EGYPTIAN JOURNAL OF AQUATIC RESEARCH **ISSN 1110-0354**
VOL. 30(A), 2004:171-188

# DISTRIBUTION OF SOME MACROALGAE IN THE INTERTIDAL ZONE OF THE SUEZ BAY IN RELATION TO ENVIRONMENTAL CONDITIONS

**SHAMS EL-DIN*, N. G.; EL-MOSELHY, KH. M. AND AMER, A.**
***National Institute of Oceanography and Fisheries***

***Key words****: Suez Bay, macroalgae, discharged effluents, nutrients.*

## ABSTRACT

The Suez Bay receives daily discharged effluents from different pollution sources, such as oil refineries, harbours, fish-ports, domestic sewage and other industrial wastes. The present work aimed to study the distribution of some macroalgal species in the intertidal zone of the Suez Bay in relation to the variation in the physical and chemical characteristics of different selected sites. The results revealed that, the macroalgae of the study area was represented by four species: Ulva lactuca, Enteromorpha compressa, Padina pavonia, and Sargassum dentifolium, which belonging to two algal divisions (Chlorophyceae and Phaeophceae).The first division formed the highest total average cover percentage of 32.39% while the second one was represented by a very low total average cover percentage of 0.014%. Both species of the green algae (Ulva lactuca and Enteromorpha compressa) flourished only at the polluted stations and attained a high cover percentage of 85.8% and 75.1%, respectively. While the two brown algae attained very low cover percentage of 0.1%, and they were restricted to one site which was more or less far away from the pollution sources and they were considered as pollution sensitive species.

Correlation coefficient between the cover percentage of macroalgae and physico-chemical parameters was calculated. Principle component analysis was also performed for clarifying the relationship between the biological characteristic and the physico-chemical parameters.

## INTRODUCTION

The Suez Bay is considered as a semi-enclosed basin, which opens to the Gulf of Suez at its southern side and is connected to the Suez Canal by a dredged channel. The Bay is located between longitudes 32o28/ and 32o 34/ E and latitudes 29º54′ and 29º57′ N. Its average length along the major axis is 13.2 km and its average width along the minor axis is 8.8 km. The mean depth of the bay is 10 m and the surface area amounts to about 77.13 $km^2$ (Meshal, 1970). The bay is under the environmental stress of discharged industrial wastes, oil refineries, harbour activities, fishing, domestic wastes, and ships refuses. These effluents are potentially increasing year after year particularly after the intense expansion of the different sorts of activities along the western coast of the bay. According to the hydrographic features, such as the tidal motions and water circulation in the bay, all these discharged pollutants will be accumulated year after year till they reach to a certain level that converts the bay and consequently the Gulf of Suez to a heavily polluted environment (Soliman, 1996). Hamed (1992), Said (1992), Abd El-Azim (1996), El-Moselhy *et al.* (1999) and Hamed *et al.* (2003) studied the occurrence of different pollutants in the Suez Bay. The present work aimed to study the distribution of the macroalgae in the intertidal zone at different selected sites relative to the physico-chemical parameters in the Suez Bay.

* Corresponding author

## MATERIAL AND METHODS

Sampling was performed bimonthly from April 2001 to February 2002. The samples were collected from five stations along the coastal area in the intertidal zone of the Suez Bay which extends from 80 to 140 cm (Morcos, 1960). The five stations are subjected to different types of pollution. Station I (Adabiya) is affected by shipping activities and discharge of small community, station II lies in front of the National Institute of Oceanography and Fisheries where sewage and industrial wastes are discharged, station III is subjected to thermal pollution by Electric Power plant as well as discharge of fertilizer company, station IV (El-Kabanon) is affected by oil refineries and industrial effluents, and station V(Port Tawfik) is quite distant from the pollution sources and considered as control area (Fig.1). Water temperature was measured by using an ordinary thermometer graduated to 0.1° C. The pH values were measured in situ by a portable digital pH meter (Orion, model 230A). Water salinity was measured using a salinometer (Bench top digital Orion conductivity/ salinity/ TDS meter, model 150). Total alkalinity was measured by titration against standard HCl. Dissolved oxygen was determined by Winkler method, (APHA, 1995). Nutrient salts (NO3, NO2, NH4, PO4, and SiO4) were determined according to the methods described by Strickland and Parsons (1968). For identification of algal taxa, samples were collected when the tide was on the ebb, and then each species was stored separately in plastic bags. At lab, it was rinsed and the specimens were then conserved as herberium sheets and/or in 4 % formalin. The main references used for identification of algal taxa were: Dawson (1962), Jaasund (1976), Aleem (1993). The study of the distribution of algal flora was based on the transect technique according to Garrone (1970), where 10 quadrates were randomly sited bimonthly at each station. The main concept in taxa sampling was taxa cover percentage per quachate (Average of 10 quadrates) as biological parameter describing algal communities in the study area. Statistical analysis including correlation coefficient between the cover percentage of algae and the physico-chemical parameters was calculated (n=30) and at the confidence limit 95% ($P \geq 0.05$). Principle component analysis was also performed for more clarifying the relationship between the algal distribution characteristic and the physico-chemical parameters. The analysis was performed using Number Cruncher Statistical System (NCSS), proposed by Hintze (1993).

## RESULTS AND DISCUSSION

1- Algal flora:

The algal flora in the study area was represented only by four species namely Ulva *lactuca* and *Enteromorpha compressa,* which belong to Chlorophceae and *Padina pavonia,* and *Sargassum dentifolium* belonging to Phaeophyceae. The two members of the former division formed the highest total average cover percentage (32.39 %) while the two member of the later was represented by a very low total average cover percentage (0.014 %).

2- Distribution of algal species:

The distribution of the macroalgae varied in the selected sites of the study area, since each one is subjected to different types of pollution. In station I the green alga Ulva lactuca flourished in April, June, and February with cover percentage of 25.8%, 4.8%, 6.7% respectively, and with an average of 6.22% while the second green alga Enteromorpha compressa flourished only in February with 9.1% and with an average of 1.52% (Table 3& Fig.2). The physico-chemical characteristics in this site were suitable for the flourishing of the two green algae. Since the salinity values were relatively low ranging from a minimum of 39‰ in December to a maximum of 40.8‰ in April forming an average of 39.9‰.(Table 1). In addition to the nutrients concentrations which were quite enough to enhance the f the

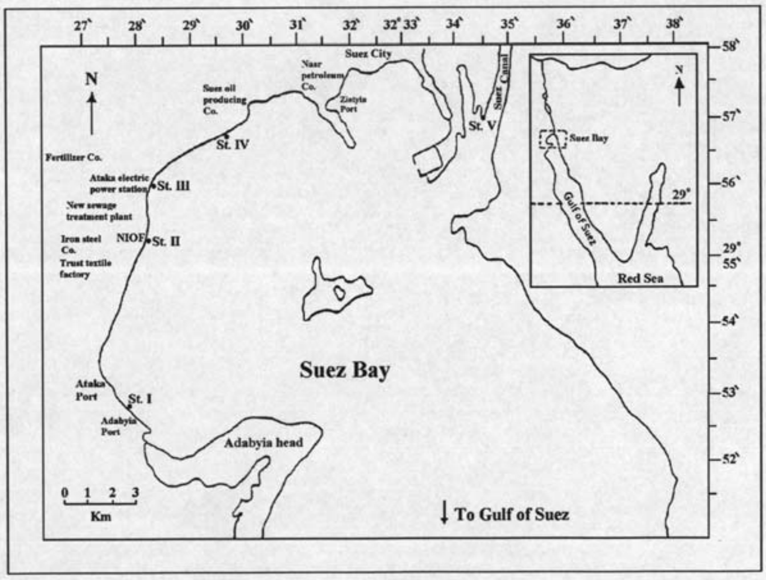


Fig. (1): Map of the Suez Bay showing the different pollution sources and the sampling stations

flourishing of the two algae. The silicate sustained high concentrations all the year round except in February where the concentration sustained low value of 0.058µmole.$l^{-1}$ (Table 2).

This indicates freshwater dispersion according to Friligos (1988) who found high concentration of silicate (0.18µmole.$l^{-1}$ ) in Saronikos Gulf (east Mediterranean) and considered the Gulf as polluted area. The phosphorus fluctuated between a minimum of 0.004µmole.$l^{-1}$ in April to 0.705µmole.$l^{-1}$ in August forming an average of 0.162 µmole.$l^{-1}$. According to Stirn (1988) these concentrations lie in the normal range except the value recorded in August since the author reported that the soluble phosphorus is normally present in small quantity except the polluted water, where the concentrations tend to be high (0.3 to 0.5 µmole.$l^{-1}$). On the other hand, the ammonia fluctuated between a minimum of 0.026µmole.$l^{-1}$ in October to a maximum of 0.872 µmole.$l^{-1}$ in February forming an average of 0.541µmole.$l^{-1}$ while the nitrite ranged from a minimum of 0.094µmole.$l^{-1}$ in August to a maximum of 1.081µmole.$l^{-1}$ in October forming an average of 0.43µmole.$l^{-1}$ and the nitrate ranged from a minimum of 0.011µmole.$l^{-1}$ in August to a maximum of 2.692µmole.$l^{-1}$ in April forming an average of 1.438µmole.$l^{-1}$ (Table 2).

Station II is characterized by the flourishing of the green alga Ulva lactuca during the whole year beginning from a minimum of 61.3% in December till reaching a maximum of 85.8% in June and forming a maximum average of 71.77% (Table 3 & Fig.2). The high cover percentage of *Ulva lactuca* in this site may be attributed to the domestic wastes which are loaded by nutrients and organic matter which enhanced the flourishing of the alga at this site. The impact of sewage pollution on marine benthic flora was studied by Bellan-Santini (1966), Bellan (1972), Belsher (1974 and 1977), Belsher et al. (1975) and Durcos-Viel (1974). In this trend, Murray and Litter (1978) found that the addition of domestic and industrial pollutants might stimulate or inhibit growth of algae. El-Manawy (1992), reported that the heavily polluted station with domestic wastes in the Bitter lakes (Suez Canal) was inhabited by reduced number of green and red algae species but some of them such as *Ulva lactuca, Enteromorpha clathrata, E. compressa, Cladophora albida, Polysiphonia frigariana* showed dense cover and biomass. In contrast, El-Nagaar *et al.* (2002) supposed that the low flourishing of seaweeds during summer at polluted area in Suez Gulf (Ras Gharib) was due to the effect of domestic sewage and chronic oil effluents discharged into the water at this region. In our view, *Ulva lactuca* could be considered as adapted species to domestic wastes. The second green alga *Enteromorpha compressa* was less represented in this site with cover percentage of 55.2% and 75.1% in December and February respectively and with an average of 21.72% (Table 3 & Fig.2). In our study, the flourishing of the two green algae may reflect the environmental conditions prevailing there. This was showed by the relatively low salinity values which fluctuated between a minimum of 39.1‰ in December and a maximum of 40.7‰ in August (Table 1) which reflect the discharge of treated domestic wastes in this site. In this trend, Hamed (1992), Abd El-Azim (1996) and Soliman (1996) recorded lower salinity values till 40.6‰ at the sites subjected to the discharge of fresh water drain while in the other sites in the Bay it attained 42.6‰ . Our results agree with Nasr and Aleem (1948) who considered Ulva *lactuca* and *Enteromorpha compressa* as euryhaline forms.

The second characteristic which enhanced the algal growth, was the relatively high concentrations of nitrogenous compounds. The concentrations of ammonia fluctuated between a minimum of 0.163µmole.$l^{-1}$ in June to a maximum of 1.372µmole.$l^{-1}$ in February with an average of 0.552µmole.$l^{-1}$ while the concentrations of nitrite ranged from a minimum value of 0.169µmole.$l^{-1}$ in April and August to a maximum of 0.766µmole.$l^{-1}$ in February with an average of 0.449µmole.$l^{-1}$ and the nitrate concentrations ranged from a minimum value of 0.186µmole.$l^{-1}$ in August to a maximum of 10.107µmole.$l^{-1}$ in October forming an average of 3.75µmole.$l^{-1}$ (Table 2). The site is also characteristic by high pH values which lied on the alkaline side and fluctuated between a minimum value of 8.63 in October to 9.03 in June, in addition to the high values of the dissolved oxygen ranging from a minimum value of 6.65 mg.$l^{-1}$ in August to a maximum value of 12.54 mg/$l^{-1}$in December forming an average of 9.3 mg/L. The high values of the two parameters may be attributed to the high photosynthetic activity resulted from the high growth of the algal species. On the other hand, water alkalinity ranged from a minimum of 133.3 mg.$l^{-1}$ in February to a maximum of163.52 mg/L in April and forming an average of 149.64 mg/L (Table 1). The high values of this parameter may be attributed to the large amounts of fresh water discharged in this site as mentioned by Grasshoff (1975). All these physico-chemical conditions may reflect the discharge of domestic wastes.

**Table 1:** Levels of physico-chemical parameters in water of the Suez Bay during April 2001-February 2002.

| stations | Month | Temperature °C | Salinity ‰ | pH | Dissolved oxygen mg $O_2$. $l^{-1}$ | Total alkalinity mg. $l^{-1}$ |
|---|---|---|---|---|---|---|
| I | Apr.2001 | 27 | 40.8 | 8.71 | 6.84 | 154.16 |
| | Jun. | 29 | 40.4 | 8.57 | 8.16 | 140.37 |
| | Aug. | 31.9 | 39.3 | 8.54 | 6.56 | 163.20 |
| | Oct. | 28.5 | 40.3 | 8.63 | 6.99 | 128.65 |
| | Dec. | 18.5 | 39 | 8.63 | 3.21 | 150.23 |
| | Feb.2002 | 19.8 | 39.6 | 8.65 | 7.27 | 127.15 |
| | Average | 25.7 | 39.9 | --- | 6.51 | 143.96 |
| II | Apr.2001 | 24.2 | 41.5 | 8.77 | 7.33 | 163.52 |
| | Jun. | 30 | 40.1 | 9.03 | 9.52 | 159.57 |
| | Aug. | 34.5 | 40.7 | 8.73 | 6.65 | 144.56 |
| | Oct. | 29 | 39.6 | 8.63 | 8.37 | 143.84 |
| | Dec. | 19 | 39.1 | 8.93 | 12.54 | 153.05 |
| | Feb.2002 | 21.8 | 39.6 | 8.78 | 11.38 | 133.30 |
| | Average | 26.4 | 40.1 | --- | 9.3 | 149.64 |
| III | Apr.2001 | 30 | 41.3 | 8.5 | 5.73 | 149.84 |
| | Jun. | 34 | 41.3 | 8.37 | 6.2 | 138.51 |
| | Aug. | 39 | 41.8 | 8.41 | 4.43 | 144.56 |
| | Oct. | 32.5 | 40.5 | 8.37 | 5.64 | 136.95 |
| | Dec. | 25 | 39.4 | 8.6 | 3.8 | 150.48 |
| | Feb.2002 | 27.5 | 38.8 | 8.55 | 4.91 | 134.52 |
| | Average | 31.3 | 40.7 | --- | 5.12 | 142.48 |

Continue.

**Table 1:** Continue.

| stations | Month | Temperature °C | Salinity ‰ | pH | Dissolved oxygen mg $O_2$. $l^{-1}$ | Total alkalinity mg. $l^{-1}$ |
|---|---|---|---|---|---|---|
| IV | Apr.2001 | 24.8 | 35.9 | 8.52 | 5.39 | 158.96 |
| | Jun. | 28 | 41.5 | 8.46 | 5.89 | 150.09 |
| | Aug. | 31 | 41.2 | 8.45 | 5.38 | 148.56 |
| | Oct. | 28 | 40.7 | 8.5 | 6.36 | 139.56 |
| | Dec. | 19 | 39.7 | 8.53 | 6.38 | 153.05 |
| | Feb.2002 | 19.8 | 39.8 | 8.91 | 10.09 | 130.72 |
| | Average | 25.1 | 39.8 | --- | 6.58 | 146.82 |
| V | Apr.2001 | 22.9 | 41.6 | 8.5 | 5.0 | 151.20 |
| | Jun. | 25 | 41.4 | 8.41 | 5.89 | 142.88 |
| | Aug. | 28.5 | 41 | 8.46 | 6.02 | 145.84 |
| | Oct. | 27 | 39.3 | 8.42 | 5.64 | 144.42 |
| | Dec. | 19 | 39.7 | 8.56 | 7.38 | 153.79 |
| | Feb.2002 | 18.1 | 39.9 | 8.51 | 5.97 | 136.34 |
| | Average | 23.4 | 40.5 | --- | 5.98 | 145.75 |

**Table (2):** Levels of nutrients (µmole.$l^{-1}$) in water of the Suez Bay during April 2001-February 2002.

| Stations | Month | Silicate | Phosphate | Ammonia | Nitrite | Nitrate |
|---|---|---|---|---|---|---|
| I | Apr.2001 | 1.431 | 0.004 | 0.734 | 0.193 | 2.692 |
| | Jun. | 1.532 | 0.064 | 0.724 | 0.498 | 0.547 |
| | Aug. | 2.401 | 0.705 | 0.235 | 0.094 | 0.011 |
| | Oct. | 2.30 | 0.028 | 0.026 | 1.081 | 2.913 |
| | Dec. | 0.323 | 0.101 | 0.658 | 0.15 | 1.560 |
| | Feb.2002 | 0.058 | 0.069 | 0.872 | 0.559 | 0.905 |
| | Average | 1.341 | 0.162 | 0.541 | 0.430 | 1.438 |
| II | Apr.2001 | 0.201 | 0.004 | 0.673 | 0.169 | 2.507 |
| | Jun. | 0.726 | 0.087 | 0.163 | 0.475 | 0.257 |
| | Aug. | 0.005 | 0.06 | 0.694 | 0.169 | 0.186 |
| | Oct. | 0.62 | 0.087 | 0.173 | 0.724 | 10.107 |
| | Dec. | 0.122 | 0.005 | 0.235 | 0.39 | 3.144 |
| | Feb.2002 | 0.058 | 0.032 | 1.372 | 0.766 | 6.322 |
| | Average | 0.289 | 0.046 | 0.552 | 0.449 | 3.75 |
| III | Apr.2001 | 0.191 | 0.004 | 0.459 | 0.033 | 2.518 |
| | Jun. | 0.302 | 0.106 | 0.26 | 0.357 | 0.001 |
| | Aug. | 0.371 | 0.051 | 0.709 | 0.132 | 1.52 |
| | Oct. | 0.673 | 0.161 | 0.755 | 0.385 | 5.156 |
| | Dec. | 0.011 | 0.005 | 1.601 | 0.639 | 6.742 |
| | Feb.2002 | 0.005 | 0.014 | 0.791 | 0.193 | 2.713 |
| | Average | 0.259 | 0.057 | 0.763 | 0.29 | 3.108 |

continue.

**Table 2 :** continue.

| Station | Month | Silicate | Phosphate | Ammonia | Nitrite | Nitrate |
|---|---|---|---|---|---|---|
| IV | Apr.2001 | 0.005 | 0.037 | 0.75 | 0.16 | 4.963 |
| | Jun. | 0.239 | 0.055 | 0.541 | 0.32 | 0.056 |
| | Aug. | 0.371 | 0.004 | 0.474 | 0.056 | 1.324 |
| | Oct. | 0.419 | 0.055 | 1.061 | 0.385 | 8.606 |
| | Dec. | 0.021 | 0.023 | 0.398 | 0.348 | 12.114 |
| | Feb.2002 | 0.005 | 0.065 | 1.489 | 0.94 | 4.099 |
| | Average | 0.177 | 0.04 | 0.786 | 0.368 | 5.194 |
| V | Apr.2001 | 0.122 | 0.004 | 0.377 | 0.061 | 1.737 |
| | Jun. | 0.307 | 0.078 | 0.117 | 0.122 | 0.568 |
| | Aug. | 0.297 | 0.004 | 0.214 | 0.033 | 1.452 |
| | Oct. | 0.551 | 0.074 | 0.806 | 0.202 | 6.008 |
| | Dec. | 0.037 | 0.028 | 0.632 | 0.094 | 4.067 |
| | Feb.2002 | 0.027 | 0.041 | 0.255 | 0.141 | 5.714 |
| | Average | 0.223 | 0.038 | 0.40 | 0.109 | 3.258 |

**Table (3):** Distribution and cover percentage (% per one quadrate)of macroalgal species in the Suez Bay.

| Stations | Months | ***Ulva lactuca* cover %** | ***Enteromorpha compressa* cover %** | ***Padina pavonia* cover %** | ***Sargassum dentifolium* cover %** |
|---|---|---|---|---|---|
| I | April 2001 | 25.8 | 0 | 0 | 0 |
| | June | 4.8 | 0 | 0 | 0 |
| | August | 0 | 0 | 0 | 0 |
| | October | 0 | 0 | 0 | 0 |
| | December | 0 | 0 | 0 | 0 |
| | February 2002 | 6.7 | 9.1 | 0 | 0 |
| | average | 6.22 | 1.52 | 0 | 0 |
| II | April 2001 | 64.71 | 0 | 0 | 0 |
| | June | 85.8 | 0 | 0 | 0 |
| | August | 68.8 | 0 | 0 | 0 |
| | October | 66.5 | 0 | 0 | 0 |
| | December | 61.3 | 55.2 | 0 | 0 |
| | February 2002 | 83.5 | 75.1 | 0 | 0 |
| | average | 71.77 | 21.72 | 0 | 0 |

Continue.

**Table 3:** Continue.

| Stations | Months | *Ulva lactuca* cover % | *Enteromorpha compressa* cover % | *Padina pavonia* cover % | *Sargassum dentifolium* cover % |
|---|---|---|---|---|---|
| III | April 2001 | 0 | 49.5 | 0 | 0 |
| | June | 0 | 68.6 | 0 | 0 |
| | August | 0 | 32.5 | 0 | 0 |
| | October | 0 | 0 | 0 | 0 |
| | December | 0 | 0 | 0 | 0 |
| | February 2002 | 0 | 0 | 0 | 0 |
| | average | 0 | 25.1 | 0 | 0 |
| IV | April 2001 | 8.2 | 19.25 | 0 | 0 |
| | June | 57 | 55.20 | 0 | 0 |
| | August | 0 | 0 | 0 | 0 |
| | October | 0 | 0 | 0 | 0 |
| | December | 0 | 0 | 0 | 0 |
| | February 2002 | 0 | 74.4 | 0 | 0 |
| | average | 10.87 | 24.81 | 0 | 0 |
| V | April 2001 | 0 | 0 | 0 | 0.1 |
| | June | 0 | 0 | 0 | 0 |
| | August | 0 | 0 | 0.1 | 0.1 |
| | October | 0 | 0 | 0 | 0.1 |
| | December | 0 | 0 | 0 | 0 |
| | February 2002 | 0 | 0 | 0 | 0 |
| | average | 0 | 0 | 0.02 | 0.05 |
| | **Total average** | 17.77 | 14.62 | 0.004 | 0.01 |

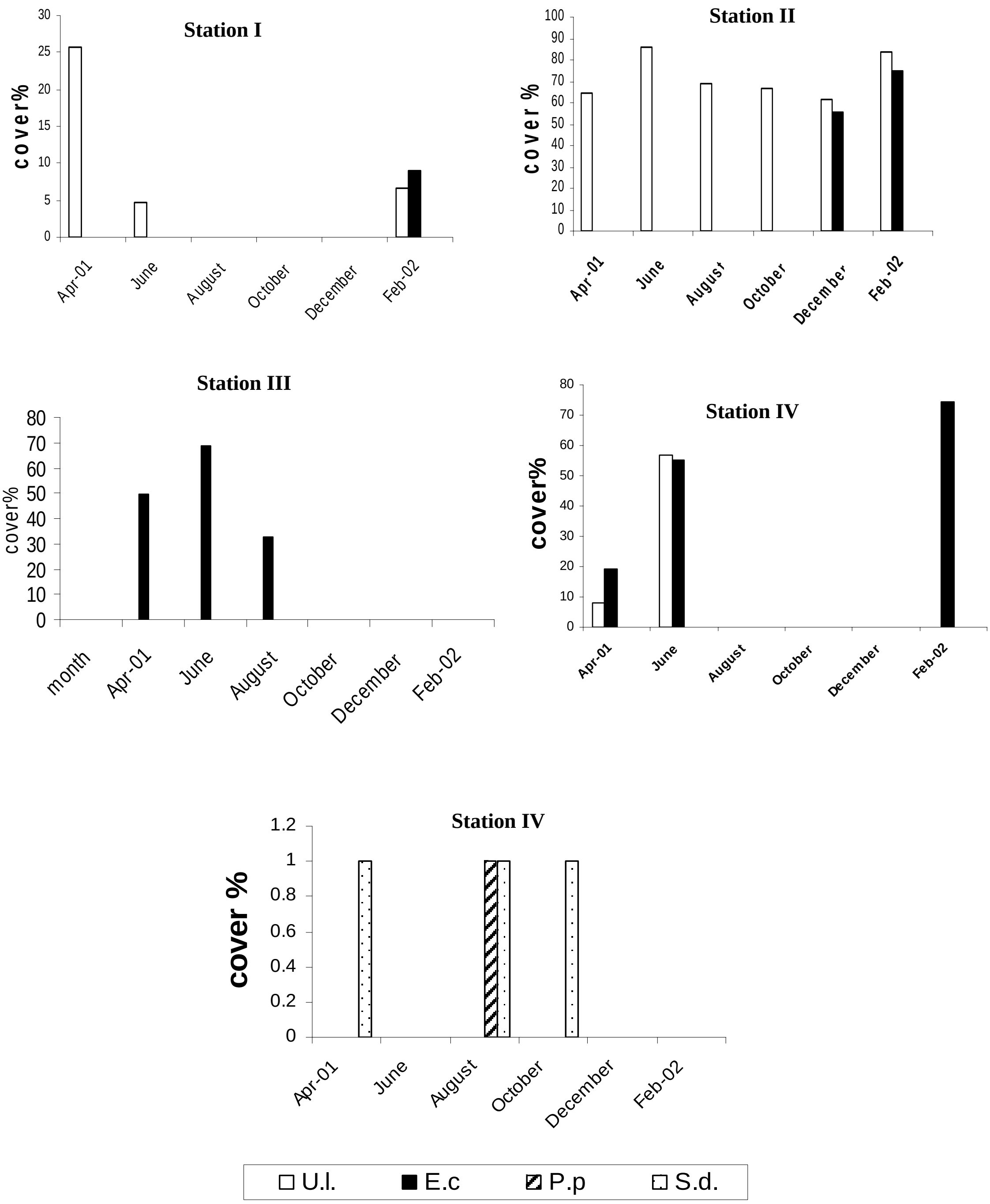


**Fig. (2):** Distribution of macroalgal species in the intertidal zone of the Suez Bay, (2001-2002)

The high temperature was the most characteristic feature at station III lying in front of the Electric Power plant. The high values were attributed to the hot water discharged from the cooling system of the plant. Our results fluctuated between a minimum of 25ºC in December to a maximum of 39ºC in August forming an average of 31.3ºC (Table 1). As the temperature plays an important role in the activity of the aquatic organisms (Goldman and Carpenter 1974), the macroalgal distribution was greatly affected. The green alga *Enteromorpha compressa* was the only species flourishing in this site with cover percentage of 49.5% in April, 68.6% in June and 32.5% in August in which the temperature was excessively high reaching 39ºC and with an average of 25.1% (Table 3 & Fig. 2). This induced that *Enteromorpha compressa* tolerates excessively high temperature, since the environmental chandes caused by thermal discharges are critically important and the heat effluent may destroy the algal vegetation there (Mihursky, 1969; North, 1969; Nugent, 1970; Roessler, 1971 and El- Manawy, 1992). They also mentioned that the species which grow in such area can withstand the thermal effects combined with the possible influences by toxicants injected into seawater entering the power plant to control the biological growth of fouling organisms. Present results agree with Nasr and Aleem (1948) who listed Enteromorpha among eurythermal and euryhaline genera which has the ability to flourish in a wide range of temperature and salinity fluctuations.

Station IV was subjected to oil refineries and industrial effluents as well as the discharge of fresh water by small community. The station is characterized by low salinity values than the other sites of the study area ranging from a minimum of 35.9‰ in April to a maximum of 41.5‰ in June forming an average of 39.8‰ (Table 1). This was attributed to the fresh water discharged by the small community enhancing the flourishing of the two green algae *Ulva lactuca* and *Enteromorpha compressa,* which are euryhaline forms as mentioned before. As well as the relatively high nitrogenous compounds. The concentrations of ammonia ranged from a minimum value of 0.398µmole.$l^{-1}$ in December to a maximum value of 1.489µmole.$l^{-1}$ in February forming an average of 0.786µmole.$l^{-1}$ while the nitrite concentrations fluctuated between a minimum of 0.056µmole.$l^{-1}$ in August to a maximum of 0.94µmole.$l^{-1}$ in February forming an average of 0.368µmole.$l^{-1}$ and the nitrate concentrations fluctuated between a minimum of 0.056µmole.$l^{-1}$ in June to a maximum of 12.114µmole.$l^{-1}$ forming an average of 5.194µmole.$l^{-1}$. On the other hand, the concentrations of phosphorus according to the records of Stirn (1988) as mentioned before lied in the normal range with a minimum value of 0.004µmole.$l^{-1}$ in August to a maximum value of 0.055µmole.$l^{-1}$ in October forming an average of 0.04µmole.$l^{-1}$ . While the concentrations of silicate was slightly high in some months and indicate the freshwater dispersion in this site according to Friligos (1988) as mentioned previously.

The results ranged from a minimum of 0.005µmole.$l^{-1}$ in April and February to a maximum of 0.419µmole.$l^{-1}$ in October with an average of 0.177µmole.$l^{-1}$ (Table 2). The distribution of the algal species in this site was affected by the physico-chemical conditions such as low salinity values, high nutrient concentrations. The green alga *Ulva lactuca* was present only in April and June with cover percentage of 8.2% and 57% respectively with an average of 10.86%. While *Enteromorpha compressa* flourished in April, June and February with 19.25%, 55.2% and 74.4% respectively and with an average of 24.74% (Table 3 & Fig 2).

The station V was quite distant from the pollution sources and was considered as control area. This was shown by several characteristic features such as the relatively high salinity ranging from a minimum value of 39.3‰ in October to a maximum value of 41.6‰ in April with an average of 40.5‰ indicating the diminution of fresh water discharge in this site. On the other hand, low dissolved oxygen and pH values indicate low photosynthetic activity, hence a minimum algal growth. The pH values fluctuated between a minimum of 8.41 in June to a maximum of 8.56 in December. While the oxygen values ranged from a minimum of 5.0 $mg.l^{-1}$ in April to a maximum of 7.38 $mg.l^{-1}$ in December with an average of 5.98 $mg.l^{-1}$ (Table 1). In addition to lower concentrations of most nutrients in this site than in the other ones. The results of silicate were slightly high during some months which indicates fresh water dispersion as mentioned before (Friligos 1988). The values fluctuated between a minimum of 0.027$\mu mole.l^{-1}$ in February to a maximum of 0.551$\mu mole.l^{-1}$ in October forming an average of 0.223$\mu mole.l^{-1}$ . The concentrations of phosphate were relatively low ranging from a minimum of 0.004$\mu mole.l^{-1}$ in April and August to a maximum of 0.078$\mu mole.l^{-1}$ in June with an average of 0.038$\mu mole.l^{-1}$ .

On the other hand ammonia concentration fluctuated between a minimum value of 0.117$\mu mole.l^{-1}$ in June to a maximum value of 0.806$\mu mole.l^{-1}$ in October forming an average of 0.40$\mu mole.l^{-1}$ . The concentrations of nitrite ranged from a minimum of 0.033$\mu mole.l^{-1}$ in August to a maximum of 0.202$\mu mole.l^{-1}$ in October with an average of 0.109$\mu mole.l^{-1}$ while the nitrate fluctuated between a minimum value of 0.568$\mu mole.l^{-1}$ in June to a maximum value of 6.008$\mu mole.l^{-1}$ forming an average of 3.258$\mu mole.l^{-1}$ (Table 2). All these characteristics has greatly affected the macroalgal distribution in this site. The two green algae *Ulva lactuca* and *Enteromorpha compressa* were completely absent. On the other hand the two brown algae Padina pavonia and Sargassum dentifolium were recorded scarcely with cover percentage of 0.1% in August for the former and 0.1% in April, August, and October for the later (Table 3& Fig.2). As it is well known, the two algal species are known to be very sensitive to any pollutants and cannot flourish in such areas. This agree with El-Komi (1996) who recorded dense growth of the brown algae *Sargassum latifolium, Padina pavonia,* and *Cystoseira trinodis* along the eastern coast of the Suez Gulf which is considered as non polluted area. El-Komi *et al.* in 1998 reported that green algae were the most abundant group followed by brown and red algae which were associated with the fouling organisms in the Suez Bay. El-Nagaar *et al.* (2002) recorded *Padina pavonia* at a non-polluted station in Hurghada, while it was completely absent at the polluted sites, Adabiya and Ras Gharib.

## STATISTICAL ANALYSIS

The simple correlation coefficient between the macroalgae cover percentage and the physico-chemical parameters showed that the *Ulva lactuca* was positively correlated with dissolved oxygen and pH (r =0.62, r =0.65) respectively, while the *Enteromorpha compressa* was positively correlated only with dissolved oxygen (r =0.46). The other environmental factors seemed not to be limiting factors to the algal cover percentage. So for more clarification and for more accuracy principle component analysis was performed to find out the relationship between algal cover percentage and the physico-chemical parameters.

The principle component analysis yielded fourteen components from which five components retained with Eigen values higher than 1, (Fig3). The first two components were loaded cumulatively with the largest part of the variance. So the first two components were retained and used to find out the final relationship between the algal cover percentage and the physico-chemical parameters (Table 4).

**Table (4):** The Eigen value and the total variance of the two first components.

| Value | Eigen value | % Total variance | Cumulative Eigen value |
|---|---|---|---|
| 1 | 3.345795 | 23.89853 | 3.345 |
| 2 | 2.143617 | 15.31155 | 5.489 |

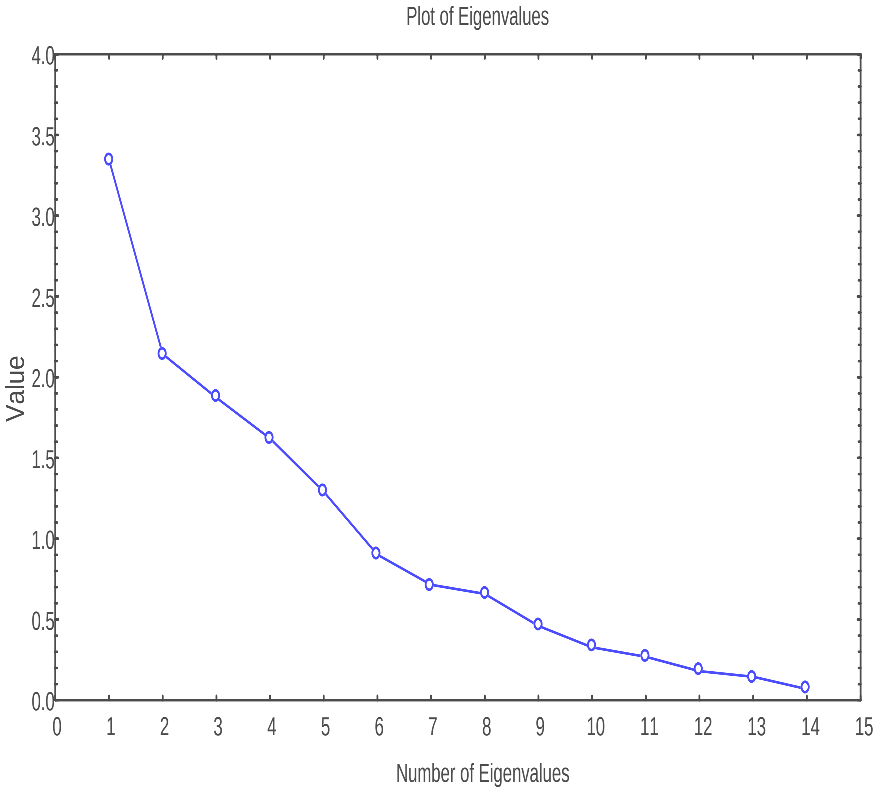


**Fig. (3):** the number of Eigen values of the fourteen components.

It was observed that the variables (dissolved oxygen, ammonia, nitrite, temperature, the cover percentage of *Ulva lactuca, Enteromorpha compressa, Padina pavonia,* and *Sargassum dentifolium*) had the highest loadings on the principle component 1, while the variables (silicate, phosphate, and nitrate) had the highest loadings on the principle component 2 (Table 5).

**Table (5):** The variables and their loadings on the two principle \ components.

(Marked loadings are >0.500000).

| | Component 1 | Component 2 |
|---|---|---|
| Dissolved oxygen | - .751825 | -.343061 |
| Alkalinity | .237616 | -.325814 |
| Silicate | .212402 | -.722172 |
| Phosphate | .231590 | -.633028 |
| Ammonia | -.443245 | .438277 |
| Nitrite | -.705531 | -.078814 |
| Nitrate | -.352072 | .460256 |
| Temperature | .454654 | -.440909 |
| PH | -.745851 | -.318808 |
| Salinity | .380702 | -.099933 |
| Ulva cover% | -.550971 | -.416303 |
| Enteromorpha cover% | -.489226 | .008787 |
| Padina cover% | .384824 | .197809 |
| Sargassum cover% | .456300 | .262374 |

Plotting the principle component 1 against the principle component 2 showed two groups. In the first group the cover percentage of the two green algae *Ulva lactuca* and *Enteromorpha compressa* were positively correlated with dissolved oxygen, pH, nitrite, ammonia and nitrate. While in the second group the cover percentage of the two brown algae Padina pavonia and *Sargassum dentifolium* were positively correlated with temperature, salinity, alkalinity, phosphate and silicate concentration. This result is demonstrated by the distribution of the macroalgae in the study area, where the two green algae flourished only at the stations enriched with nutrients, specially the nitrogenous compounds. While the two brown algae flourished only at station V which has high water salinity and was relatively far from the human activities and has contained less nutrients than the other stations. Also the positive correlation between the brown algae and the temperature is well demonstrated since the two brown algae flourished only in the warm months (Fig.4).

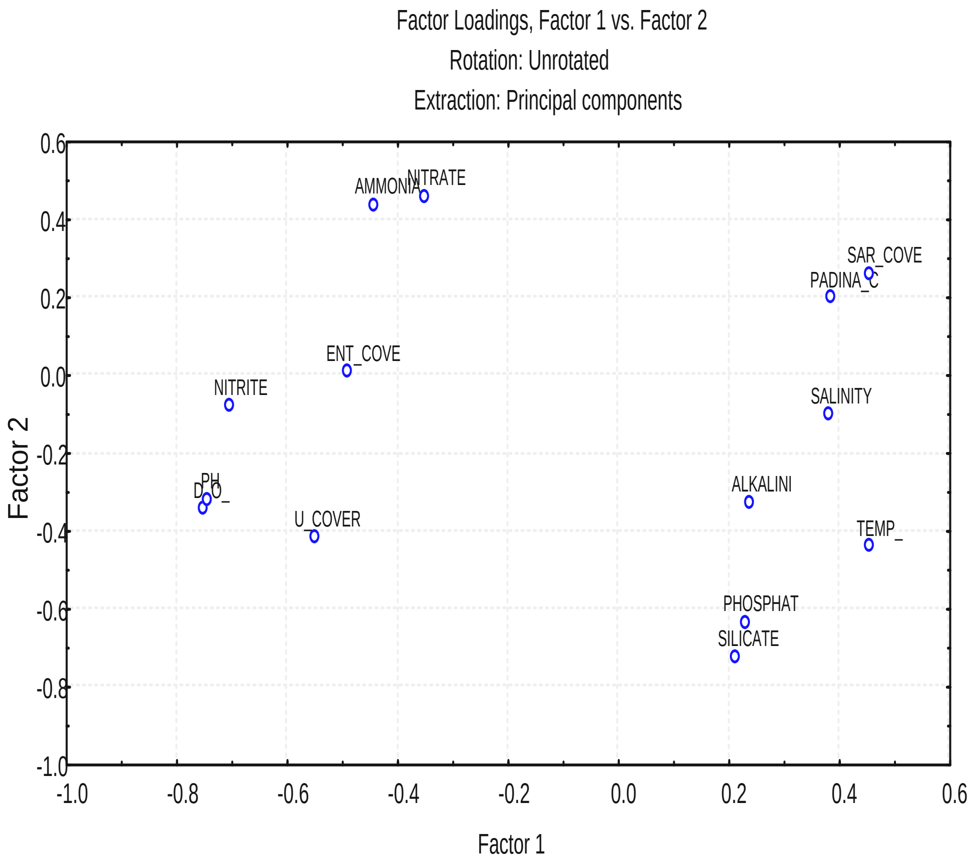


**Fig 4 :** The loadings of the variables on the principle component 1 and 2 showing the relationship between the cover percentage of algae and the physico-chemical parameters.

In conclusion, the study area comprised five selected sites which represent different habitats since each site is subjected to different types of pollution which affect on distribution of macroalgae as well as on the environmental conditions prevailing there.

# REFERENCES

Abd El-Azim H. (1996): Lead dynamics in Suez Bay. M. Sc. Thesis, Fac Sci., Helwan Univ.

Aleem, A.A. (1993): The marine algae of Alexandria, Egypt. 139 pp.

APHA (1995): Standard Methods for the examination of water and wastewater. 19th Edition, EPHH, Washington, 1015 pp.

Bellan, G. (1972): Pollution et peuplements marins. Sci. et Nat., 109: 7pp.

Bellan-Santini, D. (1966): Influence de la pollution sur quelques peuplements superficiels de substrat rocheux. G.I.E.S.M., Symp. Pollut. Mar. Microorgan. Prod. Petrol. , Monaco.127-131.

Belsher, T. (1974): Sequence des effets d ?un egout urbain en fonction de l'éloignement de la source de pollution sur les peuplemrnts photophiles battu (fraction algale): premiers resultants. Bull.Soc.Phycol.Fr., 19: 158-163.

Belsher. T. (1977): Analyse des repercutions de pollutions urbaine sur les Macrophytobenthos de Mediterranee (Marseille, Port Vendres, Port Cros). These, C.U.M.L., Uni. D ?Aix -Marseille Π.

Belsher, T.; Boudouresgue, C.F.; Marcot, J. and Perret, M. (1975): Le Peuplement algal du port de Vendres: Dominances qualitatives des grands groupes systematique. Rapp. Comm. International explor. Sci. Mer Medit., 23: 87-89..

Dawson, E.Y. (1962): New taxa of benthic green, brown and red algae. Beaudette foundation, Santo Ynez, California, 105 pp.

Durcos-Viel, M. (1974): Lutte contre la pollution des eaux. Le point actuel de la legislation et de la reglementation. S.O.S, Vie Nature, 11: 73-80.

El-Komi, M. M. (1996): Coastal development and pollution impact on the distribution of macrobenthic communities along the eastern coast of the Gulf of Suez (Egypt). Pakistan Journal of Marine Science, 5(1): 1-13.

El-Komi, M. M.; Emara, A.M. and Mona, M.H. (1998): Ecological settlement of the marine fouling in the Suez Bay, Egypt. Proceedings of the 8th is a must Inter. Confer.On: Environmental protection is A Must. Nat. Oceanogr.& Fish., Euro-Arab Cooperation center, Inter.Sci.Asso.& Soci. Fund for development, 234-251.

El Manawy, I. M. (1992): Ecological studies on the marine benthic flora of the Bitter Lakes (Suez Canal). Ph. D. thesis, Suez Canal Uni., 155pp.

El-Moselhy, Kh. M.; Diab, A. A.; Tolba, M. R. and Mohamadein, L. I. (1999): Levels of some heavy metals in coastal water, sediment and the limpet Patella sp. from the northern part of the Gulf of Suez (Suez Bay). Egypt. J. Aquat. Biol. & Fish., 3(2): 69 - 84.

El-Nagaar, A. H.; Osman, M.E.H.; El-Sherif, M.Z. and Nassar, M.Z. (2002): Phytoplankton and seaweeds of the Western Coast Of The Suez Gulf (From Red Sea) in relation to some physico-chemical factors, oil and sewage pollution. Bull. Fac. Sci., Assiut Univ., 31: 77-104.

Friligos, N. (1988): Eutrophication of Saronifros Bay. In UNEP/UNESCO/ FAO, 123-132.

Garrone, B. (1970): Sur l emploi de quelques methods statistiques pour l étude de la Sociologie et de l ecologie vegetale (Application aux formations ligneuses d un transect allant de Montpellier aux basses Cevennes). These doc. Specialiste. Univ. Montpellier.

Goldman, J.C. and Carpenter, E.J. (1974) : A kinetic approach to the effect of temperature on algal growth. Limnol. Oceonogr., 19: 756-766.

Grasshoff,G.(1975): The hydrochemistry of land locked basins. Fjords.Chemical oceanogr. 2:568-574.

Hamed, M. A. (1992): Sea water quality at the northern part of the Gulf of Suez and the nearby area of the Suez Canal. M. Sc. Thesis, Fac. Sci., Mansoura Univ., 81pp.

Hamed, M. A.; Said T. O. and Nassar M. Z. (2003): Effect Of Heavy metals and aromatic hydrocarbons On phytoplankton biomass as represented by Chlorophyll-A in the northern part of the Suez Gulf, Egypt. J. Egypt. Acad. Soc. Environ. Develop., (D-Environmental Studies), 4(1): 67-85.

Hintze, J. L. (1993): Number Cruncher Statistical System (NCSS). Version 5. 035/93.

Jaasund, E. (1976): Intertidal seaweeds in Tanzania. Edition Uni. Tromso. 160 pp.

Meshal, A. H. (1970): Water pollution in Suez Bay. Bull. Inst. Oceanogr. and Fish., Egypt, 1: 463-473.

Mihursky, J. A. (1969): Patuxent thermal studies: Summary and recommendations. National Reserch Inst., Univ. Maryland, NRI special report no.1.

Morcos, S. A. (1960): The tidal currents in the Southern part of Suez Canal. Gen. Ass. of Helsiniki, 51: 307-316.

Murray, S. N. and Litter, M. M. (1978): Patterns of algal succession in a perturbated marine intertidal community. J. Phycol., 14: 506-512.

Nasr, A. H. and Aleem, A. A. (1948): Ecological studies of some marine algae from Alexandria. Hydrobiologia, 1: 251-280.

North, W. J. (1969): Biological effects of a heated water discharge at Morro Bay, California. In Proc. Sixth Inxt. Seaweed Symp. Ed. R. Margalef. 275-286. Madrid: Subsecretaria de la Marina Mercante.

Nugent, R. S. (1970): The effects of thermal effluent on some of the macrofauna of a subtropical estuary. Sea Grant Tech. Bull. no.1, Univ. of Miami, Fla.

Redfield, A. C. (1958): The biological control of chemical factors in the environment. Amer. Sci., 46: 205-222.

Roessler, M. A. (1971): Environmental changes associated with a Florida power plant. Mar. Pol. Bull., 2: 87-90.

Said T. O. (1992): Study of oil pollution in the Northern part of the Gulf of Suez. M. Sc. Thesis, Fac. Sci., Mansoura Univ

Soliman, G. F. (1996) Simulation of water circulation in the Suez Bay and its hydrographic features during winter and summer.Proceedings of the 6th is a must Inter. Confer.On: Environmental protection is A Must. Nat. Oceanogr.& Fish., Euro-Arab Cooperation center, Inter.Sci.Asso.& Soci. Fund for development,400-433.

Stirn, J. (1988): Eutrophication in the Mediterranean Sea. Mediterranean Action Plan, Technical Reports Series, no.21: 161-187.

Strickland, J. D. H. and Parsons, T. R. (1968): A practical handbook of sea water analysis. Fish. Res., Bd. Ca.167 : 311 pp.