastal resources assessment and management. *J. Environ. Man*. 55(3): 157-166.

Murray MR, Zisman SA, Furley PA, Munro DM, Gibson J, Ratter J, Bridgewater S, Minty CD & Place CJ (2003) The mangroves of Belize. Part 1. distribution, composition and classification. *Forest Ecology and Management* 174(1-3): 265-279.

Neera S, Kumudranjan N, Sen N & Kaskar K (2002) Algal communities in the intertidal mangrove niches of Sundarbans. *J. Interacademicia* 6(4): 420-433.

Piper, C. S. (1950). *Soil and Plant Analysis.* University of Adelaide Press. Australia.

Proches S & Marshall DJ (2002) Epiphytic algal cover and sediment deposition as determination of arthropod distribution and abundance on mangrove pneumatophores. *J. Marine Biol. Assoc*.,UK,82(6): 937-942

Rathindranath M, Kumudranjan N, Mandal R, Naskar K & Malabika R (1994) Studies on the periphytic algae on the aerial roots of the mangroves of Sundarbans in West Bengal. Environmetal Pollution: Impact of Technology on Quality of Life. Proceedings of Symposium, Santiniketan, India, 21-23 Feb, 91-94; Recent Researches in Ecology, *Environment and Pollution* (9): 321-330

Reed RH (1990) Solute accumulation and osmotic adjustment. in *Biology of the Red Algae*, edited by K. M. Cole and R. G. Sheath: 147-170. Cambridge Univ. Press. , Cambridge, U. K.

Saenger P, Blasco F, Youssef A & Loughland R (2002) The mangrove resources of the UAE with particular emphasis on those of the Abu Dhabi Emirate. *Proceedings of the International Symposium on "Optimum Rresources Uutilization in Salt-Affected Ecosystems in Arid and Semi-arid Rregions*,8-11 April 2002. *Desert Inst. Bull*. 321-331.

Saito H, Bellan MF, Al Habshi A & Blasco F (2003) Mangrove research and coastal ecosystem studies with SPOT-4 HRVIR and TERRA ASTER in the Arabian Gulf. *Inter. J. Remote Sensing* 24 (21): 4073-4092.

Sarpedanti V & Sasekumar A (1996) The abundance of diatom species on a low shore mangrove forest, Sementa, Malaysia. *Wallaceana* 77: 21-26.

Sigmastat S (1994) Sigmastat for windows. Jandel Scientific, San Rafael, CA.

Smith GM (1969). *Marine Algae of the Monterey Peninsula California.* Stanford, University Press, Stanford, California. 2nd edition, 751pp.

USEPA (2000) Test methods for evaluating solid waste. Vol.IB: Laboratory manual , physical and chemical methods. National Technology Information Service.

Wee WC (1986) Mangrove algae. *Wallaceana,* 46: 13-16.

Wilde SA, Corege RB, Layer JG & Voigt GK (1979) *Soil and Plant Analysis for Tree Culture*. Oxford and IBH Pub. Co. New Delhi and Bombay.

Youssef AM, Hassanein RA, Hassanein AA & Morsy AA (2003) Changes in quaternary ammonium compounds, proline and protein profiles of certain halophytic plants under different habitat conditions. *Pak. J. Biol. Sci*. 6(10): 867-882.

Zahran MA (1965) Distribution of mangrove vegetation in UAR (Egypt). *Bull. Inst. Desert d'Egypte*, 15(2): 7-12.

Zahran MA (1977) Africa: A Wet Formation of the African Red Sea Coast In: Wet Coastal Ecosystem, edited by V. J. Chapman. Elsevier.Sci. Pub. Comp. Amsterdam, 215-231.

Zahran MA & Willis AJ (1992) The vegetation of Egypt. Chapman and Hall. Pub., London, 117-128

الملخص العربي

توزيع الطحالب المصاحبة لنبات الشورى فى بعض الأماكن على ساحل البحر الأحمر بإستخدام تقنية الإستشعار عن بعد

أشرف يوسف[١] – عادل فهمى[١] – بشرى سالم[٢]

١. قسم علم النبات – كلية العلوم – جامعة عين شمس
٢. قسم علوم البيئة – كلية العلوم – جامعة الإسكندرية

تم خلال هذه الدراسة إستخدام تقنية الإستشعار عن بعد لرصد الطحالب البحرية المصاحبة لنبات الشورى على طول ساحل البحر الأحمر وذلك بإستخدام صور الأقمار الصناعية لاندسات مع المشاهدة الحقلية فى منطقتى الغردقة وجزيرة سفاجا. أوضحت الدراسة أن نبات المانجروف يمثل على طول الشاطئ بأشجار صغيرة يصل إرتفاعها حوالى ٥ متر على طول ساحل الغردقة وسفاجا. تم دراسة الخواص الطبيعية والكيميائية للتربة المصاحبة للنبات. أظهرت الدراسة وجود ٢٣ نوعاً من الطحالب المصاحبة لنبات الشورى وكانت مجموعة الريدوفايت هى أكثر الأنواع تمثيلاً بينما تواجدت الطحالب الحمراء والخضراء والبنية مع أماكن تواجد الشعاب المرجانية. أوضحت دراسة الأقمار الصناعية أن مناطق الدراسة يمكن تقسيمها إلى خمس مناطق وهى أعماق البحار – الشعاب المرجانية – الطحالب المصاحبة للشعاب المرجانية – نبات الشورى – الطحالب الأرضية