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# SEASONAL OCCURRENCE AND VARIATIONS IN MACRO-ALGAL POPULATIONS IN HURGHADA, SAFAGA AND QUSIER COASTS OF RED SEA, EGYPT

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## ABSTRACT

The aim of this study is to provide the seasonal variations in the coastal macro-algal communities which inhabiting the upper intertidal zone of Hurghada, Safaga and Qusier coasts at the Red Sea, Egypt. The distribution of algal communities, degree of relative dominance and diversity of the species in different habitats were investigated from autumn 2005 up to summer 2006. Also, the changes in the environmental factors and the abundance of the algal species were correlated. A total of 35 algal species were recorded in the studied area, 7, 7 and 21 species of them belong to Chlorophyta, Rhodophyta and Phaeophyta, respectively. Qusier coast had the highest account of individuals / $m^2$ (12.71) and total covering (60 %) compared with Hurghada and Safaga coasts. Both Chlorophyta and Rhodophyta were more abundant (66.67 and 48.15 %, respectively) and widely distributed during the summer season along Hurghada and Safaga coasts. Meanwhile, Phaeophyta highest percentage (74.05%) was during autumn season at Qusier coast. The highest species diversity index (3.31) was recorded during autumn season at Qusier coast.

**Key words**: Algal populations, Hurghada, Safaga, Qusier, Red Sea, Egypt.

## INTRODUCTION

Floristic composition of aquatic algal flora, their distribution and sequence of periodicity can be used in evaluating ecological changes. This is of special significance as the marine environment was subjected to considerable alternation during the last decades. These changes were intensively monitored.

The Red Sea has been a region of natural history exploration by European scientists from more 240 years. The first record of marine algae in the Red Sea was by Strand (a pupil of Linnaeus's), who in his thesis on the flora of Palestine listed three species (Papenfuss, 1968). The next person to collect algae in the Red Sea was Petrus Forsskal, (1775). He was the first to describe new species from the region, followed by the British algologist (Turner, 1808, 1809, 1811 and 1819).

Nasr (1939) was the first Egyptian scientist to publish the symposia of the marine algae of the Egyptian Red Sea coast. This was one of his eight important publications during (1939-1955) in this field. Papenfuss (1968) wrote bibliography of the Red Sea benthic algae emphasizing on the taxonomy localities and distribution of species.

Aleem since 1948 till 1984 contributed several reports on species type and migration of marine algae from the Red Sea (Aleem, 1948, 1950, 1978$_{a \& b,}$ 1980 and 1984).

The Red Sea is along narrow basin separating the African from the Asiatic continent. It extends from lat 30° 00¯N and 12° -40¯ N, almost in a straight line. Its total length is 1932 Km and average breadth is 280Km. The maximum breadth is along 306 Km in the souyhern sector near Massawa. At Ras Banas, two-thirds of the way from the southern straits to the northern gulfs, the Sea is only 145 Km wide (Neumann, 1967). It attains its minimum breadth of 26 Km at the southern and of the Bab-el-Mandab strait. The average depth of the Red Sea is 491 m. The greatest depth is over 2500m in the axial trough between 22° and 19 ° N (Clark and Goher, 1953; Gohar, 1954 and Morcos, 1970).

The main objective of the present investigation is to undergo a complete survey of the algal flora inhabiting the upper intertidal zone of the Egyptian shores along the Red Sea coast, in three different areas, Hurghada, Safaga and Qusier that are distinctly differentiated in their topography. Seasonal variation of the marine algal flora, their

distribution, species composition and sequence of periodicity will be considered. The effects of some environmental factors will be taken into consideration. It aims also to illustrate the distribution of algal communities in different habitats to throw light on the degree of relative dominance, diversity of species, percentage distribution, individual counts, average standing crop, succession, and density of each species. Such study was initiated as well to correlate between the changes might take place in the environmental parameters and the above mentioned biological phenomena.

## MATERIALS AND METHODS

The aim objective of the present investigation was carried out through establishment of four permanent sites at each region for a period extended from autumn 2005 to summer 2006.

**The studied area:**

The area investigated extends along three different cities at Hurghada, Safaga and Qusier coasts on Red Sea (Fig. 1).

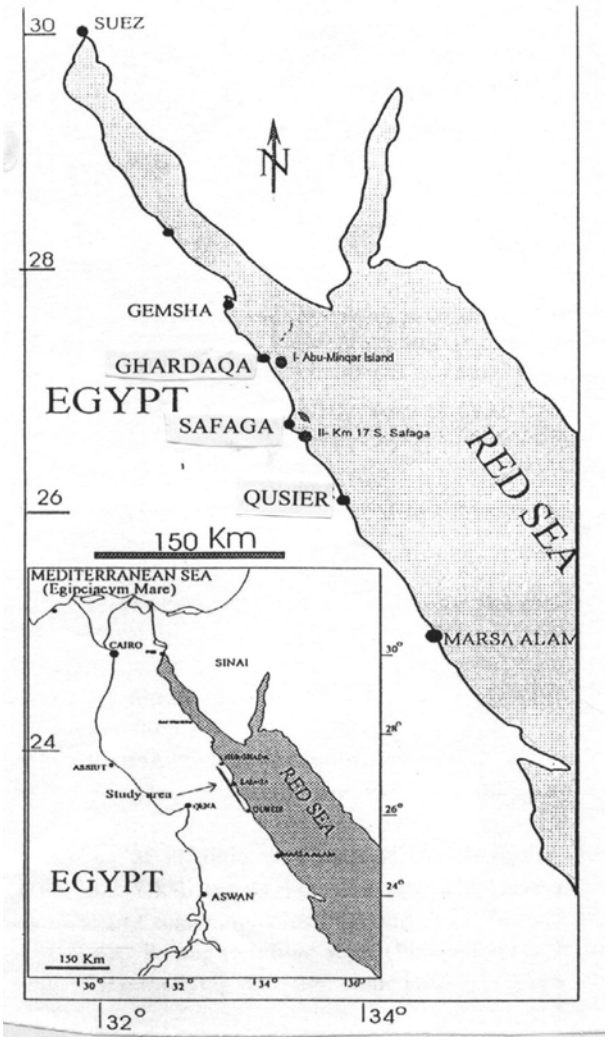


Fig. 1. Location map for the study area, Hurghada, Safaga and Qusier coasts of Red Sea, Egypt.

**Sampling:**

Seasonal visits were made to each of the three regions for collecting algal materials and sea water samples. Quadrate technique (Russell, 1977) was used in collecting the samples; steel quadrate 100 x 100 Cm was used. Four sites along 20 Km were used and five quadrates samples were taken at each site.

**Algal identification:**

For identification study specimens of all different species were seasonally collected, washed carefully and kept in labeled plastic bags. Portion of these samples were fixed in 4% Formaldehyde sea water solution. For further studies another portion was spread on Herbarium sheets. Algal species were identified according to Nasr 1939, 1940 a & b, 1941, 1947 and 1955, Nasr and Aleem 1949, Aleem, 1948, 1950, 1993, Farghaly 1975, 1980, Negm 1988 and Feldman 1951.

**Water analysis:**

Subsurface water samples were collected seasonally from all sites in clean polyethylene bottles of one liter capacity and transported to the laboratory. Analysis of water was carried out within few hours from the time of collection for determination of total hardness, salinity, carbonate, bicarbonate, chloride, phosphate, sulfate, nitrate, copper, cadmium, lead, and zinc contents. Moreover, pH and water temperature were measured directly at field.

Temperature was recorded by a thermometer 110$^{o}$C graduated to read differences of 0.2$^{o}$C. Standard pH papers (B.D.H) within the limits of pH variations of the sea water were used for measuring the pH of water in the field. Measurements were repeated in the laboratory by using an electric pH meter.

Salinity was determined according to Strickland and Parsons (1972). For estimation of chlorides, water samples were titrated against 0.1N $AgNO_3$ using potassium chromate indicators according to Standard Methods for the Examination of Water and Wastewater (1985).

The estimation of phosphate content was carried out using Rbinson and Thompson method (1948). Sulphate contents were determined using the method described by Harvey (1955). Nitrate contents were estimated according to the method described by Dickinson (1950).

Copper, cadmium, lead, and zinc contents were determined in ppm according to Analytical methods for Atomic Absorption Spectrophotometry (1983).

**Statistical analysis:**

The physicochemical analyses were compared using one-way ANOVA (SPSS package, version 11, 2001) and LSD at levels 1 and 5 % of probability (Snedecor and Cochran, 1967). Two indices were chosen for

estimation of the diversity of algal species in each region (Pielou, 1975 and Zhang, 1995):

Species Richness: D = S

Shannon-index of diversity: $H^{-} = -\sum_{i=1}^{5} Pi \ln Pi$

where pi = Ni/N, Ni is the number of individuals of species i, N is the total number of individuals of all species present, and S is the number of species present.

## RESULTS

The seasonal variation in some physico-chemical parameters of the water samples in Hurghada Red-Sea shore study area was summarized in Table 1. pH values were generally in the alkaline side and ranged between 7.9 and 8.2 during spring and autumn seasons. The results further revealed that, all seasons are characterized by high percentage of salinity ranged between 39.08 - 41.87% during autumn and spring, but no significant difference occurred. The chloride content varied within narrow range during the study period among all seasons. Whereas, there was a remarkable increase in phosphate levels recorded at spring and summer (0.09 and 0.142 ppm, respectively). On the other hand, both sulfate and nitrate were recorded with a clear fluctuation.

Table 1. Physicochemical characters of water samples in Hurghada Red Sea shore during period of autumn 2005 to summer 2006 (data represented by mean of three replicates collected from three different sites).

| Parameter | Season | | | | P-value |
|---|---|---|---|---|---|
| | Autumn 2005 | Winter 2006 | Spring 2006 | Summer 2006 | |
| Temp.ºC | 27.66 ± 0.35 | 19.83 ± 0.21 | 25.50 ± 0.09 | 30.5 ± 0.14 | *** |
| pH | 8.2 | 8.14 | 7.94 | 8.06 | ns |
| Salinity % | 39.08 ± 1.11 | 41.35 ± 1.02 | 41.87 ± 1.07 | 41.02 ± 1.06 | ns |
| $Cl^{-}$ ($gl^{-1}$) | 21.26 ± 0.51 | 23.4 ± 0.6 | 23.56 ± 0.80 | 23.44 ± 0.3 | ** |
| $PO_4^{---}$ (ppm) | 0.050 ± 0.01 | 0.035 ± 0.001 | 0.09 ± 0.003 | 0.142 ± 0.025 | *** |
| $SO_4^{--}$ (ppm) | 0.036 ± 0.003 | 0.029± 0.008 | 0.017 ± 0.006 | 0.011 ± 0.002 | ** |
| $NO_3^{-}$ (ppm) | 0.129 ± 0.032 | 0.130± 0.052 | 0.063 ± 0.051 | 0.098 ± 0.02 | ns |

* p ≤ 0.05 , ** p ≤ 0.01, *** p ≤ 0.001
ns No significant difference

Table 2, represents some physico-chemical analysis during the different seasons in the second study area (Safaga Red Sea shore). The temperature recorded a significant difference (p≤0.001) among the four seasons, and recorded its lowest degree in winter (19.3ºC) and its highest degree during the summer (33.1ºC). At the same time, pH still in the slight alkaline side but there was no significant seasonal difference occurred. It was obvious that no significant differences occurred in the salinity percentage during the study period. In contrast, high significant difference in the chloride was occurred (p≤0.001), whereas the maximum value (26.34 $gl^{-1}$) represented in summer the minimum was in spring (19.48 $gl^{-1}$). There was a significant difference between the different seasons in the phosphate, sulfate and nitrate occurrence.

Table 2. Physicochemical characters of water samples in Safaga Red Sea shore during period of autumn 2005 to summer 2006 (data represented by mean of three replicates collected from three different sites).

| Parameter | Season | | | | P-value |
|---|---|---|---|---|---|
| | Autumn 2005 | Winter 2006 | Spring 2006 | Summer 2006 | |
| Temp. ºC | 23 ±0.94 | 19.3 ±0.12 | 25.5 ± 0.34 | 33.1± 0.88 | *** |
| pH | 7.8 | 7.8 | 7.75 | 7.77 | ns |
| Salinity (‰) | 39.8 ±1.45 | 41.56 ±1.20 | 42.30 ± 2.12 | 40.5 ±0.65 | ns |
| $Cl^{-}$ ($gl^{-1}$) | 22.88 ± 0.23 | 21.83 ± 0.91 | 19.48 ± 0.38 | 26.34 ± 0.39 | *** |
| $PO_4^{---}$ (ppm) | 0.072 ± 0.009 | 0.057 ± 0.007 | 0.101 ± 0.003 | 0.163 ± 0.005 | *** |
| $SO_4^{--}$ (ppm) | 0.04 ± 0.0087 | 0.036 ± 0.002 | 0.018 ± 0.004 | 0.013 ± 0.007 | *** |
| $NO_3^{-}$ (ppm) | 0.128 ± 0.008 | 0.161 ± 0.007 | 0.064 ± 0.002 | 0.098 ± 0.011 | *** |

* p ≤ 0.05 , ** p ≤ 0.01 , *** p ≤ 0.001
ns No significant difference

Table 3 illustrates the physicochemical characters of water samples in Qusier Red Sea shore during the different seasons. The temperature recorded a significant difference (p≤0.001) among the four seasons and its lowest degree in winter (19.4ºC) and its higher degree during the summer (33ºC). No significant difference was detected between the different seasons in the pH values which still in the slight alkaline range. Along the studied four seasons, salinity still fluctuated in a narrow range; accordingly, non significant variations were recorded. Phosphate recorded its maximum during summer (0.188 ppm) and significantly differed from the other seasons. The data revealed also that, sulfate was present in very low concentrations along all seasons. Autumn was the richest with nitrate (0.164 ppm) and significantly differed (p≤0.001) from the other seasons.

Table 3. Physicochemical characters of water samples in Qusier Red Sea shore during period of autumn 2005 to summer 2006 (data represented by mean of three replicates collected from three different sites).

| Parameter | Season | | | | P-value |
|---|---|---|---|---|---|
| | Autumn 2005 | Winter 2006 | Spring 2006 | Summer 2006 | |
| Temp. ºC | 23.00 ± 0.08 | 19.4 ± 0.12 | 25.5 ± 0.09 | 33.0 ± 0.31 | *** |
| pH | 7.8 | 7.8 | 7.75 | 7.77 | ns |
| Salinity (‰) | 39.8 ±1.17 | 41.84 ±1.05 | 41.9 ±2.01 | 40.50 ±1.03 | ns |
| $Cl^{-}$ ($gl^{-1}$) | 23.09 ± 1.05 | 22.4 ± 0.84 | 20.01 ± 1.34 | 26.32 ± 0.58 | *** |
| $PO_4^{---}$ (ppm) | 0.062 ± 0.009 | 0.046 ± 0.001 | 0.100 ± 0.002 | 0.188 ± 0.006 | *** |
| $SO_4^{--}$ (ppm) | 0.044 ± 0.008 | 0.033 ± 0.003 | 0.014 ± 0.005 | 0.015 ± 0.003 | *** |
| $NO_3^{-}$ (ppm) | 0.164± 0.001 | 0.153 ± 0.009 | 0.085 ± 0.007 | 0.098 ± 0.010 | *** |

* p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001
ns No significant difference

Table 4. Seasonal variations in concentrations of certain heavy metals (ppm) in the three studied sites of the Red Sea shore during the period of autumn 2005 to summer 2006.

| Element | $Cu^{2+}$ (ppm) | | | $Cd^{2+}$ (ppm) | | | $Pb^{2+}$ (ppm) | | | $Zn^{2+}$ (ppm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Season | Hurghada | Safaga | Qusier | Hurghada | Safaga | Qusier | Hurghada | Safaga | Qusier | Hurghada | Safaga | Qusier |
| Autumn 2005 | 0.006 | 0.0032 | 0.0047 | 0.026 | 0.0201 | 0.0104 | 0.046 | 0.0422 | 0.0305 | 0.001 | 0.0001 | 0.0004 |
| Winter 2006 | 0.009 | 0.0 | 0.0043 | 0.030 | 0.0212 | 0.0251 | 0.060 | 0.0511 | 0.0344 | 0.008 | 0.0033 | 0.0017 |
| Spring 2006 | 0.020 | 0.0137 | 0.0104 | 0.020 | 0.0109 | 0.006 | 0.040 | 0.0328 | 0.0244 | 0.010 | 0.0 | 0.0083 |
| Summer 2006 | 0.009 | 0.0053 | 0.0051 | 0.025 | 0.0135 | 0.0151 | 0.039 | 0.0364 | 0.035 | 0.003 | 0.0008 | 0.0011 |

The present study involved the presence of certain heavy metals as copper, cadmium, lead and zinc (Table 4). It was obvious that these metals were occurred in trace amounts among the studied sites all over the different studied seasons. In general, lead recorded the highest concentrations followed by cadmium. On the other hand, zinc and copper were recorded in very low concentrations in all seasons within the studied sites even zinc and copper could not be recorded in Safaga during spring and winter seasons, respectively.

The present study monitored the macroalgal communities of the Red Sea shore in three areas which inhabiting the upper intertidal zone of Hurghada, Safaga and Qusier coasts at different seasons (Tables 5, 6 & 7). A total of 35 species were identified out of them 7 species belonging to Chlorophyta, 7 to Rhodophyta and 21 species to Phaeophyta.

Table 5. A list of the recorded macroalgae through the upper intertidal zone of Hurghada during period of autumn 2005 to summer 2006.

| Algal species | Autumn 2005 | Winter 2006 | Spring 2006 | Summer 2006 |
|---|---|---|---|---|
| Chlorophyta : | | | | |
| *Caulerpa serrulata* (Forsskal) J. Agardh | - | - | - | - |
| *C. racemosa* (Forsskal) J. Agardh | - | - | - | - |
| *Codium tomentosum* (Hudson) Stackhouse Sensu Hamel | 6 | *3* | 7 | 5 |
| *Enteromorpha intestinalis* (Linnaeus) Nees | 11 | *4* | 10 | 13 |
| *Halimeda opuntia* (Linne) Lamouroux | - | - | - | - |
| *H. tuna* (Ellis et Solander) Lamouroux | - | - | - | - |
| *Ulva lactuca* Linnaeus (C. Agardh) legolis | 13 | *5* | 12 | 14 |
| Rhodophyta: | | | | |
| *Digenea simplex* (Wulfen) C. Agardh | - | *5* | - | - |
| *Galaxaura elegans* Tanaka | - | - | - | - |
| *G. oblongata* J. Agardh | 6 | *3* | 2 | 4 |
| *Jania capillacea* Harvey | - | - | - | - |
| *Laurencia elata* (C.Ag.) Harvey | - | - | - | - |
| *L. obtusa* (Hudson) Lamouroux | 4 | - | 5 | 3 |
| *L. papillosa* (C. Ag.) Greville | - | - | 2 | 2 |
| Phaeophyta | | | | |
| *Cystoseira crinita* (Desfontaine) Bory | - | - | - | - |
| *C. myrica* (S.G. Gmelin), C. Agardh | - | - | - | - |
| *C. trinodis* (Forsskal) C. Agardh | - | - | - | - |
| *Dictyota dichotoma* (Hudson)Lamouroux | - | - | 1 | - |
| *Ectocarpus siliculosus* (Dillwyn) Lyngbye | 2 | - | 2 | 5 |
| *Hydroclathrus clathratus* (C. Ag.) Howe | - | - | - | - |
| *Liagora farinosa* Lamouroux | - | - | - | - |
| *Padina boryana* Thivy | - | - | - | - |
| *P. gymnospora* (Kutz) Vickers | - | - | 1 | - |
| *P. pavonia* (Linnaeus.) Gaillon | 1 | *2* | 3 | - |
| *Phacelocarpus tristichus* (Madag.) | - | - | - | - |
| *Sargassum aquifolium* (Turn.) Ag. | - | - | - | - |
| *S.* binderi sonder | - | - | - | - |
| *S. crispum sonder* (Forsskal) Ag. | - | *1* | 1 | - |
| *S. dentifolium* Grunow (Turner) Ag. | 2 | *2* | 1 | - |
| *S. laifolium* (Turner.) J. Agardh | 1 | *1* | 1 | - |
| *S. parvifolium* (Turn.) Ag. | - | *2* | - | - |
| *S. platycarpum* Montagne | - | - | - | - |
| *S. virgatum* (Mert.) Ag. | - | - | - | - |
| *Turbinaria decurrens* Bory | 2 | *1* | 1 | 2 |
| *T. ornata* (Turn.) J. Agardh | - | *1* | - | - |
| Total number of individuals | 48 | 30 | 49 | 48 |
| Total number of species | 10 | 12 | 14 | 8 |
| Species diversity index | 1.98 | 2.32 | 2.22 | 1.83 |

Table 5 summarized the seasonal variations in the occurrence of the algal groups in Hurghada study area. Three main algal groups (Chlorophyta, Rhodophyta and Phaeophyta) were observed and represented by 17 species. Phaeophyta gained high occurrence among the other groups and represented by 10 species dominated by *Ectocarpus siliculosus*. Spring season was the richest season with the number of individuals which represents 14 species. *Ulva lactuca* and *Enteromorpha intestinalis* were the dominated species with a percentage of total count reached to 24.5 and 20.4 %, respectively during spring season.

The seasonal variation among the different algal groups in Safaga study area listed in Table 6. Thirty algal species were recorded during the period of the study throughout the four seasons in Safaga. Six of them belong to Chlorophyta, 7 to Rhodophyta and 17 species belonging to Phaeophyta. Spring season was the richest season which represented by 21 species and *Jania capillacea* was the dominant

species (19%) followed by *Laurencia elata* (16.2%) which still the dominant at the next season (summer).

Table 6. A list of the recorded macroalgae through the upper intertidal zone of Safaga during period of autumn 2005 to summer 2006.

| Algal species | Autumn 2005 | Winter 2006 | Spring 2006 | Summer 2006 |
|---|---|---|---|---|
| Chlorophyta : | | | | |
| *Caulerpa serrulata* (Forsskal) J. Agardh | 2 | 2 | 3 | 2 |
| *C. racemosa* (Forsskal) J. Agardh | - | - | - | - |
| *Codium tomentosum* (Hudson) Stackhouse Sensu Hamel | - | - | - | - |
| *Enteromorpha intestinalis* (Linnaeus) Nees | - | - | - | 1 |
| *Halimeda opuntia* (Linne) Lamouroux | 1 | 1 | 2 | - |
| *H. tuna* (Ellis et Solander) Lamouroux | - | - | - | - |
| *Ulva lactuca* Linnaeus (C. Agardh) Iegolis | - | - | - | - |
| Rhodophyta: | | | | |
| *Digenea simplex* (Wulfen) C. Agardh | - | - | - | - |
| *Galaxaura elegans* Tanaka | 3 | - | 1 | 2 |
| *G. oblongata* J. Agardh | - | - | - | - |
| *Jania capillacea* Harvey | - | 1 | 7 | 5 |
| *Laurencia elata* (C.Ag.) Harvey | - | 5 | 6 | 6 |
| *L. obtusa* (Hudson) Lamouroux | - | - | - | - |
| *L. papillosa* (C. Ag.) Greville | 7 | - | 2 | - |
| Phaeophyta | | | | |
| *Cystoseira crinita* (Desfontaine) Bory | 1 | 2 | 1 | 1 |
| *C. myrica* (S.G. Gmelin), C. Agardh | - | - | 1 | - |
| *C. trinodis* (Forsskal) C. Agardh | - | - | 1 | - |
| *Dictyota dichotoma* (Hudson)Lamouroux | - | - | - | - |
| *Ectocarpus siliculosus* (Dillwyn) Lyngbye | - | - | - | - |
| *Hydroclathrus clathratus* (C. Ag.) Howe | - | - | 1 | - |
| *Liagora farinosa* Lamouroux | - | - | 1 | - |
| *Padina boryana* Thivy | - | - | 1 | - |
| *P. gymnospora* (Kutz) Vickers | - | - | - | - |
| *P. pavonia* (Linnaeus.) Gaillon | - | - | - | - |
| *Phacelocarpus tristichus* (Madag.) | 1 | 2 | 2 | 3 |
| *Sargassum aquifolium* (Turn.) Ag. | 2 | 1 | 1 | 3 |
| *S.* binderi sonder | 3 | 1 | 2 | - |
| *S. crispum sonder* (Forsskal) Ag. | - | 1 | 1 | - |
| *S. dentifolium* Grunow (Turner) Ag. | - | 2 | 2 | 2 |
| *S. laifolium* (Turner.) J. Agardh | - | - | - | - |
| *S. parvifolium* (Turn.) Ag. | - | 1 | - | - |
| *S. platycarpum* Montagne | - | - | - | - |
| *S. virgatum* (Mert.) Ag. | 2 | - | 1 | - |
| *Turbinaria decurrens* Bory | - | 1 | 1 | 2 |
| *T. ornata* (Turn.) J. Agardh | - | - | - | - |
| Total number of individuals | 22 | 20 | 37 | 27 |
| Total number of species | 9 | 12 | 21 | 10 |
| Species diversity index | 1.98 | 2.32 | 2.68 | 2.15 |

Table 7, shows the variation in the algal species according to the different seasons in Qusier study area. Thirty algal species were recorded; 4, 7 and 19 species represented Chlorophta, Rhodophyta and Phaeophyta, respectively. It was obvious that spring season was the richest with algal species (27 species) with a total count of 216, dominated by *Laurencia obtusa* (7.8%) followed by autumn season with 26 species and 158 total counts.

Table 7. A list of the recorded macroalgae through the upper intertidal zone of Qusier during period of autumn 2005 to summer 2006.

| Algal species | Autumn 2005 | Winter 2006 | Spring 2006 | Summer 2006 |
|---|---|---|---|---|
| Chlorophyta : | | | | |
| *Caulerpa serrulata* (Forsskal) J. Agardh | 1 | - | 7 | 3 |
| *C. racemosa* (Forsskal) J. Agardh | 2 | 3 | 5 | 6 |
| *Codium tomentosum* (Hudson) Stackhouse Sensu Hamel | - | - | - | - |
| *Enteromorpha intestinalis* (Linnaeus) Nees | - | - | - | - |
| *Halimeda opuntia* (Linne) Lamouroux | - | 3 | 6 | 7 |
| *H. tuna* (Ellis et Solander) Lamouroux | - | - | - | - |
| *Ulva lactuca* Linnaeus (C. Agardh) Iegolis | 6 | - | 2 | 4 |
| Rhodophyta: | | | | |
| *Digenea simplex* (Wulfen) C. Agardh | 5 | 2 | 9 | 4 |
| *Galaxaura elegans* Tanaka | 19 | 3 | 8 | 11 |
| *G. oblongata* J. Agardh | 1 | 2 | 3 | 6 |
| *Jania capillacea* Harvey | 1 | 1 | 2 | 7 |
| *Laurencia elata* (C.Ag.) Harvey | 4 | 3 | 15 | 13 |
| *L. obtusa* (Hudson) Lamouroux | 2 | 1 | 17 | 9 |
| *L. papillosa* (C. Ag.) Greville | - | 3 | 4 | - |
| Phaeophyta | | | | |
| *Cystoseira crinita* (Desfontaine) Bory | 18 | 13 | 16 | 10 |
| *C. myrica* (S.G. Gmelin), C. Agardh | 2 | 1 | 8 | 7 |
| *C. trinodis* (Forsskal) C. Agardh | 4 | - | 5 | 2 |
| *Dictyota dichotoma* (Hudson)Lamouroux | 1 | - | - | - |
| *Ectocarpus siliculosus* (Dillwyn) Lyngbye | 8 | - | 6 | 1 |
| *Hydroclathrus clathratus* (C. Ag.) Howe | 7 | - | 12 | 6 |
| *Liagora farinosa* Lamouroux | 1 | 1 | - | - |
| *Padina boryana* Thivy | 14 | 2 | 11 | 3 |
| *P. gymnospora* (Kutz) Vickers | - | - | - | - |
| *P. pavonia* (Linnaeus.) Gaillon | 8 | 10 | 15 | 14 |
| *Phacelocarpus tristichus* (Madag.) | - | 4 | 9 | 6 |
| *Sargassum aquifolium* (Turn.) Ag. | 13 | 2 | 14 | 15 |
| *S.* binderi sonder | - | 6 | 2 | - |
| *S. crispum sonder* (Forsskal) Ag. | 9 | - | 2 | 8 |
| *S. dentifolium* Grunow (Turner) Ag. | 12 | 2 | 6 | 7 |
| *S. laifolium* (Turner.) J. Agardh | - | - | - | - |
| *S. parvifolium* (Turn.) Ag. | 2 | 3 | 7 | - |
| *S. platycarpum* Montagne | 5 | - | - | - |
| *S. virgatum* (Mert.) Ag. | 2 | 5 | 13 | 19 |
| *Turbinaria decurrens* Bory | 3 | - | 6 | - |
| *T. ornata* (Turn.) J. Agardh | 8 | 4 | 6 | 4 |
| Total number of individuals | 158 | 74 | 216 | 74 |
| Total number of species | 26 | 21 | 27 | 23 |
| Species diversity index | 2.91 | 2.78 | 3.31 | 2.97 |

On the other hand, winter season was lowest in species number but had a similar total counts with summer season (74). Thus, the count was reduced to a twenty one species dominated by *Cystoseira crinita* having a richness percentage of 17.6%.

A comparison between the three studied areas according to the seasonal variation of the three major algal groups is represented in Figure 2 (a, b and c). It is noticeable that Chlorophyta was detected in a high occurrence (66.67%) in Hurghada especially during summer, while it had lowest occurrence in both Safaga and Qusier at all seasons. Rhodophyta reached its maximum percentage during summer (48.15%) and followed by the next season (autumn) which represented by 45.45% in Safaga area. Obviously high occurrence in Phaeophyta community was recorded in Qusier study area and represented by 74.05% and 71.62% during autumn and winter seasons, respectively.

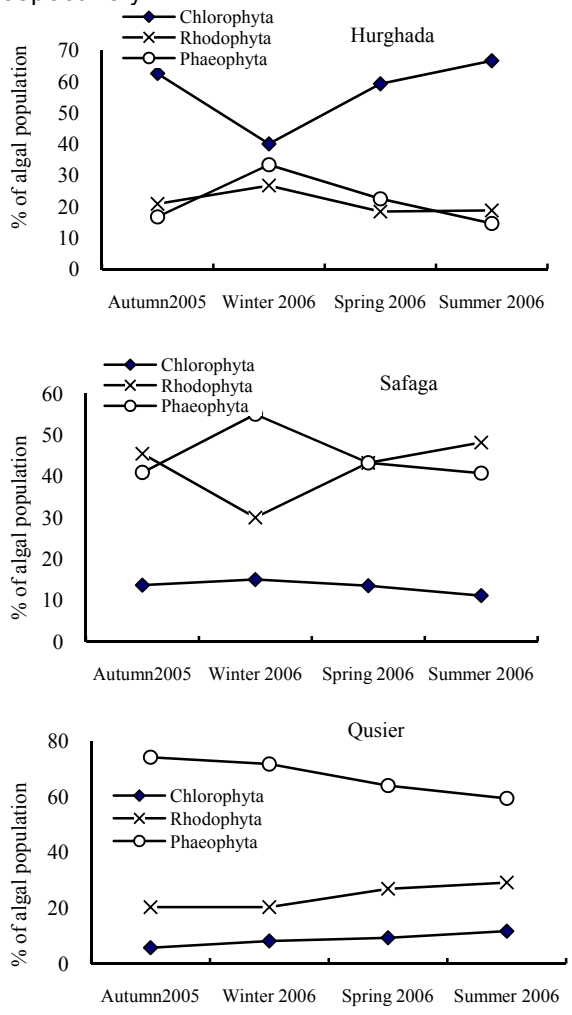


Fig. 2. Seasonal variations in Chlorophyta , Rhodophyta and Phaeophyta at Hurghada (A), Safaga (B) and Qusier (C) coasts during autumn 2005 to summer 2006

Regarding to the total numbering of individuals / $m^2$ which represents the standing crop of the benthic communities was varied greatly at all areas throughout the period of study. It was fluctuated between 1.66 and 5.12 individuals / $m^2$ at Hurghada, 2.67 and 4.85 individuals / $m^2$ at Safaga and 3.67 and 12.71 individuals / $m^2$ at Qusier coast (Fig 3). The data revealed that, summer and spring seasons were harbored the highest density along the area of Qusier coast. The average standing crop reached to 12.71 and 12.67 individuals / $m^2$ during summer and spring, respectively.

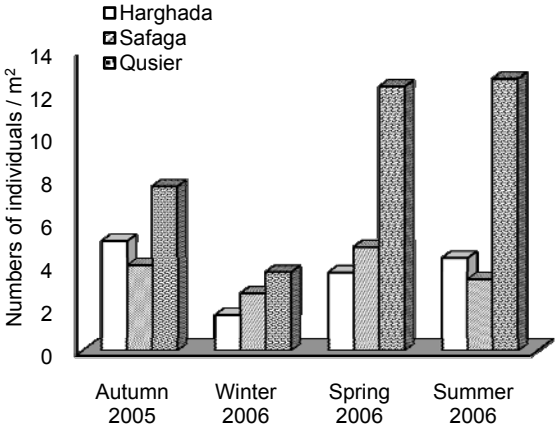


Fig. 3. Seasonal variations in the average of total numbers of individuals / $m^2$ at Hurghada, Safaga and Qusier coasts during autumn 2005 to summer 2006

Based on the total covering of algal species, Qusier was the first record of total coverage which represented approximately 60% during summer and spring followed by autumn season, represented by 45% (Fig. 4).

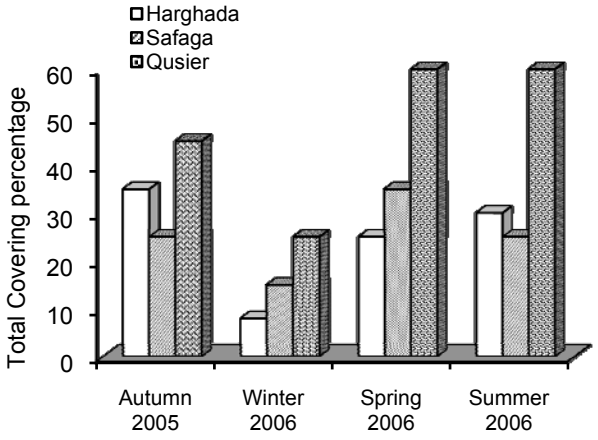


Fig. 4. Seasonal variations in the average of total covering of algal populations at Hurghada, Safaga and Qusier coasts during autumn 2005 to summer 2006

## DISCUSSION

The abiotic variables used to describe off shore areas in coastal margins in seas, mainly related to climatic factors and sea water chemistry, led to understand the proper interpretation of the effect of these variables on seashore biology. The analysis of these physicochemical characteristics of water as

well as recording of macroalgal species inhabiting Hurghada, Safaga and Qusier seashores constitute the major goals of the present survey.

It was of prime importance to notice that one of the factors which affected to a great extent the floral composition and density of the species in the surveyed area was the physico-chemical characteristics of the Sea water.

Water temperature is considered as the most important abiotic factor which affects directly or indirectly the distribution and abundance of marine vegetation. It well exhibits the distribution of the recorded algal species throughout the investigation period (autumn 2005, winter, spring, and summer of year 2006) at the study seashores. This may be expressed by Van Hoff's law according to which the rate of biological processes may increase for three times with a rise in temperature to $10^{o}$ C within the tolerable limits (Clarke, 1965).

The effect of water temperature on the algal vegetation was noticed during the present study and manifested on the periodicity of the individual species and hence the standing crop of the main algal groups of the algal communities. This may show a seasonal succession that was in accordance with temperature changes. This is also in accordance with Chapman (1964) and Hock (1982) whom reported that water temperature affects geographic distribution of species. The number and biomass of algal species have been fall to a winter low and gradually increases through the next spring and early summer (Riegl and Piller, 2000).

The pH values of water at all experimental sites may be ranged as being on the alkaline and slightly alkaline side ranging approximately from 7.75 to 8.14. Moreover, the narrow limits of fluctuations in pH values throughout the period of investigation denote that there were no significant differences or distinct seasonal variations in the pH values.

With regarding to salinity, it well known that the marine algae have the ability to tolerate salinity variations. Although there is no significant differences in salinity between all studied localities, this may demonstrate the absence or presence of species that grown at a site. It is proved to be in accordance with the findings of Burns and Mathieson (1972) who stated that salinity is a dominant factor influencing both the local distribution and growth of algae.

Although there is a significant differences in the chlorinity contents of water samples which reached its maximum levels during summer season throughout all studied sites, there is no evidences indicating that, chlorinity is a controlled factor for the distribution of algae. Such results appeared to be in conformity to the findings of Benz *et al*. (1979).

With regard to the phosphate contents of water samples, it was noticed that these contents tended to increase during summer and decreased during winter. Such trend was generally correlated with a concomitant elevation in density of algal populations and number of species in most cases that is in consistence with results of Lubchenco (1980) and Abou-Aisha *et al*. (1994). On the other hand, nitrate and sulfate exhibited the highest content during autumn, an observation that was accompanied by decaying of most algal thalli at the end of their life cycles (Negm, 1995).

Analysis of water samples revealed that Hurghada and Safaga recorded the highest contents of investigated cations, namely $Cu^{2+}$, $Cd^{2+}$, $Pb^{2+}$ and $Zn^{2+}$ along the investigation four seasons. It may be attributed to the eutrophication caused by pollution reach to the beach from towns, which may affect also the biomass and distribution of collected algae (Abdallah, 2006). So, Hurghada and Safaga recorded a relatively low percentage of algal abundance. Meanwhile, the quadrates of Qusier cost recorded high number of individuals / $m^2$ and also high total covering percentage of algae throughout the study seasons, which may be attributed to the low eutrophication percentage.

During this study, it was possible to evaluate the relationship between biomass and density of individuals. A parallel relationship between these items was observed. This is in accordance to a great extent with Margalef (1969) who suggest that the relationship between diversity and productivity are logarithmic rather than linear, as small changes in diversity cause large changes in productivity. On the other hand, such results appeared to be in contradiction to the findings of Berger and Parker (1970) who obtained a well marked negative correlation between dominance and diversity.

From the above mentioned results we may be concluded that, the benthic algal flora inhabiting the upper-intertidal zones along Hurghada, Safaga and Qusier seashores showed significant seasonal variations which, at least in some cases were related to the abiotic factors. It is well known that the habitat may determine the type of algal flora present and allow for the dominance of representation of a particular group on the expense of the others. In this case, abiotic factors such as water composition together with all other hydrographic factors should furnish the differences in the occurrence of algae in the same or other area that allow the representatives of certain species to flourish better than the other.

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# الاختلافات الموسمية للعشائر الطحلبية الكبيرة والمنتشرة في ساحل الغردقة ، وسفاجا والقصير بالبحر الأحمر، مصر.

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الملخص العربى

استهدفت الدراسة فى هذا البحث تسجيل الاختلافات الموسمية فى العشائر الطحلبية الكبيرة والمنتشرة فى سواحل مدن الغردقة ، القصير ، وسفاجا بالبحر الأحمر فى مصر خلال الفترة من خريف ٢٠٠٥ وحتى صيف ٢٠٠٦ . كما استهدفت الدراسة تقييم تأثير بعض العوامل المناخية وكذلك الصفات الفيزيقية والكيميائية لمياه البحر الأحمر على تنوع هذه العشائر.

تم ذلك من خلال تسجيل التوزيع العشوائى للعشائر الطحلبية بما فيها العشائر السائدة والتنوع البيولوجى للأجناس. تم تسجيل خمسة وثلاثين نوعاً من الطحالب الكبيره ، تنتمى سبعة أنواع منها إلى مجموعة الطحالب الخُضر، وسبعة أنواع تنتمى إلى مجموعة الطحالب الحُمر ، بينما سُجل واحد وعشرون نوعاً منها تنتمى إلى الطحالب البنيه.

أظهرت النتائج أعلى نسبة تواجد للأفراد الطحلبية وصلت إلى ١٢,٧١ نوعاً للمتر المربع بنسبة تغطية كلية وصلت ٦٠ % وكان ذلك فى ساحل مدينة القصير مقارنة بساحل مدينتى الغردقة وسفاجا.

سجلت مجموعات الطحالب الخُضر والحُمر أعلى نسبة تواجد للعشائر الطحلبية وصلت إلى ٦٦,٦٧ ، ٤٨,١٥ % خلال موسم صيف ٢٠٠٦ فى ساحلى الغردقة وسفاجا على التوالى ، بينما سجلت الطحاالب البنية أعلى نسبة تواجد لها وصلت إلى ٧٤,٠٥ % خلال موسم الخريف لعام ٢٠٠٥ فى ساحل مدينة القصير، والتى سجلت أيضاً أعلى معدل للتنوع وصل إلى ٣,٣١ خلال موسم الخريف لعام ٢٠٠٥ .

ثبت أيضاً من خلال الدراسة الإحصائية التى تم إدراجها فى البحث أن للعوامل المناخية والصفات الفيزيقية والكيميائية لمياه البحر الأحمر تأثير على التنوع البيولوجى لعشائر الطحالب الكائنة فى منطقة الدراسه.