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Diversity, community structure and distribution of macrobenthos from a subtropical river, Bangladesh

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ABSTRACT

Macrobenthos are ecological indicators and also work as biological engineers in any aquatic ecosystem. The present study aims to assess the abundance and distribution of macrobenthos along the *Gomti* river, Bangladesh during the post-monsoon season. A total of 11 families of macrobenthos were identified during the study period and reporting to be 58400 ind./m^2 (mean 7300 ind./m^2) from the 8 sampling stations. The maximum abundance (15200 ind./m^2) was found at station 2 and the minimum (1300 ind./m^2) at station 3. The variations in the macrobenthos community were identified, and the species composition of the community showed that Oligochaeta was the dominant group (83.05%) followed by Insecta (10.27%), Gastropoda (2.57%), Gymnolaemata (2.23%), Polychaeta (1.54%) and Malacostraca (0.34%). The alpha diversity (taxa distribution) was the highest (α= 6) at station 4 and the lowest (α= 3) at stations 1 and 3. Moreover, the values of different diversity indices; Simpson diversity index (0.52-0.66), Shannon-Wiener index (0.85-1.25), Evenness index (0.71-0.99), Margalef Species Richness Index (0.2-0.51), and Equitability index (0.78-0.99) indicated an intermediate state of environmental stress and pollution. The information gathered here could be useful to measure the impact of pollution and to conserve these riverine habitats' biodiversity.

INTRODUCTION

Benthos is considered as indicator of past and present environmental conditions of an ecosystem, which is more effective than the physical and chemical index of waters and sediments. They are the best indicator of pollution due to their sedentary, sessile, and long-lived nature, and also easy to collect **(McLusky and Elliot, 2006)**. Benthic macrofauna in the aquatic ecosystem makes the dynamic sediment diversified, effectively transports solutes into burrows, increases sediment oxygen uptake, stimulates microflora and enhances disintegration rates **(Jones *et al.*, 1994)**. These characteristics denote that

the benthic species can act as ecosystem engineers **(Gogina and Zettler, 2010; Al-Asif *et al.*, 2020)**. These infaunal species dwell in the sediments and show relatively low mobility, being exposed to stress due to contaminants, low dissolved oxygen, limiting nutrient levels and physical disturbances **(Dauer *et al.*, 1992; Weisberg *et al.*, 1997; Cowie *et al.*, 2000)**. Benthic communities comprise species with different life cycles and specific tolerances to stress events, making them suitable to be classified into different functional groups that reflect the magnitude of disturbances **(Bilyard, 1987)**. They also perform a vital role in the chemical fluxes of the water/sediment interface **(Aller *et al.*, 2001)**, and are one of the main chambers of aquatic food webs, being useful indicators of impacts at higher levels of biological organization **(Bilyard, 1987; Alden *et al.*, 1997)**. The spatial distribution of individuals is affected by resource availability and habitat fragmentation that are created by natural factors such as dispersal, migration, dispersion, and human-caused factors **(Gilad, 2008)**. The environmental variables also showed some correlation with the benthic infaunal abundance and diversity **(Ullah *et al.*, 2020)**. Studies by **Ali *et al.* (2014)** and **Yunandar *et al.* (2020)** reported that understanding the pattern of species biodiversity distribution is significant and in current years it has attracted the attention of ecologists.

The *Gomti* river is one of the major rivers and an important spawning and feeding ground for riverine fish species of Bangladesh **(Bhuiyan and Khondker, 2018)**. Good number of researches on macrobenthos and hydrology of the rivers, estuaries, ponds and lakes from Bangladesh have been directed **(Matin *et al.*, 2018; Noman *et al.*, 2019; Abu Hena *et al.*, 2012; Lipi *et al.*, 2020; Mamun *et al.*, 2018**), but a few attempts have been recorded on macrobenthos diversity in the *Gomti* river. Henceforward, the present study was designed to know the abundance and distribution of macrobenthos and their relationship to water variables, and also to presume possible environmental stress or pollution status of the *Gomti* river.

MATERIALS AND METHODS

Study area

The study was conducted during the post-monsoon season (October-December 2019) at 8 stations of *Gomti* river at *Cumilla* district, Bangladesh situated at 23°28´12´´ N; 91°14´36´´ E and 23°38´7´´ N; 90°55´45´´ E (Figure 1).

Sampling, sorting and identification

Three replicate sediment samples were collected from each of the stations using mud corer with a mouth opening of 0.01m^2 and washed through a 0.5 mm mesh size sieve with water for separating the sediment and the debris. After that, samples were transferred to the laboratory for further analysis. A small amount of "Rose Bangle" was added for the sorting purpose within the 10% formalin solution in the plastic vials in the laboratory. Identification was made using an electronic microscope ((Model No. XSZ 21-

05DN, China) and following the works of **Pratt,** (**1935**); **Gosner,** (**1972**); **Sterrer,** (**1986**) **and Belaluzzaman,** (**1995**).

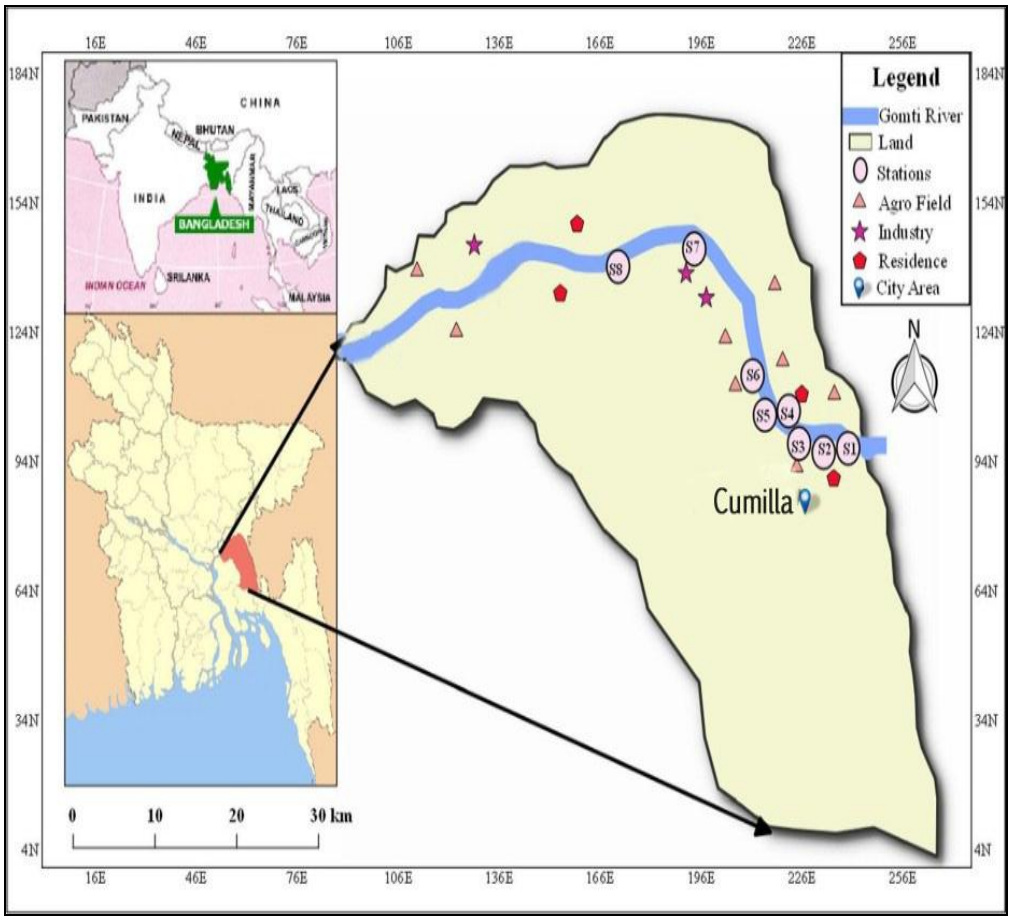

Figure 1. Location of the sampling area showing the stations (S1-S8) in *Gomti* river, Bangladesh

Measurement of water samples

Different physicochemical parameters of waters such as temperature, salinity, pH and dissolved oxygen (DO) were measured *in situ* from the stations using a centigrade thermometer (HANNA instrument Model no. HI-93510N), refractometer (Model no. HI-98319), digital pH (Model no. HI-98108) and DO meter (Model no. HI-98108), respectively.

Data analysis

The Simpson diversity index (D), Shannon-Wiener species richness index (*H´*), Margalef's richness index (J), and Pielou's evenness index (E) were obtained from the Shannon-Wiener index to determine the diversity of benthic fauna. Evenness has a relation to the absolute distribution of the relative abundance of species at a site. Alpha diversity was used to reveal the differences in the diversity of benthic infauna. Statistical

analysis was performed using SPSS (IBM, version 25), PAST (Paleontological statistics, version 3.26) software, and Microsoft Office Excel 2019. One-way ANOVA was brought into account to test the hypothesis of whether the means of two or more groups are equal.

RESULTS

Abundance and microbenthic community distribution

A total of 11 taxa (families) and 6 major groups of macrobenthos were recorded from eight sampling stations (Table 1 and Figure 2). The present study also generated a total number of 58400 ind./m^2 with the mean abundance of (7300±4611.79 ind./m^2) for all stations. The most abundant family was Naididae (18700 ind./m^2) followed by Tubificidae (16800 ind./m^2) and Enchytraeidae (11900 ind./m^2, Table 1). Among all 11 taxa, Tubificidae (28.77%) and Chironomidae (10.27%) were recorded at every station of the study area. Microchaetidae (0.17%), Nereididae (0.68%) and Capitallidae (0.86%) were only found at stations 4 and 7. Gecarcinucidae (0.34%), Lumbriculidae (1.71%) and Schizoporellidae (2.23%) were found in stations 1 and 4 only. The highest number of 6 taxa was found at station 4 and the lowest 3 taxa were recorded at stations 1 and 3.

Table 1. The abundance of macrobenthic families **(**ind./m^2**)** recorded from the study area at *Gomti* river, Bangladesh

		Station									
Major group	**Family**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Total**	**Mean**
	Naididae	0	7800	400	3300	2400	3000	1800	0	18700	2337.5
	Tubificidae	100	3600	300	1200	1300	4100	2400	3800	16800	2100
Oligochaeta	Enchytraeidae	0	2100	400	700	700	2500	2000	3500	11900	1487.5
	Lumbriculidae	0	100	0	900	0	0	0	0	1000	125
	Microchaetidae	0	0	0	100	0	0	0	0	100	12.5
Insecta	Chironomidae	600	1500	100	100	500	1700	400	1100	6000	750
Gastropod	Cypraeidae	500	100	100	100	400	100	100	100	1500	187.5
Gymnolaemata	Schizoporellidae	700	0	0	600	0	0	0	0	1300	162.5
Malacostraca	Gecarcinucidae	100	0	0	100	0	0	0	0	200	25
Polychaeta	Capitallidae	0	0	0	500	0	0	0	0	500	62.5
	Nereididae	0	0	0	0	0	0	400	0	400	50
	Total	2000	15200	1300	7600	5300	11400	7100	8500	58400	7300
	Family taxa	3	5	3	6	4	4	5	4		

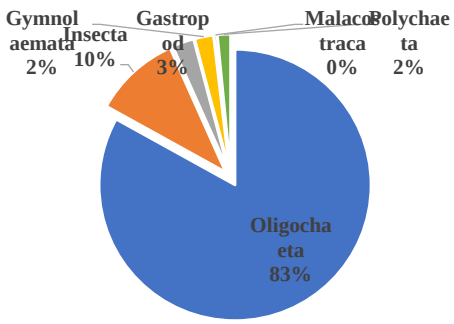

Figure 2. Macrobenthic community distributions recorded from the *Gomti* river

River water variables

The water temperature varied from 19.1°C to 22.8°C and showed a little fluctuation pattern among the sampling stations. The highest water temperature (22.8°C) was recorded at station S7 and the lowest temperature (19.1°C) was at station S1 (Table 2). The salinity data obtained from all the stations almost remained the same with a range of 0.4 to 0.5 psu . Water pH remained static throughout all the stations without major fluctuation and ranges from 8.36 to 8.88. The range of DO was 7.96 to 8.85 ppm with a maximum value (8.85) at station 3 and a minimum value (7.96) at stations 7 and 8 (Table 2).

Table 2. Values of different physico-chemical factors of water during the study period

	Station							
Parameter	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Temperature (°C)	19.1	19.8	20.7	21.7	21.7	21.7	22.8	20.8
pH	8.52	8.41	8.36	8.64	8.85	8.88	8.45	8.44
Salinity (psu)	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
DO (ppm)	8.7	8.51	8.85	8.51	8.6	8.63	7.96	7.96

Diversity indices

The Simpson diversity index value of macrobenthos ranges from 0.52 to 0.66. The highest value was observed at station 1 and the lowest was at station 3. The Shanon-Wiener (*H*') index value of benthic fauna in the present study ranges from 0.85 to 1.25. The maximum value was observed at station 4 and the minimum was at station 3. The Evenness index value of benthic fauna ranges from 0.71 to 0.99. The highest value was observed at station 1 and the lowest was at station 4 (Figure 3). The Margalef Species Richness Index of benthic fauna ranges from 0.27 to 0.51. The highest value was

observed at station 4 and the lowest was at station 4. The Equitability index (J) value of benthic fauna in the present study ranges from 0.78 to 0.99. The maximum value was observed at station 1 and the minimum was at station 4 (Figure 3).

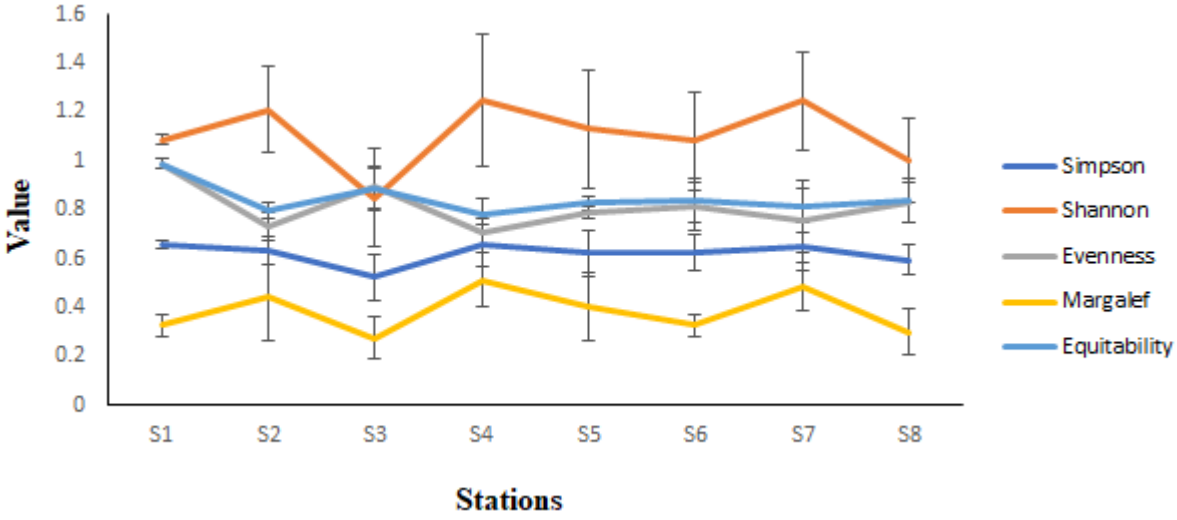

Figure 3. Diversity indices observed at different stations of *Gomti* river

Alpha diversity (α-diversity)

Alpha diversity showed clear differences in the diversity of benthic infauna of the present study, while data were presented as station-wise. The diversity was the highest at station 4 and the lowest at stations 1 and 3. The value of the diversity profile starts from α=0, the highest value of α was 6, and the lowest value of α was 3 (Figure 4).

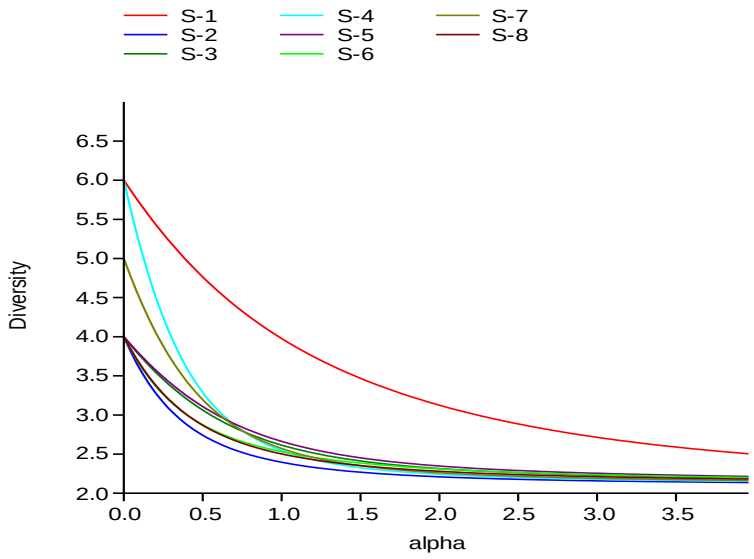

Figure 4. Alpha diversity of the studied macrobenthic community based on taxa distribution in *Gomti* river

Spearman's rank correlation analysis

The data of the present findings were not normally distributed. So, Spearman's rank correlation analysis (non-parametric statistics) was run to determine the nature of the relationships between the collected data. The analysis showed that the Simpson (D) and temperature were negatively significant ($p<0.05$). The Spearman's rank correlation analysis of physico-chemical and biological parameters (Table 3) also indicated that the temperature and salinity, temperature and taxa (S), temperature and Shannon H', pH and salinity, pH and individual, pH and evenness, DO and taxa (S) were intermediately correlated ($0.25\leq r<0.75$). The temperature and individual, temperature and Simpson (D), pH and DO, pH and taxa (S), DO and Simpson (D), salinity and Shannon (H'), salinity and Evenness, salinity and Margalef, salinity and Equitability (J), salinity and Simpson (D), salinity and individual, respectively were strongly correlated ($0.75\leq r<1$).

Table 3. Spearman's rank correlation analysis among water parameters and diversity indices

	Temp.	pH	Sal.	DO	(S)	Ind.	(D)	(H)	(E)	(M)	(J)
Temp.	1										
pH	0.488	1									
Sal.	-0.387	0.252	1								
DO	0.469	0.060	0.765	1							
(S)	0.284	0.241	0.064	-0.451	1						
Ind.	0.122	0.143	-0.126	-0.542	0.301	1					
(D)	-0.024	0.333	0.126	-0.120	0.771	0.071	1				
(H)	0.415	0.286	0	-0.494	0.988	0.262	0.714	1			
(E)	-0.512	-0.167	0	0.578	-0.807	-0.548	-0.286	-0.833	1		
(M)	0.537	0.357	0	-0.518	0.952	0.381	0.619	0.976	-0.905	1	
(J)	-0.512	-0.167	0	0.578	-0.807	-0.548	-0.286	-0.833	1	-0.905	1

S=Taxa, D=Simpson, H=Shannon, E=Evenness, M=Margalef, J=Equitability

DISCUSSION

This study shows the distribution and abundances of macrobenthos in soft sediments, including those concerned with environmental monitoring, are incompatible at a range of spatial scales. A total of 11 taxa (families) were identified during the present investigated periods, which is comparable with the findings elsewhere. Studies by **Matin *et al.* (2018)** recorded 17 taxa (families) of soft-bottom macrobenthos in a subtropical estuary, Bangladesh. **Ysebaert and Herman (2002)** observed the mean number of taxa per station varied within 6 and 19 in an estuarine, intertidal soft-sediment environment. **Basu *et al.* (2012)** also discovered about 10 taxa of macrobenthic organisms from their study areas elsewhere.

The present work addressed, macrobenthos abundance varied within 1300 ind./m^2 to 15200 ind./m^2, and which is more or less similar to other tropical and subtropical area's findings (Table 4). Studies by **Sharif *et al.* (2017)** recorded within the range of 1248.7 to 27180.0 ind./m^2 in the Meghna river estuary, which is higher compared to the present findings. **Ysebaert *et al.* (2003)** observed that in the Schelde estuary, NW Europe, total abundance varied within 0 and 225568 ind./m^2. Studies by **Hossain *et al.* (2009)**, observed the range of macrobenthos from 112 ind./m^2 to 9410 ind./m^2, while **Matin *et al.* (2018)** recorded a total number of 34726 ind./m^2 with a mean of (2480±781) from a subtropical estuary, Bangladesh. These values are comparable with the present findings at the *Gomti* river.

Table 4. A comparative study of present work with some other tropical and subtropical area's research findings

Area	Taxa (Families)	Abundance (ind./m^2)	References
Gomti river, Bangladesh	11	7300 (1300-15200)	**Present study**
Saltmarsh habitat, Noakhali Coast	16	15333.33 (23200-2600)	**Ullah *et al.* (2020)**
Naf river estuary, Bangladesh	47	1572-2972	**Noman *et al.* (2019)**
Feni river, Bangladesh	17	2480	**Matin *et al.* (2018)**
Mouri river Bangladesh	16	630-1040	**Khan *et al.* (2007)**
Tawi river, India	52 (sp.)	3044	**Chowdhary *et al.* (2013)**
Karnafuli estuary, Bangladesh	33 (sp.)	NA	**Islam *et al.* (2013)**
Meghna river, Bangladesh	17	27180-1248.7	**Sharif *et al.* (2017)**
Hatiya and Nijhum Dweep, Bangladesh	10	4433-511	**Asadujjaman *et al.* (2012)**
Amazonian saltmarshes	51	4344	**Braga *et al.* (2011)**
Yangtze river estuary, China	23	3,539	**Chen *et al.* (2009)**
Greater Noakhali-Bangladesh	14	5481	**Sarker *et al.* (2016)**
Bakkhali river estuary, Bangladesh	28	1555-4488	**Sarker *et al.*, (2016)**
Meghna estuarine bed, Bangladesh	20	112-9410	**Hossain *et al.* (2009)**
Meghna river, Bangladesh	8	44-3358	**Hossain *et al.* (2018)**

NA = Not available

The contribution of individual faunal groups (in percent) to the total macrobenthos was as follows Oligochaetes (83%), Insecta (10%), Gastropods (3%), Polychaetes (2%) and Gymnolaemates (2%), which is more or less similarity with the findings of **Hossain *et al.* (2009); Ansari *et al.* (1986); Harakantra and Parulekar (1986); Jegadeesan and Ayyakkanun (1992)** and **Kumar (1997)**. It was noticed from the present work that tubificidae was the most common and found in almost every station. **Azrina *et al.* (2006)** also observed tubificidae consistently at every downstream station in Langat river, Peninsular Malaysia during their study period.

The abundance and distribution of macrobenthos are closely related to the bottom sediment's physico-chemical variables **(Sharif *et al.*, 2017).** Benthic community structure also depends on various environmental factors such as salinity, temperature, DO, depth, organic matter, soil texture and size of the sediment **(Perkin, 1976)**. In the present study, the maximum water temperature was observed 22.8°C at station 7 and the minimum was 19.1°C at station 1. **Sharma and Saini (2016)** observed the water temperature of the river Basantar from 19.17ºC to 25.8ºC. **Allen (1951)** established a positive correlation between temperature and abundance of the benthic communities. This is inconsistent with the present findings. The recorded pH value in the present study was ranging from 8.36 to 8.88, indicating that the study stations were slightly alkaline. **Sharma *et al.* (2013)** also observed pH values ranging from 7.61 to 9.3 in Kunda river, India. **Sarang and Sharma (2009)** researched macrobenthic fauna as a bioindicator of water quality in Kishore Sagar lake, Kota (Rajasthan), India, where they observed the water was alkaline and found to be associated with a greater number of species, which is in agreement with the present findings. **Patil and Panda (1986)** recorded DO ranges from 0 to 3 mg/L in an originally polluted system in Peddacheru, which is much less than the present finding (7.6 to 8.9 mg/L).

The Shannon-Wiener index is considered as a subtle indicator of pollution. The Shannon-Wiener diversity index in the present study was recorded from 0.85 to 1.25, and these values were comparable with the findings of **Chowdhary *et al.* (2013)** and **Basu *et al.* (2018)** in sub-tropical rivers. Studies by **Sharif *et al.* (2017)** made a similar observation in their work on the Meghna river estuary. They found maximum evenness value was at the estuarine area of Sandwip (0.95) whereas, the minimum value was at the river waters of Barisal (0.20). The recorded Margalef Species Richness Index (0.27 to 0.51) in the present study was within the range as observed by **Basu *et al.* (2018)** and **Matin *et al.*, (2018)** elsewhere.

CONCLUSION

The present study was an effort to provide a comprehensive idea about macrobenthos abundance and its relationship with the water variables of the *Gomti* river. Current findings reported that macrobenthos diversity and abundance fluctuated frequently within the stations observed. The maximum abundance of macrobenthos in certain stations could be due to the higher content of organic matter with the presence of suitable natural foods, while a lower abundance of it could be due to man-made disturbances like dam constructions with sandy soil substrates. This revealed that anthropogenic impacts are destructive to benthic community structures which might imbalance the river ecosystems.

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