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Seagrass Species Composition and Distribution in Coastal Water of the Red Sea in the Sudan

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Abstract: **Seagrasses are distinctive angiosperm marine plants that grow submerged in the seawater. They are one of the important marine ecosystems components that stabilize the marine and coastal environment. During the investigation seagrass species composition, percentage cover and distribution, besides some water characteristics such as temperature, salinity, transparency and hydrogen ion concentration (pH) were examined at eleven sites of Sudanese Red Sea coastal area. The seagrasses were sampled using the permanent line transects and quadrates. Analysis of variance (ANOVA) between sites and correlation coefficient for seagrass percentage cover cross environmental factors were tested on data. Nine seagrass species were encountered during the study. The highest numbers of species (7 species) and utmost average of total percentage cover (36.56 %) were encountered at Dungonab Bay. *Thalassia hemprichii* was the most dominant and widely distributed species along the coastline. The least distributed species were *Halophila minor*, *Syringodium isoetifolium*, and *Thalassodendron ciliatum* each encountered only in one site. The statistical tests of ANOVA demonstrated insignificant difference of seagrass percentage cover and environmental factors between sites but there were high significant differences of seagrass percentage cover between species. The correlation of seagrass percentage cover with environmental factors showed negative correlation with water temperature and pH, and positive correlation with salinity and transparency.**

Keywords: **Composition, Distribution, Percentage cover, Red Sea coast, Seagrass, Species, Sudan.**

1. INTRODUCTION

Seagrasses are flowering marine plants living mainly in shallow and soft-bottom waters like estuaries, lagoons, mud flats, muddy and sandy bays (Kirkman, 1990; English et al., 1997). Globally, there are about 72 documented species (Short et al., 2016). Seagrass beds involve a prospective to control chemical and physical factors in the marine water (Radke, 2000). Seagrasses comprise important donation in the feeding production (Wood et al., 1969; McRoy and Helfferich, 1977; McRoy and Helfferich, 1980). The MEPA/IUCN (1992) documented that dugongs, green turtles, and some birds and invertebrates are reliant on seagrasses. Seagrasses were the main diet for the endangered dugong (*Dugong dugon*), (Lipkin, 1975). Worldwide there are many studies and publications related to seagrass species and their taxonomy such as Phillips and Menez (1988), Kuo and Den Hartog (2001), and Waycott et al. (2004).

Jones et al. (1987) informed that the Red Sea seagrasses have not been adequately mapped, but some general summaries have appeared from the few studies on their distribution. According to Den Hartog (1970), Aleem (1979), Jacobs and Dicks (1985), El Shaffai (2016), and Sheppard (1992), the Red Sea provides asylums for twelve seagrass species.

The investigations and surveys conducted by Gaiballa (2005) and Gaiballa (2013) provided important baseline information about the distribution, species composition, diversity, abundance and associated invertebrates and fishes in some coastal sites along the Sudanese Red Sea. So far, the literature on seagrass habitats in the Sudanese Red Sea coast includes very few published studies. Within such a context, the seagrasses in the Red Sea coastal waters of the Sudan require more studies on their taxonomy, distribution, importance and threats. Special emphasis is needed on the evaluation and assessment of the role of seagrass meadows on the carbon sequestration and consequently, on their contribution in the alleviation of the severity of climate change.

The current study aimed to investigate the species composition and percentage cover of seagrasses and test the variation between the different sites and species at the eleven selected studied sites along the Red Sea coastal water of the Sudan.

2. MATERIALS AND METHODS

2.1. Study area

The study was conducted along the Sudanese Red Sea coast at eleven sites: Marsa Sheikh Saad (N 18º 49.889` E 37º 26.479`), Marsa Sheikh Ibrahim (N 18º 52.690` E 37º 24.246`), Suakin Harbour N 19º 7.373` E 37º 21.289`), Marsa Atta (N 19˚ 18.781` E 37˚ 18.947`), Marsa Bashayer (N 19º 24.00` E 37º 16.00`), Marsa Kilo Tammania (N 19º 33.231` E 37º 14.832`), Port Sudan Harbour (N 19º 35.730` E 37º 14.067`), Marsa Halout (N 19º 47.00` E 37º 15.00`), Marsa Darah (N 20˚ 08.529` E 37˚ 12.764`), Mohammed Qol (N 20º 54.033` E 37º 9.260`) and Dungonab Bay (N 21º 7.066` E 37º 7.441`) (Fig. 1).

Figure 1. Satellite Image showing the geographical location of study sites (modified from www.motherplanet.com).

2.2. Methodology

The line transects and quadrates techniques were adopted during the study according to English et al. (1997) and PERSGA/GEF (2004). Three line transects at each sampling sites were established. Regular stations by 10 m interval along transects were located. A 0.5 X 0.5 m frame divided into 25 small quadrates of 10 X 10 cm was set up at each station along transect. The seagrass identification sheets of McKenzie and Campbell (2002) and the species identification guide for fishery purposes by Carpenter et al. (1997) were utilized. The seagrass percent cover standards of McKenzie et al. (2003) were used to estimate the percent cover of seagrasses at the study sites.

For each sampling sites, the surface water temperature, salinity, transparency, and hydrogen ion concentration (pH) were measured.

2.3. Statistical analysis

Data of each sampling parameters were entered into EXCEL sheets. Data were analyzed using standard statistical methods and programme (Minitab 17). Descriptive statistical values were derived. Analysis of variance (ANOVA) was used to compare and test the variations in environmental factors between sites and the variation in percentage cover between sites and between different species. The Pearson correlation coefficient (r) was conducted to examine the relationship between seagrass percentage cover and environmental factors at sites (Pearson, 1895).

3. RESULTS

3.1. Species composition and distribution

Nine seagrass species belonging to six genera were identified and recorded from the eleven sites during the study period (Table 1). The most frequent species were *Thalassia hemprichii* (Ehrenberg) Ascherson, *Halodule uninervis* (Forsskal) Ascherson and *Halophila ovalis* (R. Brown) Hooker f., recorded at all sampling sites, followed by *Cymodocea rotundata* Ehrenberg and Hemprich ex Ascherson, *Halophila stipulacea* (Forsskal) Ascherson and *Cymodocea serrulata* (R. Brown) Ascherson and Magnus at nine, seven and three sampling sites, respectively (Table 1). The least frequentl species are *Halophila minor* (Zollinger) den Hartog, *Thalassodendron ciliatum* (Forsskal) Den Hartog and *Syringodium isoetifolium* (Ascherson) Dandy, each encountered only in one site. The uppermost numbers of species were encountered at Dungonab Bay with seven species, followed by Marsa Atta, Marsa Kilo Tammania and Port Sudan Harbour with six species. The lowest numbers of species were documented at Suakin Harbour with only three species.

Table 1. Species composition and distribution of seagrass at the study sites

Site \ Species	*Thalassia hemprichii*	*Halophila ovalis*	*Halophila stipulacea*	*Halophila minor*	*Halodule uninervis*	*Cymodocea rotundata*	*Cymodocea serrulata*	*Thalassodendron ciliatum*	*Syringodium isoetifolium*
Marsa Sheikh Saad	+	+	-	-	+	+	-	-	-
Marsa Sheikh Ibrahim	+	+	+	-	+	-	-	-	-
Suakin Harbour	+	+	-	-	+	-	-	-	-
Marsa Atta	+	+	+	-	+	+	+	-	-
Marsa Bashayer	+	+	+	-	+	+	-	-	-
Marsa Kilo Tammania	+	+	+	-	+	+	+	-	-
Port Sudan Harbour	+	+	+	-	+	+	+	-	-
Marsa Halout	+	+	-	+	+	+	-	-	-
Marsa Darah	+	+	+	-	+	+	-	-	-
Mohammed Qol	+	+	-	-	+	+	-	-	-
Dungonab Bay	+	+	+	-	+	+	-	+	+

Present (+)   Absent (-)

3.2. Percentage cover

The highest average of seagrass species percentage cover over all sites was gained by *Thalassia hemprichii* (41.57 %), followed by *Halophila stipulacea* (35.85 %) and *Halodule uninervis* (32.43 %). The lowest average of seagrass species percentage cover was obtained by *Thalassodendron ciliatum* (1.34 %) (Fig. 2).

The variation of percentage cover between different seagrass species portrayed high significant difference (f = 10.98, p = 0.00, df = 8).

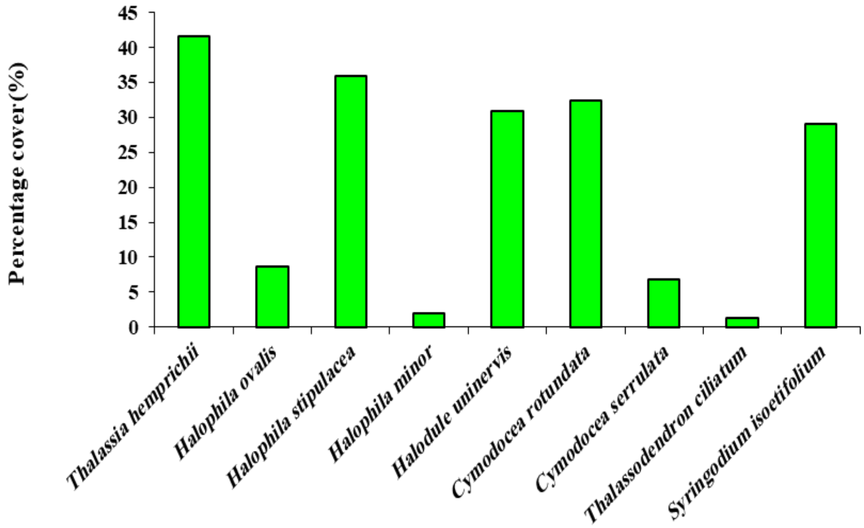

Figure 2. Average percentage cover of seagrass species for overall study sites

Halophila stipulacea achieved the highest mean of seagrass species percentage cover at Dungonab Bay (53.36 %). On the other hand, *Thalassodendron ciliatum* at Dungonab Bay scored the smallest amount of seagrass species percentage cover (0.76 %) (Fig. 3).

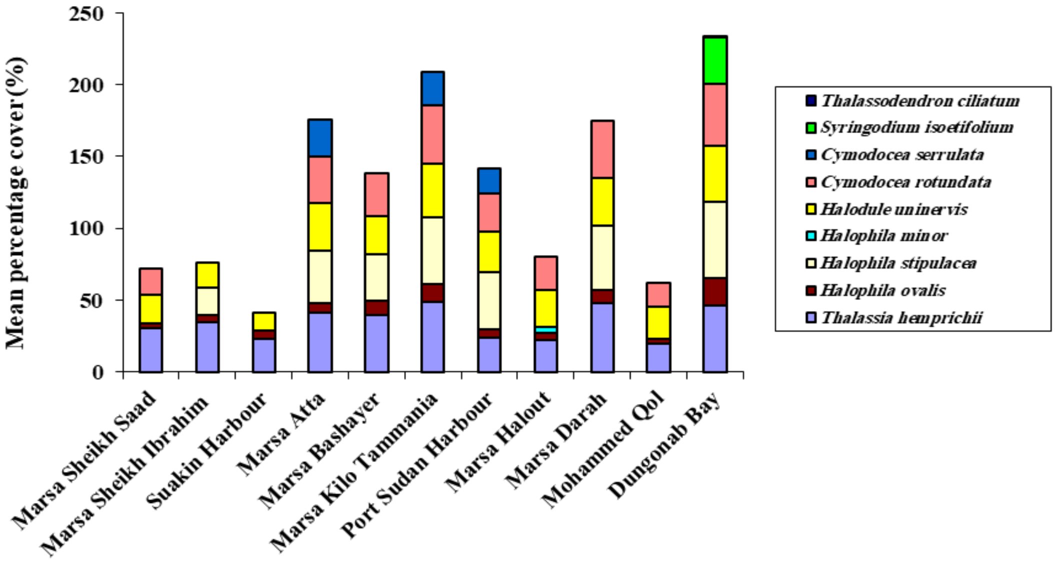

Figure 3. Mean percentage cover of seagrass species at study sites

Dungonab Bay attained the greatest average of total seagrass species percentage cover at (36.56 %), followed by Marsa Darah at (33.83 %), Marsa Atta at (26.49 %) and Marsa Kilo Tammania at (23.65 %). Suakin Harbour acquired the lowest average of total seagrass species percentage cover at (8.12 %) (Fig. 4).

The variation of seagrass total percentages cover between sites showed insignificant differences between the study sites (f = 1.87, p = 0.076, df = 10). The correlation of seagrass percentage cover with environmental factors showed negative correlation with water temperature (p = 0.368, r = -0.301) and pH (p = 402, r = -281); and positive correlation with salinity (p = 0.470, r = 0.244) and transparency (p = 0.224, r = 0.399).

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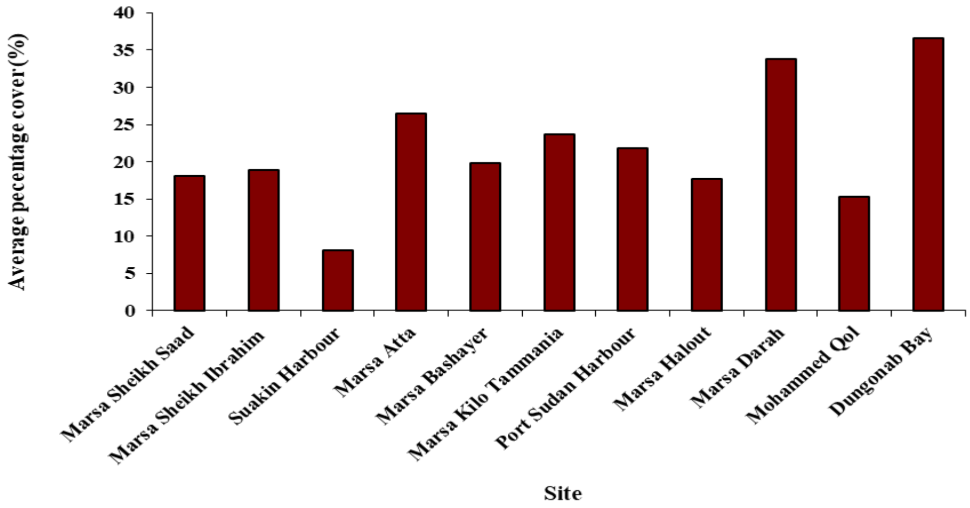

Figure 4. Average of total percentages cover of seagrass at study sites

3.3. Water characteristics

The means of surface water temperature, salinity, transparency, and pH in the study sites are demonstrated in Fig. 5 (A, B, C and D, respectively). The variations of environmental variables among sites exhibited insignificant difference ($p > 0.05$).

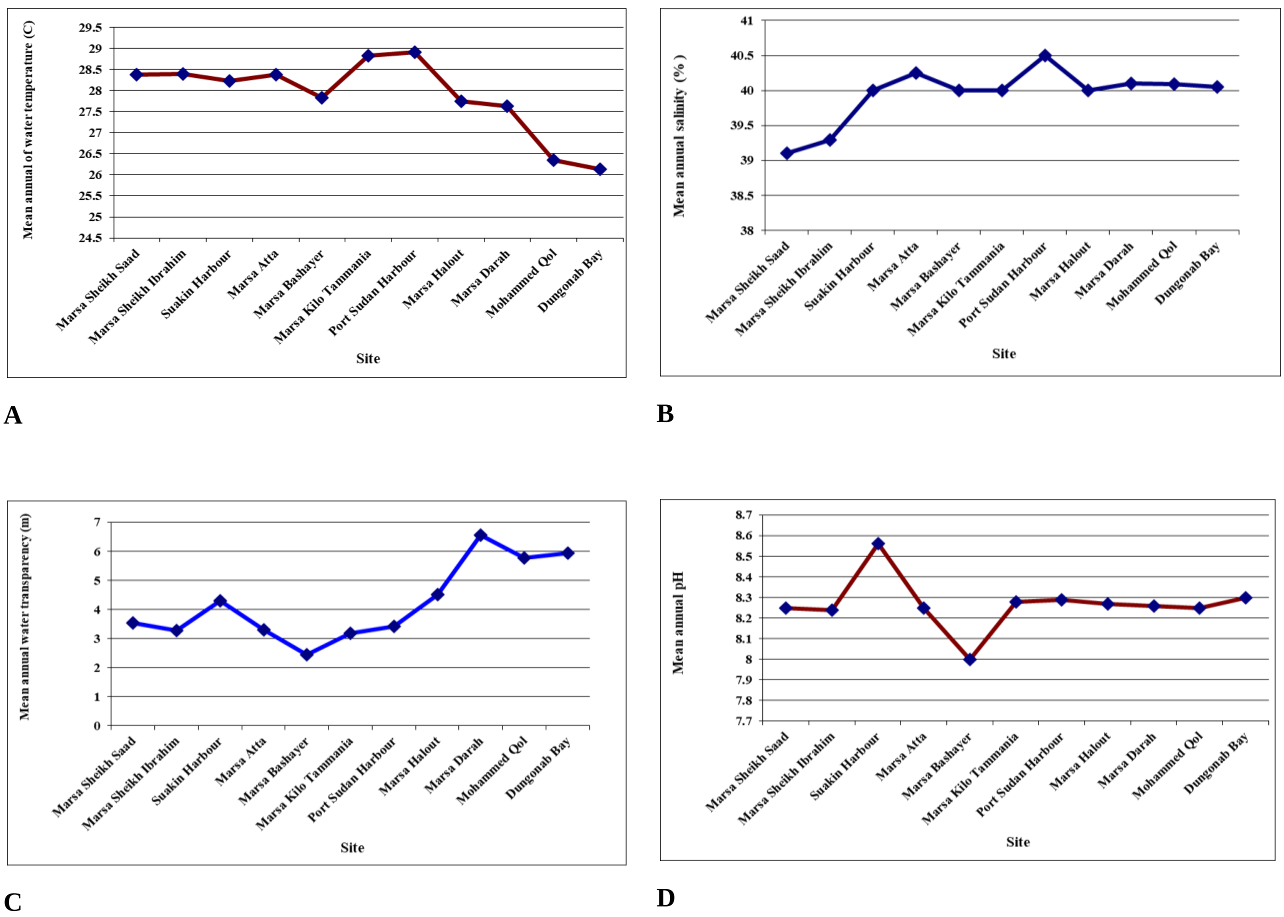

Figure 5. Means of A, water temperature (°C); B, salinity (‰); C, transparency (m) and D, pH at study sites.

4. DISCUSSION

Nine seagrass species were encountered during the present study. These species are among the twelve species that have been reported by Sheppard et al. (1992) in the Red Sea and its two northern gulfs, and known from Red Sea (Aleem, 1979; Jacobs and Dicks, 1985; Lipkin and Zakai, 2003; El Shaffai, 2016). Lipkin (1977), and Hulings and Kirkman (1982) reported only seven species in the Red Sea. Eight of the seagrass species recorded in the current investigation were among the eleven seagrass species accounted by El Shaffai et al. (2011) at the Red Sea coast of Egypt.

The most frequent and widely distributed species during the present study were *Thalassia hemprichii*, *Halodule uninervis* and *Halophila ovalis*, followed by *Cymodocea rotundata* and *Halophila stipulacea*. This may be due to their ability to grow in a wide variety of environmental conditions. Noel et al. (2012) reported that the common occurrence of *Halophila ovalis* could be attributed to its characteristics as a pioneering species.

Aleem (1984) recorded four seagrass species in the Suez Canal including *Halodule uninervis*, *Halophila stipulacea*, *Halophila ovalis* and *Thalassiah emprichii*). These four species are within the species that occurred in the present study. Wahbeh (1980) confirmed that at the extreme northern end of the Gulf of Agaba only *Halophila stipulacea*, *Halophila ovalis* and *Halodule uninervis* were present. Jones et al. (1987) found that the seagrass species *Halophila stipulacea*, *Halodule unnervis*, *Thalassodendron ciliatum*, *Syringodium isoetifolium* and *Halphila ovalis* were the commonest species in the Red Sea.

During the present study *Thalassia hemprichii* was the dominant seagrass species in percentage cover followed by *Halophila stipulacea*. The same situation was documented by Gaiballa (2013) at some sites in the Red Sea coast of the Sudan. Den Hartog (1977) considered *Thalassia hemprichii* as representing the terminal stage in seagrass succession. Wahbeh (1980) explicated that the dominance of *Halophila* species in New Argao (Philippines) is favourable for the dugongs, which are constantly seen during the present study. Ingles (2000) in Davao Gulf (Philippines), reported that seagrass species with high percentage cover comprised *Enhalus*, *Thalassia*, *Cymodocea*, *Halophila* and *Halodule*. Sheppard et al. (1992) reported that the percentage cover of seagrasses varies from site to the other, depending on species, environmental factors and impacts type and magnitude.

Most seagrass species in the current survey were encountered at shallow water less than one meter depth, with the exception of some areas where *Thalassodendron ciliatum* and *Halophila stipulacea* were observed. Environmental factors affect the distribution, abundance, and diversity of seagrasses in the marine environment (Sheppard et al., 1992; Walker et al., 1999; Touchette and Burkholder, 2000; Touchette, 2007; Cabaco et al., 2008; Kendrick et al., 2008; Leoni et al., 2008; Warry and Hindell, 2009). The slight variation in transparency between sites during the present study might be attributed to the variation in turbidity and/or other factors. The seasonal Khors (watercourses) in some of study sites may play important factors in the variation in transparency, mainly during rainy season. The study of Lipkin (1977) in Sinai specified that light and not wave action is probably the main influence on leaf shape of *Halodule uninervis*. Price et al. (1988) underlined that interaction of environmental factors almost certainly organize the occurrence of individual seagrass species.

5. CONCLUSIONS

Overall, the findings and information achieved from the current study at the coastal water of the Sudanese Red Sea will further provide a scientific base for the subsequent monitoring, management measures and sustainable development of the seagrass habitats and related fauna and flora. Specific research is needed on the role of the seagrasses of the Red Sea coast could play in the sequestration of carbon and how this role is augmented or impacted by other marine physical, chemical and biotic factors.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

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