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Research Article

Seasonality of physicochemical parameters and fin fish diversity at Hakaluki Haor (Fenchungonj Upazilla), Sylhet, Bangladesh

Mohammad Amzad Hossain[1]*, Ahmad Fazley Rabby[2]

*Corresponding author: mamzad.fbg@sau.ac.bd
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Affiliations

[1]Department of Fish Biology and Genetics, Faculty of Fisheries, Sylhet Agricultural University, Sylhet-3100, BANGLADESH

[2]Bangladesh Fisheries Research Institute, Marine Fisheries & Technology Station, Cox's Bazar, BANGLADESH

Keywords
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ABSTRACT

A one-year-long field survey had been conducted to investigate the seasonal fluctuations in the water quality properties and fin fish diversity at Hakaluki Haor, Bangladesh. Different water quality parameters and fish catchment data were taken from each site on monthly basis. Fish were identified in family basis through surveying in fish landing centre, fish markets and fisher's community and samples were brought to laboratory for accurate taxonomic identification. Temperature, turbidity and pH were found to be different depending on season; while, dissolved O_2 and NH_3 were moderately uniform in all season. Almost twenty taxonomic families have been identified. Among them, the Cyprinidade family was the most abundant familiy (34%), following Bagridae (8%), Siluridae (6%); while, the Mugilidae (1%) was the least abundant one. The highest and lowest value in the majority of diversity indices were observed in monsoon and winter, respectively. The Pearson correlation test was conducted to evaluate the regression coefficient between different water quality parameters and diversity indices.

Introduction

The river tributaries system at greater Sylhet region has been originated from the hilly water of India and flow through joining the Surma and Kushiyara Rivers in Bangladesh (Chowdhury et al., 2019; Hossain et al., 2012). The floodplain hoar areas surrounding the tributaries are unique and very productive due to discharge of water from upstream freshwater area and discharge of land-based nutrients which was released during the monsoon period. This hoar system rules vital pathway for navigation and transportation of local communities and, a lot of fishers' community also depends upon its resources for their life and culture (Hossain et al., 2012). The freshwater fish resources in Bangladesh are very abundant and diversified (Das et al., 2017; Hossain et al., 2017; Jannatul et al., 2015). The Hakaluki hoar is popular host for wide range of freshwater fish species and it is known with the high seasonal production biomass of aquatic resources (Islam et al., 2011). Therefore, hoar is considered as biodiversity hotspot, heritage site and local community economic zone (Haque and Basak, 2017). The diversity of ecology also serves as a good indicator of water quality and has been used as biomarker by several researchers (Iqbal et al., 2015; Maria et al., 2016; Sarkar et al., 2017; Siligato and Böhmer, 2001). In addition, the fish protein contribute to the major nutrition supplement for poor people around the country (Mian et al., 2020; Uddin et al., 2017) and natural production has been reducing day by day.

The water quality of a particular ecosystem plays key rules in determination of species composition and productive, as well (Bera et al., 2014; Shetty et al., 2015). The water temperature, turbidity, pH, dissolved O_2 and NH_3 are major regulating water quality parameters for most of the aquatic system (Mondal et al., 2010; Latifa et al., 2019; Shahnawaz et al., 2010). Therefore, current research includes both analysis of seasonal variation in the water quality along with the fluctuation in different diversity

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indices of freshwater fish species at Hakaluki Haor (Fenchungonj Upazilla), Sylhet, Bangladesh.

Material and Methods

Study Site and Duration

The study area includes the haor portion located in Fenchugonj (Figure 1). It carries an importance due to conjunction with nearby Kushiyara River and easy transportation facility with markets and other cities. The sampling sites constitute series of flood plain and wetland water systems, where water from both conjunction river and hilly freshwater runoff constitutes the major water source during rainy season. Also, the freshwater runoff from nearby hills and cities caries significant amount of nutrient and anthropogenic pollution.

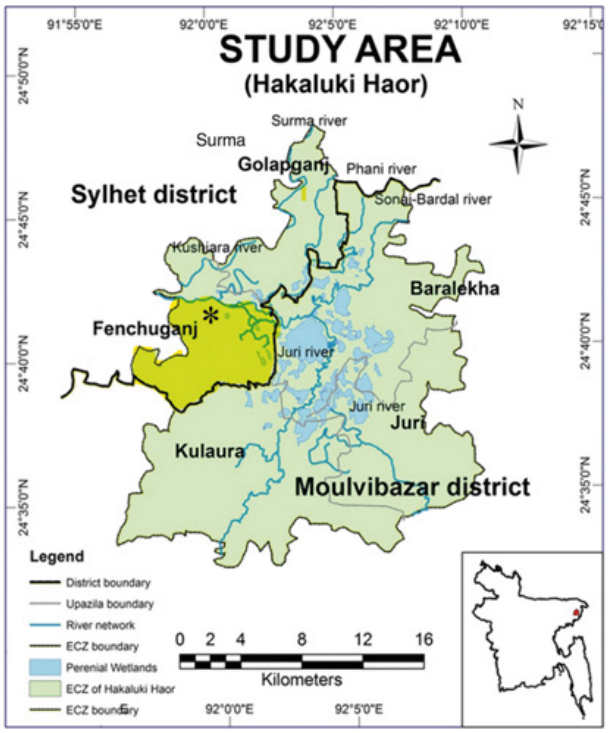

Figure 1. The geographical location of study site (*) map adopted from Islam et al., (2018)

Water Quality Sampling and Diversity Data Acquisition

The seasonality pattern followed in current study were described by Iqbal et al. (2015), which refers from December to February as winter, from March to May as pre-monsoon, from June to August as monsoon/ rainy season, from September to November as post-monsoon season. Water quality data i.e., water temperature, turbidity, pH, dissolved O_2 and NH_3 have been conducted using YSI multiprobe meter on site and catch per unit effort data were collected by direct interview with fishermen on site or landing center. A preset questionnaire was prepared to draw diversity data from fishermen, local artisanal fishers, and community stockholders through voluntary interview. All the interview, data acquisition process and water quality recording have been done monthly and inputted as season based. Fish were identified on family basis and some species that were difficult in identifying on spot have been brought to the laboratory for further taxonomic confirmation.

Tools of Diversity Analysis

Shannon-Weaver diversity index (H')=Sum [p_i x log(p_i)] (Shannon, 1948), Where, H'=Shannon-Weaver index, $P_i=n_i/N$, (n_i=no. of individuals of a species, N=Total number of individuals)

Pielou's evenness index (J') =H(s)/H(max) (Pielou, 1966), Where, H(s)=the Shannon-Weaver information function, H(max)=the theoretical maximum value for H(s) if all species in the sample were equally abundant.

Margalef species richness (d)=(S-1)/log(N) (Farris, 1976); Where, S=numbers of available species, N=total numbers of individuals.

Simpson dominance index (c)=Sum$(n_i/N)^2$ (Simpson, 1949); Where, n_i=number of individuals in the 'each' species, N=total number of individuals, S = total number of species.

The catch per unit effort CPUE (g/h or n/h)= (TSGCB or TSGCN)/TSEH, (Ghosh & Biswas, 2017); Where total sampling effort hours (TSEH)=SEHPD (sampling effort hours/day/gear)xSGD (sampling gear density), g=gram, n=number, h=hour.

Statistical analysis

Raw data has been recorded on excel sheet, descriptive data were treated before further analysis. Data were analyses and graphs were produced by using IBM SPSS Statistics version 26.

Results and Discussions

Fish belong to twenty taxonomic families have been identified either on site or in laboratory for further taxonomic analysis. The highest percentage of contribution was recorded for Cyprinidae (33.5%), following Bagridae (8.4%), Cobitidae (6.5%), Siluridae (6.3 %), Andantidae (5.9%), Channidae (5.9%) and Clupeiade (5.5%) (Figure 2). The lowest percentile coverage was estimated for Mugilidae (1%), Notopteridae, Gobidae and Plotosidae (1.3%). Rest of the major percentile were covered by Ambassidae (3.1%) and Tetraodontidae (3.1%), Mastacembelidae (4.4%) (Figure 2).

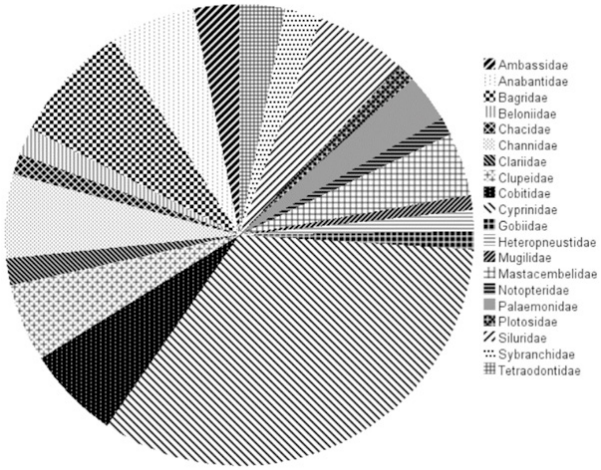

Figure 2. Percentage contribution of different family in Hakaluki Haor (Fenchungonj Upazilla), Sylhet, Bangladesh.

Freshwater reservoir and floodplains in Bangladesh are found to be very diversified according to several previous literatures. A study from Ali et al. (2014), recorded 23 taxonomic family in the Chitra River, Southwestern Bangladesh. Afrad et al. (2019), reported 20 families from the Titas River, Bangladesh. Hossain et al. (2017), obtained 23 families in Khusiara River near to Hakaluki haor and 18 families have been located on Dhepa River of Dinajpur, Bangladesh by Biosci et al. (2019). Again, previous research on different flood area includes 28 taxonomic families in Ratatgul Swamp forest (Das et al., 2017), 24 families were identified in Dekhar Haor (Pandit et al., 2015) and 17 families were recorded in haor areas of Kishorgonj Bangladesh (M. Hasan et al., 2017). However, in most of the cases Cyprinidae were mostly abundant family followed by Siluridae or Bagridae (Akhi et al., 2020; Chowdhury et al., 2019; Jannatul et al., 2015; Maria et al., 2016; Mazumder et al., 2016; Sunny et al., 2020). Therefore, current results reflect to be supportive to previous investigations on others freshwater habitat of Bangladesh.

The fluctuation in water temperature throughout the year ranges between 21-280C, while Sechi's disk depth was strongly variable among seasons and ranged between 19-30 cm (Table 1). The value of pH, dissolved O2 and NH3 were very uniform depending on seasons and range between 6.99-7.48, 5.33-5.98 (mg/L) and 0.009-0.016 (mg/L), respectively (Table 1).

The Pearson's correlation analysis between environmental parameters and diversity indices were established. The values for temperature, turbidity and pH have been reported to be significantly correlated with Simpson dominance index, Shannon- Wiener diversity index, Pielou's evenness index, Catch Per Unit Effort and Marglef richness; while, another environmental parameters i.e., dissolved O2 and NH3 values were nonsignificant (Table 2). Again, Simpson's dominance index and Marglef richness were

Table 1. Seasonal changes in water quality parameters at Hakaluki Haor (Fenchungonj Upazilla), Sylhet, Bangladesh

	Winter	Pre-monsoon	Monsoon	Post-monsoon
Water Temperature (^{0}C)	21.6±0.76^a	25.37±1.01^b	27.47±0.89^b	25.46±3.04^b
Turbidity (Sechi's disk in cm)	19.17±0.29^a	26.55±4.99^b	30.11±2.09^b	18.33±2.19^a
pH	6.99±0.15^a	7.48±0.31^b	7.45±0.28^b	7.22±0.30^b
Dissolved Oxygen (mg/l)	5.63±0.26^a	5.51±0.17^a	5.33±0.87^a	5.98±0.59^a
NH3(mg/l)	0.015±0.004^a	0.016±0.003^a	0.009±0.005^a	0.013±0.005^a

Table 2. Pearson correlation coefficients matrix between the physicochemical parameters and diversity indices of study area.

	T	Td	pH	DO	NH3	C	H	J	CPUE	d
T	1	.581*	.676*	0.183	-0.200	.826**	.705*	0.189	0.289	-.736**
Td	.581*	1	.632*	-0.386	-0.110	.770**	0.535	0.338	.623*	-.725**
pH	.676*	.632*	1	0.332	0.284	.582*	0.526	0.143	0.167	-0.469
DO	0.183	-0.386	0.332	1	0.322	-0.140	0.154	-0.412	-0.332	0.356
NH3	-0.200	-0.110	0.284	0.322	1	-0.256	-0.053	-0.092	-0.103	0.175
C	.826**	.770**	.582*	-0.140	-0.256	1	0.485	0.460	0.552	-.841**
H	.705*	0.535	0.526	0.154	-0.053	0.485	1	-0.429	0.395	-0.354
J	0.189	0.338	0.143	-0.412	-0.092	0.460	-0.429	1	0.043	-.656*
CPUE	0.289	.623*	0.167	-0.332	-0.103	0.552	0.395	0.043	1	-0.293
d	-.736**	-.725**	-0.469	0.356	0.175	-.841**	-0.354	-.656*	-0.293	1

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)
***T=Temperature (^{0}C), Td=Turbidity (Sechi's disk in cm), DO=dissolved O_2 (mg/L), C=Simpson dominance index, H´=Shannon- Wiener diversity index, J=Pielou's evenness index, CPUE=Catch Per Unit Effort, d=Marglef richness)

corrolated with environmetal properties, but othetr diversity indices i.e., Shannon-Wiener diversity index, Pielou's evenness index and Catch Per Unit Effort were less correlated with environmental properties (Table 2).

Variation of water quality parameters in freshwater bodies were found to be more influenced by location due to pollution runoff from nearby cities or industries other than seasonal fluctuations (Akhi et al., 2020; Barakat et al., 2016; Bashar and Fung, 2020). The temperature and turbidity were the most common fluctuating factors in freshwater reservoirs (Naher and Chowdhury, 2017; Tareq et al., 2013). The optimal temperature for sustained aquatic life ranged between 20-30°C in tropical climate (Rahman and Bakri, 2010). pH ranged from 6.5 to 8.5 which was recommended as perfect for aquatic organism (Alabaster, 1982; Hasan et al., 2019), the concentration of the dissolved O_2 should be more than 5 mg/L (Bhatnagar and Devi, 2013) and the NH_3 must be below 0.1 mg/L for a healthy aquatic environment (Kroupova et al., 2005). Considering the aforesaid aspect, the water physico-chemical properties of Hakalauki haor during the study period was healthy and supportive for optimal aquatic life.

Most of the diversity indices exhibit peak on moon season, covering vale of 0.97±0.03 for Simpson dominance index, 1.36±0. 28 for Shannon- Wiener diversity index, 1.52±0.015 for Pielou's evenness index and 0.69±0.25 for Catch Per Unit Effort, but Marglef richness (15.28±2.81) does not follow this trend. Again, for all cases except Marglef richness lowest values were obtained for winter season (Figure 3) followed by post-monsoon and pre-monsoon. The value of Simpson dominance index, Shannon- Wiener diversity index, Pielou's evenness index, Catch Per Unit Effort indices in winter and Marglef richness is 0.94±0.04, 1.22±0.51, 1.42 ±0.03, 0.64±0.34, and 15.76±2.60 in pre-monsoon, and 0.87±0.06, 1.16±0.20, 1.25±0.04, 0.45±0.13 and 16.46±3.00 in post-monsoon (Figure 3).

Biodiversity indices are the measure of the species community, characterization of biological, structural and physico-chemical health of a particular ecosystem (Alam et al., 2013; Islam and Yasmin, 2018; Mia et al., 2019). The value of dominance index was reported to be varied between 0.06 to 0.96 at Atrai River, Dinajpur, Bangladesh (Mia et al., 2019), 012-0.16 for at Shitalakshya River (Rahman et al., 2020) and 0.33-0.89 for River Dhaleshwari, Bangladesh (Islam and Yasmin, 2018). The Shannon-Wiener diversity index fluctuated between 0.32-3.97 at Atrai River, Dinajpur, Bangladesh (Mia et al., 2019), 3.4-3.8

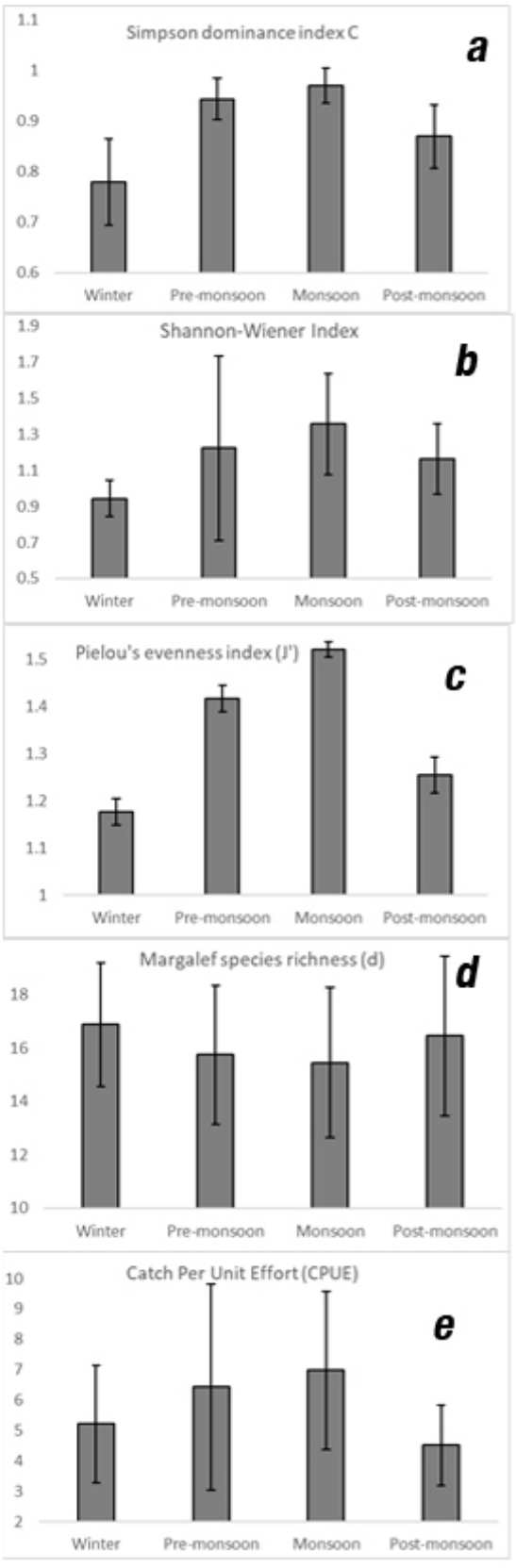

Figure 3. Seasonal changes in different diversity indices **a.** Simpson dominance index (c), **b.** Shannon-Wiener diversity index (H′), **c.** Pielou's evenness index (J′), **d.** Marglef richness (d), **e.** Catch Per Unit Effort (CPUE) at Hakaluki Haor (Fenchungonj Upazilla), Sylhet, Bangladesh.

at River Choto Jamuna, Bangladesh (Galib et al., 2013), 1.52-2.7 at Shitalakshya River (Rahman et al., 2020), 2-2.5 for the Surma River (Chowdhury et al., 2019) and 20.1-2.41 for the Kushiara River Bangladesh (Hossain et al., 2017). The evenness 0.80-0.93 at Choto Jamuna River (Galib et al., 2013), 0.35-0.67 at Shitalakshya River (Rahman et al., 2020), 0.00-1.5 for Kusiara River in Bangladesh (Hossain et al., 2017) and 0.117-0.588 in River Dhaleshwari, Bangladesh (Islam and Yasmin, 2018). The richness indices moved between 4.83 -5.87 in Lakhandaha Wetland and Atari River, Bangladesh (Jewel et al., 2018), 2.78-7.44 in Kusiara River (Hossain et al., 2017) and 4.03 -9.58 in Chalan Beel, Bangladesh (Parlinah et al., 2020). A study by Chowdhury et al., (2019) observed CPUE 0.15-.44 for Surma river and Ghosh and Biswas, (2017) recorded CPUE of 0.04-00.46 for an oxbow lake ecosystem in Eastern India. However, most of the studies noted the higher diversity indices and catch per unit effort during the monsoon period (Chowdhury et al., 2019; Hossain et al., 2017; Iqbal et al., 2015; Islam and Yasmin, 2018; Jannatul et al., 2015; Mia et al., 2019; Parlinah et al., 2020).

The temperature, turbidity and pH were found as most seasonally varied parameters which was similar to the previous studies (Alabaster, 1982; Naher and Chowdhury, 2017; Tareq et al., 2013). The pH and turbidity level changes seasonally due reception of rainfall water and huge siltation from nearby hilly areas. The value of different diversity indices in current research were reported to be moderately aligned with previous studies (Chowdhury et al., 2019; Galib et al., 2013; Hossain et al., 2017; Iqbal et al., 2015, Mia et al., 2019). However, the numbers of families recorded were found to be reduced in recent years which might be a consequent of excessive fishing practices, anthropogenic pollution from nearby chemicals factories and markets. Also, catching brood fish and use of small mesh net during breeding season would be possible cause of reduced diversity of families in study areas. The current research outcomes followed diversity pattern of previous research on freshwater and haor floodplain areas of Bangladesh, but slight deviations are due to differences in location, water sources and exploitation intensity, as well.

Conclusion

To be concluded, current investigations show very little changes in the water quality parameters following the seasonal trends, except temperature and turbidity. Diversity indices were less depending upon the described water quality parameters, however seasonal trends were moderately observed in diversity indices and catch per unit efforts. The over exploitation is one of the major causes for reduced biodiversity measurement, which demands better management and conservation approach for haor based fisheries in suggested area.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

Authors contributed equally to this paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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