ISSN 1110-0354
*Bull. Nat. Inst. of Oceanogr. & Fish., A.R.E., Vol. (27) 2001: 95 - 112*

# *PRELIMINARY STUDY ON THE HYDROCHEMISTRY OF THE EGYPTIAN COASTAL WATER OF AQABA GULF, AS A UNIQUE ECOSYSTEM DURING YEAR 2000*

*By*

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**Key words: Aqaba Gulf, Coastal zone, Water quality, Hydrographical conditions, Nutrients, Eutrophications**

## *ABSTRACT*

*The Environmental Information and Monitoring Program (EIMP) was established to assess the aesthetic quality of Aqaba Gulf, to initiate monitoring and database system for the Egyptian coastal water by using the quality assurance and quality control work and for sustainable use of the Gulf coast line. Within the framework of this program, six bimonthly field trips were carried out during year 2000. A total of 11 coastal stations were selected to cover different locations of the Gulf. The surface distribution pattern of hydrographical conditions (water temperature S‰, DO and pH) and eutrophication parameters (Chl-a, TSM, trans, $NH_4$, $NO_2$, $NO_3$, TN, $PO_4$, TP and $SiO_4$) were investigated and the obtained data deduced that: Water temperature was relatively high with almost no thermocline or thermal pollution. Variations in the distribution pattern of S‰ and pH values were insignificant. The oxygen measurements clearly indicated that the water column is well oxygenated and the present load of organic matter and nutrients reached the Aqaba Gulf is below the level which bring about oxygen deficiency. Nitrogen in the dissolved inorganic forms ($NH_4$, $NO_2$, $NO_3$) is quite low in the surface coastal water of most locations of Aqaba Gulf. The abundance of different inorganic nitrogen forms were in the order $NH_4 > NO_3 \geq NO_2$ reflecting the increasing rate of $NH_4$ production, as compared with the other inorganic nitrogen forms, than its uptake rate as a*

*preferable inorganic nitrogen forms for phytoplankton. Phosphorus is principally the responsible nutrient for the limitation of phytoplankton growth. Nitrogen and phosphorus are found in the Egyptian coastal water of Aqaba Gulf principally in organic forms. Based on the levels of Chl-a. trans $NH_4$. $NO_3$. TN. $PO_4$ and TP Aqaba Gulf surface coastal water can be classified under oligotropic to mesotrophic states. It is safe to conclude that the main body of Aqaba Gulf is not yet seriously threatened by eutrophication. the problem instead is sometimes local and regional and limited largely to specific coastal area of the northern part of the Gulf.*

## *INTRODUCTION*

Aqaba Gulf (150km long) is considered one of the unique ecosystem with highly diversified marine life including corals and big mammals. It is in great values for recreational, environmental and scientific interests. The (EIMP) was established to assess the aesthetic quality of the Egyptian coastal water of Aqaba Gulf due to its importance for the tourism and consequently the national income. The EIMP is also meant to establish a baseline and data base system for the Egyptian coastal waters following the .quality assurance and quality control work (Quality manual 2000).

## *MATERIAL AND METHODS*

Within the framework of EIMP program, six field trips were performed in January, March, May, July, September and November, 2000. A total of 11 stations along the Egyptian coast of Aqaba Gulf were selected to represent different locations situated under the direct effect of human activities, public resort beaches and some protected and reference sites ( Fig.1 & 1). The hydrographical parameters water temperature, salinity, dissolved oxygen (DO) and pH were measured in situ of station using CTD (YSI-6000) .The geographic as well as temporal distribution pattern of different nutrients ($NH_4$, $NO_2$, $NO_3$, total-N ,$PO_4$ and total-P beside $SiO_4$) were investigated. Water samples were collected in duplicate from 2m depth at each station, using a PVC Nisken's bottle. Water samples for NH4 were eluted first then fixed .This followed by subsequent measurements using the indophenol blue technique

**Table (1): List of name, site code, locations of different stations for Aqaba Gulf during 2000.**

| Name | Site Code | Latitude | Longitude |
|---|---|---|---|
| Sharm El Sheikh Ras Mohamed | Aq01 | 27° 47' 40" | 34° 12' 51" |
| Sharm El Sheikh Harbour | Aq02 | 27 51 23 | 34 16 50 |
| Sharm El Sheikh Na'ama bay | Aq03 | 27 54 39 | 34 19 47 |
| Nahlat Al Tel | Aq04 | 28 11 45 | 34 25 51 |
| Dahab | Aq05 | 28 28 39 | 34 30 44 |
| Ras Mamlah | Aq06 | 28 35 00 | 34 36 00 |
| Hibeiq-Ras Nabar | Aq07 | 28 52 54 | 34 38 43 |
| Nuweiba harbour-El Saiadin | Aq08 | 28 58 15 | 34 39 12 |
| Nuweiba | Aq09 | 29 20 22 | 34 40 30 |
| Mersa Muqibila | Aq10 | 29 23 38 | 34 48 36 |
| Taba | Aq11 | 29 29 17 | 34 53 34 |

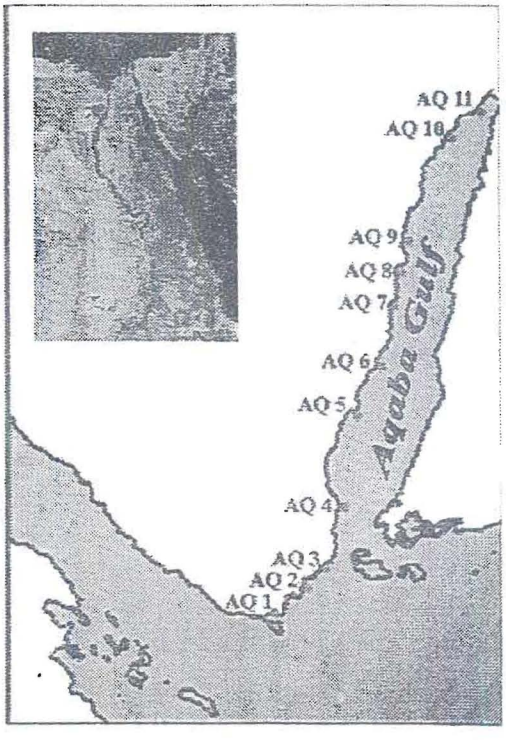


Figure 1. Locations of sampling sites in Aqaba Gulf Egypt.

Table (2): Stational annual average values of different physicochemical characteristics of Aqaba Gulf surface coastal water during 2000.

| St.Code | S | pH | DO | DO | Chl-a | TSM | Tr. |
|---|---|---|---|---|---|---|---|
| | (‰) | | (mg/l) | % | µg/l | mg/l | m |
| Aq1 | 39.93 | 8.19 | 7.37 | 111.40 | 0.22 | 6.89 | 10.17 |
| Aq2 | 39.92 | 8.17 | 7.29 | 111.08 | 0.18 | 6.09 | 5.92 |
| Aq3 | 39.93 | 8.17 | 7.19 | 109.22 | 0.17 | 6.56 | 9.98 |
| Aq4 | 40.07 | 8.17 | 7.56 | 111.99 | 0.14 | 5.56 | 15.75 |
| Aq5 | 40.10 | 8.17 | 7.70 | 113.73 | 0.15 | 6.32 | 11.17 |
| Aq6 | 40.20 | 8.18 | 7.41 | 108.65 | 0.14 | 6.14 | 20.67 |
| Aq7 | 40.05 | 8.17 | 7.37 | 108.62 | 0.15 | 5.89 | 13.67 |
| Aq8 | 40.17 | 8.24 | 7.40 | 109.24 | 0.11 | 5.75 | 20.08 |
| Aq9 | 40.13 | 8.18 | 7.40 | 109.34 | 0.13 | 6.65 | 8.42 |
| Aq10 | 40.05 | 8.20 | 7.46 | 109.54 | 0.15 | 5.64 | 21.00 |
| Aq11 | 40.10 | 8.15 | 7.54 | 110.51 | 0.20 | 5.56 | 19.83 |
| Ann. Av. | 40.06 | 8.18 | 7.43 | 110.30 | 0.16 | 6.10 | 14.24 |
| Stdev. | 0.09 | 0.02 | 0.13 | 1.53 | 0.03 | 0.44 | 5.24 |
| Var. % | 0.03 | 0.00 | 0.06 | 7.82 | 0.00 | 0.65 | 91.44365 |

DO is considered as one of the most important and useful parameters for the identification of different water masses and in assessing the degree of pollution in the marine environment. The measurements of DO indicated well oxygenated water column at all stations with a tendency towards a slight decrease in oxygen content with increasing depth. However, the level of DO was never even close to being depleted on any of the stations. The lowest and highest concentrations measured were 6.57 and 8.46mg/l (corresponding to 91.06 and 131.35%) at sts Aq11 and Aq5 in March and July respectively, with a general annual mean 7.43mg/l (corresponding to 110.30%) for the coastal region of the gulf. The oxygen measurements clearly indicated that the present load of organic matter and nutrients reached the Aqaba Gulf is below the level which bring about oxygen deficiency.

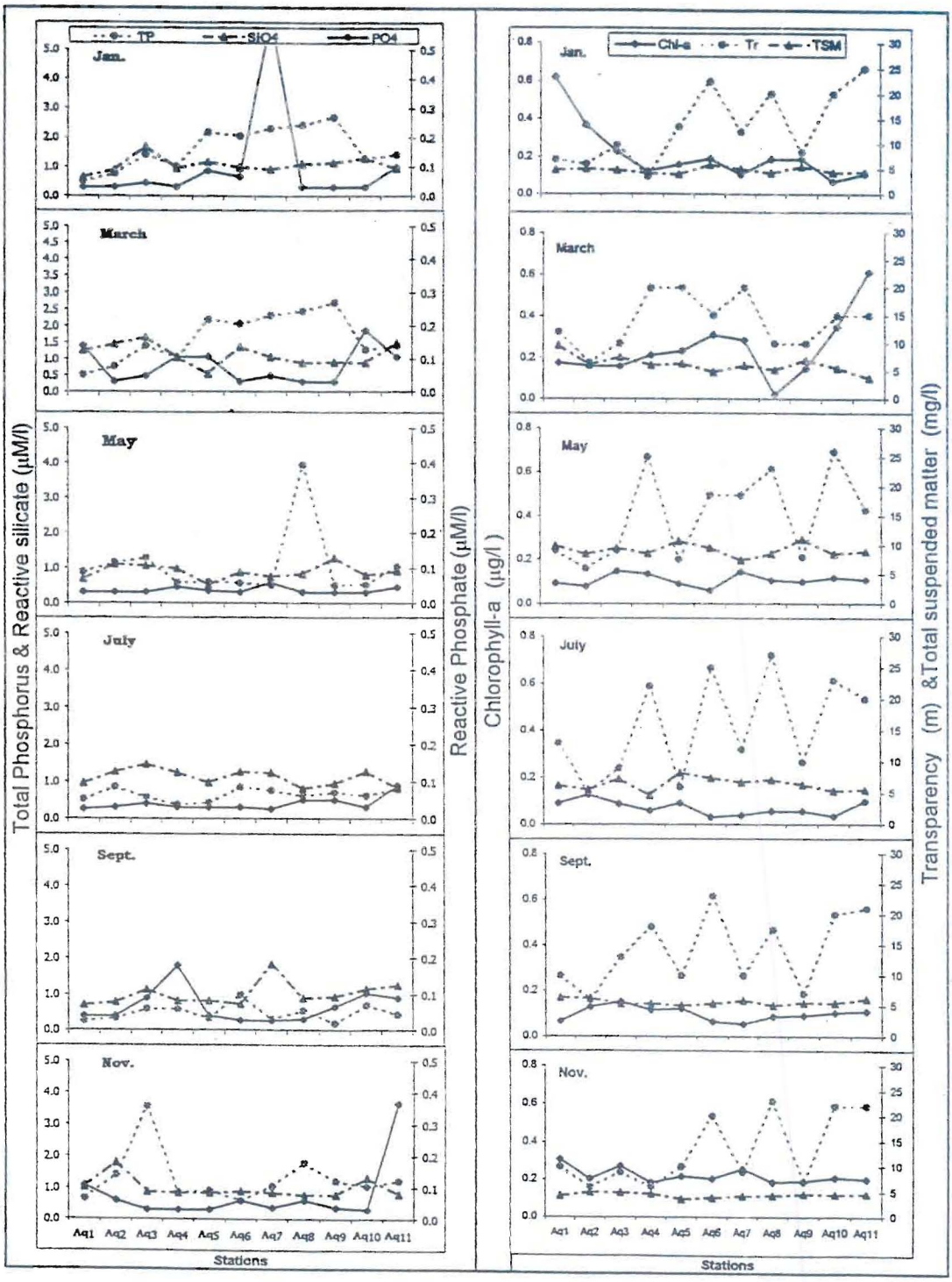


Fig. 3. Chl-a (µg/l), TSM (mg/l) , trans. (m) $PO_4$, TP and $SiO_4$ (µM/l) distribution at Aqaba Gulf coastal water during 2000

pH values were always on the slight alkaline side, they were very stable since the differences between their absolute and regional average values were insignificant. This can be justified from the absolute minimum and maximum pH values amounted 7.93 at st. Aq11 in March and 8.38 at sts Aq1and Aq3 in Jan., with an annual mean 8.18 for the whole surface coastal water of study area. Hottinger (1984) pointed out that within the open water of Aqaba Gulf, the sea surface values ranged from 20.75-26.70°C for water temp., 40.03-40.51 for S‰ and the maximum DO content was 6.1ml/l (equivalent to 8.72mg/l). under the arid and hot climatic conditions of the area, evaporation is extremely high and greatly exceeds precipitation and runoff, the evaporation loss is compensated by inflow from the Red Sea through the strait of Tiran. He added, the residence time of the water in the Gulf is about 4 months for the upper water and 3 years for the deep waters. Based on the above, considering the small size of the Gulf or, equivalent to the short residence time of its waters, these narrow ranges of different hydrographical conditions are not surprising.

**2- Eutrophication parameters**

**a- Chlorophyll-a, total suspended matter and transparency**

Phytoplankton biomass has been estimated using chlorophyll-a as biomass indicator. Actual chl-a concentrations were, generally low and the pattern was remarkably consistent (Table 2 & Fig. 3). Chl-a concentrations were always less than 0.3µg/l except Aq1 and Aq2 (0.62 and 0.36µg/l) in January Aq6 Aq10 and Aq11 (0.31, 0.35 and 0.61µg/l) in March and Aq1 (0.30µg/l) in November, respectively. No pronounced seasonal variations were observed, relatively slight increase in January, March and November and decrease in May-September was found. Seasonal averages of chl-a ranged from 0.07-0.24µg/l in July and March respectively with an annual mean 0.16µg/l for the whole surface coastal water of investigated region were encountered. On average, the data obtained during the present investigation (0.16µg/l) is comparable with that (0.15µg/l) which obtained by Halim (1969) for the Red Sea Region.

The load of total suspended matter (TSM) in the coastal water of Aqaba Gulf was generally low. This can be signified from their lowest and highest values amounted 3.56 and 11.03 mg/l at sts Aq5 and Aq9 in November and May respectively with an annual mean 6.10mg/l for the whole surface coastal water of investigated region (Table 2 & Fig. 3).

**Table (3): Stational annual average values of different nutrients (µM/l) in Aqaba Gulf surface coastal water during 2000.**

| Code | NH4-N | NO2-N | NO3-N | DIN | TN | PO4-P | DIN/P | TP | SiO4-Si |
|---|---|---|---|---|---|---|---|---|---|
| Aq1 | 0.79 | 0.03 | 0.87 | 1.57 | 12.86 | 0.08 | 41.75 | 0.60 | 0.88 |
| Aq2 | 0.65 | 0.04 | 0.39 | 1.12 | 17.63 | 0.05 | 32.08 | 0.86 | 1.21 |
| Aq3 | 0.60 | 0.05 | 0.76 | 1.39 | 15.67 | 0.06 | 34.75 | 1.32 | 1.31 |
| Aq4 | 0.57 | 0.03 | 0.54 | 1.14 | 26.12 | 0.11 | 26.71 | 0.77 | 0.98 |
| Aq5 | 0.73 | 0.04 | 0.78 | 1.54 | 24.84 | 0.07 | 41.52 | 0.90 | 0.81 |
| Aq6 | 0.39 | 0.04 | 0.92 | 1.35 | 15.71 | 0.05 | 35.99 | 1.00 | 1.02 |
| Aq7 | 0.62 | 0.11 | 1.15 | 1.76 | 13.62 | 0.13 | 48.22 | 0.95 | 1.11 |
| Aq8 | 0.33 | 0.04 | 0.28 | 0.65 | 14.34 | 0.05 | 18.61 | 1.64 | 0.88 |
| Aq9 | 0.52 | 0.04 | 0.61 | 1.17 | 21.96 | 0.05 | 29.07 | 0.95 | 1.00 |
| Aq10 | 0.63 | 0.06 | 0.46 | 1.15 | 15.68 | 0.11 | 34.27 | 0.90 | 1.12 |
| Aq11 | 0.39 | 0.08 | 0.95 | 1.29 | 18.33 | 0.09 | 35.18 | 0.93 | 1.04 |
| Ann. Av. | 0.56 | 0.05 | 0.70 | 1.28 | 17.89 | 0.08 | 34.18 | 0.98 | 1.03 |
| Stdev.± | 0.15 | 0.02 | 0.27 | 0.29 | 4.51 | 0.03 | 10.09 | 0.28 | 0.15 |
| Var. % | 0.10 | 0.00 | 0.33 | 1.87 | 94.57 | 0.00 | 470.73 | 0.36 | 0.10 |

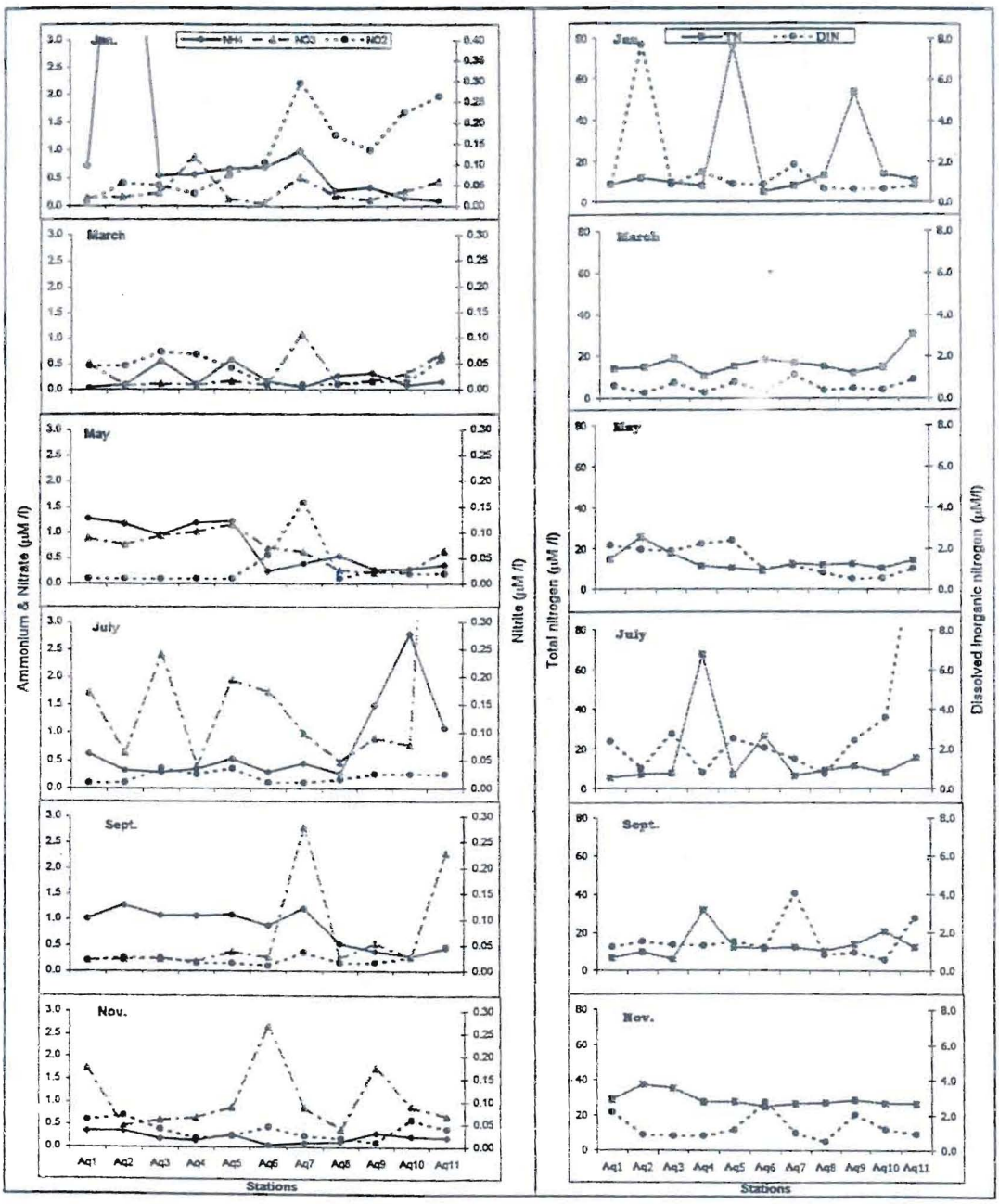


Fig.4.Different nitrogen forms (µM/l) distribution at Aqaba Gulf surface coastal water during 2000.

$NO_2$ is the most unstable compound of inorganic nitrogen forms because of its intermediate position in oxidation reduction processes between $NH_4$ and $NO_3$ . In the present investigation $NO_2$ was rarely present in measurable quantities Their values were always less than 0.1μM/l $NO_2$-N except Aq6-Aq11 in Jan. (0.11, 0.30, 0.17, 0.14, 0.23 and 27μM/l respectively) and Aq7 in May (0.16μM/l) . It harbored an annual mean 0.05μM/l .

$NO_3$, in general its level of concentration was relatively low at most sts of Aqaba Gulf. Except few locations, their values were always below 1.0μM/l $NO_3$-N .This can be pointed out from their absolute values which fluctuated between 0.05-2.79 μM/l at sts Aq8 and Aq7 in January and September respectively with an annual mean 0.70 μM/l. An unexpected value (11.34 μM/l) was detected at the surface coastal water of Taba city (Aq11) in July. This could be accompanied with presence of large amounts of sewage conveyed to this location from the nearby resort. Meanwhile, this value is an exceptional case and not representing the main trend of $NO_3$ concentration in the Gulf, accordingly it is excluded from the calculations of $NO_3$ mean values, as well as from the figure of this month. No pronounced seasonal pattern was observed with respect to $NO_3$ . Morcos (1970) pointed out that, in the Red Sea regions, NO3 is almost depleted in the upper layer and increased with depth under the euphotic zone. The supply to the upper layer can be made by advection and diffusion from underlying water which flows into the Red Sea from Aden Gulf. So this supply should be less significant from south to north. Stirn (1988) stated that in oligotrophic areas both $NO_3$ and $NH_4$ originate from marine regeneration and from the atmosphere.

The obtained levels of DIN ( $NH_4$-N + $NO_2$-N + $NO_3$-N ) from Aqaba Gulf surface coastal water indicated that nitrogen in the form of inorganic compounds is quite low. They fluctuated between 0.23-4.03μM/l at Aq2 in March and Aq7 in Sept. respectively, with an annual mean 1.29μM/l. The DIN concentrations recorded at sts Aq2 in Jan. and Aq11 in July (7.66 and 12.45μM/l, respectively) were relatively high and not representing the actual DIN concentrations in the Gulf coastal water, (due to high $NH_4$ or $NO_3$ concentrations as previously mentioned) accordingly they excluded from the calculations of DIN mean values. The abundance of different inorganic nitrogen forms therefore were mainly in the order $NH_4$ -N > $NO_3$ -N ≥ $NO_2$ - N reflecting the increasing rate of $NH_4$ production, or increasing rate of $NO_3$ consumption as compared to the other inorganic nitrogen species, by

respect to that of Redfield's (16N:1P). This suggests that $PO_4$ is principally the responsible nutrient for the limitation of phytoplankton growth in the Aqaba Gulf coastal water. Low phosphate contents could be related mostly to their sorption and deposition on iron born dust conveyed to the basins from the great areas of surrounding deserts. Beltagi (1984) pointed out that, in the Red Sea regions three water layers can be identified by their $PO_4$ concentrations the upper layer (120 - 170m thickness) has $PO_4$ concentrations of about 4.0-4.5mg $P/m^3$ ( $\cong$ 0.1 µM P/l) or even less. The second layer of 100-150m thickness below the first, contains $PO_4$ concentrations of 5-10mg $P/m^3$ (0.16-0.32 µM /l). Concentrations of phosphate in the inflowing Indian Ocean waters at the entrance of the Red Sea was 10mg P/m3 ($\cong$ 0.3 µM /l) and 30mg/$m^3$ ($\cong$ 1.0 µM P/l) at a depth of 75-100m. Marchetti: (1984) stated that, generally, the concentrations of $PO_4$ in the surface waters of the Mediterranean Sea are extremely low and expressed as values for orthophosphate 0.03 µM/l or less, typical concentrations for eutrophic coastal waters are above 0.15 µM/l and for highly eutrophied systems well be beyond 0.3µM. Based on the above, $PO_4$ concentrations in the surface coastal water of Aqaba Gulf are still very low and comparable to those in the surface water of the Red and Mediterranean Seas.

The geographic and temporal distribution pattern of TP showed relatively variable levels during the present investigation. These can be justified from the fluctuations amounted from 0.18-3.94µM/l at sts Aq9 and Aq8 in Sept and May, respectively, with an annual mean 0.98µM/l. These indicated that phosphate is present in the Egyptian coastal water of Aqaba Gulf principally, in organic and particulate forms, since dissolved $PO_4$ represented 4% of Total-P concentrations. In natural as well as moderately polluted coastal waters, the relative composition of phosphorus forms are particulate of 28.5 - 98%, colloidal of 1.2-4%, reactive $PO_4$ of 0.1-22% and dissolved organic-P of 0.1-6% of total-P (Compiled from numerous sources, basically from Nalewajko & Lean 1980). The mean annual values of TN (17.89µM /l) and TP (0.98µM /l) obtained during the present investigation may confirm the oligo-to meso-trophic state of Aqaba Gulf surface coastal waters. Giovanardi and Tromellini (1992) stated that the levels of TN and TP are 47.2 and 0.27µM /l in oligolrophic and 53.8 and 0.89µM /l in mesotrophic seawater, respectively.

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