Composition of Macrobenthos in the Bakkhali Channel System, Cox’s Bazar with Notes on Soil Parameter

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Abstract: Macrobenthos in coastal environment that play a significant role in the food web. It could also use as a good indicator of aquatic ecosystem health. The abundance and composition of macrobenthos in Bakkhali channel system, Cox’s Bazar were conducted in relation to the soil parameters. Samples were collected using Ekman Berge bottom grab from five different stations of Bakkhali channel. Macrobenthos were comprised of five major groups namely Polychaeta (9.96-30.31%), Oligochaeta (3.68-59.70%), Crustacea (0.02-58.40%), Bivalvia (1.40-82.09%) and Gastropoda (0.08-4.25%). Total number of macrobenthos was higher at station I (9000 individuals m⁻²) and station II (8517 individuals m⁻²) compared to other stations. Shannon diversity index among the stations ranged from 0.65-1.04. Soil pH and soil moisture ranged from 6.1-6.4 and 23.44-31.29%, respectively. The highest organic carbon concentration was observed at station I (2.11%) and lowest at station III (1.40%). Maximum fraction of sand by weight was found at stations II (81.88%) and III (87.88%) while the highest fraction of clay (21.52%) and silt (8.6%) were recorded in station I. It was observed that benthic bivalves were positively correlated (r = 0.891, p=0.05) with silt fraction of the sediments.

Key words: Macrobenthos, abundance, diversity index, soil parameters, Bakkhali channel, Cox’s Bazar, Bangladesh

INTRODUCTION

Macrobenthos in estuarine ecosystem provides significant support to the aquatic food web. They contribute to ecosystem stability through the sustenance of fishery resources including birds. The composition, abundance and distribution pattern of macrobenthos can act as an ecosystem index by indicating trophic structure, quality of water and the eutrophication level of the aquatic ecosystem (Mehdi et al., 2005). Physicochemical parameters of the environment may influence macrobenthic organisms either positively or negatively depending on their sources. Excessive input of nutrients and changes of soil parameters can cause long or short-term shifts in benthic species composition, abundance and richness (Aura et al., 2011).

Benthic faunas developed naturally in aquatic ecosystems. Besides the trophic relationship with microbes, they have important roles in estuarine ecosystems, especially with regards to food supply, productivity, fish growth and nutrient cycling. The composition of benthic faunal compositions in the estuarine ecosystems depends on several factors like siltation, water quality, sediment condition and temperature. Previous studies revealed that the macrobenthos were essential for many estuarine species i.e., fishes, shellfish and avifauna through their entire life stages. A number of studies argued that the richest fisheries of the world are closely related to the benthic community, particularly demersal fishes and shrimps are closely related to the benthic communities as their major source of food (Longhurst, 1957; Chong and Sasekumar, 1974). Longhurst (1957) investigated the relationship between demersal fishes and soft bottom benthos in the West African estuary and found that macro invertebrates are the main diet for the demersal fisheries.

Benthic fauna can influence water chemistry, regulate sediment properties and control nutrient cycle by
mobilizing and rearticulating sediment and organic matter (Coull, 1970). Many literatures are available on the descriptive and correlative studies of benthic faunal taxa with environmental factors (Coull, 1970). Benthic organisms may be dependent on textural composition of estuarine sediments that might limit the distributions of certain organisms (Davis, 1971). However, the study on macrobenthos composition and abundance in the estuarine channel system is scanty in Bangladesh. Therefore, the main objective of this study was to investigate the macrobenthos composition and their abundance in the channel system of Bakkhali river estuary of Cox’s Bazar. Several physicochemical parameters of soil were also investigated to understand the relationship between the soil parameters and the macrobenthos composition in this river system.

**MATERIALS AND METHODS**

**Study area:** The Bakkhali river estuary is located at the south-eastern coast of the Bay of Bengal (Fig. 1). This river is relatively wide (about 67 km) compared to other rivers of the Cox’s Bazar district. Bakkhali river estuary has a semidiurnal tidal regime and heavily influenced by monsoonal wind. The tidal range of Bakkhali river varied between 0.07 m and 4.42 m during neap and spring tide respectively (Mahmood, 1986). The estuarine zone is also characterized by long intertidal mudflats where mangrove vegetation (*Avicennia alba*, *Avicennia marina* and *Acanthus ilicifolius*), macro algae (*Ulv a intestinalis*), salt tolerant grass *Imperata cylindrica*, cord grass *Porteresia* sp. and seagrass *Halophila beccarii* are present (Abu Hena et al., 2007). The lower part of this estuary is heavily influenced by anthropogenic and industrial activities including fish harbours, fish processing plants and a large number of fish and shrimp farms. The large amount of organic and inorganic waste changes the chemical characteristics of the water body by producing toxic substances, which ultimately affect the biodiversity of this estuarine system. Five sampling stations were selected for the present study namely Station I (Bakkhali Mouth), Station II (North Nuniya Chona), Station III (Kustura Ghat), Station IV (Mazir Ghat) and Station V (Gudar Para). The distance from one station to another station was 1 km (Fig. 1).

**Collection of macrobenthos:** For macro benthic fauna, samples were collected using a small boat during March-April, 2007. Sampling was done using an Ekman Berge bottom grab having a mouth opening of 0.04 m². Three samples were collected from each station with three replicates. Samples were sieved through 500 μm mesh screen to retain macrobenthos. All samples were preserved immediately with 10% buffered formalin. The organisms were counted and calculated for total amount in m² for macrobenthos. The major taxonomic group of benthos was identified following the references described by Arnold and Birtles (1989), Chuang (1961), Berry (1972), Lim (1963), Huys et al. (1996), Day (1967) and Fauchald (1977).

**Soil collection and analysis:** Soil samples were collected from each station in the study area with 3 replicates. Soil samples were collected using grab sampler from a depth

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Fig. 1: Location of the study area showing the study stations in the Bakkhali channel system, Cox’s Bazar
of 0-10 cm at each sampling location and the samples were kept in self-sealed plastic bags. In the field, the soil pH (wet) and soil temperature were detected *in situ* using a pH meter (Soil pH tester, Takamura Electric Works Ltd) and thermometer (Centigrade thermometer, Japan), respectively.

For determination of soil moisture, initially the soil sample was taken in petri-dish and heated in incubator for 1 hour and cooled it in desiccators. Then, the final weight was measured to detect the moisture content. Soil texture was measured following the procedure described by Bouyoucos (1962). Soil organic matter was detected following procedure described by Boyd (1995). Soil organic carbon was calculated dividing the organic matter by a factor of 1.9 following the procedure described by Nelson and Sommers (1982).

**Data analysis:** The Shannon diversity index is commonly used to describe the diversity of the particular community and as an indicator for the assessment of an ecosystem with regards to abundance and diversity (Bahls *et al.*, 1992). The Shannon-Wiener diversity (Shannon and Weaver, 1949), the Pielou evenness, richness and Fisher-alpha were calculated by PAST Version 2.13. Shannon diversity index (\(H^\prime\)) and evenness (\(E\)) were calculated for each of the sample based on the following formula (Magurran, 1988):

\[
H^\prime = - \sum p_i \log p_i
\]

where, \(p_i\) is the relative cover of the \(i\)th species = \((n_i/N)\), \(n_i\) is the number of individual species counted, \(N\) is the total number of species:

\[
E = \frac{H^\prime}{\log S}
\]

where, \(\log S\) is the natural log of the total number species.

Richness was measured by Margalef index (\(d\)) (Margalef, 1968) using the following formula:

\[
d = \frac{S-1}{\log N}
\]

where, \(S\) is total species and \(N\) is total individuals.

Pearson’s correlation coefficient (\(r\)) was used to identify relationships between the abundance of macrobenthos and soil parameters. Stepwise multiple regression analysis was used to examine the effect of macrobenthos abundance with soil parameters using statistical software SPSS version 19.0. All the statistical significance were tested at a 95% confidence level.

**RESULTS**

**Abundance and composition of macrobenthos:** The total number of macrobenthos at station I (9000 individuals \(1^{-2}\)) and station V (8517 individuals \(1^{-2}\)) were higher compared to the other sampling stations. The major groups of macrobenthos were comprised of the Bivalvia, Polychaeta, Oligochaeta, Crustacea, and Gastropoda. The density range of macrobenthos was, Polychaeta (401-2126 individuals \(1^{-2}\)), Oligochaeta (148-1822 individuals \(1^{-2}\)), Crustacea (1-974 individuals \(1^{-2}\)), Bivalvia (52-6276 individuals \(1^{-2}\)), and Gastropoda (3-171 individuals \(1^{-2}\)) (Table 1). In term of percent composition of macrobenthos, the figures recorded were 9.96-30.31%, 3.68-59.707%, 0.02-58.40%, 1.40-82.09% and 0.08-4.25% for Polychaeta, Oligochaeta, Crustacea, Bivalvia, and Gastropoda, respectively (Table 1).

The Shannon diversity index was found 0.88 for station I, 1.03 for station II, 0.97 for Station III, 0.65 for station IV and 1.03 for station V. The diversity indices were not uniform among the stations. The evenness indices among the stations were ranged between 0.38 and 0.56. The diversity index of station II and station V were higher than the other sampling stations (Fig. 2).

**Physicochemical parameters of estuarine sediments:** Soil pH among the sampling stations ranged between 6.1 and 6.4. Soil moisture ranged from 23.44-31.29%. Organic carbon displayed considerable spatial variability where

| Table 1: Abundance of macrobenthos (individuals \(1^{-2}\)) recorded from the Bakakhali channel system, Cox’s Bazar |
|---|---|---|---|---|---|
| Group | Station I | Station II | Station III | Station IV | Station V |
| Polychaeta | 1252 | 751 | 925 | 401 | 2126 |
| Oligochaeta | 1323 | 774 | 1822 | 148 | 1250 |
| Crustacea | 124 | 2126 | 5 | 1 | 4974 |
| Bivalve | 6276 | 52 | 174 | 3304 | 151 |
| Gastropoda | 25 | 3 | 126 | 171 | 16 |
| Total | 9009 | 3706 | 3652 | 4025 | 8517 |
| Shannon (\(H^\prime\)) | 0.883 | 1.035 | 0.975 | 0.649 | 1.025 |
| Evenness | 0.484 | 0.563 | 0.530 | 0.382 | 0.558 |
| Margalef | 0.439 | 0.487 | 0.499 | 0.482 | 0.442 |
| Fisher alpha | 0.511 | 0.569 | 0.584 | 0.563 | 0.515 |
Table 2: Physicochemical parameters of soil collected from the Bakkhali channel system, Cox’s Bazar

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Station I</th>
<th>Station II</th>
<th>Station III</th>
<th>Station IV</th>
<th>Station V</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.40</td>
<td>6.30</td>
<td>6.10</td>
<td>6.40</td>
<td>6.40</td>
</tr>
<tr>
<td>Soil moisture (%)</td>
<td>31.59</td>
<td>26.08</td>
<td>23.44</td>
<td>26.54</td>
<td>30.73</td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>4.00</td>
<td>3.00</td>
<td>2.65</td>
<td>3.15</td>
<td>3.65</td>
</tr>
<tr>
<td>Organic carbon (%)</td>
<td>2.11</td>
<td>1.58</td>
<td>1.40</td>
<td>1.66</td>
<td>1.92</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>70.18</td>
<td>81.88</td>
<td>87.88</td>
<td>79.48</td>
<td>74.68</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>8.00</td>
<td>3.92</td>
<td>2.60</td>
<td>5.60</td>
<td>5.12</td>
</tr>
</tbody>
</table>

Table 3: Pearson’s correlation matrix of macrobenthos abundance and physicochemical parameters of soil from Bakkhali channel system, Cox’s Bazar

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Polychaeta</th>
<th>Cladocera</th>
<th>Crustacea</th>
<th>Bivalve</th>
<th>Gastropoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>0.245</td>
<td>-0.062</td>
<td>0.322</td>
<td>0.513</td>
<td>-0.275</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>0.663</td>
<td>-0.024</td>
<td>0.439</td>
<td>0.522</td>
<td>-0.572</td>
</tr>
<tr>
<td>Organic matter</td>
<td>0.562</td>
<td>-0.016</td>
<td>0.271</td>
<td>0.663</td>
<td>-0.507</td>
</tr>
<tr>
<td>Organic carbon</td>
<td>0.599</td>
<td>-0.012</td>
<td>0.263</td>
<td>0.668</td>
<td>-0.504</td>
</tr>
<tr>
<td>Sand</td>
<td>-0.489</td>
<td>0.138</td>
<td>-0.257</td>
<td>-0.680</td>
<td>0.480</td>
</tr>
<tr>
<td>Silt</td>
<td>0.181</td>
<td>-0.246</td>
<td>-0.696</td>
<td>0.891*</td>
<td>-0.234</td>
</tr>
<tr>
<td>Clay</td>
<td>0.092</td>
<td>-0.097</td>
<td>0.408</td>
<td>0.554</td>
<td>-0.563</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed)

Fig. 2: Diversity profile of different sampling stations from Bakkhali channel system, Cox’s Bazar

The highest concentrations were observed at station I (2.11%) and lowest at station III (1.40%). Maximum fraction of sand by weight was found at stations III and II (8.78% and 8.18%, respectively), while the highest fraction of clay (21.52%) and silt (8.0%) were found at station I (Table 2). In the Pearson’s correlation matrix, it is observed that the benthic bivalve group was positively correlated with silt fraction (r = 0.891, p<0.05). No significant correlations were found between other benthos groups and soil parameters (Table 3).

DISCUSSION

The five major groups of macrobenthos recorded from the channel system of Bakkhali estuary were mostly common and dominant taxa of the coastal and estuarine environment of Bangladesh. These species are also common in the coastal seagrass and mangrove habitats. Usually the diversity of macrobenthos is higher in the tropical and sub tropical climate. The number of macrobenthos group observed in the present study is similar to the number of groups encountered in other tropical tidal areas (Aura et al., 2011).

The abundance of macrobenthos was higher in the Stations I and V, assuming that the habitat and environmental condition of those stations probably be suitable for benthos compared to other sampling stations. The variation among the stations could also probably be due to higher input of nutrients from the sediments. Generally, relatively soft surface and high detritus or organic matter (>3%) in these stations may cause for high food diversity hence supports greater benthic organisms (Arshad et al., 2011; Aura et al., 2011). Siddique et al. (2012) observed that salt marsh sediment of Bakkhali estuary especially at Stations III and IV features metal pollution from urban runoff and other coastal activities which eventually may affects on benthic community.

Studies by Hossain (2003) recorded 20 major taxa of macrobenthos in the Meghna river estuary that is higher than the present study. Compared to the studies done by Belaluzzaman (1995) the abundance of macrobenthos is lower in the channel system of the Bakkhali estuary, which probably due to the unsustainability of the estuarine bottom due to continuous runoff that leads to increase sediment loads in the estuarine basin (Aura et al., 2011). The variation of diversity index among the stations in the Bakkhali estuary could probably be due to other unknown factors which might regulate the index values. The diversity index (1.17-4.64) recorded in the present study is similar with Belaluzzaman (1995) and Islam (2003).

The physicochemical property of the sediment plays a regulatory role in determining the abundance and seasonal variation of benthic organisms in the estuarine environments. Estuaries are cordial to benthos which is
able to cope with the harsh environment. In the present study, highest amount of organic matter (4.0%) was found at station I. The mean concentration of organic matter of Bakhali channel system (3.29%) is almost similar to results (3.19±1.00%) recorded from Karnafally river (Siddique and Aktar, 2012). However, the mean concentration of organic matter is lower than the results obtained by Weis et al. (2001) for wetland sediments in Tijuana Estuary, California (range of 8.7-13.8%).

Among different sampling locations, both stations I and IV observed to have higher fraction of clay and silt than the other stations. The mean percentage of clay particles in Bakhali river estuary was found to be 16.07%, which is lower than the mean value obtained from Karnafally river (33.52±3.81%; Siddique and Aktar, 2012) and Tijuana estuary (59.42±8.93%; Weis et al., 2001). The mean percentage of silt was 5.05%, which is lower than the results (24.2±2.34) obtained by Weis et al. (2001). Usually, soil condition or sediment particles are important parameter to colonize the benthic fauna in the estuarine environment (Chou et al., 2004). According to Chou et al. (2004), sedimentation not only affects faunal communities in the estuarine ecosystem but also changes sediment composition, organic matter and nutrient input. The present study showed that the abundance and benthic fauna diversity was higher in the areas where organic matter is rich (Bhat and Neelankant, 1988).

CONCLUSION

This study revealed that the abundance of macrobenthos depends on soft sediment surface and concentration of high detritus and organic matter. The maximum abundance of macrobenthos was related to nutrients input in this channel systems. However, the lower abundance of macrobenthos probably due to continuous environmental disturbance like sedimentation, urban runoff and pollution in this river, which might badly affect in the river ecosystems.

REFERENCES


