Understanding hydro-ecological factors influencing abiotic-biotic interactions in the Meghna River basin, Bangladesh: Pathways to sustainable management

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Abstract
The Meghna River, a vital lifeline for Bangladesh, sustains ecosystems and livelihoods, facing increasing threats from a variety of natural and anthropogenic activities including rapid urbanization, advance agricultural production, industrialization, development of flood control devices, over exploitation, pollution, habitat degradation, and climate change. Thus, to achieve this aim, complete understanding of the River dynamics is an essential requirement for sustainable management. This paper examines the spatio-temporal distribution in the Meghna River Basin, particularly hydro-physico-chemical characteristics and bio resources. These included water color, depth, temperature, ph, dissolved oxygen, carbon dioxide levels, alkalinity, hardness, transparency, salinity, turbidity and TDS, conductivity. Two other groups of bio resources phytoplankton, zooplankton and bottom dwellers (benthic macro invertebrates) were also considered. Field surveys, laboratory analysis and satellite images were used for collection of data in relation to site selection. The analysis of this research work indicated that all the hydro-physico-chemical attributes and bio resources of the study area had spatial temporal coherency at congenial level. Furthermore, relations between these variables and their effect on the ecosystem were established and no anomally was found. The findings emphasize the critical state of the ecosystem amidst anthropogenic stressors and climate change, underscoring the need for effective conservation strategies to maintain the ecological balance and livelihood support of this vital river system. The presented data serves as a valuable resource for policymakers and conservationists aiming to protect and sustainably manage the river basin.

Keywords: Meghna River Basin, Spatio-Temporal, Hydro-Physico-Chemical, Sustainable management

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Introduction

The Meghna River – the river that flows practically from the center of Bangladesh – is not solely a river which contains water. It is a lifeline and a life support system, which feeds the land, sustains millions of people's livelihoods, and hosts a complex system of biotic communities. Here in that region where the sedimentary waters of the river expand the green ambience of the country side, begins a lively drama. Meghna River is one of the east Himalayan Rivers and a major river of the GBM, the largest deltaic system in the world. In the course of its meandering course through Bangladesh the Meghna both sculpts the terrain, creating wide, alluvial fertile plains, and sustains a biome diverse from its delta to its uplands. This case its waters are critical in irrigating farmlands, transporting goods, and supply food to millions of its inhabitants depending on its resources foods sources (Sultana *et al*., 2023).

However, this all-important ecosystem is faced with several key challenges. It is in danger through pollution, deterioration of its environment, climatic change, and natural human interference. This paper therefore seeks a better understanding of the Meghna River Basin's dynamics to inform effective conservation and management strategies. Studying the Meghna River Basin entails deciphering a puzzle of spatio–temporal distribution in the basin. The hydro-physico-chemical characteristics and bio resources create a complex picture of this ecosystem mosaic. These patterns offer fundamental insights into the state of health of the basin and help us to guide management into the future of the basin in a sustainable manner. The hydro-physico-chemical characteristics of the Meghna River has also been presented below: They explain the current state of the river, the ways the river changed in response to stressors and the levels of its.

The study has given insight into the following- Recognizing such attributes helps to evaluate the river's state and make some estimations about its further development (Miah *et al*., 2021). Clear water temperature, turbidity, dissolved oxygen, phosphate content, total dissolved salts, the level of alkalinity, carbon dioxide concentration, and even salinity all fall under consideration. These factors affect the aquatic life of the river in addition to indicating the general environment (Rabbani *et al*., 2018). The bio resources of the Meghna River Basin includes both microscopic phytoplankton, fish species and benthic macro- invertebrates. These are not just the dwellers of the smaller opening in the river but shareholders of this complex environment. The water of the river favors growth of the phytoplankton which are the foundation of the aquatic food chain. Their abundance, composition and distribution give insight on the general state of health of the ecosystem. Similarly, all tissues are involved in maintaining the balance of an ecosystem, including zooplankton, rotifers, copepods, cladocerans and

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other aquatic organisms. Diverse and ignored but occupy a significant ecological position in the ecosystem, benthic macro-invertebrates inhabit silt at the river bottom. Given population density and species richness, their presence and abundance can reflect the conditions for the riverbed and indicated the general state of the environment (Sarker *et al*., 2020).

Literature on the causal effect of spatio-temporal distribution of abiotic-biotic factors on hydro-ecological attributes in the Meghna River basin is quite limited. A study was done on hydro morphological changes of Meghna estuary of Bangladesh by Bangladesh Water Development Board, ministry of water resources (MoWR, 2001). This article sets out on an explorative mission to demystify the Meghna River Basin, to study its spatial and temporal characteristics, its hydro-physico-chemical characteristics, and bio resources. It will thus become much easier for us to lead the charge and make the future a reality where the Meghna River remains pristine and a source of livelihood and hope. Analysis of all those parameters in the Meghna River Basin is not simply an academic exercise as such. This is a search for knowledge that has significant implications in the development of the future for the region. This research will provide understanding of how the management practices should continue in order to support the conservation and utilization of the current resources.

Methodology

Data collection procedure

Primary data practiced for this study were satellite data for sampling site selection, GPS based field survey, hydro-physico-chemical attributes, plankton and macro-benthic community. Secondary data includes different thematic information and other applicable printed information.

Satellite data for sampling site selection

Sampling sites were selected through analysing a real-time live earth observatory of Google Earth Engine, 2021. Twenty sampling stations with three sub-stations were selected along the Meghna River basin starting from near Brahmanbaria to Shahbazpur channel following the main river course, downwards to the Meghna estuary including Hatiya and Monpura Island (Table 1, Fig. 1). The distance between sampling sites was approx. 20km and the distance between 3 consecutive sub-stations was approx. 1km covering total 3 km area in each sampling sites to picturize the whole Meghna River basin from upper to lower Meghna.

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Table 1: List of sampling stations.

No of Stations	Location Name	District
S1	Singapore Jame Mosque (Sub-station 1, 2 & 3)	
S2	Ashuganj Ferry Terminal (Sub-station 1, 2 & 3)	Brahmanbaria
S3	Sahabnagor Bazar (Sub-station 1, 2 & 3)	
S4	Nazarpur Natural Park (Sub-station 1, 2 & 3)	Narsingdi
S5	Tidirchar (Sub-station 1, 2 & 3)	Comilla
S6	Gazaria (Sub-station 1, 2 & 3)	Munshiganj
S7	Ekhlashpur Launch Terminal (Sub-station 1, 2 & 3)	
S8	Horina Ferry Terminal (Sub-station 1, 2 & 3)	Chandpur
S9	Altaf Master Launch Ghat (Sub-station 1, 2 & 3)	Laksmipur
S10	Motirhaat Machh Bazar (Sub-station 1, 2 & 3)	
S11	Alexander New Launch Terminal (Sub-station 1, 2 & 3)	Noakhali
S12	Ruhulamin Market Masque (Sub-station 1, 2 & 3)	
S13	Sukh Char (Sub-station 1, 2 & 3)	
S14	Sonadia(Sub-station 1, 2 & 3)	
S15	Daulatkhan Launch Terminal (Sub-station 1, 2 & 3)	
S16	Tajumuddin Launch Terminal (Sub-station 1, 2 & 3)	
S17	Char Annadaprasad (Sub-station 1, 2 & 3)	Bhola
S18	Char Kukri Mukri (Sub-station 1, 2 & 3)	
S19	Monpura Launch Terminal (Sub-station 1, 2 & 3)	
S20	Monpura Bangla Bazar (Sub-station 1, 2 & 3)	

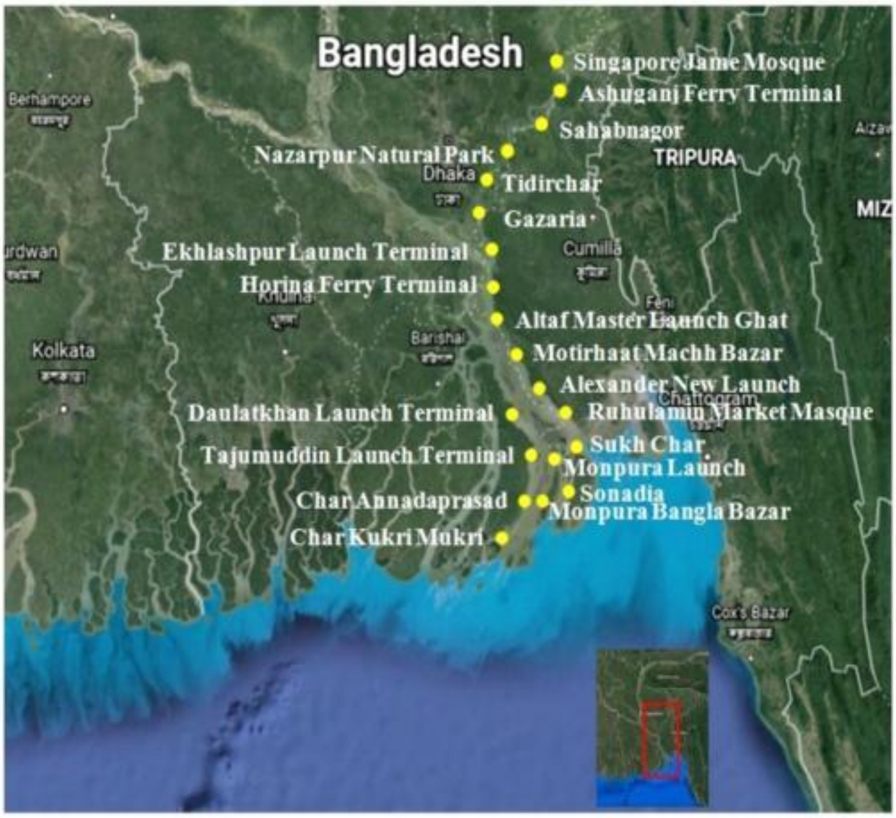

Figure 1: Location of Sampling Station.

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Analysis of hydro-physico-chemical attributes

Primary data regarding hydro-physico-chemical properties came from field experiments conducted on-site, followed by laboratory analysis. Temperature, electrical conductivity, salinity, pH, transparency, dissolved oxygen, TDS, and turbidity were measured on-site to evaluate the hydro-physico-chemical characteristics; following this, analyses of free carbon dioxide, hardness, alkalinity, and ammonia were conducted in a laboratory (Water Quality laboratory, Bangladesh Fisheries Research Institute, Riverine Station, Chandpur).*Collection of samples*

Every sampling station yielded about three subsamples of water. Using a 500 ml bottle and a previously cleaned plastic tub, we only sampled the surface water.

Preservation of sample

Collected water sample were preserved (Table 2) for laboratory analysis by the following methods:

Analysis of physico-chemical properties of water

The EC300A conductivity meter was used to measure the temperature, salinity, electrical conductivity, and total dissolved solids (TDS) in the water. The pH meter (EcoSense® pH100, YSI Inc.) was used to measure the pH of water. The Transparency of the water was determined with the use of Secchi Disk visibility. The Turbidity Meter (Portable) (Turb® 430 T WTW Germany) was used to test the turbidity of the water. As recommended by Sarker *et al.,* (2020), the total alkalinity of the sample water was ascertained using the titration method with 0.02 N H_2SO_4. NH4-N was determined by following Sultana *et al.,* (2023) using a spectrophotometer (Digital UV Spectrophotometer, Labtronocs). According to Sarker's (2020), the complexometric titration method was used to determine the hardness of the sample water using ethylene diamine tetra acetic acid (EDTA). The water's dissolved oxygen content was measured using a DO meter (EcoSense® DO200, YSI Inc.).The titration method was used to measure free carbon dioxide. 0.045N Na_2CO_3 was used to titrate in accordance with APHA (1976), for the titrimetric determination of free carbon dioxide in water.

Table 2: Use of preservatives in chemical analysis of water.

Parameter	Preservative	Permissible Time
Carbon-di oxide	Cooling at <4°C	24 hrs
Alkalinity	Cooling at 4°C	24 hrs
Hardness	1 ml Conc. HNO3 L^{-1}	7 days
Ammonia	1 ml Conc. H_2SO_4 L^{-1}	7 days

Source: Sarker *et al.,* 2020

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Collection and identification of plankton

Plankton was collected from every sampling station by sieving 50 liters of habitat water from about 10 to 12 cm below the surface, passing it through a 25 µm mesh net, and then condensing it to 25 mL. After the plankton population accumulated in the container, it was moved to another bottle, preserved in 4% formalin right away, labeled, and brought to laboratory for additional testing. Before each sample was examined under a microscope, it was gently agitated. Using a wide mouth graduated pipette, one milliliter of the agitated sample was transferred to a Sedgewick Rafter counting cell. By counting the number of plankton per focus of the tiny field, the abundance of the organism was assessed.

The total number of plankton per litre of water were estimated by the following formula: N=((A*C)/L), where, A=Average number of plankton counted per mL concentrated sample, C=Volume of concentrated sample in ml, L=Volume of original water in litre passed through the plankton net, N=Total number of plankton/L of original water.

Collection and identification of macro-benthic community

The macro-benthos were collected from all sampling stations using the Ekman (15.2-by-15.2-cm cutting edge; 5.5 kg). The samples were processed as outlined in APHA (1976) standard procedures after being passed through a 0.595 mm sieve. With the exception of worms, which were classified by family, all organisms were recognized by genus or species.

Thematic information

From Bangladesh Fisheries Research Institute, Department of Fisheries, Asiatic Society of Bangladesh, Bangladesh Water Development Board, Meteorological Department, different types of thematic information, historical maps and secondary data on the study were collected.

Results and discussion

The study was designed for characterizing and spatio-temporal modelling of causal influences on niche resources using deterministic stressor modelling. For this study different primary and secondary data (hydro-physico-chemical attributes, riverbed attributes, data about bio-resources etc.) were collected and analyzed.

a) Spatial distribution and fluctuation of hydro-physico-chemical attributes with bio resources

Spatial fluctuation of hydro-physico-chemical attributes *viz*. water colour (light greenish to blackish), depth (min. 5.65 m at Nazarpur and 60 m at Daulatkhan) water temperature (min., 18˚C at Nazarpur & max., 32.87˚C at Char kukrimukri), pH (min. 7.20 at Nazarpur and max., 8.5 at Ashuganj), Dissolved Oxygen (min., 5.67 mg/L at Char Alexander & Tajumuddin ; max., 9.35 mg/L at Gazaria), free Carbon dioxide (min., 6.27 mg/L at Ekhlaspur; max., 19.67 mg/L at Gazaria), alkalinity (min., 43 mg/L at Singapore Mosque & max., 124 mg/L at Char kukrimukri), hardness (min., 58 mg/L at Shahebnagar & max., 257 mg/L at Char Annadaprasad), transparency (min., 35 cm at Tajumuddin & max. 113 cm at Singapore Mosque), salinity (min 0 ppt from Singapore Mosque to Altaf Master Mach Ghat and highest 9.92 ppt at Sonadia), Turbidity (min., 1.89 FNU at Shahebnagar & max., 84.67 FNU at Motirhat), TDS (min., 62.33 ppm at Singapore Mosque and Nazarpur & max., 6698.33 ppm at Char kukrimukri), Conductivity (min., 144.33 µS/cm at Singapore Mosque & max., 9826.67 µS/s at Char kukrimukri) of sampling sites were monitored (Table 3, Figs. 2 and 3). All the hydro-physico-chemical parameters were found congenial in range, although free Carbon dioxide near Horina (18.02 mg/L), transparency near Singapore Mosque (111 cm), Turbidity near Char Alexander (104 FNU) was found slightly high. Ammonia was reported in Gazaria (0.35 mg/L) and Ashuganj (0.25 mg/L) only. Most of the attributes of all the stations differed statistically (Fig. 7). Air temperature was positively associated with water temperature, DO, CO2, NH3 and plankton composition (Fig. 8).

Table 3: Summary of observed data.

	Wid (m)	Dep (m)	Sal (ppt)	AT (°c)	WT (°c)	pH	DO (mg/L)	CO_2 (mg/L)	Alk (mg/L)	Har (mg/L)	Tra (cm)	Tur (NTU)	Con (µs/cm)	TDS (ppm)	NH_3 (mg/L)
AVG	6.63	29.19	2.21	27.91	25.88	8.07	7.22	13.11	83.51	146.98	64.91	22.07	2417.58	1356.65	0.04
RANGE	31.73	54.33	9.92	12.87	13.67	1.30	3.69	13.40	80.33	199.67	78.00	82.78	9682.33	6636.00	0.42
SEM (±)	1.91	3.74	0.68	0.92	0.91	0.07	0.30	0.94	5.38	14.95	4.47	4.97	713.88	411.12	0.03
CV (%)	1.29	0.57	1.38	0.15	0.16	0.04	0.18	0.32	0.29	0.45	0.31	1.01	1.32	1.36	3.09
PE (±)	1.29	2.52	0.46	0.62	0.61	0.05	0.20	0.63	3.63	10.08	3.02	3.35	481.51	277.30	0.02
MaxE (±)	25.60	50.15	9.18	12.41	12.19	0.96	3.98	12.59	72.23	200.52	60.00	66.65	9577.75	5515.81	0.36
Precision	0.19	0.09	0.21	0.02	0.02	0.01	0.03	0.05	0.04	0.07	0.05	0.15	0.20	0.20	0.47

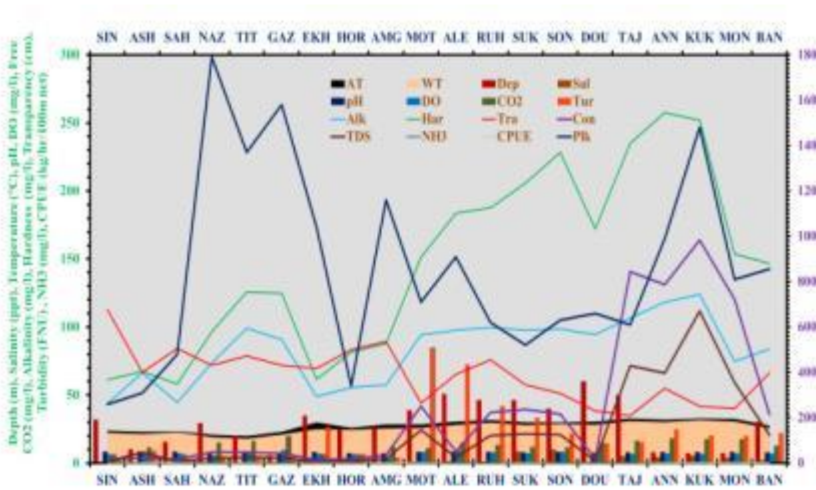

Figure 2: Spatial distribution and fluctuation of hydro-physico-chemical attributes along with bio resources.

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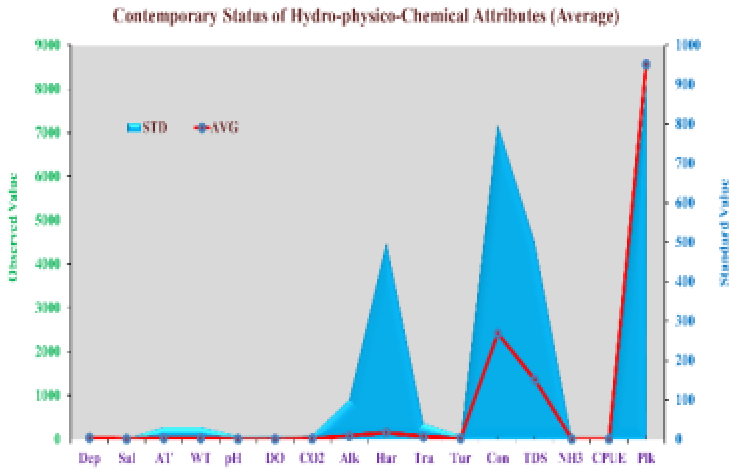
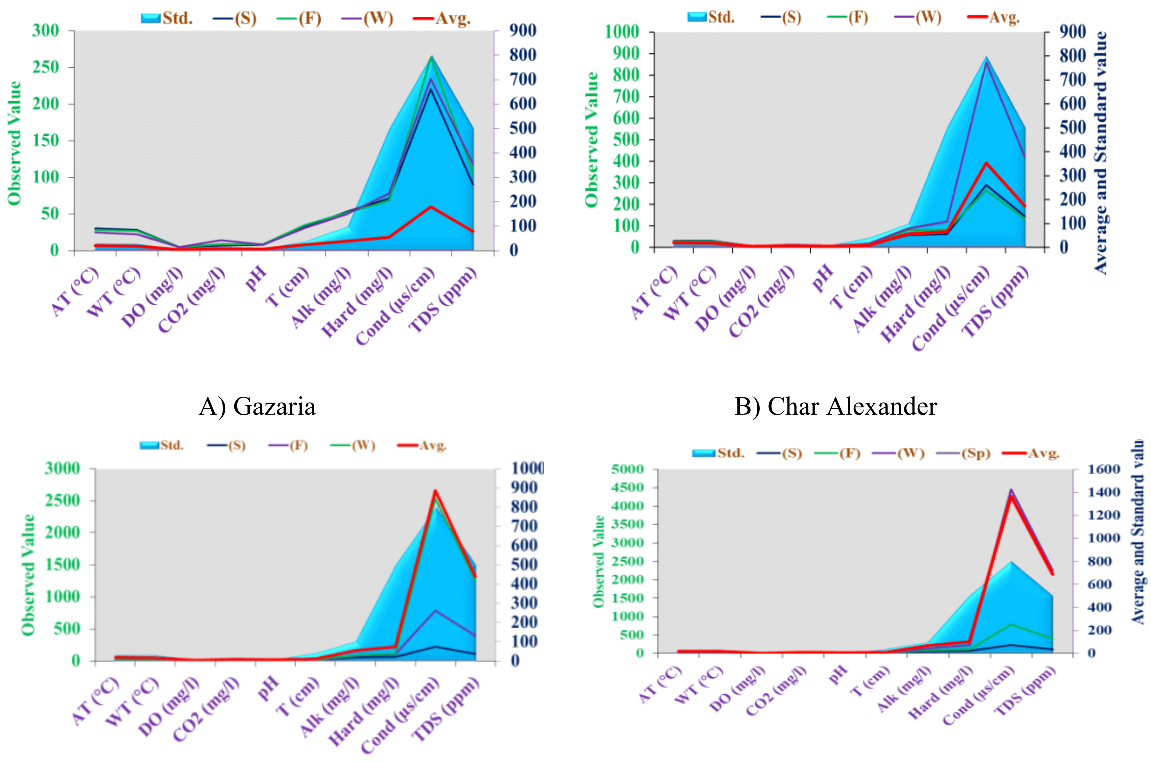


Figure 3: Contemporary distribution of hydro-physico-chemical attributes along with bio resources (in situ).



A) Gazaria

B) Char Alexander

C) Daulatkhan

D) Char Annadaprasad

Figure 4: Temporal (in situ) distribution and fluctuation of hydro-physico-chemical attributes (a-d)

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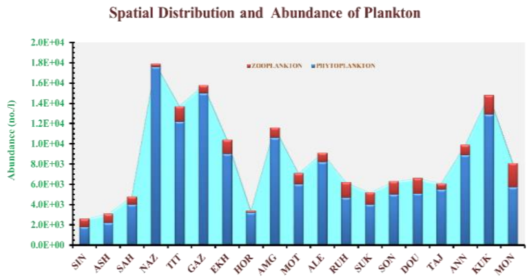
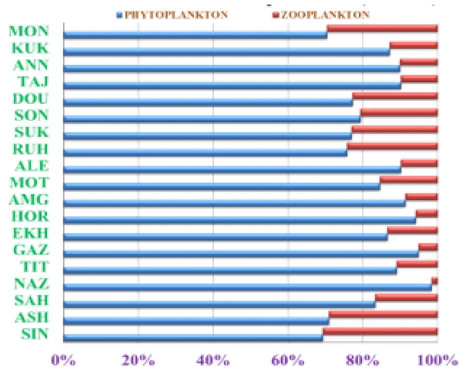
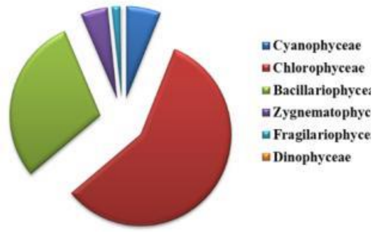


a) Spatial distribution and abundance of Plankton

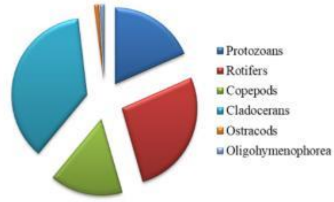


b) Relative abundance of Plankton

c) Total plankton, composition

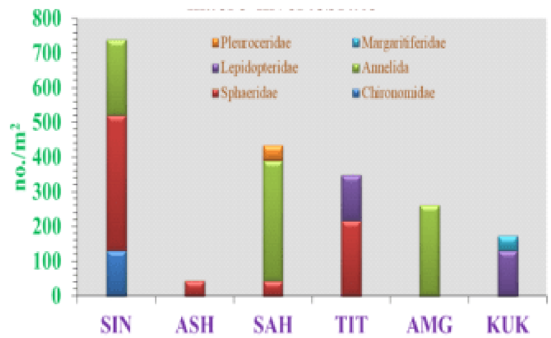


d) Phytoplankton composition

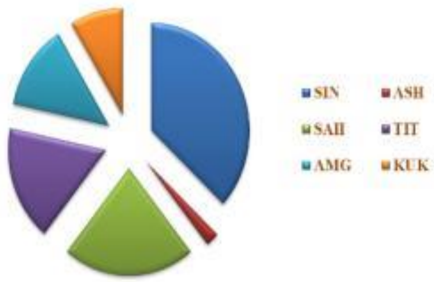


e) Zooplankton composition

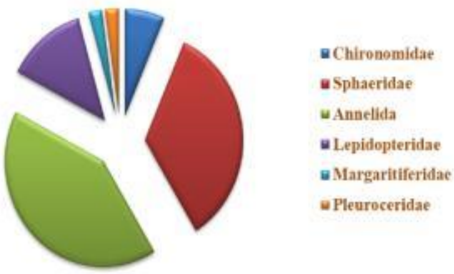
Figure 5: Availability and composition of plankton (a-e).



a) Spatial distribution and abundance of benthic macro-invertebrates



b) In situ composition of benthic macro-invertebrates



c) benthic macro-invertebrates composition

Figure 6: Availability and composition of benthic macro-invertebrates (a-c).

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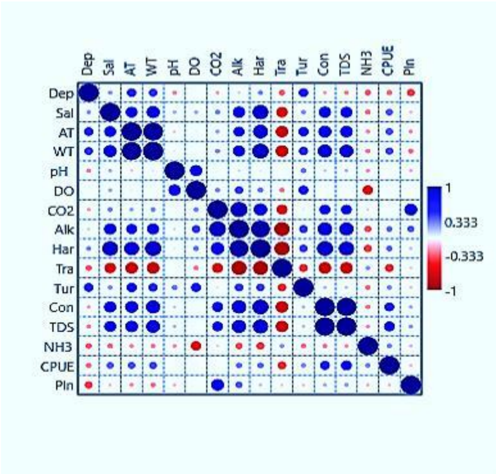

Figure 7: Degree of Association Plot.

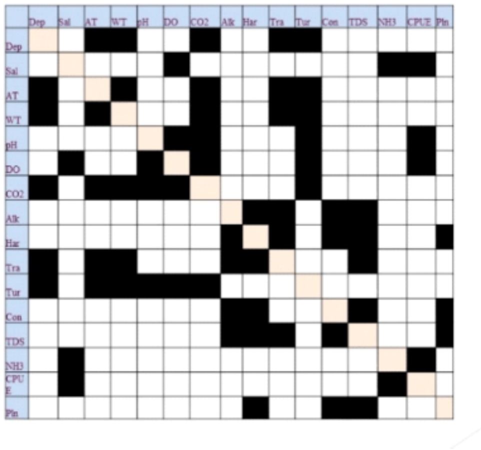

Figure 8: Post Hoc. Checker board.

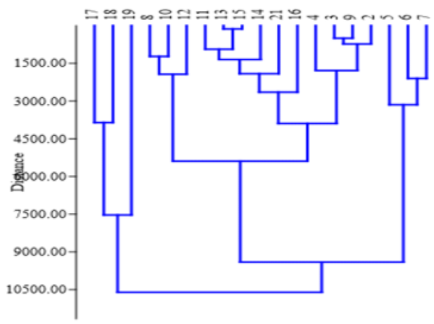

Figure 9: Spatial Clustering (In situ).

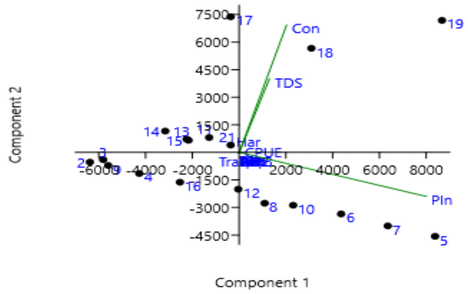

Figure 10: PCA (In situ).

Among the three clusters, S2-S4, S8-S16 and S20 formed the biggest cluster with maximum similarity (Fig. 9). Among 16 diver factors Plankton and CPUE were found as a major driver factor; TDS and conductivity were found as a second driver factor (Fig. 10).

At every test station, the pH of the Meghna River's water was found to be between 7.0 and 8.0, neutral to alkaline (Ahmed *et al*., 2005). Total alkalinity was found to range from 48 to 98 mgL^{-1}, with mean values of 74.61±11.37 mgL^{-1}, according to Hasan *et al.* (2015). The concentrations of dissolved oxygen (DO) varied greatly, with mean values of 7.24±1.03 mgL^{-1} and a range of 5.91 to 9.50 mgL^{-1}. 2015 reported by Hasan *et al.* (2015).

b) Temporal distribution and fluctuation of hydro-physico-chemical attributes with bio resources

Temporal fluctuation of hydro-physico-chemical attributes *viz*. water colour (light greenish to blackish) water temperature (18-31.67˚C, Avg. 25.88˚C), pH (7.2-8.5, Avg. 8.07), Dissolved Oxygen (5.67-9.35 mg/L, Avg. 7.22 mg/L), free Carbon dioxide (6.27-19.67 mg/L, Avg. 13.11 mg/L), alkalinity (43.67-124 mg/L, Avg. 64.91 mg/L), hardness (58-257.67 mg/L, Avg.

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146.98 mg/L), transparency (35-113 cm, Avg. 60.46 cm), salinity (0-9.92 ppt, Avg. 0.80 ppt), Turbidity (1.89-84.87 FNU, Avg. 22.07 FNU), TDS (62.33-6698.33 ppm, Avg. 1356.65 ppm), Conductivity (144.33-9826.67 µS/cm, Avg. 2417.58 µS/s) and ammonia (0-0.42 mg/L, Avg. 0.04 mg/L) of sampling sites were monitored (Fig. 4A-D). All the physico-chemical parameters were found amiable in range, even though free Carbon dioxide, transparency and turbidity were found high to some extent throughout the winter season (Table 3). Ammonia was reported in only Gazaria and Ashuganj during the winter season. Most of the attributes of all the stations differed statistically (Fig. 7).

Hasan *et al.* (2015) found that variations in air temperature were reflected in the water's temperature. According to Ahmed *et al.* (2005), the Meghna River's surface water temperature ranged from 24.1 to 30.5ºC, with a mean of 27.6±0.68. The Hooghly-Bhagirathi River system's ideal water temperature was estimated by Bhaumik *et al.* (2011) to range from 29.3–30.2ºC for breeding activities and 29.8–30.8ºC for hilsa nursery activities. They also estimated the threshold values of physico-chemical parameters for hilsa migration, breeding, and rearing. Ahmed *et al.* (2005) reported that TDS had a mean of 0.20±0.05 and varied between 0.12 and 0.32 mgL^{-1}. The Meghna River system had the highest conductivity value (220 mS/cm), according to Ahmed *et al.* (2005).

According to Hossain *et al.* (2014), rainfall and water temperature were also discovered to be significant influencing factors for species distribution.

Table 4: List of available phytoplankton.

Group	Genus	No.
Cyanophyceae	*Spirulina, Scenedesmus, Microcystis, Polycystis, Anabaena, Nostoc, Oscillatoria, Coelosphaerium, Phormidium, Rivularia*	10
Chlorophyceae	*Pediastrum, Closterium, Ankistrodesmus, Eudorina, Crucigena, Chlamydomonas, Ceratium, Acanthocystis, Gonatozygon, Microspora, Genecularia, Pleodarina, Spirogyra, Volvox, Mougeotia, Zygnema, Oedogonium, Tetraspora, Penium, Coelastrum, Docidium, Tetrapedia*	22
Bacillariophyceae	*Naviculla, Melosira, Amphora, Tabellaria, Frustulia, Coscinodesmus, Cyclotella, Ditoma, Fragilaria, Nitzchia, Polycistis, Stphanodesmus, Gomphonema, Anomoeoneis, Asterionella, Campylodiscus, Gyrosigma, Stephanodiscus*	18
Zygnematophyceae	*Euastrum, Staurastrum, Netrium, Spirotenia, Cosmarium*	5
Ulvophycea	*Ulothix*	1
Fragilariophyceae	*Synedra*	1
Trebouxiophycae	*Botryococcus, Protococcus*	2
Dinophyceae	*Ceratium*	1

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Table 5: List of available zooplankton.

Group	Genus	No.
Protozoans	*Euglena, Phacus, Volvox, Difflugia, Colpoda, Euglepha, Spirostomum*	7
Rotifers	*Brachionus Sp., Trichocera, Polyarthra, Asplancha, Keratella, Filinia, Rotaria, Lindia, Mytilina, Eubranchiopus, Trichocera*	12
Copepods	*Nauplius, Diaptomus, Cyclops, Mesocyclops, Limnocalanus*	5
Cladocerans	*Daphnia, Diaphnosoma, Sida, Leptodora, Eubranchipus*	5
Diaphanosoma	*Chydorus, Bosmina, Moina, Ceriodaphnia*	4
Ostracods	*Cypridopsis*	1
Oligohymenophorea	*Paramecium*	1

According to Maes *et al.* (2004), one of the key elements influencing fish distribution and abundance is dissolved oxygen.

c) Spatial distribution and variation of bio resources

A total of eight groups and 65 kinds of species of phytoplankton and 7 groups of zooplankton were abundant in the Meghna River basin (Tables 4 and 5). Abundance of plankton was highest in Nazarpur and lowest in Char Kukrimukri (Fig. 4a). Relative abundance of zooplankton was about 4 times lower than phytoplankton (Fig. 4b-c). Among all phytoplankton groups, chlorophycea was the most abundant and dinophycae was the lowest abundant group (Fig. 4d). Among all seven zooplankton groups (35 species), cladocera was the most abundant and oligohymenophycae was the lowest abundant group (Fig. 4e). Hasan *et al.* (2015) categorized six families of phytoplankton, which include Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae, and Xanthophyceae, encompassing a total of 58 genera. Additionally, they identified various groups of zooplankton, specifically Copepoda, Cladocera, and Rotifera.

The abundance of phytoplankton and zooplankton in the Meghna River basin highlights the ecological dynamics of aquatic ecosystems, with findings indicating that chlorophycea dominated the phytoplankton community while cladocera prevailed among zooplankton. This pattern aligns with Hasan *et al.* (2015), who documented similar phytoplankton diversity, supporting the notion that certain taxa thrive under specific environmental conditions. The observed discrepancy between the abundance of phytoplankton and zooplankton suggests potential bottlenecks in the food web, with lesser zooplankton biomass possibly impacting higher trophic levels, as noted in similar studies that explored the ecological implications of plankton dynamics in freshwater ecosystems (Wetzel, 2001; Reynolds, 2006). Understanding these community structures and their interactions is crucial for assessing ecological health and informing conservation strategies within the Meghna River basin and analogous freshwater environments.

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Six groups of benthic macro-invertebrates were abundant in meghna river basin, among those annelida was most abundant and pleuroceredae was lowest abundant group (Fig. 6c). Singapore Mosque contained highest abundance and highest no. of groups and Ashuganj Ferry Terminal contained lowest abundance and lowest no. of groups of benthic macro-invertebrates (Fig. 6a-b).

In the Meghna River basin, research has indicated a significant diversity of benthic macro-invertebrate groups, with annelids (segmented worms) being the most abundant, likely due to their role in nutrient cycling and sediment aeration, which enhances ecosystem productivity (Wetzel, 2001). In contrast, the Pleuroceridae family, which includes freshwater snails, was noted as the least abundant group, potentially indicating habitat preferences and environmental stressors (Holt, 2004). The Singapore Mosque site displayed the highest abundance and variety of macro-invertebrate groups, suggesting optimal habitat conditions (e.g., stable substrates and food availability) conducive to biodiversity (Friedrich, 2015). Conversely, the Ashuganj Ferry Terminal's low abundance and limited group diversity may reflect anthropogenic impacts such as pollution and habitat alteration (Burdon *et al*., 2019), underscoring the importance of habitat conservation in maintaining aquatic biodiversity.

The catch per unit effort (CPUE) of Hilsa fish (*Tenualosa ilisha*) has been found to exhibit positive associations with water quality parameters such as CO2, alkalinity, and hardness, which suggest that favorable nutrient conditions may enhance the availability of food resources and suitable habitats for this species (Mahmud *et al.,* 2022). Conversely, the negative correlation with transparency (Fig. 7), indicates that turbidity may impair the visual foraging ability of Hilsa, potentially leading to decreased feeding efficacy and lower CPUE (Hossain *et al*., 2014). Additionally, the negative relationship with the composition of available plankton implies that changes in the plankton community, possibly due to eutrophication or other anthropogenic impacts, could influence the growth and reproduction of fish species, further impacting fishery yields (Nõges, *et al*., 2016). These findings underscore the importance of maintaining optimal water quality for sustaining Hilsa populations and highlight the need for effective management strategies to preserve critical aquatic ecosystems.

Conclusion

The Meghna River Basin in Bangladesh is a critical ecosystem that sustains livelihoods, biodiversity, and provides essential resources. Through meticulous data collection and analysis, this research shed light on the complex dynamics of the Meghna River Basin. It revealed the spatial and temporal fluctuations of hydro-physico-chemical attributes, including water temperature, pH, dissolved oxygen, and more. They identify specific aspects of river health and the ways in which the river reacts

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to stressors; these attributes can therefore be used for state assessment. This study also revealed various types of bio resources present in the basin right from the phytoplankton to the benthic macro invertebrates. It was important to know the quantity, elements, and location of these species for the assessment of the condition of the whole environment. Besides, understanding the ecological importance of the plankton and benthic macro-invertebrates' data this study provides evidence for the assessment of the ecological balance in the basin. Ecologically and culturally, this study offers much insight that can help towards the protection and management of the Meghna River Basin. Thus, by specifying and explaining the nature of these spatio-temporal dependencies within this ecosystem, we provide important information that can be useful for politics and preservation organizations. The results can guide how to combat the impacts of pollution, habitat degradation, climate change, and anthropogenically induced pressures.

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Competing interest

He authors declare that there is no competing interest.

Data Availability

Data will be made available upon reasonable request.

References

Ahmed, K.K.U., Ahmed, S.U., Haldar, G.C., Hossain, M.R.A. and Ahmed, T., 2005. Primary production and fish yield estimation in the Meghna River system, Bangladesh. *Asian Fisheries Science*, 18, pp. 95-105. https://doi.org/10.33997/j.afs.2005.18.2.002.

APHA, 1976. Standard methods for the examination of water and waste water. American Public Health Association, Washington DC. American Public Health Association, American Water Works Association, Water Environment Federation.20th Edition. 120 P.

Bhaumik, U., Srivastava, N.P., Satpathy, B.B., Mukhopadhyay, M.K. and Sharma, A.P., 2011. Impact of hydro-ecology on fish migration in selected east coast estuaries. *Journal of Inland Fisheries Society of India*, 43(**1**), 1-9.

Burdon, F.J., Munz, N.A., Reyes, M., Focks, A., Joss, A., Räsänen, K., Stamm, C., 2019. Agriculture versus wastewater pollution as drivers of macroinvertebrate community structure in streams. *Science of the Total Environment*, 659, 1256-1265. https://doi.org/10.1016/j.scitotenv.2018.12.372.

Friedrich, C., 2015. Biodiversity and abundance of freshwater macroinvertebrates. 245 P.

Hasan, K.M.M., Wahab, M.A., Ahmed, Z.F. and Mohammed, E.Y., 2015. *The biophysical assessments of the hilsa fish (Tenualosa ilisha) habitat in the lower Meghna, Bangladesh*. International Institute for Environment and Development. 80-86 Gray's Inn Road, London WC1X 8NH, UK.

[DOI: 10.22034/INJBIR.3.2.1]

Hasan, M.T., Rahman, M.M. and Hossain, M.S., 2015. Diversity of phytoplankton and zooplankton in the Meghna River Basin, Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 3(**2**), 175-179.

Holt, A.R., 2004. Ecology of freshwater snails of Pleuroceridae in wetlands.

Hossain, M.M. and Roy, S.K., 2014. An overview of the Meghna River Basin in Bangladesh: water resources, environment, livelihood and integrated management. In Proceedings of the International Conference on Water and Environment. pp. 29-43.

Hossain, M.S., Sarker, S., Chowdhury, S.R. and Sharifuzzaman, S.M., 2014. Discovering spawning ground of Hilsa shad (*Tenualosa ilisha*) in the coastal waters of Bangladehs. *Ecological Modelling*, 282, 59-68. DOI:10.1016/j.ecolmodel.2014.04.001.

Maes, J., Van Damme, S., Meire, P. and Ollevier, F., 2004. Statistical modeling of seasonal and environmental influences on the population dynamics of an estuarine fish community. *Marine Biology*, 145, 1033-1042.

Mahmud, Y., Rahman, M.A., Rahman, M.H., Rashid, M.H., Alam, M.A. and Moniruzzaman, M., 2022. An Assessment of the Water Quality Factors: A Case of Hilsa Fishery River Areas. *Asian Journal of Fisheries and Aquatic Research*, 20(**1**), 30-47.

Miah, M.Y., Hossain, M.M., Schneider, P., Mozumder, M.M.H., Mitu, S.J. and Shamsuzzaman, M.M., 2021. Assessment of ecosystem services and their drivers of change under human-dominated pressure—the Meghna River estuary of Bangladesh. *Sustainability*, 13(**8**), 4458.DOI:10.3390/su13084458.

MoWR., 2001. Hydro-morphological dynamics of the Meghna estuary. In: Meghna Estuary Study, Vol. I and II. Report prepared by the Department of GIS, Government of Netherlands and Ministry of Water Resources (MoWR), Government of Bangladesh. 130 P.

Nõges, T., Järvalt, A., Haberman, J., Zingel, P. and Nõges, P., 2016. Is fish able to regulate filamentous blue green dominated phytoplanton? *Hydrobiologia*, 780, 59-69. DOI:10.1007/s10750-016-2952-y.

Rabbani, G., Rahman, A., Naz, N. and Salehin, M., 2018. Spatial distribution of dissolved oxygen, biochemical oxygen demand, and nutrient loads in the Meghna River, Bangladesh. *Environmental Monitoring and Assessment*, 190(**6**), 340. DOI:10.1007/s10661-018-6739-0.

Reynolds, C.S., 2006. The Ecology of Phytoplankton (Ecology, biodiversity and conservation). Cambridge University Press.551 P. ISBN:0-84413-0521-0-978.

Sarker, M.S., Khan, M. N. A., Hoque, A. T. M. R. and Sikder, M. S. U., 2020. Wetland resources and their ecological significance in the Meghna River Basin of Bangladesh. *Environmental Challenges*, 2, 100023.DOI:10.1016/j.envc.2020.100023.

Sultana, M.A., Hussain, M.A., Schneider, P., Nahiduzzaman, M., Barman, B.K., Wahab, M.A. and Kunda, M., 2023. Community-Driven Insights into Fish Assemblage, Microhabitats, and Management Strategies in the Meghna River Basin of Bangladesh. *Sustainability*, 15(**14**), 11466. DOI:10.3390/su151411466.

Wetzel, R.G., 2001. *Limnology: Lake and River Ecosystems* (3rd ed.). Academic Press. 1006 P. ISBN: 0-12-744760-1.

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