International Journal of Science Academic Research
Vol. 03, Issue 10, pp.4464-4471, October, 2022
Available online at http://www.scienceijsar.com
ISSN: 2582-6425

Research Article

# PHYCO PERIPHYTON COMMUNITY STRUCTURE IN EMBIKHAH KHOR AT MUKALLA COASTAL ZONE, HADHRAMOUT-YEMEN

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**Received** 07th August 2022; **Accepted** 12th September 2022; **Published online** 13th October 2022

**Abstract**

A weekly sampling schedule was carried out from January to March, 2019 for studying phycoperiphyton community structure at four stations in Embikhah Khor which receives continuous effluent discharge and solid waste dumping from adjacent areas. A total of 53 phycoperiphyton species were identified under 6 major phyla. The Bacillariophyta made up a large proportion of the species composition contributing to 66.00 %, with 13.20 % Dinophyta and 11.30 % Cyanophyta followed by 5.70 % for Chlorophyta and 1.90 % for both Chrysophyta and Rhodophyta. Although Baillariophytic (diatom) species representation was higher than other classified phyla species, but all together provide information concerning the general nature of the microalgal composition and the formation of phycoperiphyton community structure. These results indicated the relatively pristine nature of Embikhah Khor water. Among the four stations, lowest number of species of 36 were recorded at stations 1 and 2 which affected by wastewater discharge while the highest number (43) of species were recorded at control station (station 4). *Vaucheria* and *Batrachospermum* genera are a new recorded in this study. A small non-significant fluctuation ($P > 0.05$) of phycoperiphyton showed the levels of dissimilarities between the stations in richness and α-diversity. The results of α-diversity and the dominance of diatoms indicate that Embikhah Khor nature is an oligotrophic waterbody.

**Keywords:** Phycoperiphyton, Community, Structure, Embikhah Khor.

## INTRODUCTION

Periphyton is the term that is used to express all attached microorganisms on natural or artificial substrates. Foerster and Schlichting (1965) introduced the term phycoperiphyton to describe the benthic microalgal (microphytobenthos) components. Phycoperiphyton and phytoplankton communities play an important role as primary producers, forming the base of the trophic chain. Microphytobenthos are found at the sediment water interface (MacIntyre *et al.,* 1996). Benthic microalgae biomass greatly exceeds that of integrated phytoplankton biomass in the overlying water column on an areal basis (Pinckeny, 2018). These assemblages exhibit excellent continuity through time and with changes in water quality (Verity *et al.,* 2002). Changes in phytoplankton species can occur under diverse circumstances including in response to a variety of irritants (Zmarly and Lewin, 1986). Phycoperiphyton and phytoplankton are critical to the productivity and are key indicators of water quality, habitat condition and biodiversity (Saeck *et al.,* 2019). Changes in the abundance and diversity of benthic diatoms have been used to indicate physico-chemical conditions of surface water (Stevenson, 1984; Cazaubon *et al.,* 1995). In Yemen and the adjacent countries, most of the researches focused on the studies of phytoplankton communities. In Yemen, Alkershi and Menon (2011) studied the phytoplankton in polluted waters of the Red Sea coast of Yemen while Al kawri and Majambo (2014) studied phytoplankton distribution in the Red Sea and Aden Gulf.

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In addition to, many researches were done in phytoplankton community in Hadhramout coast such as Al-Gahwari and Baabbad (2015), Ali Attaala and Bazar (2016) and Aideed et al. (2018). In the adjacent countries, Banse and English (2000) studied phytoplankton pigment in the Arabian Sea. Al-Azri *et al.* (2009) and Al-Hashmi *et al.* (2012) studied phytoplankton community of coastal waters of Oman. Al-Najjar *et al.* (2007) and Ismael (2015) studied phytoplankton of the Red Sea. Despite many studies in benthic microalgae were carried out in USA, North America (Canada), Australia, and European and Asian countries, very little studies had been done in Middle East countries. The most recent extensive reviews of the literature on the subject are of those Mohanna *et al.* (2007) in their study of benthic microalgae on a sheltered intertidal mudflat in Kuwait Bay of the North Arabian Gulf and Khomayis *et al.* (2014) in their study of intertidal epilithic phytoplankton community composition and seasonal dynamics at Jeddah coast, Red Sea. Khomayis *et al.* (2014) stated that no previous research had been done in Red Sea benthic microalgae before their study. The coastal zone is the most productive ecosystem. Microalgae comprises the major portion of primary productivity in the coastal zone. Microphytobenthos contribute significantly to primary production in many estuarine and coastal waters (Longphuirt *et al.,* 2006). Aden Gulf coastal zone represents a unique and diverse collection of habitats and biodiversity (Bawazir, 2009). Nowadays, the coastal zone of the northern part of Gulf of Aden (Yemen) is subjected to a significantly increasing stress. It continuously receives non treated wastewaters as a result of municipal, agricultural and industrial human activities (Saleh and Al-Halmi, 2021). Coastal areas in Mukalla City as a part of Aden Gulf are subjected to a proximately 100% of untreated wastewater (Al-Gahwari, 2022). Embikhah Khor, as one of more than 10 khors along Mukalla coastal zone, is considered a unique area due to the availability of mangal ecosystem. Recently, this khor is exposed to different types of stresses by illegal human activities. Attached microorganisms have been utilized for the detection of pollution because the results obtained from periphyton analysis are more reliable than plankton analysis (Kelly *et al.,* 1995). Notwithstanding their importance, information biodiversity of phycoperiphyton is lacking for many ecosystems and habitats. Marine phycoperiphyton in Aden Gulf has remained largely unstudied. In view of this, coastal phycoperiphyton were thus selected to be studied in Embikhah Khor at Mukalla coastal zone. This research had been done as a scientific contribution through providing new baseline information in understanding the structure of phycoperiphyton community at Mukalla coastal zone.

## MATERIALS AND METHODS

### Study Area

Embikhah Khor is located approximately at latitude 14 50' 69" N, and longitude 49 07' 13" E on the northwest of Mukalla City (Figure 1).

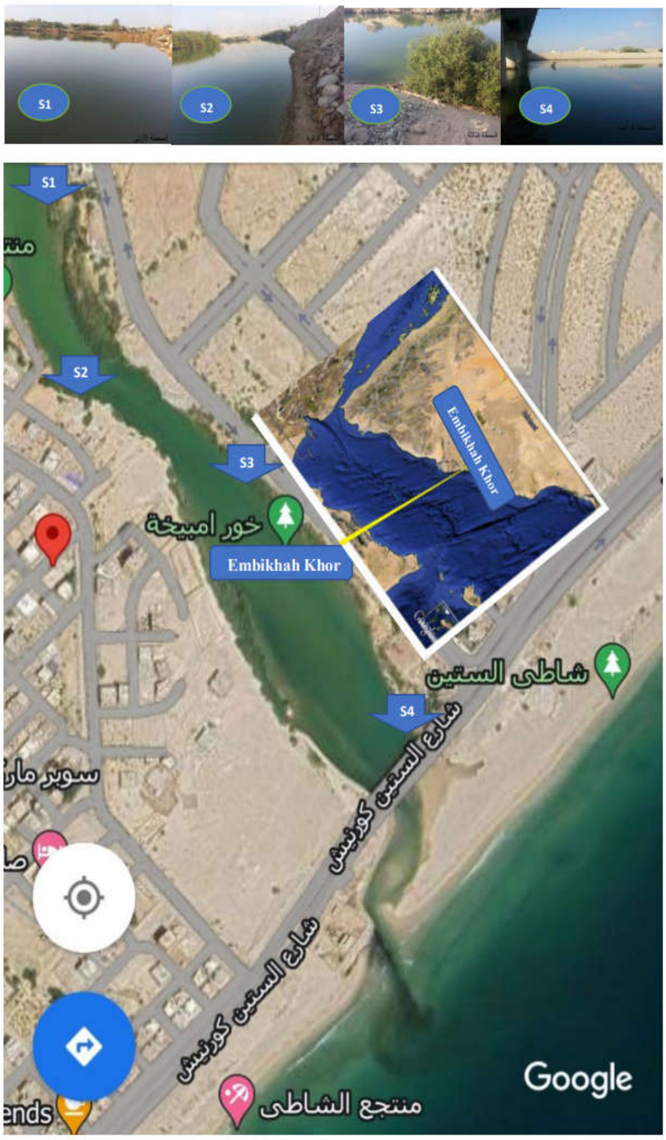


**Figure 1** Map of Yemen Republic showing the situation of Embikhah Khor with the location of stations, whereas; S1 =station 1, S2 =station 2, S3= station3 and S4 = station 4.

The phycoperiphyton assemblages in Embikhah Khor were assessed qualitatively and quantitatively during a period from January to March, 2019. These assemblages were collected weekly from four sampling stations to represent the khor area that covers around 0.26 $Km^2$. The stations were preselected based on possible influence of land activities nearby that are capable of changing the quality of Embikhah Khor water. Four sampling stations were identified along the course of Embikhah Khor as shown in Figure 1. Station 1 (S1) which is located at the mouth of the khor receives sewage discharge of the surrounding area and run off during rainfall. Station 2 (S2) is located in the area of dumping of solid wastes destruction. This dumping had resulted in heavy silting and stoning over the mangrove trees ecosystem causing damage to the mangal and algal communities. Station 3 (S3) which is situated in the intensive available area of mangrove trees influences by small sewer discharge from nearby area. Station 4 (S4) which was near the seashore is selected in this study as a control station because it is considered far from human disturbance.

### Sampling for Algal Communities

Many big pebble stones with almost the same size were placed on marked positions in four stations at Embikhah Khor in January, 2019. The phycoperiphyton species composition were studied using five big pieces of pebble stones that were submerged in each sampling station as substrates for unicellular and multicellular algal growth. Detritus on the stone was discarded by little amount of distilled water. Whole surface area of each stone was lightly brushed and rinsed into polyethylene bottle. Samples in polyethylene bottles were preserved with 7% formalin and transported to the Faculty of Environmental Sciences and Marine Biology labs to keep for further study. The phycoperiphyton analysis was carried out on TV microscope, JVC Labscope type. The microalgae were identified using that microscope with other three Wagtech compound microscopes under 10, 40 and 100 X magnification. The phycoperiphyton was identified as far as possible down to the species level with the help of taxonomic keys, drawings and descriptions based on Chapman and Chapman (1981), Shamsudin (1990), Yamagishi and Kanetsuna (1991), Tomas (1997) and Chihara and Murano (1997).

### Species Richness and Diversity

The biological diversity of the phycoperiphyton community was determined as below:

### Species Richness

According to Ludwig and Reynolds (1988), the number of species at each sampling station refers as species richness. The more species present in a sampling station, the 'richer' the sampling station.

### Alpha Species Diversity (α-Diversity)

The mean species diversity in a site at a local scale (Whittaker, 1960).

### Taxa (Division) Composition

Each taxa composition calculated using the following formula:
Taxa composition = (Total taxa species/Total phycoperiphyton species) × 100

### Statistical Analysis

The data obtained was statistically analyzed using Excel and SPSS programs. Analysis of Variance (ANOVA), followed by Tukey's test was carried out to compare data of different biological parameters in the stations, whereby $P < 0.05$ was considered as significant.

## RESULTS

### Checklist of Phycoperiphyton and Species Numbers and Composition

A total of 53 dominant phycoperiphyton species were identified from Embikhah Khor samples (Table 1 and 2). The identified phycoperiphyton were classified into 6 major divisions (phyla) which were recorded as following: Bacillariophyta, Dinophyta, Cyanophyta, Chlorophyta, Chrysophyta and Rhodophyta. Phycoperiphyton were further classified into 31 genera under 22 families (Table 2). The highest number of phycoperiphyton genera and species were recorded in the family of Naviculaceae (4 genera and 13 species) followed by Fragilariaceae (3 genera and 6 species) and Peridiniaceae (2 genera and 5 species). The next three families (Chaetocerotaceae, Rhizosoleniaceae and Nitzschiaceae) possessed 3 species each and Surirellaceae with (2 genera and 2 species). The rest of families contributed with only small proportion of phycoperiphyton community with 1 genus and between 1 or 2 species. Bacillariophyta (diatom) as dominant group in the phycoperiphyton assemblages covered 66% of the total species encountered in this study (Figure 2).

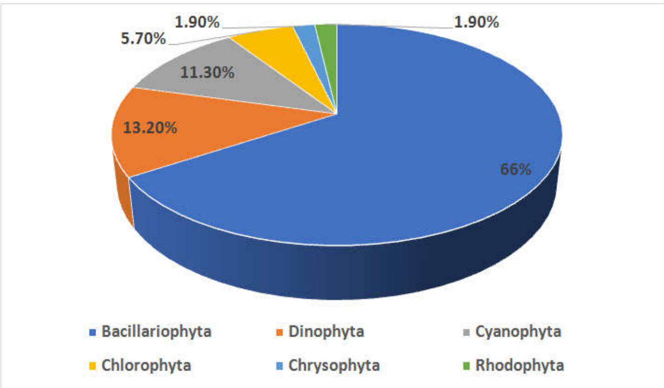


**Figure 2. The phycoperiphyton composition at all sampling stations during this study**

Dinophyta division (dinoflagellates) was the second major group among all the benthic microalgae found during this study. Their species number represented 13.20% of the total phycoperiphyton species. Cyanophyta (blue green algae) and Chlorophyta (green algae) are considered the third and fourth respectively major groups of phycoperiphyton in this study. Similar results were also documented by other previous studies of Hadhramout coastal zone such as Al-Gahwari and Baabbad (2015) and Ali Attaala and Bazar (2016). The cyanophyte species covered 11.30% of the total phycoperiphyton species composition and chlorophyte species covered 5.70%. Species of Rhodophyta (red algae) and Chrysophyta (yellow green algae) divisions comprised the same amount of 1.90% of the total phycoperiphyton species composition (Figure 2).

**Table 1. Checklist of identified phycoperiphyton species and their available at four sampling stations during the study period**

| Species | Stations 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Bacillariophyta(Diatoms) | | | | |
| *Amphora crassa* | - | x | x | x |
| *Amphora spectabilis* | x | x | x | x |
| *Asterionella glacialis* | - | x | - | - |
| *Bacillaria paradoxa* | - | x | x | x |
| *Bacteriastrumdelicatulum* | - | - | x | x |
| *Bacteriastrum hyalinum* | x | x | x | x |
| *Biddulphia sp* | x | x | x | x |
| *Chaetoceros sp* | - | - | x | x |
| *Coscinodiscus sp* | - | - | x | x |
| *Cymatopleura sp* | x | x | x | x |
| *Cymbella sp1* | x | - | x | x |
| *Cymbella sp2* | x | - | - | x |
| *Fragilaria oceanica* | x | x | x | x |
| *Fragilaria sp1* | x | x | x | x |
| *Fragilaria sp2* | x | x | x | x |
| *Guinardia striata* | - | - | - | x |
| *Melosira moniliformis* | x | x | x | x |
| *Navicula distans* | x | x | x | x |
| *Navicula gracilis* | x | x | x | x |
| *Navicula punctata* | x | x | x | x |
| *Navicula rectangulata* | x | x | x | x |
| *Nitzschia closterium* | x | x | x | x |
| *Nitzschia marina* | x | x | x | x |
| *Nitzschia sicula* | x | x | x | x |
| *Pleurosigma angulatum* | x | x | x | x |
| *Pleurosigmacapense* | x | x | x | x |
| *Pleurosigmadirectum* | x | x | x | x |
| *Pleurosigmaelongatum* | x | x | x | x |
| *Pleurosigmapelagicum* | x | x | x | x |
| *Rhizosolenia robusta* | x | x | x | x |
| *Rhizosolenia styliformis* | x | x | x | x |
| *Surirella sp* | x | - | x | - |
| *Synedra rumpens* | - | - | x | x |
| *Synedra ulna* | x | - | x | - |
| *Thalassionemanitzschioides* | x | x | x | x |
| Diatom Richness | 27 | 26 | 32 | 32 |
| Chlorophyta (Green algae) | | | | |
| *Ankistrodesmus falcatus* | - | - | - | x |
| *Desmidium sp* | - | - | - | x |
| *Stigeoclonium sp* | - | - | x | x |
| Green Algae Richness | 0 | 0 | 1 | 3 |
| Dinophyta (Dinoflagellates) | | | | |
| *Ceratium furca* | - | - | x | X |
| *Ceratium longipes* | - | - | x | - |
| *Peridinium cinctum* | - | - | - | X |
| *Peridinium gatunense* | x | x | x | X |
| *Peridinium orientale* | x | x | - | - |
| *Gonyaulax schilleri* | - | x | x | - |
| *Gonyaulax sp* | x | x | - | - |
| Dinoflagellates Richness | 3 | 4 | 4 | 3 |
| Cyanophyta (Blue green algae) | | | | |
| *Anabaena sp* | x | x | - | - |
| *Oscillatoria sp1* | x | x | - | - |
| *Oscillatoria sp2* | x | x | x | X |
| *Trichodesmium erythraeum* | x | x | x | X |
| *Trichodesmium sp* | x | x | x | X |
| *Tolypothrix sp* | - | - | - | X |
| Blue Green Algae Richness | 5 | 5 | 3 | 4 |
| Rhodophyta (Red algae) | | | | |
| *Batrachospermum sp* | - | x | - | - |
| Red Algae Richness | 0 | 1 | 0 | 0 |
| Chrysophyta (Yellow green algae) Golden brown algae | | | | |
| *Vaucheria sp* | x | - | - | X |
| Yellow Green Algae Richness | 1 | 0 | 0 | 1 |
| α- Diversity | 36 | 36 | 40 | 43 |

### Phycoperiphyton Species Distribution

The tabulated number of phycoperiphyton species recorded for all stations varied form 36-43 species. Microphytobenthic assemblages survive widely in benthic habitats (Janousek, 2009). Gradually decreasing trend in the phycoperiphyton species number observed from station 1 to station 4. The maximum species number (43) was collected at station 4 followed by 40 species at station 3 and the minimum species number (36) was recorded in station 1 and 2 which were exposed to effluent from human activities. The species number sometimes simply shows the stressed habitats i.e., highly polluted waters have smaller species number complements than the bulk of water which are intermediate (eutrophic) (Patrick and Roberts, 1979). From the results obtained, station 4 recorded the highest variation of its total species numbers compared to the other stations. It represented 81.13% of the total phycoperiphyton counts. Greater relative variation of (75.47%) was also recorded at station 3 while stations 1 and 2 recorded similar smallest relative variation of (67.93%). The dominant phycoperiphyton in this study consisted of diatoms, dinoflagellates, blue green algae, green algae and red algae as well as yellow green algae (Figure 2). The diatom species at stations 1, 2, 3 and 4 consisted of 27, 26, 32 and 32 species respectively (Table 1). Although there is a slightly significant difference ($p < 0.05$) in genera numbers between stations but the most predominant genera at these four stations were *Pleurosigma*, *Navicula*, *Nitzschia* and *Fragilaria*. Among the dinoflagellates, the common genera were *Peridinium* and *Gonyaulax*. Blue green algae species numbers at stations (1 and 2) which were near the source of freshwater was found to be expectedly higher than that near the coastal area stations (3 and 4). Commonly, the predominant genera at these four stations were *Trichodesmium*, *Oscillatoria* and *Anabaena*. In terms of green microalgae species present, it was apparent that two species, *Ankistrodesmus falcatus* and *Desmidium sp* were absent at stations 1, 2 and 3 and *Stigeoclonium sp* was found at stations 3 and 4. Surprisingly, the phycoperiphyton species of green algae were not expected to classify at station 4. Faria *et al.* (2021) found that phycoperiphyton natural community was dominated by green algae in one of the shallow lakes of southern Brazil. *Vaucheria sp* and *Batrachospermum sp* recorded in this study as two new recorded species. *Vaucheria sp* was found sparsely attached to stones at stations 1 and 4 while *Batrachospermum sp* was just found at station 2. The results showed that the species richness was not significantly different ($p > 0.05$) among the sampling stations (Figure 4).

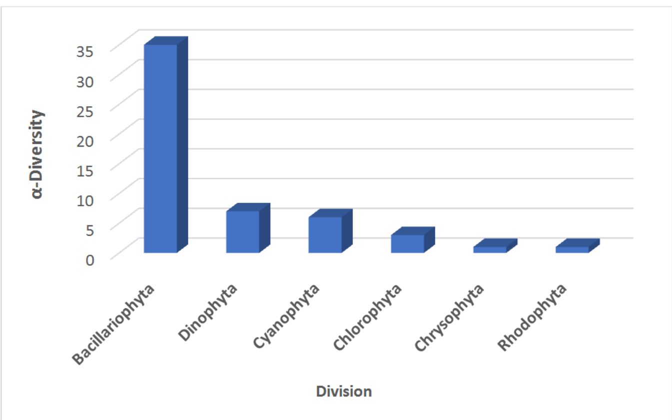


**Figure 3. The phycoperiphyton α- diversity at all sampling stations during this study**

**Table 2. Checklist of the total number of phycoperiphyt on families, genera and species estimated during this study**

| Species | Family | No. genera | No. species |
|---|---|---|---|
| Bacillariophyta | 11 | 19 | 35 |
| *Amphora crassa* | | | |
| *Amphora spectabilis* | | | |
| *Cymbella sp1* | | | |
| *Cymbella sp2* | | | |
| *Navicula distans* | | | |
| *Navicula gracilis* | | | |
| *Navicula punctata* | Naviculaceae | 4 | 13 |
| *Navicula rectangulata* | | | |
| *Pleurosigma angulatum* | | | |
| *Pleurosigma capense* | | | |
| *Pleurosigma directum* | | | |
| *Pleurosigmaelongatum* | | | |
| *Pleurosigmapelagicum* | | | |
| *Asterionella glacialis* | | | |
| *Fragilaria oceanica* | | | |
| *Fragilaria sp1* | Fragilariaceae | 3 | 6 |
| *Fragilaria sp2* | | | |
| *Synedra rumpens* | | | |
| *Synedra ulna* | | | |
| *Bacillaria paradoxa* | Bacillariaceae | 1 | 1 |
| *Bacteriastrumdelicatulum* | | | |
| *Bacteriastrum hyalinum* | Chaetocerotaceae | 2 | 3 |
| *Chaetoceros sp* | | | |
| *Biddulphia sp* | Biddulphiaceae | 1 | 1 |
| *Coscinodiscus sp* | Coscinodiscaceae | 1 | 1 |
| *Cymatopleura sp* | Surirellaceae | 2 | 2 |
| *Surirella sp* | | | |
| *Guinardia striata* | | | |
| *Rhizosolenia robusta* | Rhizosoleniaceae | 2 | 3 |
| *Rhizosolenia styliformis* | | | |
| *Nitzschia closterium* | | | |
| *Nitzschia marina* | Nitzschiaceae | 1 | 3 |
| *Nitzschia sicula* | | | |
| *Melosira moniliformis* | Melosiraceae | 1 | 1 |
| *Thalassionemanitzschioides* | Thalassionemataceae | 1 | 1 |
| Chlorophyta | 3 | 3 | 3 |
| *Ankistrodesmus falcatus* | Oocystacaeae | 1 | 1 |
| *Desmidium sp* | Desmidiaceae | 1 | 1 |
| *Stigeoclonium sp* | Chaetophoraceae | 1 | 1 |
| Dinophyta | 2 | 3 | 7 |
| *Ceratium furca* | Ceratiaceae | 1 | 2 |
| *Ceratium longipes* | | | |
| *Peridinium cinctum* | | | |
| *Peridinium gatunense* | | | |
| *Peridinium orientale* | Peridiniaceae | 2 | 5 |
| *Gonyaulax schilleri* | | | |
| *Gonyaulax sp* | | | |
| Cyanophyta | 4 | 4 | 6 |
| *Anabaena sp* | Nostocaceae | 1 | 1 |
| *Oscillatoria sp1* | Oscillatoriaceae | 1 | 2 |
| *Oscillatoria sp2* | | | |
| *Trichodesmium erythraeum* | Microcoleaceae | 1 | 2 |
| *Trichodesmium sp* | | | |
| *Tolypothrix sp* | Scytonemataceae | 1 | 1 |
| Rhodophyta | 1 | 1 | 1 |
| *Batrachospermum sp* | Batrachospermaceae | 1 | 1 |
| Chrysophyta | 1 | 1 | 1 |
| *Vaucheria sp* | Vaucheriaceae | 1 | 1 |
| Total | 22 | 31 | 53 |

Species of diatoms appeared to be more diverse and dominant forms. In contrast, dinoflagellates exhibited very low species diversity comparing with diatoms and high diverse comparing with the other major taxa. Phytoplankton community of coastal waters of Oman dominated by diatoms for most part of the year, but for a short period in summer, dinoflagellates were dominant (Al-Azri *et al.,* 2009). A small fluctuation in the total numbers of phycoperiphyton species reflect changes in α-species diversity of the taxa at all the sampling stations (Figure 3).

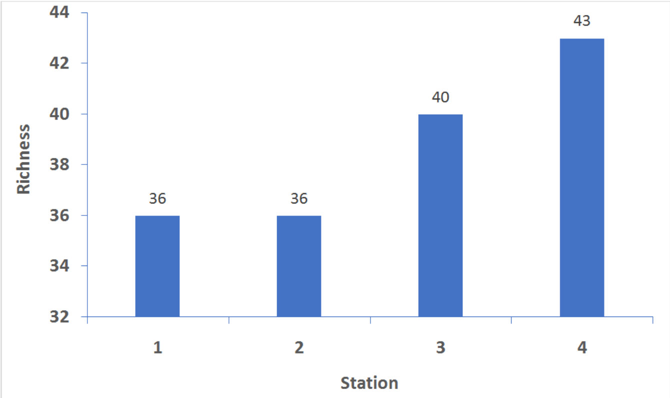


**Figure 4. The phycoperiphyton species richness at all sampling stations during this study**

However, the stations 4 and 3 which had higher numbers of phycoperiphyton recoded higher α- diversity of the taxa. Twenty-one of the record species were potentially harmful species, all of them found in low α- species diversity. Amongst these species, some species of diatoms such as *Navicula distans*, *Navicula gracilis*, *Navicula punctata, Navicula rectangulata*, *Nitzschia closterium*, *Nitzschia marina*, *Nitzschia sicula*, *Chaetoceros sp*, and dinoflagellates such as *Ceratium furca*, *Ceratium longipes*, *Peridinium cinctum*, *Peridinium gatunense*, *Peridinium orientale*, *Gonyaulax schilleri*, *Gonyaulax sp*, and blue green algae such as *Anabaena sp*, *Oscillatoria sp1*, *Oscillatoria sp2*, *Trichodesmium erythraeum*, *Trichodesmium sp* and *Tolypothrix sp*.

These common species which their habitat is marine or freshwater usually present in low richness. To our knowledge, no harmful blooms have been previously reported in Embikhah Khor, and the presence of the potentially harmful species cannot attribute all of them to Mukalla coast. However, Embikhah Khor is a shallow (7 m maximum depth), narrow, saltwater creek and cut off from the sea along the year except for few months. Stations 3 and 4 recorded less numbers of toxic Cyanophyta and Dinophyta species. However, toxic species such as *Peridinium orientale*, *Gonyaulax sp*, *Anabaena sp* and *Oscillatoria sp1* were absent at both stations (Table 1). The differences in diatoms species composition during this study at 4 stations were not significant ($p > 0.05$) and a small fluctuation of diatoms richness was observed (Figure 5). This fluctuation showed the levels of dissimilarities between the stations in richness.

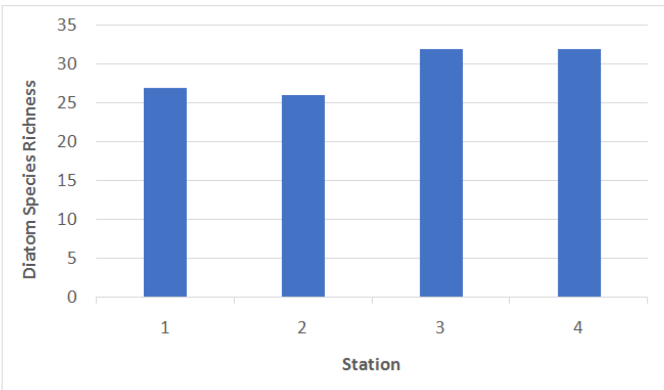


**Figure 5. Diatoms species richness at all sampling stations during this study**

## DISCUSSION

It's well known that the study results are just considered as preliminary information on structure and variability of phycoperiphyton in the region during the period of study. According to Tomas (1993), the species identified (53) during this study were not all common species in coastal waters. Some freshwater phycoperiphytonic species were mainly recorded at station 1 and 2 such as *Batrachospermum sp*, freshwater red microalgae and all species of green microalgae: *Ankistrodesmus falcatus*, *Desmidium sp*, *Stigeoclonium sp* and blue green microalgae: *Anabaena sp*, *Oscillatoria sp1 and sp2*, *Trichodesmium erythraeum*, *Trichodesmium sp* and *Tolypothrix sp*. It is significant to note that some freshwater phycoperiphytonic species were recorded in this study especially at stations that were near the sources of freshwater input. Yang *et al.* (2018) suggested in their study that the spatial factors play important roles in influencing the benthic algal distribution. Anton *et al.* (1998) reported that the periphytic algae such as *Desmids*, *Ankistrodesmus*, *Tolypothrix* were found in high nutrient habitats. The highest number of Bacillariophyta genera and species were recorded under Naviculaceae family followed by Fragilariaceae family while for Dinophyta was under of Peridiniaceae family. Other families under all classified phyla were mostly recorded less numbers of genera and species. Diatoms population was relatively rich in species that were generally present in the coasts during the study period. The diatoms resume greater ecological importance in phycoperiphyton community mainly because of their wider tolerance to pollution and thus less affected by increased discharges (Winter and Duthie, 2000).

Similar to other previous studies such as Al-Gahwari and Baabbad (2015) and Ali Attaala and Bazar (2016), diatoms followed by dinoflagellates were the dominant microalgae in waters of Mukalla coast. The dominance of diatoms in the phycoperiphyton suggest that the water quality of the khor is still to be good. However, the presence of a comparatively high percentages (13. 20% and 11.30%) of dinoflagellates and blue green algae respectively tends to indicate organic pollution in the studied areas. This could possibly be due to domestic discharge and rainfall run-off from land-based sources. Cosgrove *et al.* (2004) reported that wastewater significantly increased periphyton growth. A major concerning in any consideration of organic pollution is, thus the changing of the critical nutrients induced by the organic substances. Yellow green, red, green and blue green microalgae occurred in smaller species richness but they contributed significantly to the biomass accumulation owing to their large sizes (Ho, 1976; Hill *et al.,* 2000) and they contained some species numbers. Some species of green, blue green and dinoflagellates benthic microalgae take advantage of each station conditions. These results reflects that these three phyla diversities positively affected by the input of human activities at the coastal waters of Mukalla, especially the locations which influence by wastewater discharge. As the microalgae species and communities are sensitive to environmental changes, their growth may either be inhibited or stimulated by the exposure to various toxic substances. Therefore, the response of these algae should be considered when assessing the potential effects of chemicals and toxic substances on the marine and freshwater environment (Parrish, 1985). The main contribution of this study is the classify of *Vaucheria* and *Batrachospermum* as two new recorded genera. *Vaucheria sp* was found sparsely attached to stones at stations 1 and 4. A trend of decreasing species number and so α- species diversity and richness occurred at stations 1 and 2 that were far from seaside, while higher richness in species and α- species diversity was found at stations 3 and 4 that did not receive effluent from human activities (Figures 3 and 4). This trend appears to be inconsistent with the amount of organic matter and so nutrients in each station. This is interesting since such inputs are often a reduced diversity of phycoperiphytonic algae. Stewart (1995) reported that a typical response to anthropogenic stress was a decrease in the number of species and diversity. The highest richness and α- species diversity was probably due to early colonization of species that dominated the early stage of community development. The species richness and the types of responses of those manifest communities with respect to different types of pollutants are the two reasons for using species diversity to indicate water pollution (Stevenson, 1984). During this study, new baseline information in understanding the structure of phycoperiphyton is provided not only in Mukalla coast but it may be extended to include the coastal zone of Aden Gulf. As expected, the phycoperiphyton composition was totally dominated by diatoms (Bacillariophyta) which constituted the value of 66.00% of the total phycoperiphyton composition at all the sampling stations (Figure 2). The rest of the phyla together amounted to 34% of the total phytoplankton population at all the sampling stations. These indicate that Embikhah Khor is an oligotrophic waterbody. As it was reported by Oswald (1988) that the presence of algae indicates the trophic conditions of a water body: e.g., diatoms and green algae are frequent in relatively pure oligotrophic waters, while blooms of blue green algae indicate a eutrophic state and water pollution. The best results without any indication of pollution were found at station 3 and 4. The highest richness were recorded in this study was of diatom followed by dinoflagellates, blue green algae, green algae and red algae as well as golden brown algae respectively. The diatom species richness of 26, 27, 32 and 32 were recorded at stations 1, 2, 3 and 4 respectively (Figure 5). There is one possible explanation for these higher results of diatom richness at these stations that is the increases in organic matter supply as a result of runoff and input from the surrounding areas and from the bottom of the khor.

The decomposition of organic matter may contribute to the increase in inorganic nitrogen and phosphorus in the pattern of the diatom communities at these stations (Rushforth and Brock, 1991). Chrysophyta species numbers decreased in oligotrophic water and increased dramatically in more eutrophic water (Graham and Wilcox, 2000). This is another indicator of the oligotrophic state of Embikhah Khor. The increase of Chrysophyta species will show the changes of nutrients conditions in the water body (Reynolds, 1993). Therefore, nutrients conditions were important in regulating the succession of microalgae as suggested by other researchers (Hussein and Mason, 1988; Dodson *et al.,* 2000). In conclusion, the results of this study are the first data record of phycoperiphyton occurrence and distribution in Embikhah Khor at Mukalla coast. Records of two new genera of yellow green microalgae (*Vaucheria*) and red microalgae (*Batrachospermum*) were reported in this study is considered one of the main contributions of this study. Although there are no organism's morality or red tide phenomenon were reported in this study area, but the presence of harmful phycoperiphyton such as *Navicula*, *Nitzschia*, *Chaetoceros*, *Ceratium*, *Peridinium*, *Gonyaulax*, *Anabaena*, *Oscillatoria* and *Trichodesmium* indicate the need of a regular monitoring system to keep track of these populations "Phycoperiphyton Blooms" of these algae could lead to human health hazards and other problems such 'fish-kills'. Looking toward the future, continued researches on spatial and temporal distribution of phycoperiphyton productivity, biomass, abundance and diversity will provide further insight into the functional role of these taxa play in their habitats.

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