Correlation between Physical and Chemical Parameters and Marine Macro Zooplankton Community around Port Sudan Area

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Abstract

The present study was conducted at six stations around Port Sudan Harbour to correlate total macro zooplankton with the physical and chemical parameters in samples from the Sudanese Red Sea. Oxygen, transparency and NO₃ showed positive correlation with total numbers of zooplankton. The impact of other parameters varies from one station to the other with highest frequency for oxygen followed by NO₃ and pH. Calanoida Copepods and Cyclopoida Copepods were the dominant groups and Cladocerans were the least recorded from 15 identified group of zooplankton.

Keywords

Zooplankton; Physicochemical; Port Sudan; Red Sea

Introduction

Marine zooplankton communities have wide geographic ranges, population sizes and high gene flow [1]. Their communities are usually structured by the water masses they occupy [2,3]; light intensity and primary production [4]; species reproductive cycles, temperature and food availability [2,5].

Studies on plankton in the Red Sea have dealt mainly with species composition [6]. In the Sudanese coast related studies included the plankton populations in Port Sudan area [7], coastal plankton fauna [8] and thermal impact of temperature on some species of copepods [9]. Space-time variations in physical forces and hydro chemical parameters influence plankton communities [10-13]. Studies in the Red Sea suggested a relatively higher production in the summer months [14] and recorded a secondary peak in primary production in winter in the southern Red Sea [15].

Zooplankton populations are influenced by intermingling of water masses in harbours, the open sea, coastal terrain, and freshwater runoff [16].

The aim of this study is to generate base-line data on physicochemical characters and zooplankton and their correlation in order to find out indicators in any future study.

Materials and Methods

Sampling sites

Monthly water and plankton samples were collected from six stations around Port Sudan from November 2009 up to October 2010. The stations and the code of each are given in Figure 1.

Collection of samples

Qualitative samples of macro zooplankton were collected horizontally with No. 335 µm plankton net operating at a towing speed of 1m/sec. All samples were preserved in 5% formalin following Parsons et al., [17] and Goswami [18].

Physical and chemical measurements

Salinity was measured by a refractometer; water temperature by an ordinary thermometer and pH by a pH-meter.

Dissolved oxygen was determined following Winkler’s Method. Lead, nitrite and nitrates content in unfixed samples were determined in situ using electronic spectrophotometer electrodes.

Zooplankton studies

A Hydro-Bios sedimentation plankton chambers was used to count and identify the zooplankton groups under a phase contrast inverted microscope of the type OLYMPUS CKX 41 – MODEL CKX 41 SF. The total zooplankton volume was determined by the displacement volume method described by Dhargalkar and Verlecar [19].
Identification
Identification of Cyclopoid Copepods, Calanoid Copepods, brachyuran zoea, fish eggs, cladocerans, Oikopleura, shrimp larvae, Sagitta, cumaceans, tintinnids, gastropod larvae, radiolarians, Nauplii, Medusae, and polychaete larvae followed Taylor [20].

Preparation of permanent slides
Preparation of permanent zooplankton slides followed Gray [21].

Statistical Analysis
Analysis of variance was used to compare the total zooplankton between the sampling stations using Microsoft Excel statistical programme (2003). Duncan test and LSD test were used to show the significant differences between the six stations and twelve months in zooplankton using SPSS. Also p-value was calculated to determine the significance of the relationship between total plankton and physical and chemical parameters. Quantification of the relation between total zooplankton and physical and chemical parameters was done by multiple regression analysis of the type:

\[ Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 \]

Where:
- \( Y \) = Total Zooplankton
- \( X_1 \) = Water temperature (°C)
- \( X_2 \) = Transparency
- \( X_3 \) = Salinity (%)
- \( X_4 \) = pH
- \( X_5 \) = P (mg/L), \( X_6 \) = NO\(_3\), \( X_7 \) = NO\(_2\), \( X_8 \) = O\(_2\).

Results
This section displays the findings regarding (a) physical and chemical characteristics of water, and (b) zooplankton and ends up by quantifying the correlation between a and b (given above).

Physical and chemical characteristics of water
The mean monthly reading of each parameter at each station was given in Table 1 from which the followings were apparent:
1. Water temperature was comparable in all stations.
2. The highest transparency records were obtained from station 3 and the least from station 6.
3. Salinity was slightly higher at station 6.
4. The mean pH, PO\(_4\), NO\(_3\), NO\(_2\), and dissolved oxygen concentration readings were comparable in all stations.

Zooplankton
The monthly readings of each zooplankton taxa at each station were given in Table 2 that showed:
1. The recorded number of zooplankton was 15 groups. These were Calanoid Copepods, Cyclopoid Copepods, brachyuran zoea, fish eggs, cladocerans, Oikopleura, shrimp larvae, Sagitta, cumaceans, tintinnids, Gastropod larvae, radiolarians, Nauplii, Medusae and, polychaete larvae.
2. Calanoid Copepods and Cyclopoid Copepods were the dominant groups and Cladocerans were the least recorded.
3. In Station 6 (highly saline) Cyclopoida Copepods and Nauplii were encountered in large numbers compared with other groups.

Correlation between physical and chemical characteristics of water and mean total zooplankton
The total zooplankton was correlated with the physical and chemical parameters at each station by multiple regression analysis (Table 4). The results revealed that the multiple correlation coefficient was highest in station 3 and lowest in station 5. The equation for station 1 showed a high significant value (p<0.01), while for other five stations it showed no significant value (p>0.05). The LSD test was conducted for zooplankton / station and it was found that station 6 differ significantly from other five stations (p>0.05).
The equations in Table 4 were applied to obtain the calculated mean of monthly zooplankton numbers for all stations (Figures 2-7).

The differences in the mean number of zooplankton between the 6 stations was highly significant (p<0.01) as the calculated F at DF,6,4= 14.122 was higher than the tabulated F at DF,6,4= 3.339. The differences between the stations in mean number of zooplankton was assessed by Duncan test which indicated as shown in Table 5 that the readings in a row with different manuscripts are significantly different (p<0.05) and those with similar superscript showed no statistically significant differences (p>0.05). The mean salinity is similar in stations 1, 2, 3, 4 and 5, whereas at station 6 it reached 45‰ leading to 250% drop in mean total zooplankton.

Discussion

The extent of interaction between physical and chemical parameters and plankton communities results in quantitative changes, e.g., increases or decreases of size of the population [22]. The monthly water temperature (27.79°C) were in accordance with Morcos [23] who stated that the climate over the Red Sea is harmonious with aridity and hotness of the surrounding landmasses. Edwards et al. [24] stated that surface temperature increases gradually to reach a maximum value of 32°C in September. The present study recorded maximum air temperature of 38°C during June and July.

Salinity recorded 40% in most stations throughout of most of the year; only station 6 recorded readings up to 46‰ due to influx from the desalination plant. In January salinity dropped to less than 6‰ due to influx of rainfall, the consequence of this is marked drop in the average number of zooplankton in station 6.

Discrepancy in transparency between the stations is linked to rainfall, associated floods, and concentrations of organic elements, suspended matter and nutrients. High transparency and anthropogenic based land activities were inversely related in the region and/or the effect of human activities on the coastal area.

Most of the Red Sea water is oligotrophic with the exception of small areas off the Sinai Peninsula and the southern transition area between the Red Sea and the Indian Ocean [25]. Nutrients affect the zooplankton indirectly as they are influencing the phytoplankton. Phosphate, nitrite and nitrate concentrations were higher in the rainy and flood season, which is in agreement with the fact that nutrient input to the sea may occur anthropogenically or naturally through physical, chemical and biological processes. Anthropogenic sources include groundwater and river input, sewage discharge and industrial runoff, both terrestrial and sea-based [26-28].

Morcos [23] discussed dissolved oxygen in the Red Sea, and attributed its highest record (6.68 mg/L) in January due to an increase in the dissolved oxygen concentration. Dissolved oxygen concentration in the surface water of the Red Sea, which is near to saturation values of 4.8 to 6.5 ml O₂/L depends on temperature and salinity values [29]. The mean dissolved oxygen recorded during this study (5.52-5.76 mg/L) is well within the ranges given by Nasr [8] and by Quadfasel and Baudner [29].

The present study showed that Calanoid copepods recorded the largest number; this is in conformity with Chiffings’ [30] findings in the southern Red Sea.

The highest number of zooplankton in Station 4 is attributed to an increase in nutrients in the month of November driven by the North East wind. Hallegaereff [31] attributed such increase to ballast water. Increased zooplankton number is also affected by diverse environmental factors, including food availability [32] and hydrodynamics performances including currents and waves [33]. According to Weikert’s [15] changes in standing stock and the biomass of zooplankton generally coincide with the seasonal variation in phytoplankton.

In January, zooplankton numbers especially cladocerans, shrimp larvae, Sagitta and Nauplii were very low especially in Stations 2, 5, 6, which are closer to the sea coast probably due to excess turbidity, and lower salinity. Low zooplankton numbers were attributed to differences in reproductive cycles [2,5] and movement patterns [34].

The present study showed that after freshwater influx which enriches seawater with nutrients zooplankton numbers increase. This is in agreement with Marsh [26], D’Elia et al. [27] and Lewis [28]. Hamza [9] recorded in February low zooplankton numbers at Station 1 and higher number in Station 2. The opposite holds true in this study. This discrepancy is attributed to the fact that the Tires Factory
Figure 2: Observed and calculated mean of monthly zooplankton numbers from station 1.

Figure 3: Observed and calculated mean of monthly zooplankton numbers from station 2.

Figure 4: Observed and calculated mean of monthly zooplankton numbers from station 3.
Figure 5: Observed and calculated mean of monthly zooplankton numbers from station 4.

Figure 6: Observed and calculated mean of monthly zooplankton numbers from station 5.

Figure 7: Observed and calculated mean of monthly zooplankton numbers from station 6.
at station 1 is no longer operating and station 2 is currently receiving influx of nutrients from the fish market.

The decline in zooplankton numbers was more prominent at Station 5 and Station 6; the former suffers from human pressure by the Port Dock yard including oil seepage and remains of paints; while the latter is under pressure of the desalination plant resulting in high salinity values, which affects the zooplankton community. Plankton communities integrate various human and environmental inputs, thereby providing a benchmark for monitoring the synergistic effects of urbanization and climate change [35].

From August to October, a gradual increased numbers of zooplankton was observed possibly because of a gradual increase in nutrients as mentioned by Zekeria [36] that most substantial import of phosphate into the Red Sea occurs by subsurface inflow of Gulf of Aden water from July to September. Seasonal differences in the taxonomic composition of cyclopoids and poecilostomatoids occurred in the central Red Sea [37]. In the Red Sea, low to moderate primary production occurs [38] which decreases northward Halim [38].

Table 5: The relationship between the means number of zooplankton and salinity in each station.

<table>
<thead>
<tr>
<th>Stations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>1095</td>
<td>1098</td>
<td>1156</td>
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<td>460</td>
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<td>Salinity%</td>
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<td>40</td>
<td>40</td>
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References:


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