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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 (3.68-59.707%), 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 (8.0%) 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 macro-benthic 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

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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 (*Ulva 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 Chora), 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 m^2. 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 m^2 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

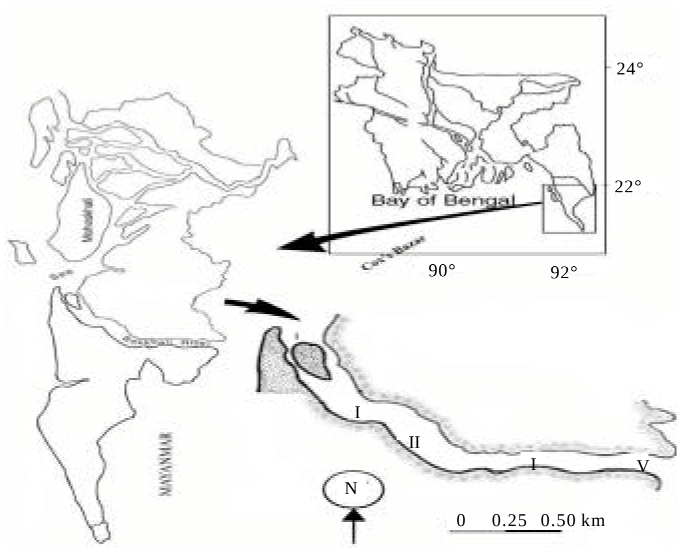

Fig. 1: Location of the study area showing the study stations in the Bakkhali channel system, Cox's Bazar

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 were taken in petri-dish and heated in incubator for 1 hour and cooled it in the 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′) and evenness (E) were calculated for each of the sample based on the following formula (Magurran, 1988):

$$H' = -\sum pi * \log pi$$

where, pi is the relative cover of the ith species = (ni/N), ni is the number of individual species counted, N is the total number of species:

$$E = \frac{H'}{\log S}$$

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:

$$d = \frac{S-1}{\text{Log } N}$$

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 m^{-2}) and station V (8517 individuals m^{-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 were; Polychaeta (401-2126 individuals m^{-2}), Oligochaeta (148-1822 individuals m^{-2}), Crustacea (1-4974 individuals m^{-2}), Bivalvia (52-6276 individuals m^{-2}) and Gastropoda (3-171 individuals m^{-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 m^{-2}) recorded from the Bakkhali 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	9000	3706	3052	4025	8517
Shannon (H')	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

Parameter	Station 1	Station II	Station III	Station IV	Station V
pH	6.40	6.30	6.10	6.40	6.40
Soil moisture (%)	31.29	26.08	23.44	26.54	30.73
Organic matter (%)	4.00	3.00	2.65	3.15	3.65
Organic carbon (%)	2.11	1.58	1.40	1.66	1.92
Sand (%)	70.18	81.88	87.88	79.48	74.68
Silt (%)	8.00	3.92	2.60	5.60	5.12
Clay (%)	21.52	14.20	9.52	14.92	20.20

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

Parameter	Polychaeta	Oligochaeta	Crustacea	Bivalve	Gastropoda
Soil pH	0.245	-0.602	0.322	0.513	-0.275
Soil moisture	0.663	-0.024	0.439	0.522	-0.572
Organic matter	0.562	-0.016	0.271	0.663	-0.507
Organic carbon	0.559	-0.012	0.263	0.668	-0.504
Sand	-0.489	0.138	-0.257	-0.680	0.480
Silt	0.181	-0.246	-0.096	0.891*	-0.234
Clay	0.602	-0.097	0.408	0.554	-0.563

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

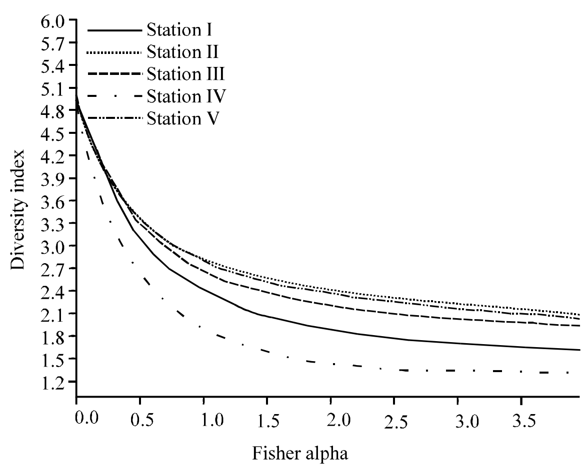

Fig. 2: Diversity profile of different sampling stations from Bakkhali channel system, Cox's Bazar

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 (87.88 and 81.88%, 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 mangroves 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 Bakkhali channel system (3.29%) is almost similar to results (3.19±1.00%) recorded from Karnafully 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 Bakkhali river estuary was found to be 16.07%, which is lower that the mean value obtained from Karnafully 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 Neelanktans, 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 likes sedimentation, urban runoff and pollution in this river, which might badly affect in the river ecosystems.

REFERENCES

Abu Hena, M.K., F.T. Short, S.M. Sharifuzzaman, M. Hassan, M. Rezowan and M. Ali, 2007. Salt marsh and seagrass communities of Bakkhali Estuary, Cox's Bazar, Bangladesh. Estuarine Coastal Shelf Sci., 75: 72-78.

Arnold, P.W. and R.A. Birtles, 1989. Soft Sediment Marine Invertebrates of Southeast Asia and Australia: A Guide to Identification. Australian Institute of Marine Sciences, Townville, Pages: 272.

Arshad, A., R. Ara, S.M.N. Amin, M. Effendi, C.C. Zaidi and A.G. Mazlan, 2011. Influence of environmental parameters on shrimp post-larvae in the Sungai Pulai seagrass beds of Johor Strait, Peninsular Malaysia. Sci. Res. Essays, 6: 5501-5506.

Aura, C.M., P.O. Raburu and J. Herrmann, 2011. Macro invertebrates' community structure in Rivers Kipkaren and Sosiani, River Nzoia basin, Kenya. J. Eco. Nat. Environ., 3: 39-46.

Bahls L.R., R. Burkantis and S. Tralles, 1992. Benchmark biology of Montana reference streams. Department of Health and Environmental Science, Water Quality Bureau, Helena, Montana.

Belaluzzaman, A.M., 1995. Ecology of the inertidal macro benthic fauna in Cox's Bazaar coastal area, Bangladesh. M.Sc. Thesis, Institute of Marine Sciences, University of Chittagong.

Berry, A.J., 1972. The natural history of West Malaysian mangrove faunas. Mal. Nat. J., 25: 135-162.

Bhat, U.G. and B. Neelanktans, 1988. Environmental impact on the macrobenthos distribution of Kali estuary, Karwar, Central west coast of India. Indian J. Mar. Sci., 7: 134-142.

Bouyoucos, G.J., 1962. Hydrometer method improved for making particle size analysis of soils. Agron. J., 54: 464-465.

Boyd, C.E., 1995. Bottom Soils, Sediment and Pond Aquaculture. Chapman and Hall, New York, USA., ISBN: 0412069415, pp: 348.

Chong, V.C. and A. Sasekumar, 1974. Distribution of macro fauna on a Malayan mangrove shore. J. Ani. Eco., 43: 51-69.

Chou, L.M., J.Y. Yu and T.L. Loh, 2004. Impacts of sediments on the soft bottom benthic communities in the southern islands of Singapore. Hydrobiologia, 515: 91-106.

Chuang, S.H., 1961. On Malayan Shores. Caslon Printers Ltd., Singapore, Pages: 225.

Coull, B.C., 1970. Shallow water meiobenthos of the Bermuda platform. Oecologia (Berlin), 4: 325-357.

Davis, H.C., 1971. On food and feeding of larvae of the American system *Crassostrea virginica*. Biol. Bull. Mar., 104: 334-350.

Day, J.H., 1967. A Monograph on the Polychaeta of Southern Africa. Vol. 1. British Museum, London.

Fauchald, K., 1977. The polychaete worms, definitions and keys to the orders, families and Genera. Natural History Museum of Los Angles County.

Hossain, M.B., 2003. Macrobenthos of the Meghna river estuary bed with special reference to polychaete faunal bio-diversity. M.Sc. Thesis, University of Hull, UK.

Huys, R., J.M. Gee, C.G. Moore and R. Hamond, 1996. Marine and Brackish Water Harpacticid Copepods. In: Synopses of the British Fauna (New Series), Barnes, R.S. and J.H. Crothers, (Eds.). The Linnean Society of London and the Estuarine and Coastal Science Association, London, UK., Pages: 352.

Islam, M.T., 2003. Study of benthic organisms into the Karnafully river estuary with notes on their abundance distribution and composition in relation to pollution. M.Sc. Thesis, Institute of Marine Sciences, University of Chittagong, Bangladesh.

Lim, C.F., 1963. A preliminary illustrated account of mangrove molluscs from Singapore and South-West Malaya. Malayan Nat. J., 17: 235-240.

Longhurst, A.R., 1957. An Ecological Survey of the West African Marine Benthos. Fishery Publication, London, Pages: 102.

Magurran, A.E., 1988. Ecological Diversity and its Measurement. Croom Helm Ltd., London, pp: 179.

Mahmood, N., 1986. Effects of shrimp farming and other impacts on mangroves of Bangladesh. Proceedings of the Workshop of Strategies for the Management of Fisheries and Aquaculture in Mangrove Ecosystems, June 19-27, 1986, FAO, Rome, Italy, pp: 46-66.

Margalef, A., 1968. Perspectives in Ecological Theory. University of Chicago Press, Chicago, ISBN-13: 978-0226505060, Pages: 111.

Mehdi, M.D., F.A. Bhat and A.R. Yousuf, 2005. Ecology of macro zoobenthos in Rambiara stream. Kashmir J. Res. Dev., 5: 95-100.

Nelson, D.W. and L.E. Sommers, 1982. Total Carbon, Organic Carbon and Organic Matter. In: Methods of Soil Analysis. Part 2 Chemical and Microbiological Properties Agronomy, Page, A.L., R.H. Miller and D.R. Keeney (Eds.). 2nd Edn., ASA-SSSA, Madison, Wisconsin, USA., pp: 539-579.

Shannon, C.E. and W. Weaver, 1949. The Mathematical Theory of Communication. 1st Edn., University of Illinois Press, Urbana, IL., ISBN-10: 0252725484.

Siddique, M.A.M. and M. Aktar, 2012. Heavy metals in salt marsh sediments of *Porteresia* bed along the Karnafully river coast, Chittagong. Soil Water Res., 7: 117-123.

Siddique, M.A.M., M.K. Abu Hena and M. Aktar, 2012. Assessment of trace metal concentrations in salt marsh sediments from Bakkhali River estuary, Bangladesh. Int. J. Environ. Stud. (In Press).

Weis, D.A., J.C. Callaway and R.M. Gersberg, 2001. Vertical accretion rates and heavy metal chronologies in wetland sediments of the Tijuana estuary. Estuaries, 24: 840-850.