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Diversity indices of plankton communities in the River Meghna of Bangladesh

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Abstract

The present investigation was conducted month-wise during July 2014 to June 2015 to analyze the phytoplankton and zooplankton community structure in the selected sampling stations on the River Meghna using various diversity indices. A total of thirteen sampling stations viz. Shatnol, Ekhaspur, Ananda Bazar, Madrasa Ghat, Horina Ghat, Ishanbala, Haim Chor, Chor Voirabi of Chandpur district; Chor Jalalpur of Sariatpur district; Hizla, Kaliganj of Barisal district; Chor Ludhua, Chor Alexandar of Laxmipur district with corresponding GPS coordinates were selected on the River Meghna for plankton collection and analysis. The Shannon Index (H) for phytoplankton was found to be the highest in Axr (0.6829) and lowest in CV (0.5387). The Shannon Index (H) for zooplankton was found to be the highest in AB (0.4506) and lowest in Axr (0.6931). The Equitability Index (EH) for phytoplankton was found to be the highest in HG (0.9917) and lowest in CV (0.7772). The Equitability Index (EH) for zooplankton was found to be the highest in AB (0.65) and lowest in Axr (1.0). The Simpson Index (D) for phytoplankton was found to be the highest in HG (0.5057) and lowest in CL (0.6102). The Simpson Index (D) for zooplankton was found to be the highest in AB (0.722) and lowest in Axr (0.4992). The Simpson Dominance Index (D) for phytoplankton was found to be the highest in HG (0.4943) and lowest in CV (0.3537). The Simpson Dominance Index (D) for zooplankton was found to be the highest in Sn (0.278) and lowest in Axr (0.4693). Margalef Richness Index for phytoplankton was found to be the highest in Sn (0.1254) and lowest in Hz (0.09347). Margalef Richness Index for zooplankton was found to be the highest in Ep (0.141) and lowest in CJ (0.1669).

Keywords: Diversity indices, Phytoplankton, Zooplankton, Meghna River, Bangladesh

1. Introduction

Bangladesh lies in the delta of the world's three great river systems (the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna river system) with a complex network of 230 rivers. These three mighty river basins drain a catchment area of 1,720,000 km² of which only 7% lies in Bangladesh^[1]. The confluence of the River Padma, Meghna and Dakatia is very significant water body. It plays an important role as the major nursery and breeding grounds of national fish, Hilsa (*Tenualosa ilisha*) and many other commercially important riverine fishes^[2]. Water maintains an ecological balance between various group of living organism and their environment^[3]. Phytoplankton is one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change^[4]. Therefore, phytoplankton community structure observation may be used as a reliable tool for biological monitoring studies to assess the pollution status of aquatic bodies. Phytoplankton is the primary producers for the entire aquatic body and comprises the major portion in the ecological pyramids^[5]. Zooplankton is also sensitive to their environment and like phytoplankton, a change in zooplankton concentration can indicate a subtle environmental change. The diversity of species, amount of biomass and abundance of zooplankton communities can be used to determine the health of an ecosystem^[6].

A biodiversity index seeks to characterize the diversity of a sample or community by a single number. The concept of the "species diversity" involves two components: the number of species or richness and the distribution of individuals among species. However, Shannon Diversity Index considers the richness and proportion of each species while Evenness and Dominance indices represent the relative number of individuals in the sample and the fraction of common species respectively.

It is a *statistic* which is intended to measure the differences among members of a set consisting of various types of objects. There is no in-depth analysis in the structure and dynamic of the phytoplankton and zooplankton community in the study area, which is fundamental as a primary producer for the management and the assessment of the water body. The present study aims to analyze the phytoplankton and zooplankton community structure in the selected sampling stations on the River Meghna using various diversity indices like Shannon Diversity Index, Equitability Index, Simpson Diversity Index, Simpson Dominance Index and Margalef Richness Index. The uses of these indices are well established in ecological literature.

2. Materials and Methods

2.1. Site selection and duration

The present investigation was conducted month-wise during July 2014 to June 2015. A total of thirteen sampling stations were selected from Shatnol of Chandpur district to Char Alexandar of Laxmipur district at the South-East side and from Ishanbala of Chandpur district to Kaliganj of Barishal district at the South-West side of the River Meghna for plankton collection and analysis. The Corresponding GPS Coordinates of the selected sampling stations were given in Table 1.

Table 1: Name of the sampling stations with corresponding GPS coordinates

Serial No.	Sampling Stations	GPS coordinates
1.	Shatnol (Sn), Chandpur	23°27.726'N, 90°35.402'E
2.	Eklaspur (Ep), Chandpur	23°22.487'N, 90°36.313'E
3.	Ananda Bazar (AB), Chandpur	23°14.825'N, 90°38.756'E
4.	Madrassa Ghat (MG), Chandpur	23°14.116'N, 90°38.423'E
5.	Horina Ghat (HG), Chandpur	23°09.717'N, 90°38.560'E
6.	Ishanbala (Ib), Chandpur	23°08.110'N, 90°38.015'E
7.	Haim Chor (HC), Chandpur	23°05.307'N, 90°38.882'E
8.	Chor Jalalpur (CJ), Sariatpur	23°04.257'N, 90°39.403'E
9.	Chor Voirabi (CV), Chandpur	23°02.072'N, 90°39.219'E
10.	Hizla (Hz), Barisal	22°53.941'N, 90°31.984'E
11.	Kaliganj (kg), Barisal	22°52.514'N, 90°35.753'E
12.	Chor Ludhua (CL), Laxmipur	22°45.523'N, 90°49.511'E
13.	Chor Alexandar (Axr), Laxmipur	22°41.275'N, 90°50.348'E

2.2. Sample collection

Plankton samples were collected from each sampling stations normally at the early morning by standard drop count method [7] during the study period. Replicate plankton samples were collected by means of a bucket (50 litre) and filtered through bolting silk plankton net of 50 μ . The filtrate were transferred to 100 ml plastic bottle and preserved immediately in 1:100 Lugol's solution. Counting and identification were done by following Ward and Whipple (1959) and Prescott (1962) [8, 9].

2.3. Diversity indices analysis

To assess the diversity indices of plankton, species were calculated by respective formula/equation as Shannon Diversity Index, Equitability Index, Simpson Diversity Index, Simpson Dominance Index and Margalef Richness Index.

The indices are as follows:

Shannon Diversity Index

$$H = \sum_{i=1}^s - (P_i * \ln P_i)$$

Where

H = the Shannon diversity index

P_i = fraction of the entire population made up of species i

S = numbers of species encountered

\sum = sum from species 1 to species S

Equitability Index (EH)

$$EH = H / \ln S$$

Where

EH = Equability index

H = Shannon Index

S = max is the maximum possible value of H and it is equivalent to ln S

Simpson Index (D)

Simpson index is calculated as follows

$$D = \frac{1}{\sum_{i=1}^s p_i^2}$$

Where

P is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N),

Σ is still the sum of the calculations, and s is the number of species

Simpson Dominance Index (D)

$$H = \sum_{i=1}^s (n_i/n)^2$$

Where

Where

n_i = number of individuals of species i

n = total number of individuals

Margalef Richness Index (d)

$$d = (S - 1) \ln N$$

Where S is the number of species,

N is the total number of individuals in the sample.

These indices were used to obtain the estimation of both Phytoplankton and zooplankton species diversity index.

3. Results and Discussion

In the present study following phytoplankton and zooplankton families with genus composition were observed during the study period (Table 2 & 3). The highest number of genera was found in the family Chlorophyceae followed by the family Dinophyceae and the lowest in Euglenophyceae among the recorded seven phytoplankton family. Copepods and cladocera were found to be the biggest family in terms of genera among recorded four zooplankton family.

Table 2: Phytoplankton families with genus composition were observed during the study period.

S. No	Family	Genus
1.	Cholorophyceae	<i>Ankistrodesmus, Eudorina, Crucigenia, Chlamydomonas, Ceratium, Closterium, Gonatozygon, Microspora, Genecularia, Pleodarina, Spirogyra, Scenedesmus, Mougeotia, Volvox, Zygenema, Pediastrum</i>
2.	Dinophyceae	<i>Ulothrix, Protococcus</i>
3.	Bacillariophyceae	<i>Amphora, Tabellaria, Coscinodesmus, Cyclotella, Ditoma, Fragilaria, Melosira, Navicula, Nitzschia, Polycistis, Sphanodesmus, Synedra, Asterionella</i>
4.	Cyanophyceae	<i>Spirulina, Scenedesmus</i>
5.	Myxophyceae	<i>Tetrapedia, Coelosphaerium, Merismopedia, Oedogonium, Aphanocapsa</i>
6.	Euglenophyceae	<i>Tribonema</i>
7.	Xanthophyceae	<i>Trachelomonas, Euglena</i>

Table 3: Zooplankton families with genus composition were observed during the study period.

SL No.	Family	Genus
1.	Rotifers	<i>Trichocera, Brachionus</i>
2.	Copepods	<i>Nauplius, Diaptomus, Cyclops</i>
3.	Cladocera	<i>Daphnia, Diaphanosoma, Chydorus</i>
4.	Ostracods	<i>Cypridopsis</i>

Abundance and quantity of both phytoplankton and zooplankton in 13 sampling stations of the River Meghna has

been presented in Table 4:

Table 4: Mean quantitative values of plankton with dominating genera in the selected sampling stations of the River Meghna.

Stations	Total Phyto. (No./l)	Dominating Phyto. (No./l)	Other Phyto. (No./l)	Total Zoo. (No./l)	Dominating Zoo. (No./l)	Other Zoo. (No./l)
Sn	29×10 ²	<i>Ulothrix</i> (17×10 ²)	12×10 ²	8×10 ²	<i>Brachionus</i> (5×10 ²)	3×10 ²
Ep	256×10 ²	<i>Melosera</i> (105×10 ²)	151×10 ²	4×10 ²	<i>Nauplius</i> (3×10 ²)	1×10 ²
AB	59×10 ²	<i>Ulothrix</i> (19×10 ²)	40×10 ²	12×10 ²	<i>Brachionus</i> (10×10 ²)	2×10 ²
MG	146×10 ²	<i>Ulothrix</i> (91×10 ²)	55×10 ²	33×10 ²	<i>Brachionus</i> (25×10 ²)	8×10 ²
HG	410×10 ²	<i>Ulothrix</i> (183×10 ²)	227×10 ²	26×10 ²	<i>Brachionus</i> (19×10 ²)	7×10 ²
Ib	293×10 ²	<i>Ulothrix</i> (185×10 ²)	108×10 ²	30×10 ²	<i>Brachionus</i> (22×10 ²)	8×10 ²
HC	267×10 ²	<i>Ulothrix</i> (193×10 ²)	74×10 ²	18×10 ²	<i>Brachionus</i> (14×10 ²)	4×10 ²
CJ	239×10 ²	<i>Ulothrix</i> (98×10 ²)	141×10 ²	35×10 ²	<i>Brachionus</i> (20×10 ²)	15×10 ²
CV	305×10 ²	<i>Ulothrix</i> (235×10 ²)	70×10 ²	13×10 ²	<i>Brachionus</i> (9×10 ²)	4×10 ²
Hz	443×10 ²	<i>Ulothrix</i> (305×10 ²)	138×10 ²	27×10 ²	<i>Brachionus</i> (20×10 ²)	7×10 ²
Kg	389×10 ²	<i>Ulothrix</i> (278×10 ²)	111×10 ²	26×10 ²	<i>Brachionus</i> (17×10 ²)	9×10 ²
CL	230×10 ²	<i>Ulothrix</i> (169×10 ²)	61×10 ²	11×10 ²	<i>Brachionus</i> (8×10 ²)	3×10 ²
Axr	196×10 ²	<i>Ulothrix</i> (112×10 ²)	84×10 ²	6×10 ²	<i>Nauplius</i> (3×10 ²)	3×10 ²
Total	3252×10 ²	1990×10 ²	1272×10 ²	249×10 ²	175×10 ²	74×10

In the present study, total phytoplankton population (3252×10²) was mostly dominated by Dinophyceae (*Ulothrix* 1885 ×10²) whereas total zooplankton population (175×10²) was mostly dominated by Rotifera (*Brachionus* 169 ×10²) in

the all the sampling stations (Table 4).

Different diversity indices of dominating phytoplankton and zooplankton are shown in Table 5 and Table 6.

Table 5: Diversity indices of phytoplankton in the selected sampling stations of the River Meghna.

Sampling Stations	Shannon Index (H)	Equitability Index (EH)	Simpson Index (D)	Simpson Dominance Index (D)	Margalef Richness Index (d)
Sn	0.6782	0.9784	0.5147	0.4853	0.1254
Ep	0.6769	0.9766	0.5161	0.4839	0.09852
AB	0.6284	0.9066	0.5633	0.4367	0.1152
MG	0.6503	0.9381	0.5422	0.4578	0.1047
HG	0.6874	0.9917	0.5057	0.4943	0.09415
Ib	0.6582	0.9496	0.5345	0.4655	0.09723
HC	0.5902	0.8515	0.5993	0.4007	0.09811
CJ	0.6769	0.9765	0.5162	0.4838	0.09919
CV	0.5387	0.7772	0.6463	0.3537	0.09685
Hz	0.6203	0.8949	0.571	0.429	0.09347
Kg	0.5979	0.8626	0.5921	0.4079	0.09462
CL	0.5784	0.8345	0.6102	0.3898	0.09957
Axr	0.6829	0.9852	0.5102	0.4898	0.1012

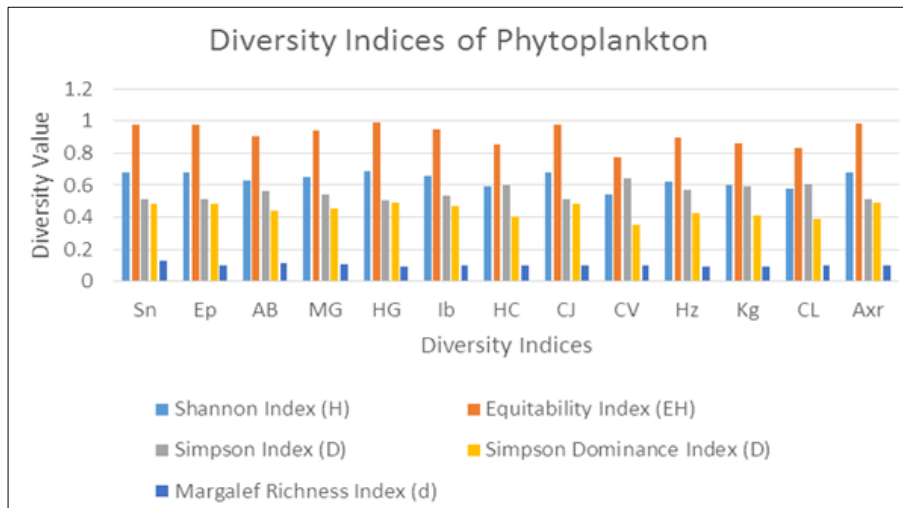


Fig 1: Diversity indices of phytoplankton in the selected sampling stations of the River Meghna

Table 6: Diversity indices of zooplankton in the selected sampling stations of the River Meghna.

Sampling Stations	Shannon Index (H)	Equitability Index (EH)	Simpson Index (D)	Simpson Dominance Index (D)	Margalef Richness Index (d)
Sn	0.6616	0.9544	0.5307	0.4693	0.1496
Ep	0.5623	0.8113	0.6241	0.3759	0.1669
AB	0.4506	0.65	0.722	0.278	0.141
MG	0.5539	0.799	0.6326	0.3674	0.1234
HG	0.5825	0.8404	0.6064	0.3936	0.1272
Ib	0.5799	0.8366	0.6088	0.3912	0.1249
HC	0.5297	0.7642	0.6541	0.3459	0.1334
CJ	0.6829	0.9852	0.5101	0.4899	0.1225
CV	0.6172	0.8905	0.5736	0.4264	0.1395
Hz	0.5723	0.8256	0.6158	0.3842	0.1266
Kg	0.645	0.9306	0.5472	0.4528	0.1272
CL	0.586	0.8454	0.6029	0.3971	0.1428
Axr	0.6931	1.0	0.4992	0.5008	0.1563

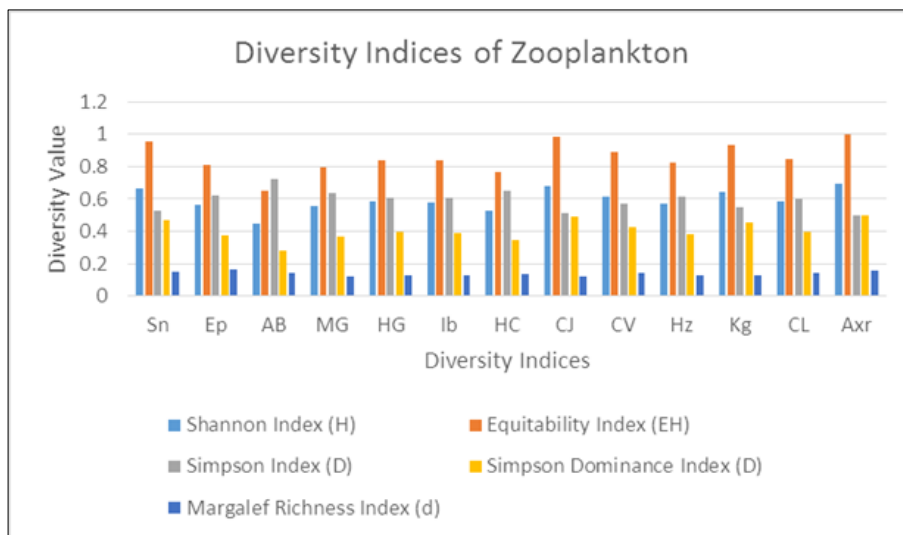


Fig 2: Diversity indices of zooplankton in the selected sampling stations of the River Meghna.

Shannon Diversity Index (H)

Shannon Diversity Index is a commonly used diversity index that takes into account both abundance and evenness of species present in the community. It is commonly used to characterize species diversity in a community.

The Shannon Index (H) takes a value between 0 and 1. The Shannon Index (H) for phytoplankton was found to be the highest in Axr (0.6829) and lowest in CV (0.5387). The Shannon Index (H) for zooplankton was found to be the highest

in AB (0.4506) and lowest in Axr (0.6931). The high value of H in Axr indicates that phytoplankton species are more evenly distributed in the selected sampling stations. Balloch *et al.*^[10] found the Shannon Diversity Index to be a suitable indicator of water quality.

The highest phytoplankton diversity (H) was recorded at Sandwip (1.517) during the monsoon season and the lowest value of diversity (H) was recorded at Sandwip (0.35) during the post-monsoon season^[11].

Dhembare (2011) ^[12] reported that Shannon Diversity Index ranged from 0.089 to 0.32 in his study which indicates conditions of intermittent surface distribution where, certain zooplankton species have better environmental conditions to reach higher individual numbers.

Equitability Index (EH)

The Equitability index is simply the Shannon diversity index divided by the maximum diversity.

This Equitability index takes a value between 0 and 1. The lower values indicate more diversity while higher values indicate less diversity. Specifically, an index value of 1 means that all groups have the same frequency.

The Equitability Index (EH) for phytoplankton was found to be the highest in HG (0.9917) and lowest in CV (0.7772). The Equitability Index (EH) for zooplankton was found to be the highest in AB (0.65) and lowest in Axr (1.0).

Sharif *et al.* (2017) ^[11] found that the maximum Equitability value at Bhola was 0.99 during the monsoon season and the minimum evenness value was observed 0.36 at Chandpur during the post-monsoon season. The highest mean value of equitability was observed in *Bacillariophyceae*, 0.92 ± 0.02 (March) and lowest in *Cyanophyceae*, 0.47 ± 0.40 (March) in the Meghna river estuary during the spawning season of hilsa ^[13].

Simpson Index (D)

The Simpson Index value also ranges between 0 and 1, the greater the value, the greater the sample diversity ^[14].

The Simpson Index (D) for phytoplankton was found to be the highest in HG (0.5057) and lowest in CL (0.6102). The Simpson Index (D) for zooplankton was found to be the highest in AB (0.722) and lowest in Axr (0.4992).

Simpson Dominance Index (D)

The Dominance Index was measured to determine whether or not particular fisheries species dominate in a particular aquatic system and can be useful index of resource monopolization by a superior competitor, particularly in communities that have been invaded by exotic species ^[15]. The Simpson Dominance Index (D) for phytoplankton was found to be the highest in HG (0.4943) and lowest in CV (0.3537). The Simpson Dominance Index (D) for zooplankton was found to be the highest in Sn (0.278) and lowest in Axr (0.4693).

Margalef Richness Index (d)

According to Margalef (1956) ^[16], the higher diversity values reflect the suitability of habitat for the organism and have been reported to be correlated with longer food chain and complex food web of the ecosystems and also more stable community. The Margalef Richness Index has no limit value and it shows a variation depending upon the number of species. Margalef Richness Index for phytoplankton was found to be the highest in Sn (0.1254) and lowest in Hz (0.09347). Margalef Richness Index for zooplankton was found to be the highest in Ep (0.141) and lowest in CJ (0.1669).

4. Conclusion

Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. The present study showed phytoplankton and zooplankton community structure and their diversity in the selected sampling stations of the River Meghna.

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