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Analyses of Macrobenthos of Hatiya and Nijhum Dweep Islands at Higher Taxonomic Resolution

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ABSTRACT

This study was carried out to describe the distribution and community pattern of benthic macrofauna collected from two nationally and internationally important islands, Hatiya and Nijhum Dweep in the period of January to June, 2010 using hand-held mud corer (10×10×10 cm) from seven stations. The coarser (order) level of taxonomic resolution was used to investigate the community attributes among the sampling stations. The study yielded a total of 10688.89 ind. m^{-2} macrofauna from all stations. Ten major taxa were identified from two islands and polychaete being the dominant. The average population density was 1526.98±1453.375 ind. m^{-2}. There was a significant difference ($p<0.05$) in faunal density between Hatiya and Nijhum Dweep with later having higher mean density. The maximum (1.97) Shannon diversity index was found in St1 and the lowest (1.14) in St5. The highest similarity (76.6%) was found between St2 and St5. Multivariate analysis was conducted at order level of benthos using PRIMER. Bray-Curtis similarity measures among macrozoobenthic communities separated the stations into several cluster groups which was supported by nMDS ordination map.

Key words: Benthic macrofauna, higher taxonomic level, multivariate analysis, Hatiya and Nijhum Islands

INTRODUCTION

Benthic macrofauna has been the subject of many studies throughout the world by realizing their importance in ecological and environmental studies (Gray *et al.*, 1990; Smith and Simpson 1993; James *et al.*, 1995; Aweng *et al.*, 2012; Asadujjaman *et al.*, 2012). They are of considerable importance in aquatic food chain and especially the main food sources of commercially important demersal fishes (Hossain *et al.*, 2009). They provide a linkage between substratum and sea bed and water column predators (Gray and Elloitt, 2009). They have long been used as indicator of pollution. There is an increasing awareness of biodiversity and the protection of all members of the biological community. All organisms, microscopic to macroscopic, play active role in balancing the ecosystem. Loss or extinction of any group of organisms hampers the functioning of the ecosystem. So, there is need to identify and protect the benthic population of conservation interest (Allen, 2000). In decision VI/26 of Convention on Biological Diversity (CBD) targeted to fulfill the three objectives, to achieve a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth by 2010 (CBD, 2004). But unfortunately the benthic habitats of Bangladesh coastal area are still comparatively untouched or understudied. Only a few unpublished (Alam, 1993; Belaluzzaman, 1995) and published (Mahmood *et al*., 1993; Hossain *et al*., 2009; Hossain, 2011; Asadujjaman *et al*., 2012) works described the benthic macrofauna of Bangladesh coastal area. The reason may be due to lack of taxonomic expertise, time consuming, cost and labor intensive work. Majority of benthos monitoring studies, have often been criticized by the scientific communities due to the high costs and long time involved in sampling and taxonomic work (Warwick, 1993). So, Warwick (1988) and other investigators Gray *et al*. (1990), Smith and Simpson (1993) and James *et al*. (1995) concluded from their investigations that studies of benthic macrofaunal communities, where strong gradient exist, can be conducted even if specimens are identified to the level of phylum. Of course, decreasing the level of taxonomic resolution will cause a certain loss of information. But it is better to use the coarser level taxonomic information rather than doing wrong identification (Warwick, 1988). Therefore, in the present study coarser taxonomic resolution as suggested by Warwick (1988) was followed.

Hatiya and Nijhum Dweep are two small islands, formed of sediment carried by the mighty Meghna River, situated in the northern part of Bay of Bengal, Bangladesh. These islands are nationally and internationally important (Khan, 2012). The eulittoral zone is the area of the foreshore and seabed that is exposed to the air at low tide and submerged at high tide. Both biotic and abiotic factors are strongly active in this zone and create a challenging environment for the organisms living therein. So, the aim of this study is to describe and characterize the macrofaunal community pattern at coarser taxonomic level in the eulittoral zone of the selected area.

MATERIALS AND METHODS

Study area: Hatiya and Nijhum Dweep are two small islands located (GPS reading: 22°22'N 91°7.5'E and 22°04'N 91°00'E, respectively) in the mouth of Meghna river, central coast of Bangladesh (Fig. 1). These two islands have an area of about 1508 km^2. They are frequently subject to cyclones and destructive ocean waves (Encyclopedia Britannica, 2012). The clusters of islets of Hatiya and its surroundings comprise various types of habitats e.g., network of intertidal creeks inside mangroves, massive mudflats, grassland, reed land, sand flats, sand beaches, sand dunes and dipper channels. These varieties of habitats harbor a high plant and animal biodiversity (Khan, 2012). At high tide a significant portion of Nijhum Dweep becomes covered in water, apart from the inhabited areas. In 2001, it was designated as the Nijhum Dweep National Park by Bangladesh government. The forestry department of Bangladesh created lush mangrove forests in Nijhum Dweep as part of conservation efforts for the area. The inter-tidal mudflats and sand-flats serves as the southern most stop-over for nearly 100 species of migratory birds, around a dozen of which are considered to be globally critically endangered (Khan, 2012). Recently a group of scientists from home and abroad surveyed the area and proposed to declare it as RAMSAR site (Khan, 2012).

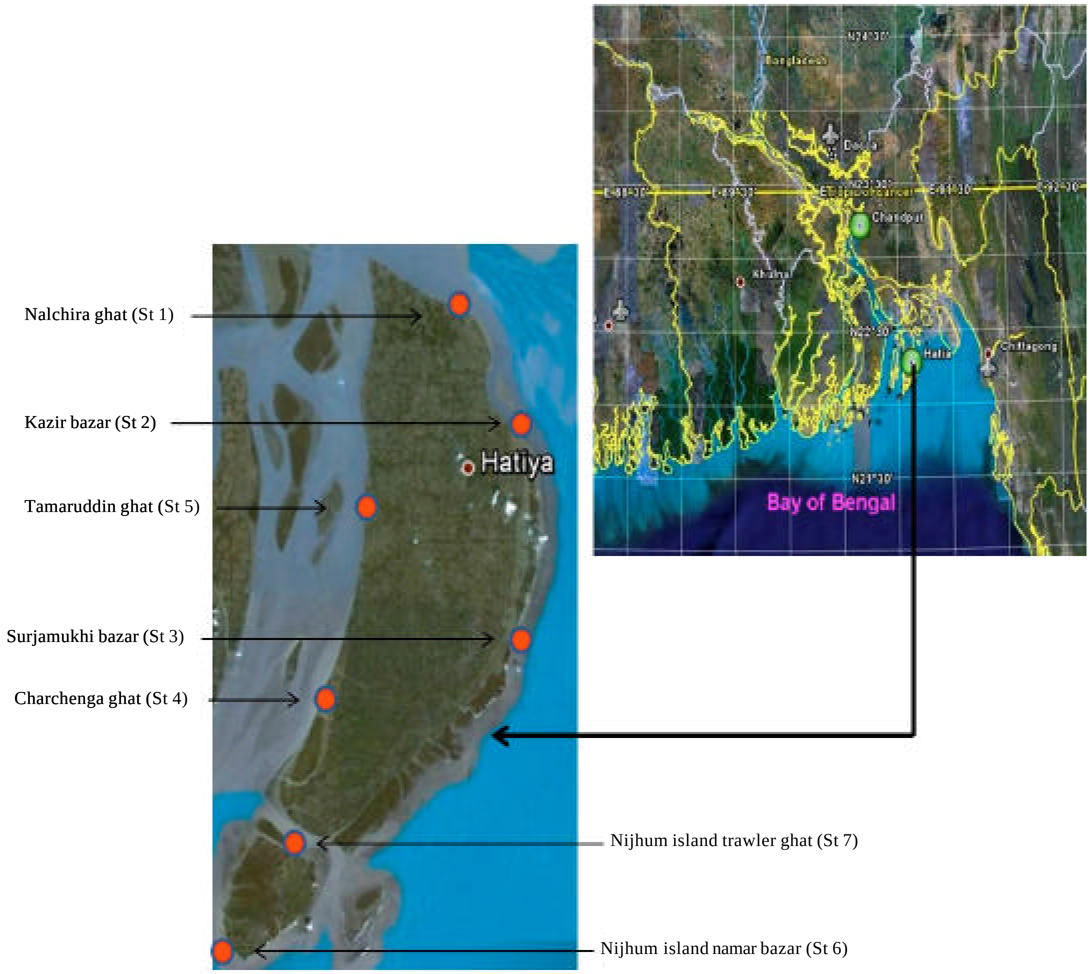

Fig. 1: Location of sampling stations in Hatiya and Nijhum Dweep islands

Sampling locations: Seven sampling stations were selected around the two islands for macrofauna collection (Table 1).

Sample collection and analysis: Three replicate sediment samples were collected from each station with hand-held mud corer (10×10×10 cm) having a mouth opening of 0.01 m^2 during pre-monsoon (January-June, 2010). The samples were washed through a 0.5 mm metallic sieve. Sieved organism samples were preserved with other residues in the plastic container with 10% buffered formalin and few drops of Rose Bengal. Organisms were sorted and enumerated under major taxa using Binocular microscope with digital camera (model No: XSZ21-05DN). Benthic invertebrates were identified upto order level. An attempt has been made to identify the macrobenthos up to lowest taxonomic level but due to time limitation, taxonomic expertise, lack of fund and appropriate literature it was not possible.

Table 1: Sampling stations of Hatiya and Nijhum Dweep Islands with basic features

Stations number	Locations	Habitat features
St 1	Nalchira Ghat	Sandy, subjected to erosion, Salinity : 3-12 ppt, Tide: Strong, Temperature: 25-32°C
St 2	Kazir Bazar	Clayey bottom, subjected to erosion, Salinity : 4-12 ppt, Tide: strong, Temperature: 26-28°C
St 3	Surjamukhi Bazar	Clay bottom area, no erosion, Tide : active, Temperature: 25-27°C, Salinity: 4-12 ppt
St 4	Charchenga Ghat	Sandy bottom area and subjected to high erosion, Temperature : 25-31°C, Salinity: 8-15 ppt
St 5	Tamaruddin Ghat	Sandy bottom and erosion area, tidal influence is very strong here, Temperature: 22-29°C, Salinity: 3-15 ppt
St 6	Nijhum Island, Namar Bazar	Sandy-clayey bottom, Salinity: 15-25 ppt, Temperature 25-33°C, Tidal influence is active here and water body is turbid
St 7	Nijhum Island, Trawler Ghat	Muddy bottom area, subjected to erosion, Tidal influence is active here, Salinity: 10-20 ppt, Temperature: 25-30°C

The coarser level (order) of taxonomic data as suggested by Warwik (1988) were analyzed using the statistical package SPSS v.17 and multivariate data analyzing software, Plymouth Routines In Marine Ecological Research (PRIMER v.6). Classification and Ordination (Nonparametric multidimensional scaling, nMDS) were performed by using Bray-Curtis similarity measure for community analysis.

RESULTS AND DISCUSSION

Density, diversity and similarity: The macrofauna comprised ten major taxa (order) and yielded a total of 10688.89 ind. m^{-2} with a mean density of 1526.98±1453.375 ind. m^{-2} from all stations and the highest being 4511.11 ind. m^{-2} in St 6 and the lowest 433.33 ind. m^{-2} in St 1 (Fig. 2). The mean density of benthos was 1137.78 ind. m^{-2} in Hatiya and 2500 ind. m^{-2} in Nijhum Dweep. The dominant taxon was polychaete contributing 45.03% of total fauna. Polychaete, oligochaete, crab were common in all stations. Bubble plot show polychaete and oligochaete were abundant in St 6 (Fig. 3a, b) whereas shrimp larvae and crab were dominant in St3 (Fig. 3c and d). Evenness and Shannon diversity indices are two important components of the diversity indices. Evenness index expresses how evenly the individuals are distributed among the different species. Pielou's evenness index and Shannon diversity are widely used indices for comparing diversity between various habitats. The value of Shannon diversity is usually found to fall between 1.5 and 3.5 and only rarely it surpasses 4.5. The evenness has very good discriminating ability between the habitats and the value varies from 0 to 1. In this study the highest (0.95) evenness value was found in St1 and the lowest (0.56) in St 6 (Table 2). The maximum (1.97) Shannon diversity index was found in St1 and the lowest (1.14) in St5 (Table 2). Similarity matrix data (Table 3) shows the highest similarity (76.6%) was found between St 2 and St 5. The highest density and diversity observed in the undisturbed and less eroded stations. Polychaete and oligochaete were found to be comparatively abundant in the disturbed and eroded stations (St 6) whereas crustaceans were dominant in undisturbed and less or non-erosion prone stations (St 3).

Community analysis: The most useful approaches for the preliminary analyzing of benthic data are classification and ordination. Generally, classification starts with a matrix of similarity coefficients between all possible pairs of individuals. The most similar pair of individuals is joined

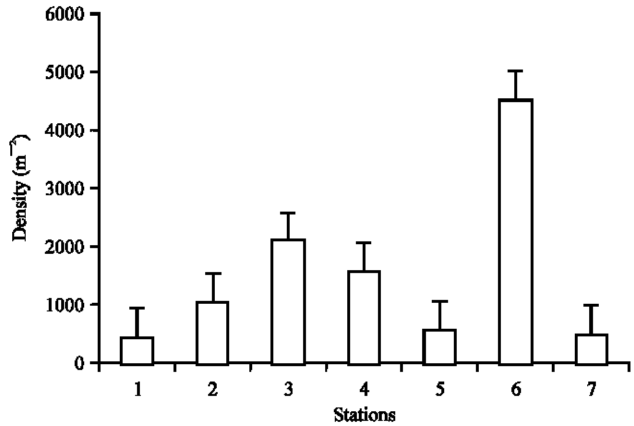

Fig. 2: Density (ind. m^{-2}) of macrobenthos in different stations, at 95% confidence interval

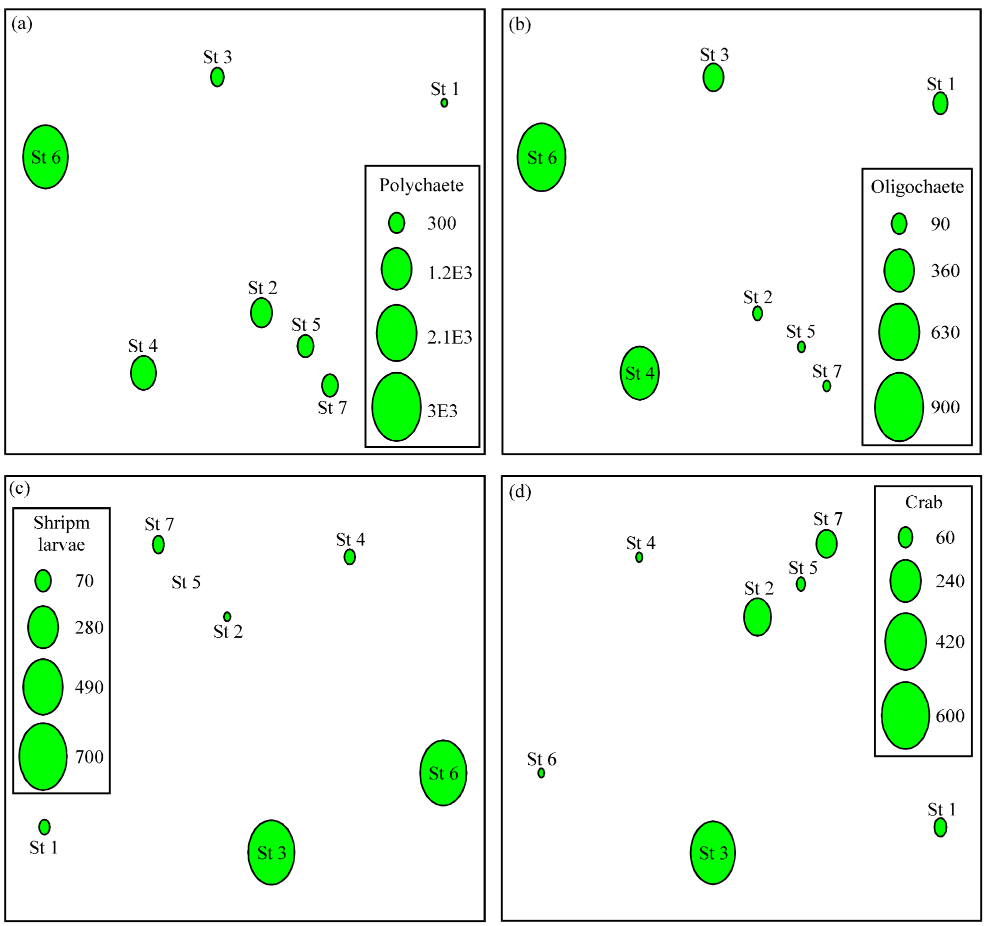

Fig. 3(a-d): Bubble plot of (a) Polychaete, (b) Oligochaete, (c) Shrimp larvae and (d) Crab distribution in the sampling stations (St)

to form a new super individual and the process is repeated until all individuals have been joined into a single group and successive grouping is plotted against some measure of the homogeneity

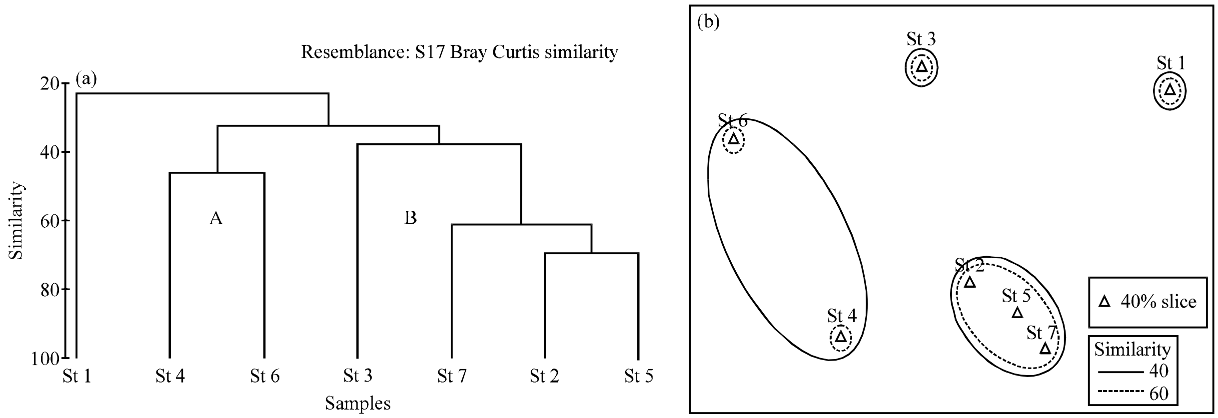

Fig. 4(a-b): (a) Dendogram plot and (b) nMDS plot of sampling stations (St) using Bray-Curtis similarity matrix

Table 2: Diversity indices in the study area

Sample	S	N	d	J'	H' (loge)
St 1	8	433	1.153	0.9484	1.972
St 2	7	1033	0.8645	0.6443	1.254
St 3	8	2100	0.9151	0.8301	1.726
St 4	5	1556	0.5442	0.7182	1.156
St 5	6	567	0.7887	0.6357	1.139
St 6	9	4511	0.9508	0.5628	1.237
St 7	6	489	0.8075	0.6937	1.243

Table 3: Similarity matrix among the stations

	St 1	St 2	St 3	St 4	St 5	St 6	St 7
St 1							
St 2	56.191						
St 3	53.175	61.713					
St 4	41.945	51.467	45.831				
St 5	53.564	76.602	55.645	47.158			
St 6	43.05	49.336	57.783	58.193	42.99		
St 7	57.581	66.648	55.714	58.836	68.992	39.059	

of the new group and then a dendogram is produced (Fig. 4). The structure of the dendogram summarizes trends in the species abundance data. In this study, the computer package, PRMER has been used for classification and ordination of abundance data. Cluster analyses were carried out, based on the square root transformed abundance of all taxa found in the study area, using the Bray-Curtis measure of similarity and group-average sorting. The analysis split the stations mainly two groups (indicated as A and B) at about 30% similarity level (Fig. 4). Group A consists of two stations (St 4 and St 6) and group B of four stations (St 3, St 7, St 2 and St 5). St1 is not grouped into any cluster remaining totally separate from other stations. In group B, St 7, St 2 and St 5 are in the same cluster whereas, St 3 remained separate. The nMDS mapping of abundance data supports the cluster groups. It shows at the both 60 and 40% similarity level St 2, St 5 and St 7 are

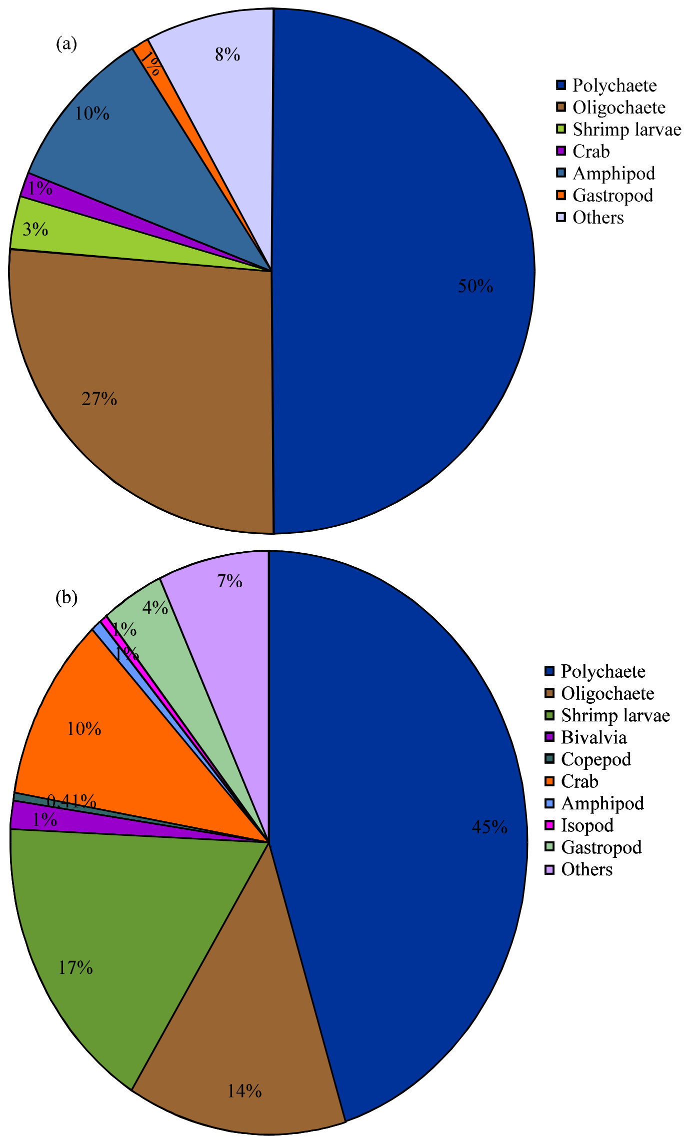

Fig. 5(a-b): Species composition of (a) Cluster group A and (b) Cluster group B

tightly closed with each other but St 4 and St 6 remained close at only 40% similarity level (Fig. 4) and St 3 and St 1 are scattered in the nMDS.

The species composition of each cluster groups is presented in Fig. 5. Both Groups are dominated by polychaetes followed by oligochaete and shrimp larvae. In group A, polychaete and oligochaete together constituted 77% of total abundance whereas in group B, polychaetes and shrimp larvae covered 62%.

Though, a certain amount of information about community identities and their temporal drifts will be lost, analyses of higher taxonomic levels are more likely to reflect a contamination gradient than are analyses based on species abundances (Gray *et al*., 1990). While community identity cannot be recognized at order level, the inter-annual variability may still be recognized. Although, environmental impact assessment studies traditionally require identification of the individuals collected to the species level, several studies have found analyses at the level of family to be acceptable, since little information appears to be lost (Warwick, 1988). This suggests that one way of reducing the cost of benthic surveys could be to shorten the time Surveys of soft-bottom macrofauna, integral to a majority of marine pollution monitoring studies. One possible reason is that sampling strategies used are very labour-intensive. There are instances, however, where a correct identification to a higher taxonomic level would be better than an incorrect identification to the species level which by requiring considerable expertise is often more error prone. Using higher taxa would be useful, especially when carrying on a pilot study about the general features of a new environment (Gray *et al.*, 1990; Smith and Simpson, 1993; James *et al.*, 1995). Although, gross, results will help in developing a subsequent, more appropriate and detailed sampling design. Warwick (1988) firstly pointed out that there were theoretical advantages to conducting both multivariate and univariate analyses at various hierarchical levels of taxonomic aggregation in programmes aimed at detecting the biological effects of marine pollution. Anthropogenic effects modify community at a higher taxonomic level than do natural environmental variables, due to the inability of species to adapt through evolution in response to a recent pollutant disturbance (Smith and Simpson, 1993; James *et al.*, 1995). So, the developing countries e.g., Bangladesh can use benthic community attributes for environmental impact assessment analyzing abundance data at higher taxonomic level which will be cost effective.

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