Distribution and Diversity of Macrobenthos in Sangu River, Bangladesh

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Distribution and Diversity of Macrobenthos in Sangu River, Bangladesh

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ABSTRACT: This study was conducted to understand the macrobenthos distribution and abundance in Sangu River to monitor the aquatic pollution level. Both surface and sub-surface water and benthic sediments were collected from three stations of the Sangu River. A few indices viz. Shannon-wiener, Simpson, Margalef's and Evenness were used to estimate the macrobenthic assemblages. In this study, a total of 11 major taxa comprising total 870 macobenthic species were identified. Shannon-wiener index was maximum (1.51) at lower part (LP) which indicated moderate to heavily pollute aquatic environment of the Sangu River. The average diversity values of Shannon, Evenness, Simpson and Margalef's indices were 1.33, 0.59, 0.49 and 1.53 respectively. The concentration of dissolved oxygen was the lowest (4.90 mg/L) at LP and the highest (5.08 mg/L) at upper part (UP). This study showed that macrobenthos abundances was influenced by higher temperature, salinity, and pH. The percentage of organic carbon content was maximum (98.18%) at LP where the macrobenthic abundance was 330 individuals/m^2, whereas it was minimum (80.77%) at UP where macrobenthic abundance was 248 individuals/m^2 that indicated carbon content also influence the assemblages of the macrobenthos in the Sangu River. A clear gradient of physico-chemical and benthic soil parameters fluctuation was also found to be responsible for the variations of macrobenthos assemblage in the Sangu River.

Keywords: Macrobenthos, Distribution, Diversity, Soil and water quality parameters, Sangu River

INTRODUCTION

Macrobenthos are organisms that are living on or inside the bottom of a water body (Barnes and Hughes, 1999; Idowu and Ugwumba, 2005; Khan et al., 2007). Generally, macrobenthos link with the primary producers and play an important role in the circulation and recirculation of nutrients throughout the aquatic ecosystems (Ikomi et al., 2005). The distribution and diversity pattern of macrobenthic communities is totally controlled by the environmental and biological factors like habitats type, water and sediment quality, food supply, dissolve oxygen, substrate composition, sedimentation rates and the bathymetry features (Olenin, 1997; Coleman et al., 2007; Gogina and Zettler, 2010). The spatial and temporal distribution of macrobenthos is remarkably exaggerated due to the changes of water depth, temperature, salinity, pressure, current, density, organic matters content, siltation, toxicity and sedimentation processes (Pearson, 1975).

The Sangu River, a transboundary river, originates in the Arakan Hills of Myanmar and enters Bangladesh near Remarki of Thanchi upazilla of Bandarban district. It is a shallow river but becomes more brutal during rainy season. Sometimes, it develops rapid currents. It falls to the Bay of Bengal through Chattogram. It is one of the most substantial rivers that offers support for fish and shellfish's spawning, nursing and feeding ground. Sangu gas field is located about 50 km at the south west of Chattogram. The ecosystem of the river might have been influenced by the anthropogenic activities such as the Sangu gas field and the confluence of the nearby mighty Karnafully River. Since the distribution and abundance of fish and shellfish species are changed temporally and spatially, it is very important to understand the aquatic ecosystem of the Sangu River. In this case, studies on macrobenthos distribution and assemblage might help to understand the condition of the river for better management. Globally macrobenthos are the most universally used

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organisms for biomonitoring in riverine habitat (Bonada et al., 2006).

A few studies for example Sarker et al. (2016), Sharif et al. (2017) and Islam et al. (2013) focused on macrobenthic community structure in the Meghna river estuary at Chairmanghat, Noakhali and the Bakkhali river estuary at Cox's Bazar, lower Meghna river estuary and Karnaphuli river respectively. Prianka et al. (2020) assessed the shellfish occurrence and distribution in the Sangu River estuary using an estuarine set bag net. However, there is scarce study on the macrobenthos distribution and abundance of in Sangu River. That is why, this study aims to assess the macrobenthos distribution and abundance in the Sangu River. In addition, this study also assesses the physico-chemical parameters of surface waters and bottom sediments of the Sangu River to understand the environmental impacts on the macrobenthos distributions and abundance in the river.

MATERIALS AND METHODS

Study Area

The study was directed to the Sangu River in Bangladesh. Three sampling stations were selected for the research- Upper Part (UP), Middle Part (MP) and Lower Part (LP) (Figure 1). Description of the sampling sites were given to the Table 1.

Figure 1. Geographical Locations of the Sampling Stations in Sangu River

Table 1. Description of the Sampling Stations in the Sangu River

Name of the River	Sampling Stations	Description of the Locations	GPS Position	
			Latitude	Longitude
Sangu	UP (S_1)	Waiddhar Hat	22.142º N	91.841º E
River	MP (S_2)	Fakir Hat	22.136º N	91.843º E
	LP (S_3)	South Gahira	22.126º N	91.849º E

Materials used in the Field and Laboratory

In this study, several scientific instruments and chemicals were used to collect, preserve and process the samples. A list is given below:

1. Grab Sampler
2. Thermometer
3. Dissolve Oxygen (DO) Meter
4. Zipper Bag
5. Ross Bengal Powder
6. Sieve Plate and Niddle
7. 10% Buffer Formalin
8. Slide, Microscope and Motic Camera

Collection of Samples and Preservation

The benthic samples and sediments were collected from the bottom substrate of each sampling location during October to December 2018 by using an Ekman grab sampler having an opening mouth of 0.95 m^2 and water samples collected by 500 ml bottle. The bottles were pre-washed properly each time to remove any form of contaminants. The water samples were preserved temporarily until analysis.

Sample Placement, Analysis and Identification

The collected samples were placed to the laboratory. All coarse materials were sorted, counted, and identified. The specimens were identified based on the external morphology and categorized into various taxa following the available keys (Belaluzzaman, 1995). The selected physical and chemical parameters were also measured. The physical and some chemical parameters were measured on the spot and the rest were determined in the laboratory.

Data Analysis

Statistical data were analyzed by using MS Excel (version-13). Diversity and other indices were calculated by using different formulas:

Taxa Richness (R)

The taxa richness of any ecosystem was built on the numbers of taxa found in the area that does not reflect the relative dominance of species.

Shannon-wiener Index (H) (Shannon, 1948)

The collected data were combined to find the values of Shannon-wiener index that support to determine both number of species and the even distribution of individuals.

Species richness index (d) was calculated by using the following equations.

$H = - \Sigma [(P_i) * \ln (P_i)]$ ----------------------------(i)

Here,

$P_i = n/N$

n = Number of individuals of species i

N = Total number of individuals of all species

The Margalef's Index (D) (Margalef, 1958)

Species Richness **(D)** is the ratio between the total species (S) and the total numbers of individual (N). It was used to compare one community with another. The index is calculated using the following formula:

$D = \frac{S-1}{LnN}$ ---(ii)

Here,
S = Number of species in all samples
N = Total number of individuals in all samples

Evenness (E) (Buzas and Gibson, 1969)

Evenness of taxa was calculated by the following formula:

E = H/Ln(R) --(iii)

Here,

H = Shannon-Wiener index
R = Species richness

Simpson Index (D) (Simpson, 1949)

The Simpson Index ranges between 0 and 1, and the greater the value, the greater the sample diversity.

Simpson Index (D) = $\sum n(n-1)/N(N-1)$ ----(iv)

Here,

n = Individuals of one particular species

N = Total number of individuals of all species

RESULTS AND DISCUSSION

Distribution and Diversity of Macrobenthos

This study identified a total of 870 species under 11 major taxa from three different stations of the Sangu River. The overall percentage of Nemertina was higher than other benthic groups in the Sangu River (Table 2). Nemertina was the most dominant taxa that occupied 48.05% of the species followed by Oligochaete (22.07%), Polychaete (16.32%), Bivalvia shell (3.22%), Echinodermata (2.99%), Platyhelminthes (1.84%), Crustacean (1.38%), Cumacea (1.26%), Cyclopoida (0.92%) and Calanoida (0.57%). However, Polychaete was the most dominated taxa in the Meghna River estuary at Chairmanghat, Noakhali and the Bakkhali River estuary at Cox's Bazar (Sarker et al., 2016). The number of microbenthos organisms (15 species) recorded in the Sangu River by Prianka et al. (2020) was very low because of sampling differences since they used estuarine set bag net to collect the samples.

Table 2. Major Taxa of Macrobenthos in three Stations of the Sangu River

Benthos Groups	S_1	S_2	S_3	Mean	Total	%
Polychaete	11	14	117	47.83	142	16.32
Oligochaete	34	72	86	64	192	22.07
Nemertina	179	148	91	139.33	418	48.05
Amphipod	-	7	5	4	12	1.38
Bivalvia shell	13	4	11	9.33	28	3.22
Calanoida	1	-	4	1.67	5	0.57
Crustacean	4	2	6	4	12	1.38
Cumacea	1	10	-	3.67	11	1.26
Cyclopedia	2	3	3	2.67	8	0.92
Echinodermata	-	24	2	8.67	26	2.99
Platyhelminthes	3	8	5	5.33	16	1.84
Total	248	292	330	290.5	870	100

The Percentage and distributions of macrobenthos in each station of the Sangu River have been documented in Figure 2. In station S_1 and S_2, the percentage of Nemertina was 72 and 51 respectively. However, in station S_3, Polychaete was the most dominated taxa. In general, Nemertina, Oligochaete, Polychaete and Bivalvia shell were the most dominating groups at all the stations of the Sangu River.

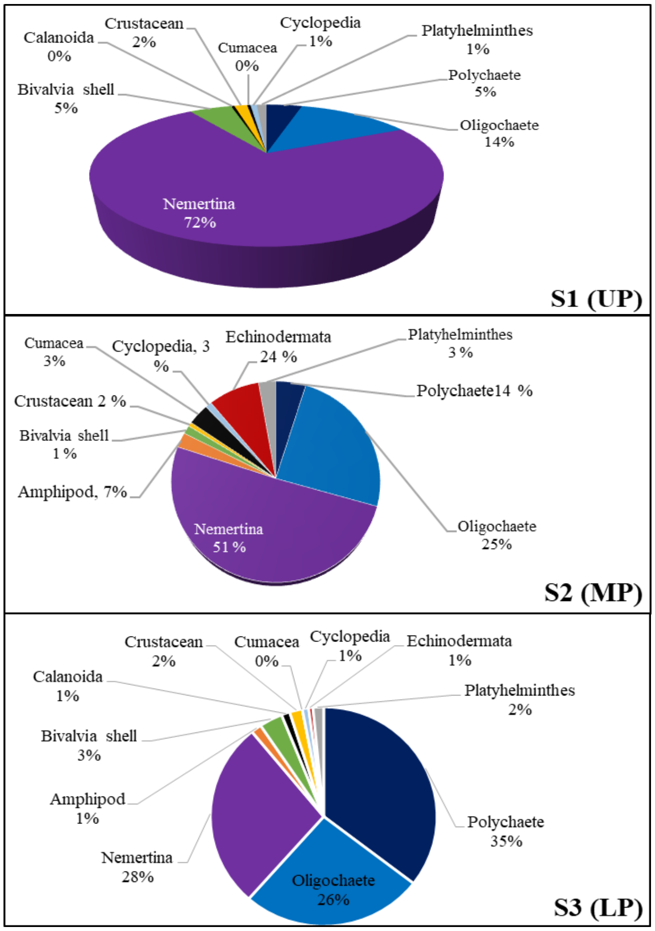


Figure 2. Distributions of Macrobenthos in three Stations (UP, MP, LP) of the Sangu River

Macrobenthic species distribution comparison among the three stations are presented in Figure 3.

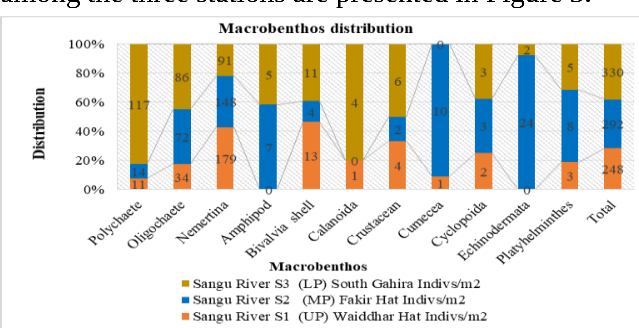


Figure 3. Comparison of Macrobenthic Species Distribution in three Stations of the Sangu River

Different diversity indices showed important differences in the studied area. Simpson values of the sampling stations were identified as the maximum in station **S_2** (0.65) and the lowest in station **S_3** (0.27) respectively. Shannon-wiener diversity index is used to present the difference in abundance and evenness of species community. Shannon diversity index was maximum at station **S_3** (1.51). In biological communities, Shannon-wiener diversity index varies from 0 to 5. If the values are less than 1, it characterizes heavily polluted condition of the aquatic environment. But the values in the range of 1 to 2 represented moderate pollution level while the values above 3 showed stable environment (Wilhm and Dorris, 1966). This study showed, the aquatic environment of the Sangu River was moderate to heavily polluted that are in line with Prianka et al. (2020). The average diversity values of Shannon index, Evenness, Simpson index and Margalef's index were 1.33, 0.59, 0.49 and 1.53. A comparative macrobenthic species diversity index of three stations of the Sangu River was given in Table 3.

Table 3. Macrobenthic Diversity Indices of three Stations of the Sangu River

Stations	S_1	S_2	S_3	Mean
Taxa_S	9	*10	*10	9.67
Individuals	248	292	*330	283
Simpson D	0.54	*0.65	0.27	0.49
Shannon_H	1.00	1.48	*1.51	1.33
Evenness	0.46	0.64	0.66	0.59
Margalef's	1.45	*1.59	1.55	1.53

*Indicates the highest value among the station.

Physico-chemical Parameters of Surface and Sub-surface Water

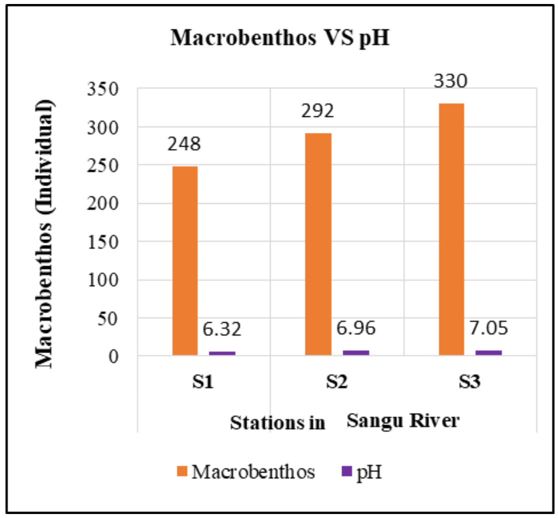
The physico-chemical parameters of the surface and sub-surface water of the studied area represented the occurrence, distribution, and diversity of macrobenthos in the Sangu River. The quality of an aquatic ecosystem is mainly dependent on the physico-chemical parameters and these parameters control the biological diversity of any organisms in the aquatic environment. The mean atmospheric and surface temperature, salinity and pH of Sangu River is shown in Table 4. Overall temperature in three stations of the Sangu River was 30.4ºC. No significant temperature difference was found among the three stations of this study though temperature variations could play an important role in macrobenthic organism's distributions (Ndome et al., 2012). Unanam and Akpan (2006) reported that the distribution of macrobenthos was correlated with the temperature. This study reported that higher temperature might influence the abundance of the macrobenthos of the Sangu River and it was found that at higher temperature the abundance of macrobenthos was minimum (Figure 4) that this study supports the findings of Unanam and Akpan (2007). Besides temperature variation, Self and Jumars (1978) reported that soil texture and salinity might also control the distributions of the microbenthic organisms in the coastal and estuarine region. Perkins (1976) also agreed and reported that benthic community structure mostly depends on the environmental factors sach us salinity, temperature, DO, organic matter, soil texture and size of sediment particles. Water qualities were also strongly correlated with the distribution and diversity of the macrobenthic communities.

Table 4. Physico-chemical Parameters of three Stations of the Sangu River

Site	Stations	Surface Tem. (ºC)	Atm. Tem. (ºC)	Salinity (ppt)	pH
Sangu River	S_1	30.8	32	0.38	6.32
	S_2	30.3	31.8	0.78	6.96
	S_3	30	31	8.44	7.05
	Mean	30.37	31.60	3.20	6.78

Variation in salinity plays a great role in the occurrence and distribution of macrobenthos (Pearson, 1975; Pearson and Rosenberg, 1978; Rosenberg, 2001; Ysebaert et al., 2003). This study showed that there was a variation in surface and subsurface water salinity in the sampling stations. Station S3 showed the highest amount of water salinity (8. 44 ppt) in this study which might influence the macrobenthos communities in water body. Kumar and Khan (2013) also reported that there was a significant positive correlation between the salinity and the benthic faunal diversity. Jones (1987) described that Polychaetes, Crustaceans and mollusks mostly interact with the salinity.

Surface water pH was slightly acidic and correlated with the macrobenthic abundance. This study showed that macrobenthic abundance was maximum at LP (S1) (about 330 individuals/m^2) where pH and salinity was maximum, and surface temperature was minimum (Figure 4).



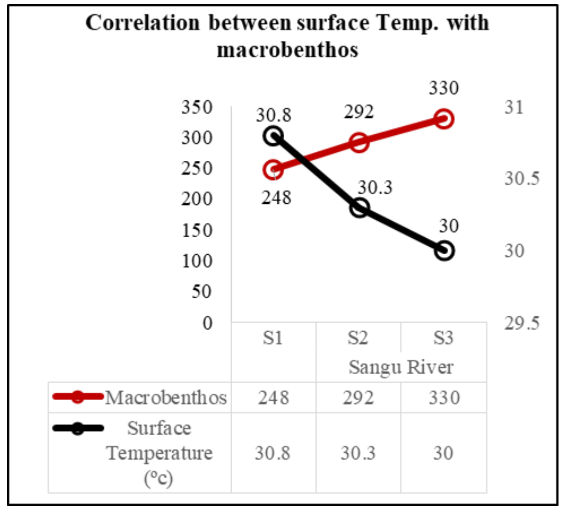


Figure 4. Macrobenthic Relationship with pH and Surface Temperature of the Sangu River

Physico-chemical Parameters of Bottom Soil

The concentration of DO was recorded at different depths of the bottom and the lowest concentration of DO was recorded at **LP** (4.90 mg/L) and the highest was at **UP** (5.08 mg/L) of the Sangu River (Table 5).

Table 5. Physico-chemical Parameters of Bottom Soil of three Stations of the Sangu River

Parameters	Stations		
	S_1 (UP)	S_2 (MP)	S_3 (LP)
Bottom Depth (m)	0.92	1.83	1.22
Bottom Temperature (ºC)	29	30	29.5
DO (mg/L)	5.08	4.97	4.90
Time (pm)	2.47	3.50	4.38
Soil Moisture (%)	51.85	34.04	8.33
Organic Carbon (OC) (%)	80.77	90.32	98.18
EC (µS/cm)	3490	2540	4090
Soil water pH	6.98	6.56	6.89
Salinity (‰)	12.6	5.96	10.7

The soil extruded water pH, moisture and salinity was recorded maximum at the **UP**. Organic carbon (OC) was maximum at **LP** and minimum at **UP**. The recorded OC was 98.18% at **LP** of Sangu River where the macrobenthic abundance was maximum (330 individuals/m^2). However, macrobenthic abundance was minimum (248 individuals/m^2) at UP of the Sangu River where the OC value was 80.77% which indicated that macrobenthos abundance was correlated with higher OC (r^2 = 0.99) (Figure 5).

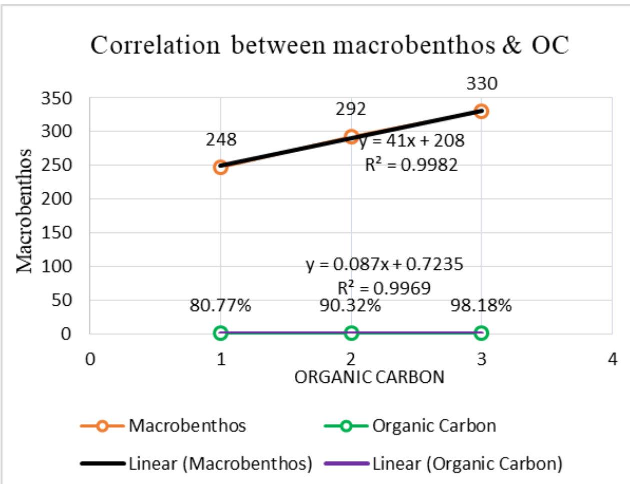


Figure 5. Correlation Between Macrobenthos and Organic Carbon (OC) in the Sangu River

Overall, this study showed that macrobenthos distribution and abundance were influenced by physico-chemical parameters of the water and benthic sediments of the Sangu River. However, aquatic pollution is a great concern for the macrobenthos assemblages in the river. Stakeholders and policy makers should take proper management strategies to conserve the macrobenthos organisms in the rivers. This study suggests monitoring the water quality of any aquatic ecosystem by using the macrobenthos structure as an indicator.

CONCLUSIONS

Environmental pollution is the major constraints for production of any aquatic area. Any organism can tolerate a certain level of environmental change. However, when there is an abrupt change of surrounding environmental conditions which is beyond the tolerance level, the living organisms are bound to migrate or decrease in that situation. In this study, a total of 11 major taxa including 870 macrobenthic species were identified where Nemertean, Polychaete, Oligochaeta and Crustacean were the dominated groups at all. Findings of this study reported that the physico-chemical parameters of water and benthic basin are mainly accountable for the variations of macrobenthic communities. Therefore, the present study might be a key upcoming framework to assess the pollution status and the macrobenthic circumstances in the Sangu River that is economically significant. Macrobenthic organism's abundance and distribution of the Sangu River gives an important indication about the health of the river. Based on the sensitivity level, proper management strategies such as reconstruction of the river should be taken to conserve the aquatic ecosystem of the river. This study suggests improving the existing methods of the biological assessment and develop new methods since there is ambiguity about the relationships between the macrobenthic diversity and particular environmental factors.

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