BIODIVERSITAS
Volume 23, Number 5, May 2022
Pages: 2295-2303

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d230507

The relationship between seagrass abundance, distribution and the abiotic factors in Big Gifton and Abu Minqar islands, Red Sea, Egypt

MOHAMED A.W.S. EBEAD[1], HUSSEIN N.M. HUSSEIN[2,♥], HASSANIEN GOMAA[1], MOHAMED ABDELMOTTALEB[1], ALDOUSHY MAHDY[3]

[1]Department of Chemistry, Faculty of Science, Al-Azhar University. Assiut Branch, Assiut 71524, Egypt
[2]National Institute of Oceanography and Fisheries, Red Sea Branch. Hurghada 84511, Egypt. Tel./fax.: +20-65-3500103,
[♥]email: hossein_n2010@yahoo.com
[3]Department of Zoology, Faculty of Science, Al-Azhar University. Assiut Branch, Assiut 71524, Egypt

Manuscript received: 15 March 2022. Revision accepted: 18 April 2022.

Abstract. *Ebead MAS, Hussein HNM, Gomaa H, Abdelmottaleb M, Mahdy A. 2022. The relationship between seagrass abundance, distribution and the abiotic factors in Big Gifton and Abu Minqar islands, Red Sea, Egypt. Biodiversitas 23: 2295-2303.* Seagrass communities represent spatially complex and biomass-producing systems**.** The current research aims to understand the relationship between the abundance and distribution of seagrass communities and the abiotic factors in Big Gifton Island and Abu Minqar Island, Red Sea, Egypt. Seasonal seagrass samples were collected during 2019-2020 using line-transect and quadrat techniques. Canonical Correspondence Analysis was used to determine the effect of environmental factors on the occurrence and abundance of seagrass species. Three seagrass species, i.e., *Halophila stipulacea*, *Halodule uninervis*, and *Halophila ovalis* were recorded in the two islands. The most dominant seagrass species in both locations was *H. stipulacea*, which accounted for 54% in Big Gifton and 45% in Abu Minqar Island, while *H. uninervis* and *H. ovalis* were less numerous, with a percentage cover of 23 and 24%; and 8 and 5% in Big Gifton and Abu Minqar island, respectively. *Halophila stipulacea* was highest in the winter season with a percentage of 62 % and lowest in the spring (47%) in Big Gifton, whereas it was highest in the spring (62%) and lowest in the winter (47%) on Abu Minqar Island (22%). Statistical analysis showed highly significant differences between both sites and seasons in terms of conductivity, total dissolved solids, salinity, and the presence of *H. uninervis* and *H. ovalis*. On the other hand, there were non-significant differences between both sites and seasons in terms of temperatures, dissolved oxygen, oxidation-reduction potential, nitrite, nitrate, ammonia, phosphorus and the presence of *H. stipulacea*. Throughout the year, Big Gifton had a higher mean phosphate value than Abu Minqar Island and this may be related to the highest abundance of *H. stipulacea* in Big Gifton Island. The findings of this study may aid decision-makers in the management of natural resources, particularly the seagrass beds of Big Gifton and Abu Minqar Island.

Keyword: Abu Minqar, Big Gifton, Egypt, nutrient, Red Sea, seagrass species

INTRODUCTION

Comparison to many more well-known and well-known ecosystems, such as mangrove ecosystems and coral reefs, are well-known for promoting a wide range of extremely valuable ecological amenities (Nordlund et al. 2017). Seagrass is also a vital food source for mega-herbivores such as green sea turtles and *Dugong dugon*, as well as critical habitat for a variety of organisms, including commercially and recreationally important fishing species (Flindt et al. 1999; Lamb et al. 2017). *Halophila stipulacea*, a seagrass species found in the Red Sea, has a large biological range that extends from the intertidal to depths of more than 50-70 meters. (Fishelson 1971; Lipkin 1975, 1979; Hulings 1979; Beer and Waisel 1982; Lipkin et al. 2003; El Shaffai et al. 2011). Seagrass beds usually occur in lagoons and bays in protected shallow areas. Moreover, they are inhabited by diverse fauna and are more prevalent in the shallow southern area of the Red Sea (Rasul et al. 2015). The distribution of seagrasses is primarily controlled by water transparency, type of seabed, movement of water, salinity and temperature. Mollusks, polychaetes, crustaceans, echinoderms, and fish are the major groups inhabiting seagrass beds (Osman 2007), perhaps about 10% of the species in seagrass beds occur nowhere else (Rasul et al. 2015).

Seagrasses are angiosperms, a true plant that is fully submerged in the sea, supplying the marine environment with a variety of important environmental functions (Costanza et al. 1998; Wright and Jone 2006). In comparison to many more recognized and well-known ecosystems, such as mangal ecosystem and coral reefs, seagrasses play an essential part in development of a wide variety of very valued ecosystem services (Nordlund et al. 2016). Their beds filter water, cycle nutrients, stabilize sediment and reduce the effects of waves and underwater currents (Haznedaroglu and Zeybeck 2007). Duarte and Chiscano (1999) describe the seagrass community as one of the most prolific autotrophic groups on the earth. Seagrass ecosystems are important for climate and food security, yet they are relatively unexplored and on the fringe of marine conservation (Duarte et al. 2002).

There are various global challenges for seagrass conservation, as described by Unsworth (2018). Among others, there is a lack of awareness regarding the importance of coastal systems for seagrasses, while the status of many seagrass meadows is unknown. The understanding of threatening activities at local scales is required as well as an understanding of the interactions between the socioeconomic and ecological components of seagrass systems. There is also a need for a better understanding of the connections between seagrass and climate change. Therefore, research should be broadened to generate scientific research that supports seagrass conservation.

Seagrass dispersal is affected by nutrients, water transparency, substrate type, current, salinity, and temperature (Osama et al. 2010). Seagrasses can absorb nutrients from both the sediment's interstitial water and the ambient water column. Leaves have a substantially higher turnover rate than roots and rhizomes, and they contain significantly more nitrogen and phosphorus in comparison to carbon (Erftemeijer et al. 1993). They also serve as a carbon sink, absorbing CO_2 from the atmosphere. This, in turn, aids in the slowing of global warming's effects. As a result, the majority of nutrients released by decomposition of dead seagrass tissue may end up in the water column, though burial of deposited seagrass leaves and leaf fragments in the sediment (via bioturbation) may limit this amount.

Traditionally, it has been assumed that nutrient uptake by aquatic weed roots takes precedence over uptake by leaves (Carignan and Kalff 1980). However, the nitrogen uptake by leaves can account for 30 to 90% of the total nitrogen uptake of seagrasses (Hemminga et al. 1994). Generally, tropical seagrass beds have high productivity of is due to low ambient nutrient concentrations in the water column and relatively high nutrient concentrations in the pore water (Erftemeijer et al. 1993). The high protein content and readily digested characteristics of seagrasses are critical to the long-term survival of mega-herbivores animals, including manatees, dugong, green sea turtles, and sea urchins, as well as a key habitat for a variety of creatures, including economically and recreationally important fishing species (Haznedaroglu and Zeybeck 2007; Lamb et al. 2017).

The standing crops and productivity of the Red Sea seagrass meadows are comparable to those reported from other tropical places across the world (Rasul et al. 2015). Seagrass beds are more common in the shallow water of the southern Red Sea, where they are found in lagoons and bays in sheltered shallow places and are home to rich fauna (Rasul et al. 2015). Due to the soft-bottom sediments found in these places, they tend to be concentrated in shallow water zones such as lagoons, sharms and mersas (Den Hartog 1970), they form vast meadows from the tidal zone to depths of 70 meters (Lipkin et al. 2003). The Red Sea has 12 seagrass species belonging to two families: Cymodoceaceae and Hydrocharitaceae (El Shaffai 2016). Seven species were reported in the Gulf of Aqaba, however only (*Halophila stipulacea* and *Halophila ovalis*) were reported at the extreme northern end (Wahbeh and Mahasne 1980). Along the Saudi Arabia shores, ten species of seagrass have been identified, whereas the northern end of the Gulf of Aqaba has a low quantity of seagrass due to colder temperatures and a substratum that is unsuitable for seagrass growth (Rasul et al. 2015). Nine species of seagrass have been found throughout the Yemeni Red Sea shores, however only three have been found along the Gulf of Aden shore. On the other hand, thirteen species of seagrass have been identified in the western Indian Ocean (Gullström et al. 2002). Mahdy et al. (2021) recorded 3 species of seagrass in the northern Red Sea protected area. The seagrass *Halophila stipulacea* has been characterized as having a large biological range in the Red Sea, ranging from intertidal to depths of 70 meters (El Shaffai et al. 2011).

Seagrass beds, like those found throughout the Red Sea region, stabilize nearshore sediments, provide juvenile habitat for a variety of commercially important crustaceans and fish, and provide food for important species (e.g., dugong and turtle), with nutrients and energy likely being exported to adjacent subtidal systems (Rasul et al. 2015). Most studies on seagrass communities focused on the distribution and abundance, especially in the shallow intertidal zone (Osama et al. 2010; El Shaffai 2016) and neglected the open water and the islands in the Red Sea (Mahdy et al. 2021). Therefore, the current research aims to better understand the relation between the abundance and distribution status of the seagrass community with nutrients in two islands in the Red Sea (i.e., Big Giftun and Abu Minqar) in order to assist decision-makers in managing natural resources, particularly the seagrass community.

MATERIALS AND METHODS

Study area

Big gifton island

It is located at 27° 11'05.6″ N and 33° 57` 41.6″ E, with a total area of 18 km^2 and it is approximately 11 km from the Hurghada city shore (Figure 1, Table 1). They are founded on NW-SE extended high topographic structures of about10 km long and 0.5-1.5 km wide. Big Gifton Island is an island is in sub-basins separated by structural ridges that run parallel to the Red Sea shelf's coastline. The Big Gifton Islands sequence, which consists of alternating coral reefs and sandstones deposited in the littoral to beach zone during the arid Pliocene period, is about 120 meters high (Mansour et al. 2006). This site is impacted by recreational activities from tourist visitors, diving activities and boat anchoring and other fishing activity. Seaward side of the reef is subjected to high waves and currents from the north-eastern direction. The reef is characterized by branching coral and a low abundance of massive coral with a lot of dead reefs and bleaching coral. As shown in Figure 1.

Abu minqar island

It is situated at 27° 12'14″ N and 33° 52` 06.7″ E, with an area of about 2 km^2 in total, it is about 3 km from the Hurghada shore (Figure 1, Table 1). The Island of Abu Minqar has a sandy beach and many shallow lagoons surrounding it. It is used in sports tourism activities like snorkeling and diving. This site represents an offshore exposed condition in a semi-sheltered shallow bay. The reef edge comes up to the water surface during low tide. The bay depth was 4 m with a sandy bottom and sparse coral patches and pinnacles. The site is exposed to strong wave action and weak current effects. Abu Minqar is the only island in the area with dense stands of *Avicennia* *marina* mangrove, located near the mouth of the Red Sea's Gulf of Suez. The mangrove vegetation on the island currently covers about 29 hectares (21% of the total area) and is made up of only one species of mangrove, *Avicennia marina*. Pollution associated with coastal activities, massive tourism development, and hotel constructions along the coast of Hurghada put the island at hazard.

Sampling

Samples were collected seasonally from the two sites (Big Gifton and Abu Minqar Islands) during 2019-2020. The community structure of the seagrass meadows along the two islands was collected using the Line Transect method (LT) of 100 m length as described by English et al. (1997). The number of LT was three in each island, according to the seagrass meadow on each island. The average coverage of the seagrass community was measured three times with a size of 1 m^2 for each line transect per island as described by Geneid (2009), and the data was collected under the seawater. The mean of the three quadrats was used to calculate the seagrass coverage along each transect. Publications by Kuo and Den Hartog (2001), Waycott et al. (2004), and El Shaffai (2016) were used to identify the seagrass communities. As shown in Figure 2.

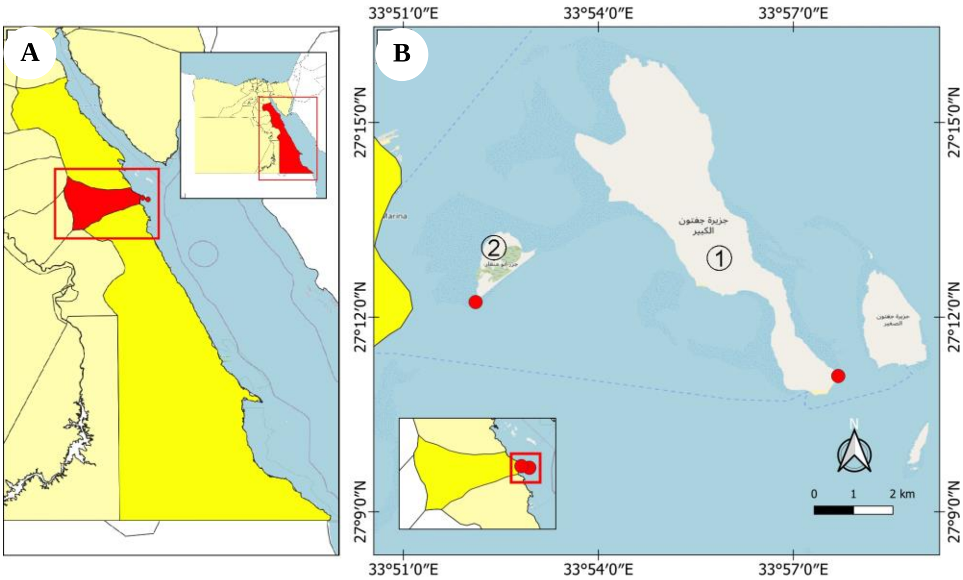

Figure 1. A. Map of Red Sea, Egypt, B. Research site for collecting and monitoring samples at 1. Gifton Island and 2. Abu Minqar Island

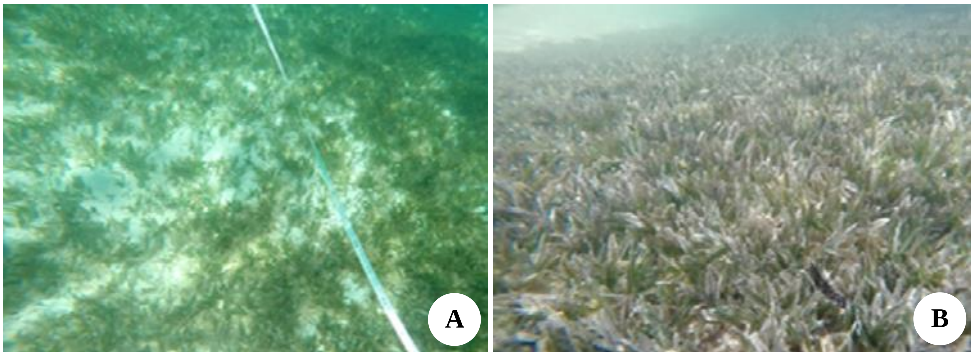

Figure 2. A. Method of measuring seagrass populations using line transect; and B. Percentage cover of seagrasses

Table 1. The geographical coordinates of the study sites at two islands in the Red Sea, Egypt

Sites	Transect	Coordinates	
		Longitudinal	Latitudinal
Site (1) Big Gifton Island	T1	27° 11`12.76″N	33° 57` 40.87″E
	T2	27° 11`8.75″N	33° 57` 42.93″E
	T3	27° 11`5.45″N	33° 57` 44.85″E
Site (2) Abu Minqar Island	T1	27° 12`36.68″N	33° 52` 36.75″E
	T2	27° 12`34.19″N	33° 52` 33.16″E
	T3	27° 12`31.41″N	33° 52` 30.37″E

Abiotic factors measurements

Water temperature (˚C), salinity (‰), dissolved oxygen content (mg/L), total dissolved solids (TDS ppm), conductivity (µs/cm), water oxidation-reduction potential (ORP) and pH values were measured directly in the field using a Hydrolab instrument. For nutrients measurement, water samples were collected and transferred in adequate cases to the lab and measured according to different methods. Ammonia NH_4^+ (μML^{-1}) was measured according to (Koroleff 1969). Dissolved nitrite NO_2^-, dissolved nitrate NO_3^- (μML^{-1}) and dissolved phosphate PO_4^- (μML^{-1}) were measured according to Grasshoff et al. (1999).

Statistical analysis

Data were analyzed using standard Analysis of Variance (ANOVA) techniques and other available analyses by SAS and SPSS (Version 22) software package to test significant differences between all dependent and independent variables observed in this study. Multivariate analysis, i.e., CCA (Canonical Corresponding Analysis), was used to determine the effect of environmental factors on one or more biota (Ekpo 2013). CCA represented by the biplot, is made up of two main axes and four quadrants. The effect of a parameter on the species and sampling sites in a quadrant shows a positive correlation but negative in the adjacent quadrant. The environmental factors are represented by the arrows, which show that the longer the arrows, the more the effect of the factors on seagrass species in particular sampling sites. CCA was made up by using the program "Canoco for Windows 4.5".

RESULTS AND DISCUSSION

Physico-chemical parameters

Seawater temperatures: Water temperature follows the seasonal change in both sites, with a mean average in all seasons was 23.6°C in Big Gifton Island and 24.9°C in Abu Minqar Island, the lowest mean were 11.90 and 13.80°C in winter in Big Gifton and Abu Minqar Island, respectively, where the highest means were 31.05 and 32.18°C in the two islands Big Gifton and Abu Minqar Island, respectively (Figure 3).

Seawater salinity: The mean salinity in the two sites was 39.9‰ in Big Gifton and 41.3‰ in Abu Minqar Island.

Dissolved oxygen contents: The mean value of dissolved oxygen in all seasons was 6.6 mg/L in Big Gifton and 11 mg/L in Abu Minqar. The lowest mean was 8.9 mg/L in winter month in Big Gifton and in spring in Abu Minqar Island. The highest mean value was 14.7 in the summer season in Big Gifton and was 13.4 in Abu Minqar Island in the winter season (Figure 3).

Total dissolved solid: The mean value of total dissolved solids in all seasons was 12.1 mg/L in Big Gifton and 39.1 mg/L in Abu Minqar. The lowest mean was 83.2 mg/L in spring in Big Gifton was 38.3 in winter in Abu Minqar island. The highest mean value was 39.3 mg/L in the winter season in Big Gifton and was 40.2 mg/L in Abu Minqar Island in the spring season (Figure 2).

Seawater conductivity: The mean value of seawater conductivity showed remarkable seasonal variations. The lowest seasonal mean was 59.3 & 62.0 µs/cm in spring, and the highest value was 60.1 and 64.1 µs/cm during winter and summer in Big Gifton and Abu Minqar Island respectively (Figure 3).

Seawater Oxidation Reduction Potential (ORP): The mean result of Oxidation Reduction Potential (ORP) in all seasons was 243.3 in Big Gifton and 242.6 in Abu Minqar Island. The lowest mean value was 185.4 in spring at Big Gifton and was 159.3 in spring at Abu Minqar Island, while the highest mean value was 346 in winter at Big Gifton and 314.5 in autumn at Abu Minqar Island (Figure 3).

Ammonia (NH_4^+): The mean value of Ammonia (NH_4^+) in all seasons was 0.88 µg/L in Big Gifton Island and was 1.2 µg/L in Abu Minqar Island. The lowest mean value was 0.5 µg/L during spring in Big Gifton and was 0.6 µg/L during autumn in Abu Minqar Island. The highest mean value was 1.5 µg/L during summer in Big Gifton and was 2.8 µg/L in summer in Abu Minqar Island (Table 2).

Nitrites (NO_2^-): The mean value of Nitrites (NO_2^-) in all seasons was 0.05 µg/L in the two sites, the lowest was 0.04 µg/L in the autumn and winter in both sites. The highest mean value was 0.08 in summer in Big Gifton and was 0.08 in spring in Abu Minqar Island (Table 2).

Nitrates (NO_3^-): The mean value of Nitrates (NO_3^-) in all seasons was 0.45 µg/L in Big Gifton Island and was 0.59 µg/L in Abu Minqar Island. The lowest mean value was 0.22 µg/L in winter in Big Gifton and was 0.24 µg/L during autumn in Abu Minqar Island. The highest mean value was 1.3 µg/L during summer in Big Gifton and was 1.1 µg/L in spring in Abu Minqar Island (Table 2).

Phosphates (PO_4^-): The mean value of phosphate (PO_4^-) in all seasons was 0.34 µg/L in Big Gifton Island and was 2.9 µg/L in Abu Minqar Island. The lowest mean value was 0.2 µg/L during autumn in Big Gifton and was 0.12 µg/L during autumn in Abu Minqar Island. The highest mean value was 0.5 µg/L during spring in Big Gifton and Abu Minqar Island (Table 2).

The statistical analysis using MANOVA showed statistical non-significant differences between sites and seasons and (NO_2^- and NO_3^-) while showing significant differences between sites and season and (NH_4^+). On the other hand, there are significant differences between season and (PO_4^-). The statistical analysis using MANOVA showed statistical highly significant differences between sites and all physical parameters while showing significant differences between season and T C°, S ‰, and ORP. On the other hand, there are non-significant differences between seasons and DO mg/L, TDS, and Cond. Mv, Respectively. Probability values $\leq$ 0.05 were defined as significant throughout the present study; however, the values > 0.05 were defined as non-significant.

Data were subjected to Canonical Correspondence Analysis (CCA) to determine the effect of the physicochemical parameters on the seagrass species. CCA represented by the biplot, is made up of two main axes and four quadrants. The effect of a parameter on the species in a quadrant shows a positive correlation but negative in the adjacent quadrant. The physicochemical parameters are represented by the arrows, which show that the longer the arrows, the more the effect of the factors on seagrass species in a particular sampling site.

In site 1 (Gifton island), some of the seagrass species showed a response to the changes of the physicochemical parameters recorded. There was a positive correlation between the seagrass species and some of the physicochemical parameters such as water temperature, DO, TDS, salinity, ORP and NO_3. The parameters of ORP and DO were the highest effective parameters on the abundance of seagrass species; *Halophila ovalis*. Parameters of TDS, Salinity and NO_3 had a positive correlation on the abundance of the seagrass species; *Halophila stipulacea*, as shown in Figure 4.

In site 2 (Abu Minqar Island), there were highly positive correlations between the parameters of water temperature and NH_4, and the seagrass species of *Halodule uninervis*. In contrast, there was a negative correlation between PO_4 and the same seagrass species of *Halodule uninervis.* On the other hand, there was a highly positive correlation between parameters of salinity and TDS and seagrass species and *Halophila stipulacea*, as shown in Figure 4.

Seagrasses abundance and distribution

In the present study, each island was represented in 3 line transects and each transect was represented in 3 quadrats. The results here will show the mean value of all three line transects in each island. Three species of seagrass were recorded in the two sites (Big Gifton and Abu Minqar Island), namely *Halophila stipulacea*, *Halodule uninervis* and *Halophila ovalis* (Table 3). *Halophila stipulacea* was the dominant seagrass species in both sites, with a percentage of 54% in Big Gifton and 45% in Abu Minqar Island. The second two seagrass species were less abundant, with a percentage cover was 23 and 24%; and 8 and 5% for *Halodule uninervis* and *Halophila ovalis* in Big Gifton and Abu Minqar, respectively (Table 3). Big Gifton Island had a higher abundance and distribution of the three seagrass species than Abu Minqar.

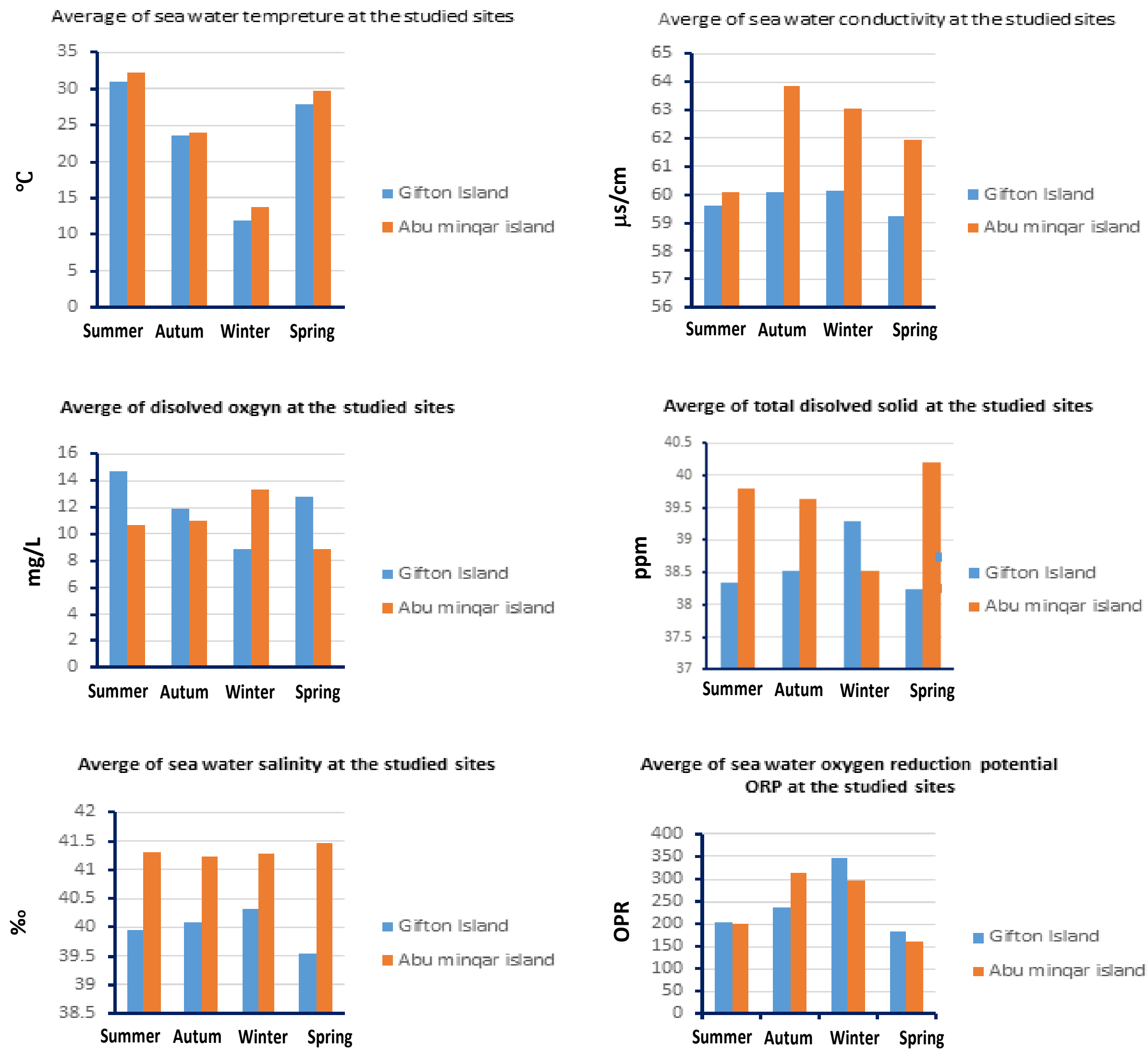

Figure 3. Seasonal variation of physical parameters of sea water at the two studied sites

Table 2. Average chemical analysis of sea water nutrients at Gifton and Abu Minqar Islands, Hurghada, Red Sea, Egypt

Sites and Seasons	Parameters	Ammonia NH_4^+ (µg/L)	Nitrites NO_2^- (µg/L)	Nitrates NO_3^- (µg/L)	Phosphates PO_4^- (µg/L)
Site (1) Gifton island	Summer	1.51	0.08	1.32	0.25
	Autumn	0.60	0.04	0.40	0.17
	Winter	0.86	0.04	0.22	0.36
	Spring	0.53	0.07	0.75	0.49
	Mean	0.88	0.05	0.45	0.34
	SD	0.41	0.02	0.45	0.13
Site (2) Abu Minqar island	Summer	2.82	0.13	0.50	0.12
	Autumn	0.59	0.04	0.24	0.18
	Winter	0.68	0.04	0.46	0.22
	Spring	0.55	0.08	1.06	0.46
	Mean	1.16	0.05	0.59	0.29
	SD.	1.03	0.04	0.33	0.14

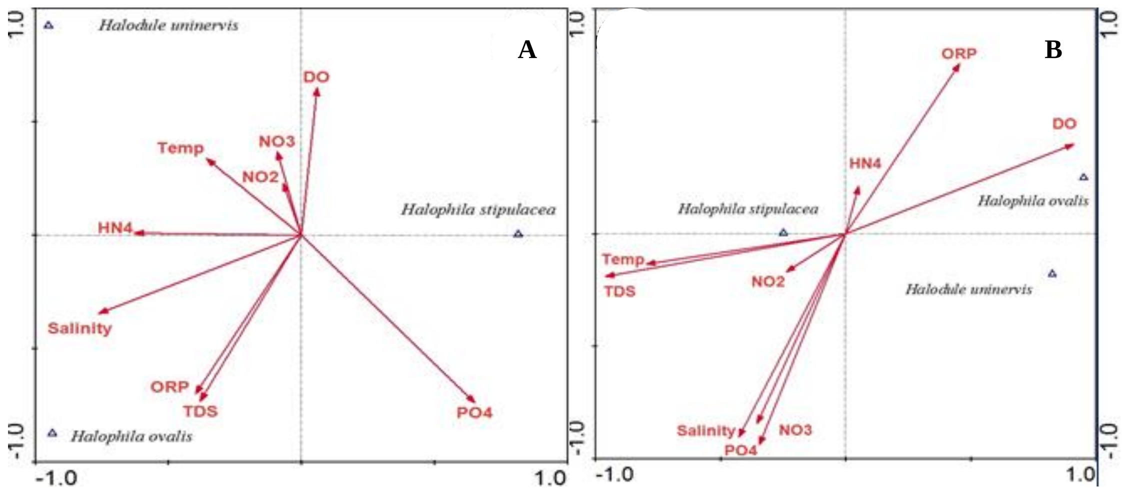

Figure 4. Ordination diagram of Canonical Correspondence Analysis (CCA) of the three studied seagrasses species for abundance data collected from sites 1 and 2, and Corresponding Environmental Parameters

In Big Gifton, *Halophila stipulacea* was highest in the winter season with a percentage of 62% and lowest on the spring (47%), whereas in Abu Minqar Island, it was highest in the spring (62%) and lowest in the winter (22%) (Table 3). In Big Gifton, *Halodule uninervis* was highest in the summer season (35%) and lowest on the spring (5%), whereas in Abu Minqar Island, it was highest in the winter (12%) and lowest in the autumn (5%) (Table 3). Finally, in Big Gifton, *Halophila ovalis* was highest in the winter season (42%) and lowest in the spring (7%), whereas in Abu Minqar Island, it was higher in the winter (8%) and lower in the spring (2%) (Table 3).

Discussion

In the present study, minor changes of physicochemical variables (i.e., seawater temperature, seawater salinity, dissolved oxygen DO, total dissolved solids TDS, seawater conductivity and oxidation-reduction potential) in water were observed at the two sites. Water temperature is probably the most important environmental variable which affects the organisms as well as chemical and biological reactions in water (Pastor 2021). In natural water bodies, water temperature is subject to great variations due to several factors, such as air temperature, seasonal variation, winds, depth, waves, gain, or loss of heat in shallow waters close to the coast. In the present study, as a result of climatic changes, the temporal distribution of water temperature was in the following order: summer > spring > autumn > winter. The current results of water temperature ranged between 11.9°C in winter and 31.8°C in summer, which varied significantly throughout the study period and this could be attributed to solar radiation and seasonal changes in air temperature. Temperature levels observed in this study are in agreement with the results of previous studies by Abdelmongy and El-Moselhy (2015) and Dorgham et al. (2012). A slightly higher temperature was recorded at Abu Minqar during all seasons due to water mixing and low water current in the island and the site is open to seawater.

Table 3. Percentage cover of seagrass species abundance in Big Gifton Island and Abu Minqar Island, Egypt during the four seasons

Sites		*Halophila stipulacea*				*Halodule uninervis*				*Halophila ovalis*			
Big Gifton island	No./S	Q1	Q2	Q3	Mean	Q1	Q2	Q3	Mean	Q1	Q2	Q3	Mean
	L1	45	75	75	65	45	60	45	50	60	45	30	45
	L2	75	60	45	60	15	15	30	20	45	15	0	20
	L3	30	60	60	50	30	45	30	35	45	30	15	30
	Summer	50	65	60	58	30	40	35	**35**	50	30	15	**32**
	L1	60	75	60	65	45	60	45	50	0	0	0	0
	L2	60	60	0	40	15	15	0	10	0	15	0	5
	L3	45	45	30	40	15	30	15	20	45	60	15	40
	Autumn	55	60	30	**48**	25	35	20	**27**	15	25	5	**15**
	L1	75	60	75	70	30	30	45	35	0	30	45	25
	L2	45	60	75	60	30	15	30	25	45	30	60	45
	L3	60	45	60	55	15	0	15	10	60	45	60	55
	Winter	60	55	70	**62**	25	15	30	**23**	35	35	55	**42**
	L1	60	30	15	35	15	0	0	5	0	0	30	10
	L2	60	60	0	40	0	0	15	5	0	0	30	10
	L3	75	60	60	65	15	0	0	5	0	0	0	0
	Spring	65	50	25	**47**	10	0	5	**5**	0	0	20	**7**
Total mean					**54**				**23**				**24**
Abu Minqar Island	L1	75	60	30	55	15	0	15	10	0	15	0	5
	L2	30	45	60	45	15	0	0	5	0	0	15	5
	L3	30	30	15	25	0	15	0	5	15	0	0	5
	Summer	45	45	35	**42**	10	5	5	**7**	5	5	5	**5**
	L1	75	60	45	60	15	0	0	5	0	0	0	0
	L2	45	60	60	55	15	0	0	5	15	0	15	10
	L3	30	60	45	45	0	15	0	5	15	0	0	5
	Autumn	50	60	50	**53**	10	5	0	**5**	10	0	5	**5**
	L1	30	15	30	25	15	15	15	15	0	0	0	0
	L2	45	15	15	25	15	0	15	10	15	15	15	15
	L3	15	15	15	15	0	15	15	10	0	15	15	10
	Winter	30	15	20	**22**	10	10	15	**12**	5	10	10	**8**
	L1	75	75	60	70	0	0	0	0	0	0	0	0
	L2	75	75	60	70	0	0	0	0	0	0	0	0
	L3	75	30	30	45	15	15	30	20	15	0	0	5
	Spring	75	60	50	**62**	5	5	10	**7**	5	0	0	**2**
Total mean					**45**				**8**				**5**

Salinity is an important ecological variable and it is important in some chemical processes, it also has a strong effect on nutrients levels at the coastal areas (Alldred et al. 1997). In the present study, the highest salinity values observed in Abu Minqar Island could be associated with a higher temperature that leads to an increased evaporation rate of seawater. Comparing with the previous studies, the present study has the same range of salinity (Abdel-Halim et al. 2007; Madkour 2013; Abdelmongy and El-Moselhy 2015).

In the present study, the highest mean of dissolved oxygen may be attributed to the variations in an ambient abiotic factor that might affect the rate of bacterial activity, decomposition of organic matter as well as solubility of dissolved oxygen (Abdelmongy and El-Moselhy 2015). On the one hand, dissolved oxygen is one of the key factors that affect the survival, activity, biological processes, and production of fauna and flora (Goher et al. 2018); on the other hand, too high or too low dissolved oxygen levels can harm aquatic life and affect water quality (Goher et al. 2018). The seawater at both sites (Big Gifton and Abu Minqar Island) was oxygenated throughout the year, making it suitable for aquatic organisms and fish life. This could be due to the abundance of phytoplankton and seagrass (MPCA 2019).

Ammonia is a good indicator for determining seawater pollution. It is a highly variable parameter that is quickly produced and processed by bacteria as organic matter decomposes (Abu Hilal and Abu Alhaija 2010). According to the current findings, the mean value of the two sites was 0.88 µg/L in Big Gifton and 1.1 µg/L in Abu Minqar. The levels of ammonia in the present study were found to be lower than those reported by Abdelmongy and El-Moselhy (2015) in the Northern Red Sea, and Soliman et al. (2015) and Diab (2017) in the Suez Canal and Suez Gulf, respectively. Ammonia is a biologically active compound present in most water as a normal biological degradation product of organic nitrogen. It can be utilized directly as nutrients by several algal species and aquatic plants (Guerrero and Jones 1996).

Nitrite is an intermediate chemical formed by the oxidation of ammonia or the reduction of nitrate, and it can be eliminated from the solution during phytoplankton nitrogen absorption. But it has the highest toxicological significance of human health if present in a perceptible concentration in diets. In the present study, nitrite did not change in different sites, with mean in all seasons was 0.05. This result is in agreement with the range of nitrite from 0.01 µg/L to 3.5 µg/L in the sea was reported by Nassar et al. (2014); Abdelmongy and El-Moselhy (2015); and Soliman et al. (2015).

Nitrate is considered as the most stable and predominant inorganic nitrogen form in seawater which is produced naturally as part of the nitrogen cycle when bacteria breaks down toxic ammonia wastes first into nitrite, then in to nitrate. In oxygenated water, nitrate is the most stable form of inorganic nitrogen. In natural water, it is the end product of the nitrification process. In this study, it was higher (0.6 µg/L) on Abu Minqar Island than on Big Gifton Island (0.5 µg/L). Summer had the highest seasonal mean, while winter had the lowest (Big Gifton), which could be attributed to plant assimilation in addition to the denitrification process (i.e., the reduction of nitrate to nitrite before releasing N_2O or N_2 molecules). Nitrate mean values were found to be lower than those reported by Diab (2017), Hamed et al. (2010) in the northern part of the Suez Gulf; and that reported by Soliman et al. (2015) in the Suez Canal but higher than that reported by Abdelmongy and El-Moselhy (2015) and Nassar et al. (2014) in the Northern Red Sea.

Nitrates stimulate the growth of plankton and water weeds that provide food for fish. Also, at winter, mixing increased nitrate enrichment into the euphotic zone from deeper water (Al-Qutob et al. 2002), which indicates the maximum nitrate concentrations at the different sites during winter, while the lower concentrations during the other seasons may be due to high flourishing of phytoplankton observed. Generally, the increase in nitrate content of seawater is followed by an increase in both production and chlorophyll-a level (Domingo-Ferrer 1996).

In the present study, the phosphorus concentrations varied from season to season and between the two islands. The higher was in Abu Minqar (0.34 µg/L) and the lower (0.29 µg/L) was in Big Gifton. Generally, phosphate concentrations are depressed in the season of highest primary production, in conformance with phosphate's role as a major nutrient. Phosphate could be considered as a limiting nutrient for phytoplankton growth (Conkright et al. 2000). The results of phosphorous in the current study were in the range reported by Soliman et al. (2015) in the Suez Canal and Abdelmongy and El-Moselhy (2015) and Nassar et al. (2014) in the northern Red Sea. The reason for the low phosphate concentrations during autumn and summer in Big Gifton and summer and winter in Abu Minqar is because of the uptake by phytoplankton and primary producers and maybe the variation was also associated with the levels of impacts (Al-Qutob et al. 2002).

From the 12 species of seagrass recorded in the Red Sea, three of them, namely, *Halophila stipulacea*, *Halodule uninervis*, and *Halophila ovalis*, were identified in the current study (El Shaffai 2016). Overall, research on the northern Red Sea seagrass community agrees with the findings of this study. Al Rousan et al. (2011) studied the distribution and abundance of seagrass communities in three locations along the Jordanian coast in the Gulf of Aqaba, Red Sea. They found the same three seagrass species in all three locations, and they agree with us that *Halophila stipulacea* has the most widespread distribution.

The current study matched those of Geneid (2009), who recorded seagrass distribution in different Red Sea locations and discovered two species, *Halophila stipulacea* and *Halodule uninervis*, on two northern Red Sea islands (Tawila Island and Um ElHimat Island). Also, our findings are very similar to those of Mahdy et al. (2021), who found the same three species in different Red Sea Northern Islands. In the present study, the low ambient nutrient in both sites and the high abundance of seagrass may be due to the low ambient nutrient concentrations in the water column and relatively high nutrient concentrations in the pore water that define tropical seagrass habitats (Erftemeijer et al. 1993).

In the present study, the biomass of seagrass species *Halophila stipulacea*, *Halodule uninervis* and *Halophila ovalis* were higher in Big Gifton with a percentage cover 54%, 23% and 24% percent cover than Abu Minqar 45%, 8%, and 5% the percentage cover for the three species, respectively. This finding may be related to phosphorous concentration in Big Gifton, which was higher than that in Abu Minqar Island, or due to the negative effect of the kite surfing sport that occurred in the Abu Minqar Island that is responsible for the

negative effects of sediment loading as this widely reported in seagrass meadows (Cabaço et al. 2008). To determine which of the physicochemical parameters regulate seagrass community within the studied sites, Canonical correspondence analysis (CCA) was applied. The result indicated that factors that have a great effect on the density of seagrass taxa were: water temperature followed by water current velocity, DO, Turbidly and TDS.

In conclusion, the remarkable abundance and extended distribution of seagrass communities in Big Gifton Island and Abu Minqar Island should be followed by a monitoring program and marine survey related to the affecting of physical and chemical parameters on seagrasses distribution and abundance.

REFERENCES

Abdel-Halim A, Aboel-Khair E, Fahmy M, Shridah M. 2007. Environmental assessment on the Aqaba Gulf coastal waters, Egypt. Egy J Aqu Res 33 (1): 1-14.

Abdelmongy AS, El-Moselhy KM. 2015. Seasonal variations of the physical and chemical properties of seawater at the Northern Red Sea, Egypt. Open J Ocean Coast Sci 21-17. DOI: 10.15764/OCS.2015.01001.

Abu-Hilal AH, Abu-Alhaija MM. 2010. Nutrients in water and sediments of King Talal Dam-Jordan. Jordan J Biol Sci 3 (3): 87-100.

Al Rousan S, Al Horani F, Eid E, Khalaf M. 2011. Assessment of seagrass communities along the Jordanian coast of the Gulf of Aqaba, Red Sea. Mar Biol Res 7 (1): 93-99. DOI: 10.1080/17451001003660319.

Alldred M, Liberti A, Baines SB. 2017. Impact of salinity and nutrients on salt marsh stability. Ecosphere 8 (11): e02010. DOI: 10.1002/ecs2.2010.

Al-Qutob M, Hase C, Tilzer MM, Lazar B. 2002. Phytoplankton drives nitrite dynamics in the Gulf of Aqaba, Red Sea. Mar Ecol Prog Ser 239: 233-239. DOI: 10.3354/meps239233.

Beer S, Waisel Y. 1982. Effects of light and pressure on photosynthesis in two seagrasses. Aquat Bot 13: 331-337. DOI: 10.1016/0304-3770 (82)90068-7.

Cabaço S, Santos R, Duarte CM. 2008. The impact of sediment burial and erosion on seagrasses: A review. Estuar Coast Shelf Sci 79: 354-366. DOI: 10.1016/j.ecss.2008.04.021.

Carignan R, Kalff J. 1980. Phosphorus sources for aquatic weeds: Water or sediments?. Science 207: 987 -989.

Conkright M, Gregg W, Levitus S. 2000. Seasonal cycle of phosphate in the open ocean. Deep Sea Res Part I: Oceanogr Res Papers 47 (2): 159-175. DOI: 10.1016/S0967-0637(99)00042-4.

Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M. 1998. The value of ecosystem services: Putting the issues in perspective. Ecol Econ 25: 67-72.

Den Hartog C. 1970. The Seagrasses of the World. Amsterdam, Holland.

Diab HM. 2017. Petroleum Hydrocarbons Assessment in water, sediment and some biota in the Gulf of Suez. [Thesis]. Marine Science Department, Suez Canal University, Egypt.

Domingo-Ferrer J. 1996. Heavy metal pollution in Coastal Red Sea Waters, Jeddah. KAU Mar Sci 7: 67-74.

Dorgham M, El-Sherbiny M, Hanafi M. 2012. Environmental properties of the southern Gulf of Aqaba, Red Sea, Egypt. Mediterr Mar Sci 13 (2): 179-186. DOI: 10.12681/mms.297.

Duarte CM. 2002. The future of seagrass meadows. Environ Conserv 29: 192-206. DOI: 10.1017/S0376892902000127.

Duarte CM, Chiscano CL. 1999. Seagrass biomass and production: A reassessment. Aquat Bot 65: 159-174. DOI: 10.1016/S0304-3770(99)00038-8.

Ekpo I. 2013. Effect of physico-chemical parameters on zooplankton species and density of a tropical rainforest river in Niger Delta, Nigeria using canonical cluster analysis. Intl J Eng Sci 2 (4): 13-22.

El Shaffai A. 2016. Field Guide to Seagrasses of the Red Sea. Second Edition. IUCN and Courbevoie, Total Foundation, France.

El-Shaffai AA, Hanafy MH, Gab-Alla AA. 2011. Distribution, abundance and species composition of seagrasses in Wadi El-Gemal National Park, Red Sea, Egypt. Indian J Appl Sci 4 (3): 1-8. DOI: 10.15373/2249555X/MAR2014/161.

English S, Wilkinson C, Baker V. 1997. Survey Manual for Tropical Marine Resources. Australian Institute of Marine Science, Townsville, Australia.

Erftemeijer PLA, Osinga R, Mars A. 1993. Primary production in seagrass beds in South Sulawesi (Indonesa): A comparison of habitats, methods and species. Aquat Bot 46: 67-90. DOI: 10.1016/0304-3770(93)90065-5.

Fishelson L. 1971. Ecology and distribution of the benthic fauna in the shallow waters of the Red Sea. Mar Biol 10: 113-133. DOI: 10.1007/BF00354828.

Flindt MR, Pardal MA, Lillebø AI, Martins I, Marques JC. 1999. Nutrient cycling and plant dynamics in estuaries: A brief review. Acta Oecologica 20: 237-248. DOI: 10.1016/S1146-609X(99)00142-3.

Geneid Y. 2009. Distribution of seagrass species along the Egyptian Red Sea coast. Egypt J Aquat Res 35 (1): 58-68.

Goher ME, El-Rouby WMA, El-Dek SI, El-Sayed SM, Noaem SG. 2018. Water quality assessment of Qarun Lake and heavy metals decontamination from its drains using nanocomposites. IOP Conf Ser: Mater Sci Eng 464: 012003. DOI: 10.1088/1757-899X/464/1/012003.

Grasshoff K, Kremling K, Ehrhardt M. 1999. Methods of Seawater Analysis. 3rd edition. Wiley-VCH, Weinheim.

Guerrero MA, Jones RD. 1996. Photo inhibition of marine nitrifying bacteria, I. Wavelength-dependent response. Mar Ecol Prog Ser 141 (1): 183-192.

Gullström M, de la Torre-Castro M, Bandeira SO, Bjork M, Dahlberg M, Kautsky N, Rönnbäck P, Öhman MC. 2002. Seagrass ecosystems in the western Indian Ocean. Ambio 31: 588-596. DOI: 10.1579/0044-7447-31.7.588.

Hamed MA, Soliman YA, Khodir AE, Soliman AH, El-Agroudy NA, Hussein F. 2010. Physico-chemical characteristics of Suez Bay water during 2006-2007, Egypt J Aquat Biol Fish 14: 43-57. DOI: 10.21608/EJABF.2010.2051.

Haznedaroglu MZ, Zeybeck U. 2007. HPLC determination of chicoric acid in leaves of *Posidonia oceanica*. Pharm Biol 45 (10): 745-748. DOI: 10.1080/13880200701585717.

Hemminga MA, Koutstaal BP, Van Soelen J, Merks AGA. 1994. The nitrogen supply to intertidal eelgrass (*Zostera marina* L.). Mar Biol 118: 223-227. DOI: 10.1007/bf00349788.

Hulings NC. 1979. The ecology, biometry and biomass of the seagrass Halophila stipulacea along the Jordanian coast of the Gulf of Aqaba. Bot Mar 22: 42530. DOI: 10.1515/botm.1979.22.7.425.

Koroleff F. 1969. Determination of ammonia as indophenol blue," International Council for the Exploration of the Sea (ICES).

Kuo J, Den Hartog C. 2001. Seagrass Taxonomy and Identification Key. Global Seagrass Research Methods. Elsevier science publishers, Amsterdam.

Lamb JB, Water JA, Bourne DG, Altier C, Hein MY, Fiorenza EAN, Abu N, Jompa J. 2017. Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates. Science 355: 731-733. DOI: 10.1126/science.aal1956.

Lipkin Y. 1975. A history, catalogue and bibliography of Red Sea seagrasses. Isr J Bot 24: 89-105.

Lipkin Y. 1979. Quantitative aspects of seagrass communities, particularly those dominated by. *Halophila stipulacea*, in Sinai (Northern Red Sea). Aquat Bot 7: 11928. DOI: 10.1016/0304-3770(79)90016-0.

Lipkin Y, Beer S, Zakai D. 2003. The seagrasses of the eastern Mediterranean and the Red Sea. In: Green EP, Short FT (eds). World Atlas of Seagrasses. Berkeley, University of California Press, CA

Madkour H. 2013. Impacts of human activities and natural inputs on heavy metal contents of many coral reef environments along the Egyptian Red Sea coast. Arab J Geosci 6 (6): 1739-1752. DOI: 10.1007/s12517-011-0482-5.

Mahdy A, Ghallab A, Madkour H, Osman A. 2021. Status of seagrass community in Northern Protected Islands, Hurghada, Red Sea, Egypt. Aquat Sci Fish Res 2: 1-8. DOI: 10.21608/ASFR.2021.55440.1011.

Mansour AM, Mohamed AW, Osman M, Naser EDA, Tahoen MA. 2006. Sedimentological and geochemical studies on some island sediments of the Red Sea, Egypt. Egypt J Aquat Res 32: 105- 130. DOI: 10.1016/j.chemer.2016.02.001.

MPCA [Minnesota Pollution Control Agency]. 2019. Statement of need and reasonableness, Proposed Amendments to Rules Governing Water Quality Standards - Class 2 and Class 7 Use Designations; Minn. R. ch. 7050; Revisor's ID No. 4561. https://www.leg.state.mn.us/archive/sonar/SONAR-04561.pdf.

Nassar MZ, Mohamed HR, Khiray HM, Rashedy SH. 2014. Seasonal fluctuations of phytoplankton community and physicochemical parameters of the north western part of the Red Sea, Egypt. Egypt J Aquat Res 40: 395-403. DOI: 10.1016/j.ejar.2014.11.002.

Nordlund LM, Koch EW, Barbier EB, Creed JC. 2016. Seagrass ecosystem services and their variability across genera and geographical regions. Plos One 11 (10): e0163091. DOI: 10.1371/journal.pone.0163091.

Nordlund LM, Koch EW, Barbier EB, Creed JC. 2017. Correction: Seagrass ecosystem services and their variability across genera and geographical regions. Plos One 12 (1): e0169942. DOI: 10.1371/ journal.pone.0169942.

Osama E, Hassan A, Abou Zaid M. 2010. Distribution and status of seagrass beds around Hurghada area, Red sea, Egypt. Egypt J Aquat Res 36 (2): 295-306.

Osman E. 2007. Ecological Study on the Seagrass Beds and Associated Fauna in the Red Sea Coast (Hurghada). UNESCO Report.

Pastor F. 2021. Sea Surface Temperature: From observation to applications. J Mar Sci Eng 9: 1284. DOI: 10.3390/ jmse9111284.

Rasul NMA, Stewart ICF, Nawab ZA. 2015. The Red Sea: The Formation, Morphology, Oceanography and Environment of a Young Ocean Basin. Springer, Verlag, Berlin.

Soliman YA, Elkholy NG, Mohamedian LI, Hamed MA, Salman AA, Zaghloul GY. 2015. Distribution of some heavy metal in Suez Canal from Port Said to Suez during 2011. Environ Res J 9 (2): 241-258.

Unsworth RKF, McKenzie LJ, Collier CJ, CullenUnsworth LC, Duarte CM, Eklo FJS, Jarvis JC, Jones BL, Nordlund LM. 2018. Global challenges for seagrass conservation. Ambio 48: 801-815. DOI: 10.1007/s13280-018-1115-y.

Wahbeh MI, Mahasneh AM. 1980. Some aspects of decomposition of leaf litter of the seagrass *Halophila stipulacea* from the Gulf of Aqaba (Jordan). Aquat Bot 21 (3): 237-244. DOI: 10.1016/0304-3770(85)90051-8.

Waycott M, McMahon K, Mellors J, Calladine A, Kleine D. 2004. A Guide to Tropical Seagrasses of the Indo-West Pacific. James Cook University, Townsville.

Wright JP, Jones CG. 2006. The concept of organisms as ecosystem engineers ten years on: Progress, limitations, and challenges. Bioscience 56: 203-209. DOI: 10.1641/0006-3568(2006)056[0203:TCOOAE]2.0.CO;2.