# Plankton Assessment in Kuwait Bay

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***Abstract- Assessment of phytoplankton and zooplankton biomass in Kuwait Bay was performed during December 2017 and April 2018, in relation to different seawater parameters along five locations across the bay. The results during winter 2017, showed that temperature, water clarity and silicates were highly correlated with phytoplankton abundance, while, salinity and TSS, were positively correlated with zooplankton abundance. On the other hand, during spring 2018, dissolved oxygen and water clarity were highly correlated with phytoplankton biomass, while silicates and temperature were positively correlated with zooplankton abundance.***

***Keywords- Kuwait Bay, Phytoplankton, Zooplankton, Biomass, seawater parameters***

## I. INTRODUCTION

Kuwait's marine environment is a unique ecosystem, characterized by a variety of habitats and wildlife and that clearly manifested in the northern part of Kuwait's waters and Kuwait Bay; the most unique ecosystem in Kuwait’s territorial waters. Kuwaiti waters particularly the Kuwait Bay are rich in a diversity of species that had supplied about 40% to 50% of the country's food demand [1]. Kuwait Bay has provided an important habitat for diverse populations of marine and bird life, has reported that the most productive shore in Kuwait [1].

To meet the population’s needs, many governmental and private sector facilities, such as desalination plants, power plants, recreational facilities, hospitals and other urban and industrial facilities, have been constructed along Kuwait Bay’s coast. Most of these facilities discharge their effluent directly into the Bay causing severe burdens on Kuwait Bay ecosystem [2], [3]. On regional scale, the discharges from Shatt Al-Arab also play significant role in variability of water quality of Kuwait marine environment in general and Kuwait Bay in particular [4]. The amount of polluted nutrient discharged from Shatt Al-Arab Estuary is exceptionally high and the intertidal mudflats are strongly and adversely polluted [5].

Locally, storm-water outfalls and sewage discharges are the two of major sources of pollution in the bay [3]; the amount of waste discharged into Kuwait Bay is expected to grow further from raw sewage, illegal disposal of partially treated sewage, and industrial waste [6]. These sources play significant roles in heavy metal, hydrocarbon, and fecal coliform bacteria inputs to Kuwait Bay's coastal waters, which impact the marine environment and lower water quality. Thus, the main aim of the present study is to assess plankton biomass (Phytoplankton and zooplankton) in Kuwait Bay, in relation to several parameters related to seawater quality.

## II. MATERIALS AND METHODS

### *A. Study Area*

Kuwait Bay is a semi-enclosed shallow body of water extending approximately 35 km inland (*see* Fig. 1). It is an ellipsis-shaped bay at the northwestern edge of Kuwait's territorial waters and covers roughly 750 $Km^2$ [7]. The average water depth of Kuwait Bay is 5 m, and the maximum depth reaches 20 m at the entrance to the Bay [1], [7], [8].

### *B. Sampling Methodologies*

In order to compare the plankton biomass expressed as ($N/m^3$) in relation to physico-chemical parameters in Kuwait Bay, five successive locations were selected forming transect across the Bay and covering both southern and northern area of the Bay (Fig. 1 and Table 1). Marine Plankton samples were collected during December, 2017 and April, 2018. For quantitative assessment of phytoplankton, a 20 μm mesh-size Plankton net was towed vertically (-5m in depth). Zooplankton net (130 μm mesh-size), was used to sample zooplankton communities, and it was towed vertically below surface water to a maximum of 5m depth). The net was then hauled in and the collected material was transferred to a 250 ml labeled glass container with screw cap and preserved with 5% formalin and transported to the laboratory. In the Lab, aliquots of one ml of the concentrated sample were investigated for plankton analysis, under binocular microscope (AmScope Binocular Microscope with calibrated eyepiece) at different magnifications (80X, 250X and 500X). Average counts were recorded and a suitable plankton sample mount was then created.


Fig. 1. Sampling location across Kuwait Bay.

TABLE 1
PLANKTON SAMPLING LOCATIONS AT KUWAIT BAY

| Station Name | Latitude (N) | Longitude (E) |
|---|---|---|
| **B1** | 29°21'55.00" | 47°52'48.07" |
| **B2** | 29°24'17.08" | 47°56'12.14" |
| **B3** | 29°27'19.37" | 47°58'42.39" |
| **B4** | 29°29'41.20" | 48° 0'38.59" |
| **B5** | 29°31'55.20" | 48° 1'36.91" |

The drop count microscope analysis method, described by Onyema [9] was used to estimate the plankton biomass and was expressed as (number of cells /$m^3$). Since each sample drop from the dropper accounts for one ml, the results on abundance / occurrence were multiplied by a calculated factor to give the values as numbers of cells / $m^3$, which is the standard unit of measurement. Biomass estimated as cells recorded for phytoplankton (cells.$m^3$) and zooplankton species were identified (adults and juvenile stages alike). Final data was expressed as number of cells per $m^3$. Two references were used for identification of the species encountered; i.e., Marine Phytoplankton Atlas of Kuwait's Waters, Kuwait Institute for Scientific Research, 2009 and Marine Zooplankton Practical Guide Volume 1 and 2 for the Northwestern Arabian Gulf, Kuwait Institute for Scientific Research, Kuwait, and 2011. Water samples were collected using Nansen bottle (3L capacity). Temperatures, salinity, dissolved oxygen (DO) and pH were measured using EXO2 and data were recorded in situ. Secchi disc was used to determine water clarity. Nutrient salts were determined according to APHA & AWWA colorimetric method. Total suspended sediment (TSS) was determined according to APHA 2540D method.

*C. Data Analysis and Approach*

Multivariate statistical routines in the SPSS software package (Version 21, 2009) were used to explore spatial heterogeneity among the surveyed samples.

## III. RESULTS

*A. Seawater Parameters*

The seawater parameters measured during the present study are shown in Table 2.

**TABLE 2**
**DESCRIPTIVE SEAWATER PARAMETERS MEASURED DURING DECEMBER 2017 AND APRIL 2018**

| Location | Temp. (°C) (Dec-17) | Temp. (°C) (Apr-18) | Salinity (psu) (Dec-17) | Salinity (psu) (Apr-18) | DO (mg/l) (Dec-17) | DO (mg/l) (Apr-18) | pH (Dec-17) | pH (Apr-18) |
|---|---|---|---|---|---|---|---|---|
| **B1** | 15.2 | 25 | 41.49 | 43.32 | 7.56 | 7.63 | 8.12 | 8.22 |
| **B2** | 15.4 | 24.9 | 42.5 | 43.64 | 8.07 | 8.21 | 8.1 | 8.27 |
| **B3** | 15.2 | 24.7 | 42.04 | 43.82 | 8.8 | 7.18 | 8.21 | 8.32 |
| **B4** | 16.1 | 24.5 | 40.98 | 43.21 | 7.86 | 7.34 | 8.1 | 8.21 |
| **B5** | 15.3 | 24.8 | 41.24 | 43.36 | 8.07 | 7.31 | 8.14 | 8.27 |
| **Average** | 15.44 | 24.78 | 41.65 | 43.47 | 8.072 | 7.534 | 8.13 | 8.26 |
| **Max.** | 16.1 | 25 | 42.5 | 43.82 | 8.8 | 8.21 | 8.21 | 8.32 |
| **Min.** | 15.2 | 24.5 | 40.98 | 43.21 | 7.56 | 7.18 | 8.1 | 8.21 |

| Location | Secchi Depth (cm) (Dec-17) | Secchi Depth (cm) (Apr-18) | TSS (mg/l) (Dec-17) | TSS (mg/l) (Apr-18) | Silicates (Dec-17) | Silicates (Apr-18) |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| **B1** | 100 | 100 | 12 | 6 | 432 | 488 |
| **B2** | 100 | 150 | 8 | 5 | 422 | 465 |
| **B3** | 70 | 100 | 6 | 9 | 419 | 530 |
| **B4** | 110 | 50 | 10 | 6 | 510 | 528 |
| **B5** | 100 | 40 | 9 | 4 | 439 | 569 |
| **Aver** | 96 | 88 | 9 | 6 | 444 | 516 |
| **Max** | 110 | 150 | 12 | 9 | 510 | 569 |
| **Min** | 70 | 40 | 6 | 4 | 419 | 465 |

**1)** *Water Temperature:* Water temperature values (°C), were compared during December 2017 and April 2018 (Fig. 2). The winter values showed more or less equal values due to vertical mixing and homogeneity of the water column with an average of 15.4 °C, while during spring, 18 values were higher than those recorded during winter, 2017, with an average value of 24.8 °C.

**2)** *Water Clarity:* Water clarity values were compared during December 2017 and April 2018 (Fig. 3). The values showed compatible values between the two seasons, with an average of 96 cm recorded in December, 2017, and an average of 88 cm recorded in April, 2018. However, the maximum value was recorded in April, 2018 (150cm).

**3)** *Hydrogen Ion Concentration*: pH values were compared during December 2017 and April 2018 (Fig. 4). The values showed slightly higher values in spring, 2018 than those values recorded during winter, 2017, with an average of value of 8.13 recorded in December 2017, as compared to 8.26 in April, 2018. This might be related to increase in organic matter concentration in the bay.

**4)**

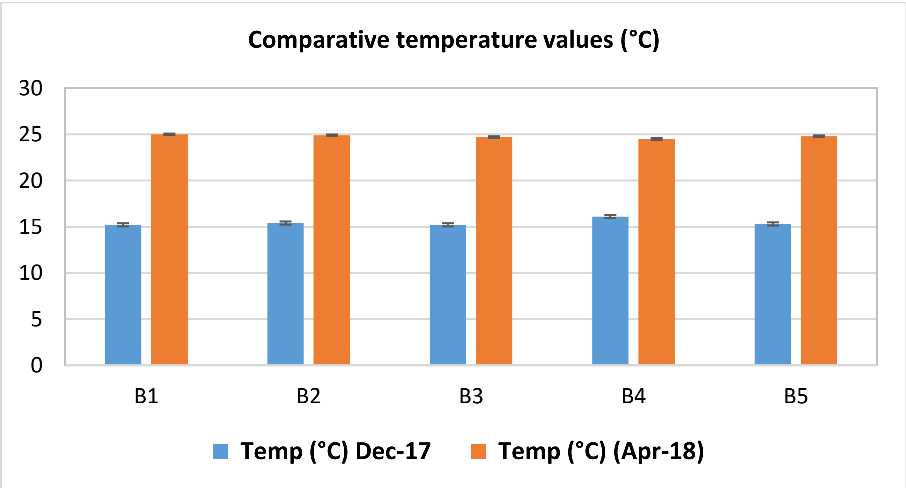



Fig. 2. Comparative water temperature values (°C) during December 2017 and April 2018.

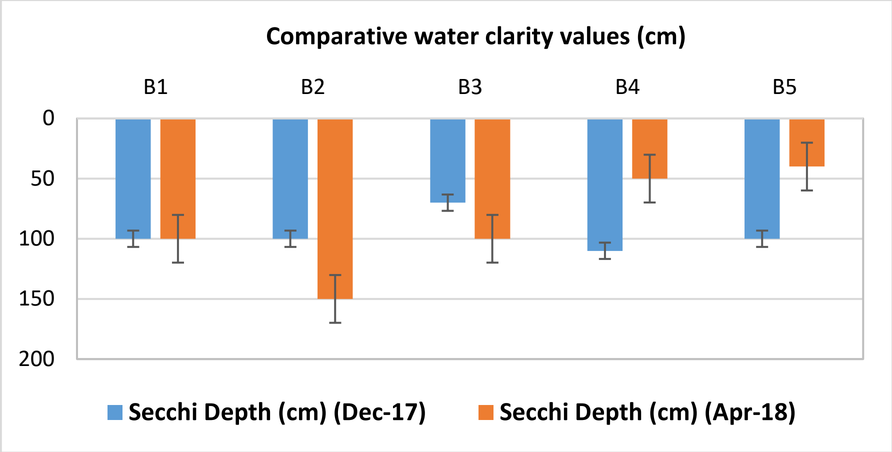



Fig. 3. Comparative water clarity values (cm) during December 2017 and April 2018.

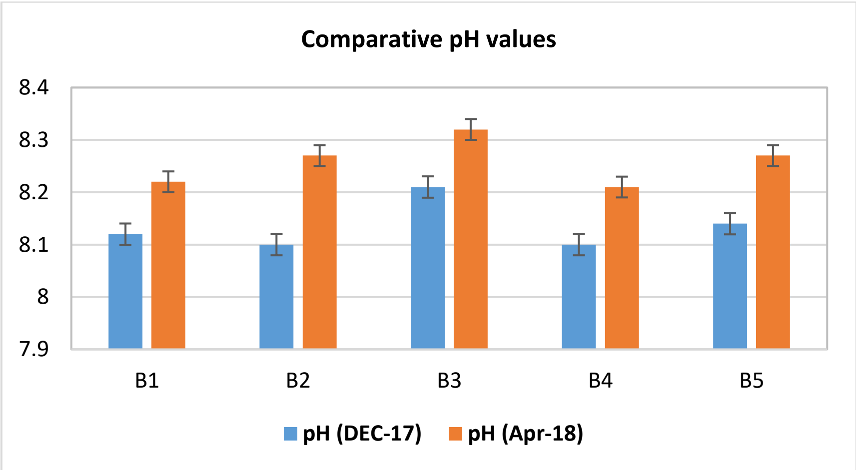



Fig. 4. Comparative pH values during December 2017 and April 2018.

**5)** *Water Salinity***:** Water salinity values were compared during December 2017 and April 2018 (Fig. 5). The values showed higher values in spring, 2018 than those values recorded during winter, 2017, with an average value of 41.65 (psu) recorded in December 2017 as compared to 43.47 (psu) recorded in April 2018.

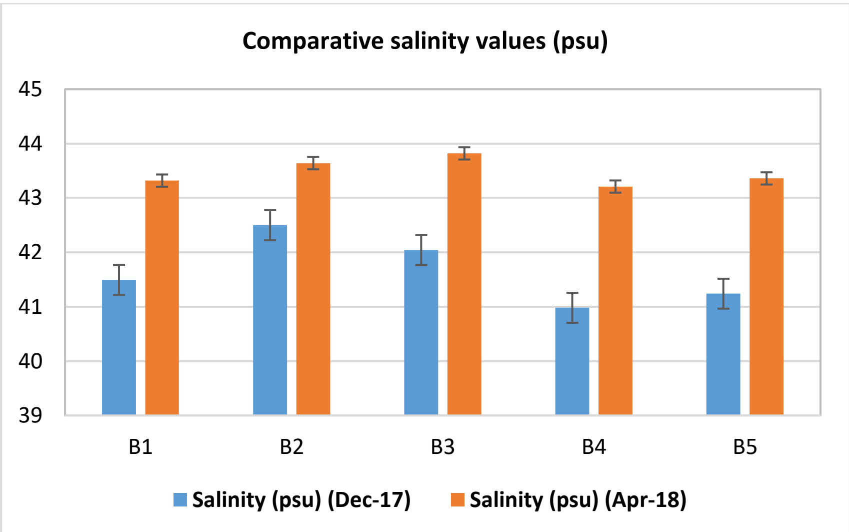



Fig. 5. Comparative salinity values (psu) during December 2017 and April 2018.

**6)** *Dissolved Oxygen:* DO values were compared during December 2017 and April 2018 (Fig.6). The values showed slightly higher average value in winter 2018 (8.07 mg/l) than those values recorded during spring 2017 (7.53 mg/l).

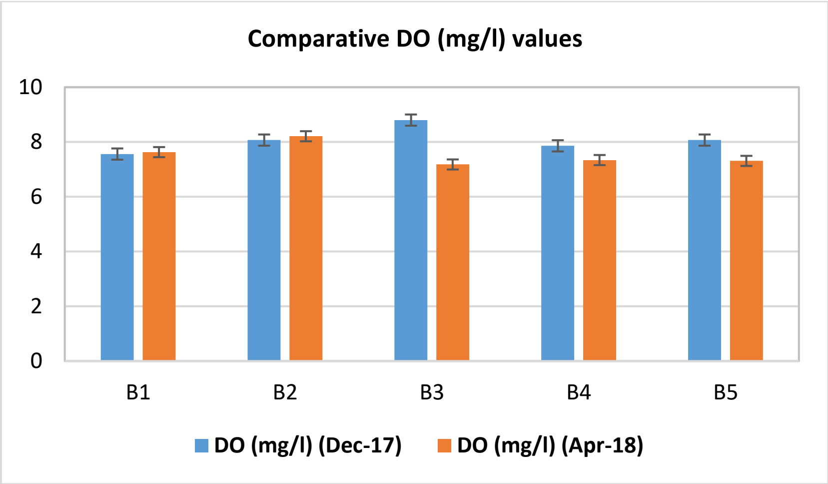



Fig. 6. Comparative DO values (mg/l) during December 2017 and April 2018.

**7)** *Total Suspended Solids:* TSS values were compared during December 2017 and April 2018 (Fig.7). The values showed slightly higher values in winter, 2018 than those values recorded during spring, 2017, with an average value of 9.0 mg/l recorded in December 2017 as compared to an average value of 6.0 mg/l recorded in April 2018; most probably due to vertical mixing during winter season.

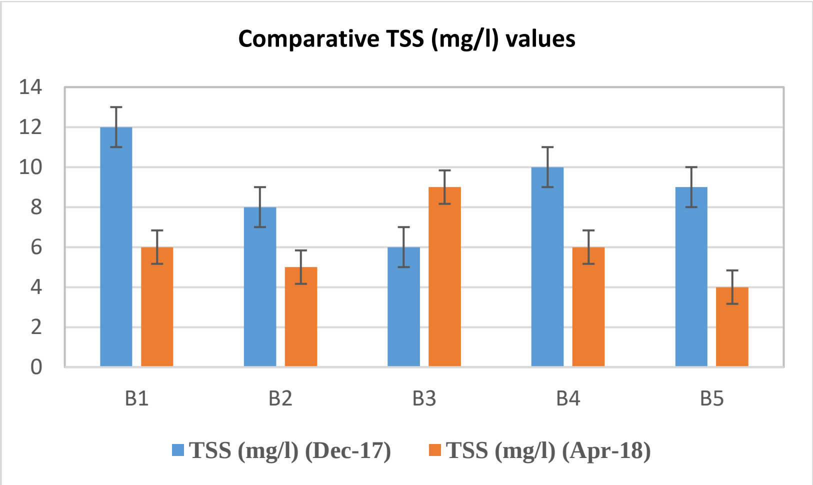



Fig. 7. Comparative TSS values (mg/l) during December 2017 and April 2018.

**8)** *Nutrient Salts:* The detected nutrient salt values (µg/l) of nutrient salts (Phosphates and nitrates and nitrites) during winter and spring seasons showed more or less similar values, while silicates ($SiO_3$) showed different values (Fig. 8). The silicates showed lower values during December 2017, with an average value of 444 µg/l, than those recorded during April 2018 (516 µg/l).

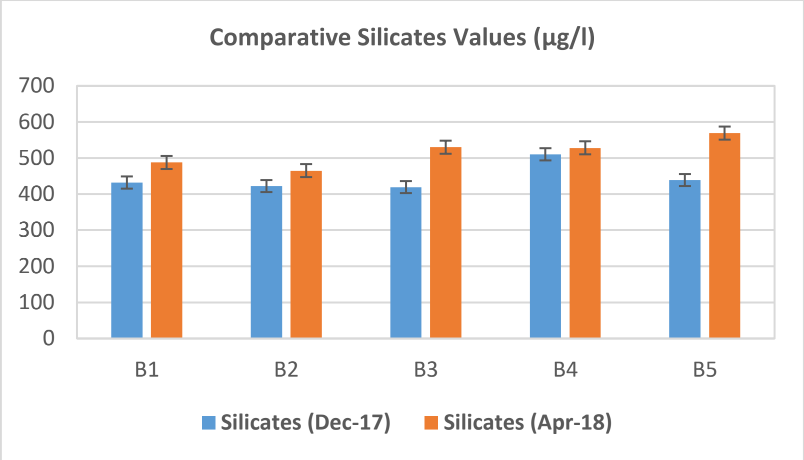



Fig 8. Comparative silicate values (µg/l) during December 2017 and April 2018.

*B. Plankton Structure*

The phytoplankton and zooplankton comparative biomass composition (expressed as number/$m^3$) during December, 2017 and April, 2018 at the study area is presented in Table 3.

**TABLE 3**
**COMPARATIVE PHYTOPLANKTON AND ZOOPLANKTON COMMUNITY COMPOSITION AT KUWAIT BAY DURING DECEMBER 2017 AND APRIL 2018**

| Average Phytoplankton Abundance/$m^3$ | | |
|---|---|---|
| **Location** | **December 2017** | **April 2018** |
| B1 | 27120 | 34400 |
| B2 | 32400 | 66800 |
| B3 | 30230 | 36600 |
| B4 | 38800 | 55600 |
| B5 | 38960 | 39400 |
| Average | 33502 | 46560 |
| Maximum | 38960 | 66800 |
| Minimum | 27120 | 34400 |
| **Average Zooplankton Abundance/$m^3$** | | |
| **Location** | **December 2017** | **April 2018** |
| B1 | 25600 | 60480 |
| B2 | 21600 | 51680 |
| B3 | 21300 | 55980 |
| B4 | 19200 | 49400 |
| B5 | 16800 | 70000 |
| Average | 34833 | 95847 |
| Maximum | 104500 | 287540 |
| Minimum | 16800 | 49400 |

The comparative average phytoplankton biomass showed that phytoplankton biomass recorded in April 2018 (46560 cells/$m^3$) was slightly higher than in December 2017 (33502 cells/$m^3$) (Fig.9). This could be related to some environmental factors such as availability of nutrient slats, upwelling and water stratification during spring season. For similar reasons, the comparative average zooplankton biomass showed higher than average value in April 2018 (95847 cells/$m^3$) than in December 2017 (34833 cells/$m^3$) (Fig.10).

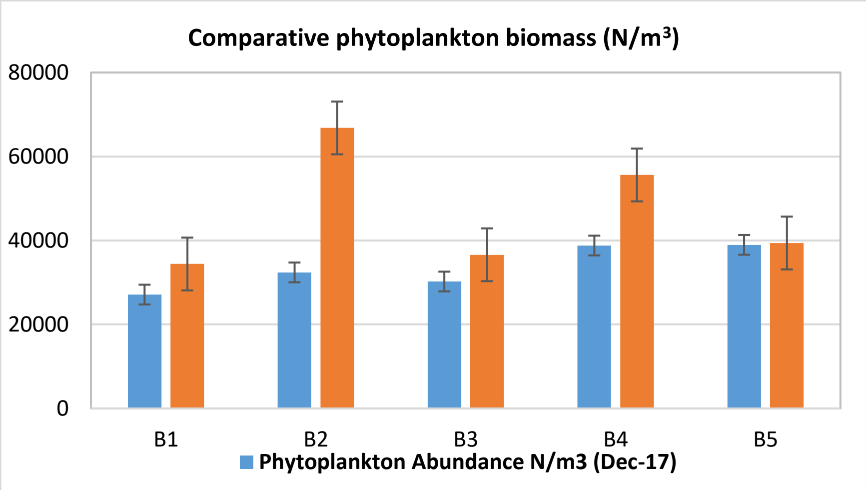



Fig. 9. Comparative phytoplankton community composition at Kuwait Bay during December 2017 and April 2018.

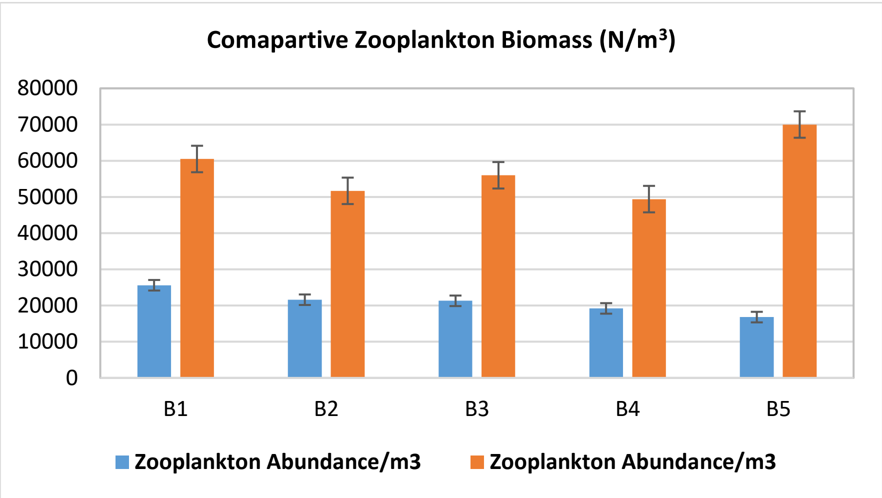


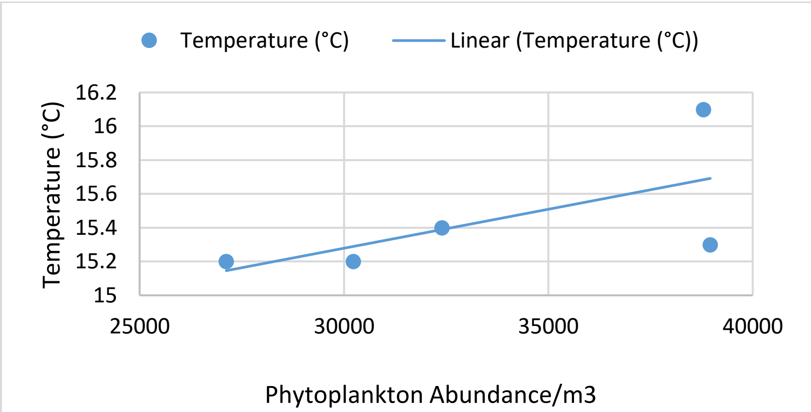

Fig. 10. Comparative zooplankton community composition at Kuwait Bay during December 2017 and April 2018.

## IV. DISCUSSION

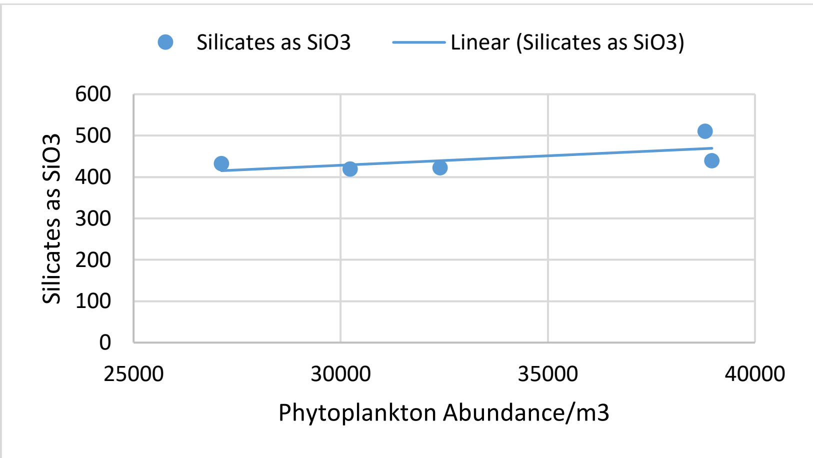
Correlation matrix was performed using plankton biomass and measured seawater parameters (Table 4). Although, the plankton biomass during December, 2017 was slightly lower than that of April, 2018, Table 4 reveals that temperature, water clarity, DO and silicates are in good correlations, thus supporting phytoplankton biomass (Fig. 11), while the positive correlation of other parameters with zooplankton biomass may indicate positive food availability.

**TABLE 4**
**CORRELATION OF SEAWATER PARAMETERS WITH PHYTOPLANKTON AND ZOOPLANKTON BIOMASS AT KUWAIT BAY**

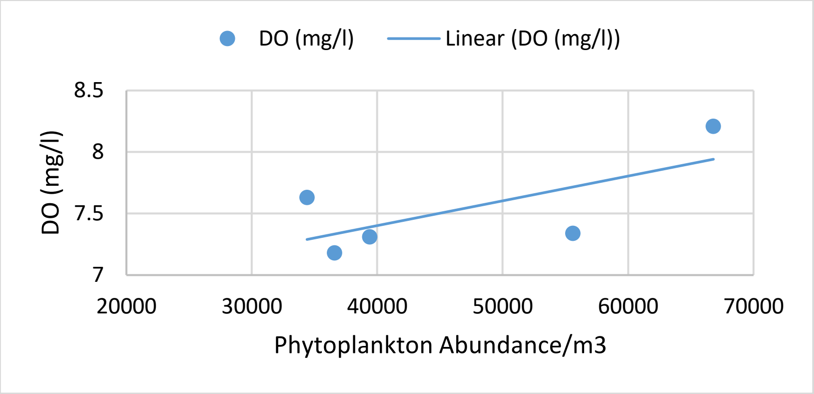
| Parameters | Phytoplankton Abundance/$m^3$ | Zooplankton Abundance/$m^3$ | Phytoplankton Abundance/$m^3$ | Zooplankton Abundance/$m^3$ |
|---|---|---|---|---|
| | During December 2017 | | During April 2018 | |
| pH | -0.281 | -0.044 | -0.173 | 0.180 |
| Temperature (°C) | **0.641** | -0.365 | -0.196 | **0.413** |
| Salinity (psu) | -0.539 | **0.351** | 0.015 | -0.150 |
| DO (mg/l) | -0.026 | -0.293 | **0.686** | -0.322 |
| Secchi Depth (m) | **0.474** | -0.147 | **0.236** | 0.035 |
| Nitrate as N | 0 | 0 | 0 | 0 |
| Nitrite as N | 0 | 0 | 0 | 0 |
| TSS | -0.062 | **0.360** | -0.340 | -0.388 |
| Silicates as SiO3 | **0.640** | -0.355 | -0.485 | **0.574** |




**a.** *During December 2017*




**b.** *During December 2017*




*c. During April 2018*

Fig. 11. Selected correlation ship of zooplankton biomass with temperature, DO and silicates at Kuwait Bay.

## V. CONCLUSION

In conclusion, the plankton biomass within Kuwait Bay is mostly affected by seawater temperature and silicate concentrations. Based on the analysis of the data gathered during this study, it seems that there is undoubtedly influence and impacts of anthropogenic activities such as reclamations, sewage inflow and desalination and power plants on the water quality of Kuwait Bay which is of ecological value since it provides a suitable habitat for marine life. Thus, more intensive studies are required to detect other marine water quality parameters affecting phytoplankton and zooplankton biomass in Kuwait Bay as the coastal waters of Kuwait Bay have been extensively exposed to a significant level of pollution.

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