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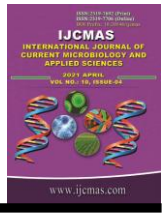

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Study on Seasonal Fluctuation of Physicochemical Properties of Water and Fish Diversity Towards Future Management of a Natural Water Bodies Rajar Beel Wetland, North 24 Parganas, West Bengal, India

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A B S T R A C T

The present study was made to find out the health status of a wetland Rajar Beel, North 24 Parganas, West Bengal, India in relation to physicochemical properties of water. This wetland is rich in aquatic biodiversity. The study focused on the seasonal fluctuation of physicochemical parameters of water and diversity of fish fauna during pre-monsoon, monsoon and post-monsoon during March 2019 to February 2020. Water samples and fish specimens were collected from three different sites of the beel every month to evaluate the correlation between physicochemical properties of water and the indices of fish diversity. A significant seasonal fluctuation in fish diversity in relation to physicochemical parameters (temperature 23-30ºC, turbidity 18.5-26.5 cm, pH 7.1-8.4, CO_2 0-40 mg/l, DO 4-7 mg/l, TA 155-218 mg/l, TH 105-186 mg/l, phosphate 0.15-0.41 mg/l and nitrate 0.03-0.15 mg/l of water) was recorded during the study period. In respect of fish faunal diversity, a total of 37 species belonging to 9 orders and 22 families were identified. Maximum representatives belong to order Cypriniformes having 7 species with 43.91% catch composition, whereas Perciformes with 15 species with 28.93% catch composition. The beel was heavily infested with aquatic vegetation creating complex environments for the growth of different faunal populations. The present study indicates that the beel is moderately productive and suitable for commercial aquaculture. This study will be helpful in the determination of the health status of the beel. The effect of seasonal variations on the assemblage of fish composition is found to be important and it should be considered into account when developing initiatives will be taken in the future to support the productivity and biodiversity of the wetland.

Introduction

Wetlands are considered biologically the most productive ecosystem and are considered as the kidney of the earth (Ramachandran *et al.*, 2006). This habitat is rich in biodiversity (Groombridge and Jenkins, 1998). Wetlands are the intermediate zone between land and water which are permanently or temporarily filled up with static or flowing, fresh, or saline water (Ramsar, 2012).

Freshwater wetlands are important feeding, breeding and drinking areas for various vertebrate and invertebrate species and home to some of the most productive and unique ecosystem. Fish species are a significant aspect of the aquatic environments and occupy a remarkable position from a socioeconomic viewpoint (Bera *et al.*, 2015). Variation in water quality characteristics and their relationship with indices of biodiversity also are important factors for assessing the biodiversity of fish in floodplain wetlands (Mondal and Kaviraj, 2010). Productivity of wetlands are improved by constant surveillance of water quality parameters which are needed to be controlled periodically, independently, or collectively to preserve the optimal aquatic environments (Mondal and Kaviraj, 2008). Various researches (Das and Chand, 2003; Madhuri and Gurav, 2008; Jawale and Patil, 2009; Abujam *et al.*, 2011; Sharma *et al.*, 2016) were carried out to measure and evaluate the abiotic parameters in relation to the productivity status of the lentic ecosystem.

West Bengal, an eastern Indian state, has several floodplain lakes encompassing a segment of 42,000 ha, accounting for around 22% of the entire state's freshwater habitat (Bhaumik *et al.*, 2003). Approx 8861 ha of water resources are found in North 24 Parganas district (Annual report 2004-2005, Department of Fisheries, Government of West Bengal). Rajar beel is one of the important wetland of North 24 parganas. Various researchers (Sarkar and Benerjee, 2000; Keshre and Mudgal, 2010; Singh, 2011; Kumar, 2012; Naik *et al.*, 2013; Basavaraja *et al.*, 2014) have reported about the physicochemical status and ichthyofauna diversity of various wetlands. But Rajar Beel's across the board information on fish biodiversity in regarding the water quality is insufficient.

In the present study, the main focus is to evaluate the limnological parameters of water and its connection with the fish biodiversity indices in several sites of Rajar Beel to assess its health status during pre-monsoon, monsoon and post-monsoon from March 2019 to February 2020.

Materials and Methods

Study Area

Rajar beel also known as Prakito Jolashay (Latitude 22°42'54.1"N; Longitude 88°24'30.7"E) (Figure 1) falls under North 24 Parganas districts of West Bengal, India, at an altitude of 6 meters above sea level. Rajar Beel wetland spreads over an area of 34 hectares. The area is mainly rain-fed. The fisherman utilizes this wetland for fish capture. Sewage from the municipality, domestic disposal directly mixes up in this wetland.

Sampling Methods

The study was conducted on monthly basis from March 2019 to February 2020 for the analysis of physicochemical parameters and the relationship of those parameters with fish diversity. A total of three representative sampling sites (Site I = Sadarhat Ghat, Site II = Taltala Ghat, Site III = Parthpur Ghat) were selected. The most variable and responsive

variables of water quality, like water temperature, pH, Turbidity, Dissolved Oxygen (DO) and Free CO_2 were measured in-situ, while rest parameters (Nitrate, Total Hardness as $CaCO_3$, Total Alkalinity as $CaCO_3$ and Phosphate) were analyzed in the laboratory.

The collection of water samples was done between 5 am to 8 am. Sample preservation and evaluation of different water quality index were performed according to standard procedures stated in APHA, (2006). The outcomes of the physicochemical study of the water sample were matched with the Indian Standards Bureau (BIS, 1993) and the Central Pollution Control Board (CPCB).

The fishes were captured at three stations with local nets and were confirmed by Talwar and Jingham method. The diversity and evenness indices were calculated by the references of Shannon & Wiener (1949). Pearson linear correlation was played to see the connection between various physicochemical parameters.

To evaluate the diversity indices, random fish samples were extracted from five nettings across each site were collected to produce a 1kg sample of small wild fish for every site per month. From these data Shannon-Weiner species diversity index ($\overline{H}$), Evenness index [J], Index of Dominance [ID] and Relative Abundance (RA) were calculated by below mentioned equations :

S.W. Species Diversity index

$$\overline{H} = -\sum_{i=1}^{s} \left(\frac{Ni}{N}\right) \log_2 \left(\frac{Ni}{N}\right)$$

Where S is the total number of species; N is the total number of the individual; N*i* is the number of specimens in each species.

Evenness Index (J) = $\overline{H}/\log_2 S$

Where $\overline{H}$ is the S.W. Species Diversity Index; S is the total number of species.

Index of Dominance (ID) = $\sum \left(\frac{Ni}{N}\right)^2$

Where N is the total number of the individual; N*i* is the number of specimens in each species.

Relative Abundance (%) = N^{th}/N X 100

Where, N^{th} = Total Number of individual species; N = Total Number of species population.

Results and Discussion

In Rajar beel water temperature showed a positive correlation with turbidity and CO_2 whereas negative correlation with pH, dissolved oxygen, total alkalinity, nitrate, and phosphate (Table 1 and Figure 3). Ziauddin et.al., (2013) reported that minimum and maximum temperature in beels of West Bengal varied from 17.5 to 35.0 °C, which conforms with the present study.

The higher pH was recorded in post-monsoon due to the low level of water, higher nutrient content, during the monsoon. In Rajar beel, pH showed a positive correlation with DO, TH and TA while showed a negative correlation (Table 1 and Figure 3) with turbidity, water temperature and CO_2. The results of the present investigation are comparable with S Debnath & A Panigrahi (2013).

A water body's transparency usually suggests its effectiveness. Throughout the monsoon month, it was found to be a maximum that may be attributed to the entry of rainwater from the surrounding area. Throughout pre-monsoon and post-monsoon it was generally low which shows similarities to earlier work (Mamta Joshi et. al., 2019). In Rajar beel, turbidity showed a positive correlation (Table 1 and Figure 3) with dissolved oxygen, nitrate and phosphate whereas it showed a negative correlation with pH, CO_2 and total hardness. Dissolved oxygen attributes are inversely

related to the temperature cycle, differing from post-monsoon upside to pre-monsoon lowest point, similar observations also reported by A. Bhatnagar and G. Singh (2010) in Hariyana. In the present investigation, dissolved oxygen of the wetlands shows a negative correlation (Table 1 and Figure 3) with temperature and CO_2 but showed a positive correlation with pH and nitrate.

In pre-monsoon the amount of Free CO2 remain high due to the rapid decomposition of organic matter and high water temperature (Hasan *et al.,* 2011; Shinde *et al.,* 2011). Lacking free carbon dioxide in other seasons could be due to its utilization by phytoplankton and other aquatic plants *via* photosynthesis and retain by calcium in form of the calcium bicarbonate. The free carbon dioxide shows a significant positive correlation with temp while negative with rest of the parameters.

The maximum total hardness was obtained in post-monsoon due to some construction activity. Nasim Ahmad Ansari (2017), also reported similar observations in Surajpur wetland. In Rajar beel, TH showed a negative correlation with water temp, turbidity, CO_2 and phosphate but showed a positive correlation with pH, nitrate and DO.

In the present study the value of total alkalinity shows close similarity with the other researchers data (Arya *et al.,* 2011; Mishra *et al.,* 2014). In Rajar beel, TA showed a positive correlation with pH, DO, nitrate and phosphate but showed a negative correlation with water temperature, turbidity and CO_2.The amount of nitrate in all three sites of this beel were found very low. During the monsoon and post-monsoon period however the level of nitrate was found bit high due to the surface runoff and some microbial activity. In winter, the activities of these microbes go down (Kaur *et al.,* 1996) resulting in a higher value of nitrate. In Rajar Beel, nitrate showed a positive correlation with phosphate, pH and DO but negative correlation with water temp and CO_2.

Phosphorus in water commonly exists as phosphate. The phosphate concentration in water above 0.5 mg l^{-1} indicates pollution (Jain *et al.*,1996) in water. Maximum phosphate was observed in Rajar beel during the monsoon and minimum during the pre-monsoon. In Rajar beel, phosphate showed a negative correlation (Table 1 and Figure 3) with water temperature, TH and CO_2 while the positive correlation with pH, DO and nitrate was observed. The concentration of phosphate which was moderate throughout the year indicates that this beel is mesotrophic.

The mesotrophic floodplain ecosystem has acceptable phosphorus levels and seems to be ideal for aquatic environment and fish development (Das Gupta *et al.,* 2016).

The resuls describe above indictes that the physicochemical parameters studies are within the acceptable limits (Anita Bhatnagar and Pooja Devi, 2013) and the water quality of this beel is good enough to support rich high species diversity and suitable for fish culture.

Fish Diversity

A total of 37 species of fishes belonging to 9 orders, 22 families and 27 genera were obtained from the Rajar beel wetland.

Table.1 Correlation matrix among the physicochemical parameters and Shannon-Wiener diversity Index of Rajar Beel wetland during March 2019 to February 2020.

	W T	pH	TUR	DO	CO_2	TH	TA	NO_3	PO_4^-	SW I
W T (^{0}C)	1.000									
Ph	-0.986	1.000								
TUR (cm)	0.298	-0.132	1.000							
DO (mg/l)	-0.894	0.957	0.161	1.000						
CO_2 (mg/l)	0.790	-0.882	-0.350	-0.981	1.000					
TH (mg/l)	-0.763	0.643	-0.844	0.393	-0.207	1.000				
TA(mg/l)	-0.959	0.993	-0.016	0.984	-0.931	0.550	1.000			
NO_3 (mg/l)	-0.713	0.821	0.457	0.951	-0.993	0.091	0.882	1.000		
PO_4^- (mg/l)	-0.172	0.337	0.889	0.595	-0.740	-0.505	0.444	0.814	1.000	
SW I	-0.754	0.854	0.403	0.968	-0.998	0.151	0.909	0.998	0.777	1.000

Table.2 Species diversity indices in three different seasons

	Shannon-Wiener Index	Evenness Index	Index of Dominance
Pre-Monsoon	2.899	0.803	0.090
Monsoon	3.023	0.837	0.075
Post-Monsoon	3.087	0.855	0.067

Fig.1 Map (source: Google Map) of the study area with three sites pointed as Site I = Sadarhat Ghat, Site II = Taltala Ghat, Site III = Parthpur Ghat

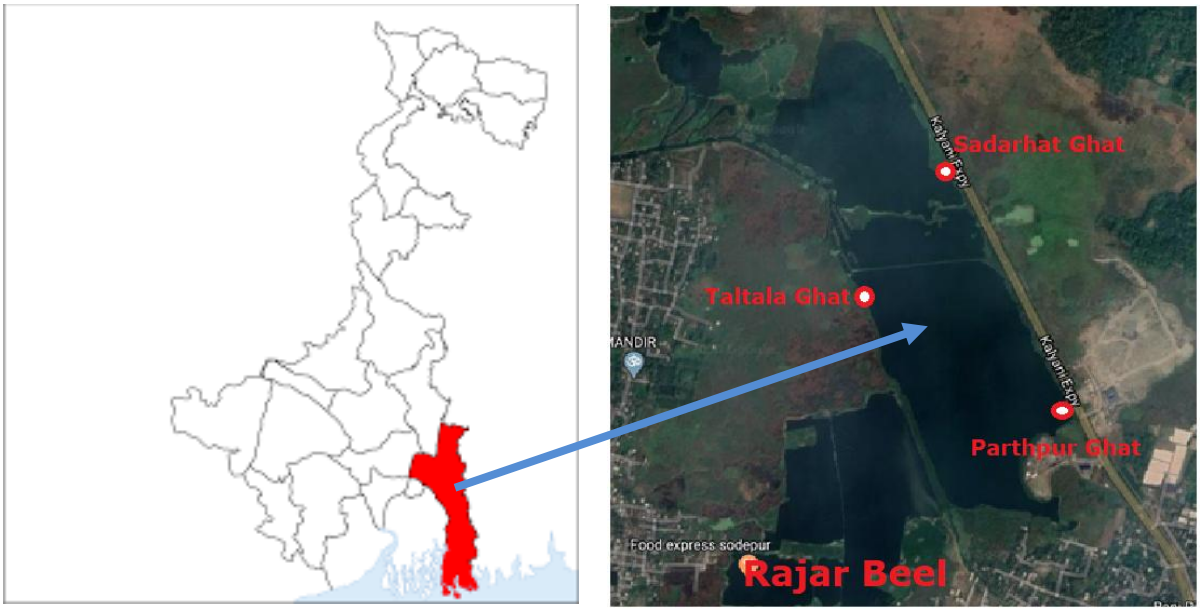


Fig.2 Seasonal variation in water quality parameters (mean values of 12 findings per quarter)

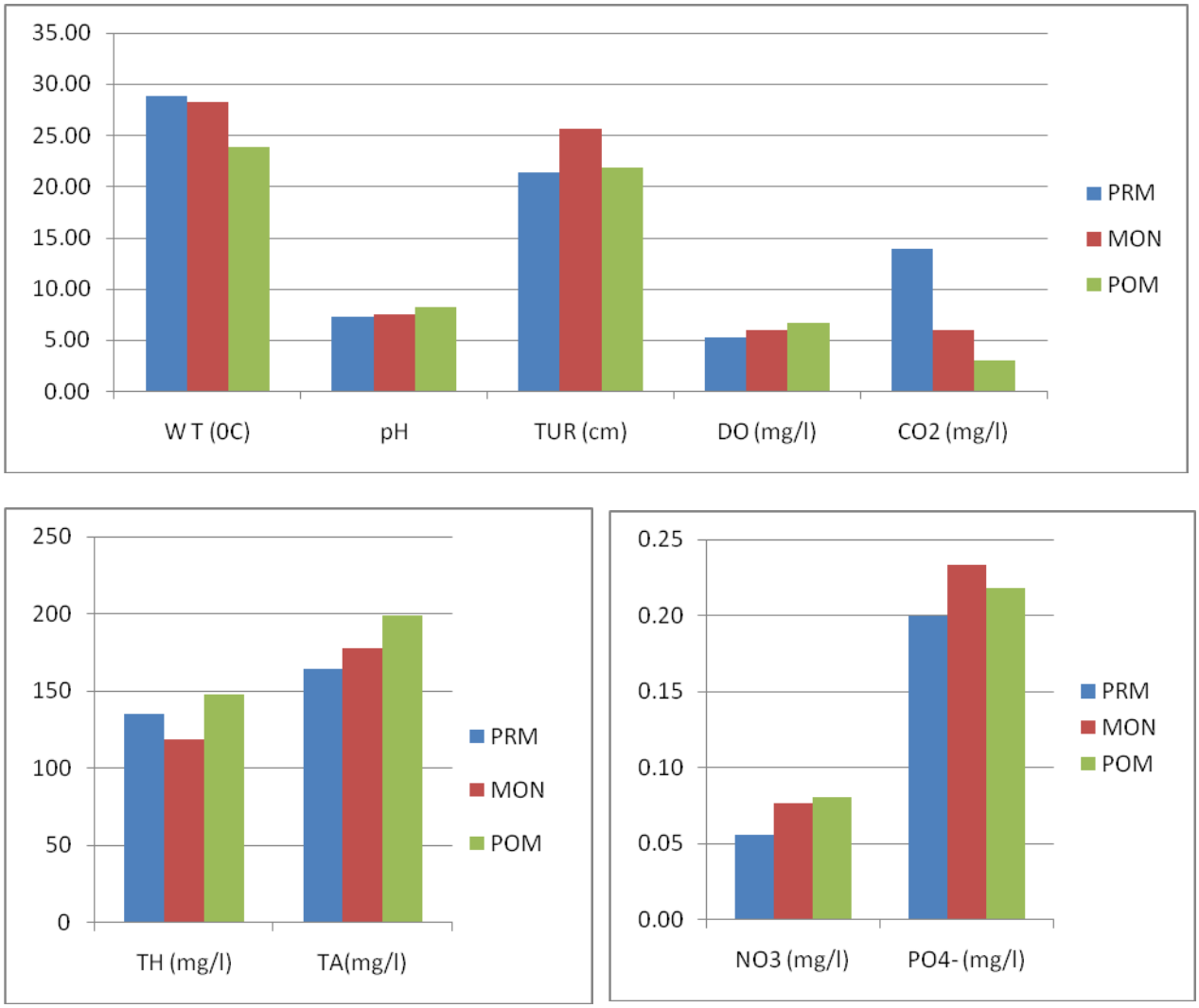


Fig.3 Heat map of Pearson correlation matrix between different physicochemical parameters and Shannon-Wiener diversity Index of Rajar beel from March 2019 to February 2020.

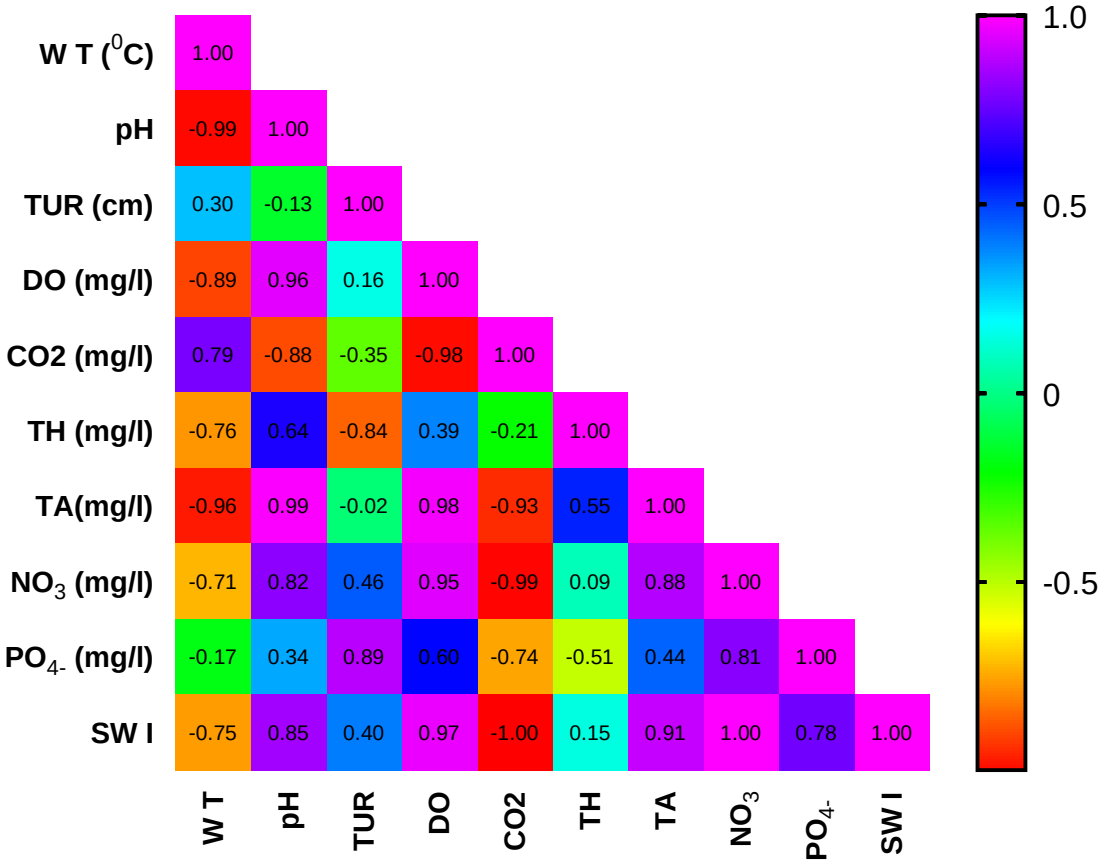
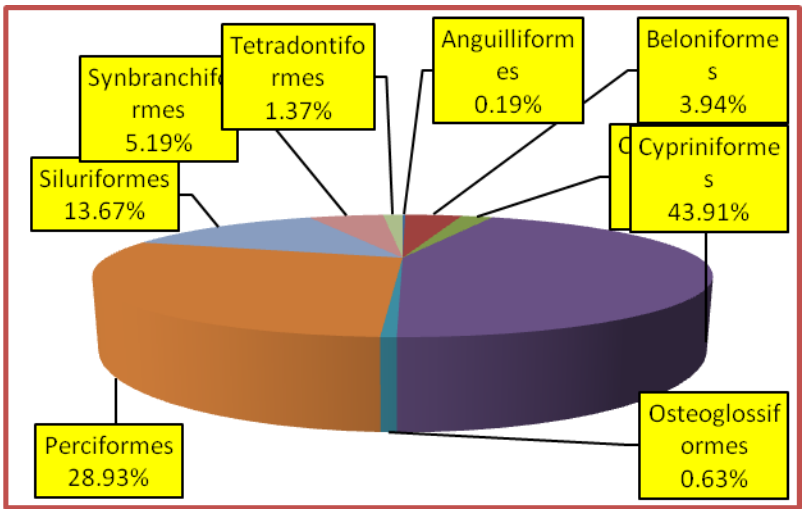


Fig.4 Relative abundance (RA) of various Fish order during March 2019 to February 2020



Out of those fishes, Cypriniformes was the most dominating order having 7 species with 43.91% catch composition, followed by Perciformes with 15 species and 28.93% catch composition, Siluriformes with 7 species and 13.67% catch composition, Synbrachiformes with 3 species and 5.19% catch composition and Beloniformes, Clupeiformes, Tetradontiformes, Osteoglossiformes and Anguilliformes was with one species and 3.94, 2.19, 1.37, 0.63 and 0.19 percentage respectively catch composition (Figure 4).

Shannon diversity index ($\overline{H}$) was obtained highest (3.087) in Post-Monsoon and lowest (2.899) in pre-monsoon. Similarly, the species evenness was found highest in post-monsoon (0.855) and lowest in pre-monsoon (0.803). Both Shannon-Wiener diversity index ($\overline{H}$) and Evenness index highest during post-monsoon, while the index of dominance lowest during post-monsoon(0.067) and similarly it was observed that Index of Dominance highest during pre-monsoon(0.090) but Evenness index and Shannon-Wiener diversity index($\overline{H}$) highest at that time (Table 2). The Shannon-wiener index shows a negative correlation with water temperature and CO_2 while positive relation with pH, DO and phosphate. Natural as well as anthropogenic activities directly impact the relative abundance of species until it becomes an endangered species(Roy *et al.,* 2013). Shannon-Wiener diversity index in the freshwater habitat and suggested a healthy environment with little alterations (Jewel *et al.,* 2018). Shannon-Wiener diversity index($\overline{H}$) of Rajar beel found matches with the findings of Iqbal *et al.,*(2015) (the range 2.90-3.12) in a freshwater wetland.

From the present study it is concluded that water quality of Rajar Beel is satisfactory for pisiculture. This beel has abundance fish diversity but the fish composition alter slightly with seasonal fluctuation. It is also observed that the seasonal variation has great impact on the physic chemical characteristic of water. The health status and fish diversity is found best during post monsoon period. The current state of this beel is considered as productive and healthy and appropriate for the fishery activities.

Appendix

WT = Water Temperature, TUR = Turbidity, DO = Dissolve Oxygen, CO_2 = Carbon Di Oxide, BOD = Biochemical Oxygen Demand, TH = Total Hardness, TA = Total Alkalinity, PO_4^- = Phosphate, NO_3 = Nitrate, SWI = Shannon Wiener Index, PRM = Pre-Monsoon, MON = Monsoon, POM = Post-Monsoon, PCA = Principal Component Analysis, WHO = World Health Organization, BIS = Indian Standards Bureau, CPCB = Central Pollution Control Board.

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