RESEARCH ARTICLE

Determination of water quality and ecology of river dihing river: A tributary of almighty Brahmaputra, Assam, NE India

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Water quality of River Dihing, a tributary of the Brahmaputra was assessed for fish production purposes. From the study, it was found that the ranges of these parameters were found almost within the permissible limit of BIS, 1983. In spite of human activity, disposal of sewage, fertilizers from paddy fields, less eutrophication was noticed in the studied aquatic body. The range of abiotic parameters of R. Dihing water was compared with the standard indexes and found within the desirable limit. Fish culture by different fishermen, self-help groups was also observed during the study period.

Present investigation was also done to identify the ichthyofaunal diversity and its utilization as alternative livelihood. River Dihing, a tributary of mighty River Brahmaputra is serving as a potential fish habitat. A total of 43 species belonging to 7 orders of 16 families were recorded. Among all these Cypriniformes had the majority occupying 40% and were recorded as dominated order.

Key Words: *Dihing; Abiotic parameter; Fish culture*

INTRODUCTION

A suitable environment is necessary for any organism, since life depends upon the continuous exchange of necessary components with the surrounding environment [1]. The freshwater of both kind- lentic and lotic is subjected to influence of a wide array of physical and chemical factors [2]. The interference in these factors may affect the fauna and alter their number and diversity. Physico-chemical factors of the aquatic habitat affect the health of fishes as well as maturity and breeding cycle. It not only affects the development and productivity of fishes but also modifies the stability of the aquatic body. Furthermore,the water parameters are often observed to be interrelated to each other. This study was aimed to assess the physico-chemicalparameters of R. Dihing for fish culture and domestic use purposes. The main aim of the present work is to develop a structurefor the better growth and management of fish production [3].

MATERIALS AND METHODS

Study area

River Dihing is the largest south-bank tributary of the Brahmaputra. Originates from the Patkai Hills in Nagaland (close to Indo-Myanmar border) and flows through Tinsukia and Dibrugarh district of Assam to its confluence with the Brahmaputra at Dihingmukh. The catchment area of the river is about 6000 km^2 and runs through the plains of Assam valley for about 300 km before joining the River Brahmaputra [4].

Water sampling

Regular sampling of water was done from three sites of the river. In all the stations, human activities, especially fishing, were observed. A total of 11 abiotic parameters like total alkalinity (TA), dissolved oxygen (DO), free carbon-dioxide (FCO_2), total suspended solid (TSS), total dissolved solid, air and water temperature, water current, pH, transparency was measured by using standard protocols of APHA (1998), and digital gadgets [5]. All the analysis was done in the laboratory of Fish & Fisheries in Dibrugarh University, Assam, India.

Specimen collection and analysis

Fish samples were collected through experimental fishing by using caste nets of various sizes, gill nets (vertical height 1.0 m-1.5 m; length 30 m-100 m), drag nets (vertical height 2.0 m), fish hooks of various sizes and a variety of gears like polo, juluki, sepa, posa, jakoi, ghana etc by local fisherman. The documentation of present study was carried out with the help of local fishermen, having more than 25 years of experience in fishing technologies. Collected fish species were preserved in 10% formaldehyde in the field itself and live ones were carried to the department of Life Sciences of Dibrugarh University and kept in the aquarium. Fish species have been identified following the literature of Talwar & Jhingran and Vishwanath et al. Status assessments of the documented species have been evaluated by the IUCN Red list of threatened species [6].

Statistical analysis

Statistical analysis was done in SPSS (2008) and MS excel (2010). Significance of correlation was recorded at 0.01 & 0.05 level.

RESULTS

In River Dihing, the water temperature showed lots of fluctuations. However, no significant difference was found among the stations. Therefore, all the data were combined and considered the average value. The mean atmospheric temperature (AT) was found highest (28.7 ± 0.98^{0}C) in August and lowest (12.5 ± 1.41^{0}C) in January. Incidentally highest (27 ± 1.41^{0}C) and lowest (14.9 ± 2.54^{0}C) water temperature (WT) was also recorded in August and January respectively (Figure 1).

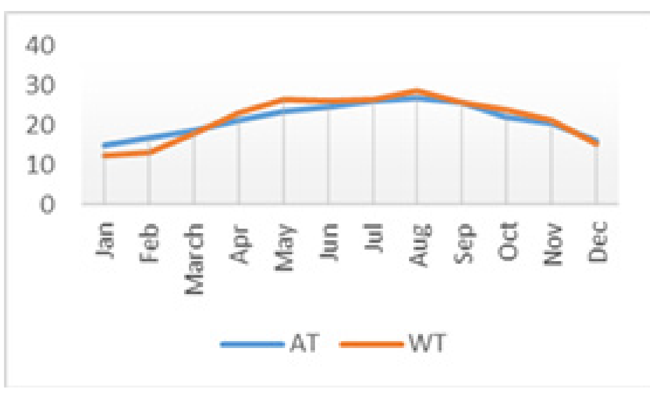

Figure 1) *Mean variation of air and water temperature*

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DO was recorded as a minimum (8.2 ± 0.72 mg/l) in January and thereafter, the value increased steadily reaching its maximum in August (11.1 ± 0.96 mg/l). FCO_2 value was having an increasing trend from winter and reached its peak in pre-monsoon (March-May). The highest value (5.07 ± 0.3) was recorded in June and the lowest (1.67 ± 0.13 mg/l) in October.

In the present study water current flow was found between 0.43 and 1.51 m/sec with a mean maximum value (1.47 ± 0.03) m/sec in July and minimum (0.55 ± 0.12) in January. The current flow rate was found to increase from pre-monsoon (March–May) to monsoon (June- August) and reached its minimum in winter December and February months. As far as pH of river water is concerned, the monthly minimum (7.23 ± 0.19) and maximum (7.85 ± 0.21) values of pH were recorded in December and March respectively. The monthly mean value of total alkalinity from River Dihing was recorded from 28.3 ± 7.15 mg/l (January) to 75 ± 5.29 mg/l (August) (Figure 2).

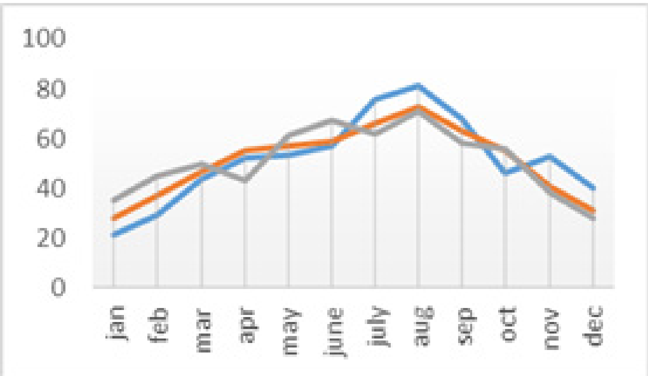

Figure 2) *Mean variation of alkalinity*

The monthly mean variation in TDS and TSS followed a similar trend of fluctuation. TDS was found to have increased from January towards monsoon and reached highest in July and later again dropped down (Figure 3). Occurrence of high TDS and TSS (Figure 4) value at the peak of rainy days, the transparency was found minimum (11.5 ± 3.04 cm) in August and maximum in February (70.3 ± 3.74 cm).

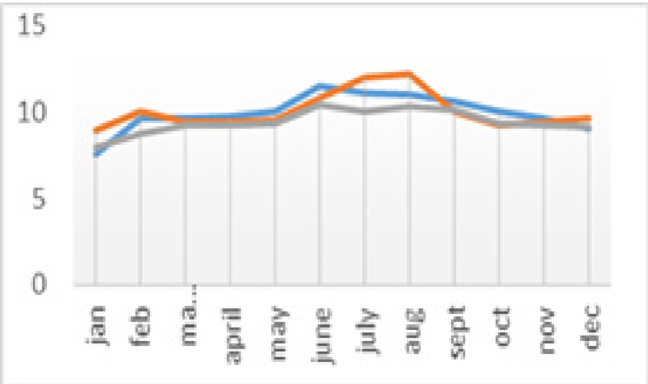

Figure 3) *Mean variation of DO*

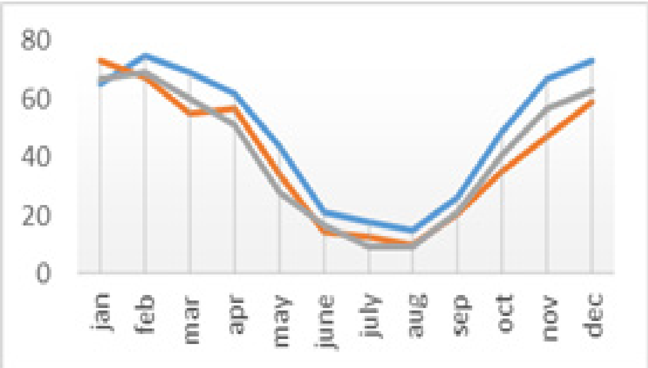

Figure 4) *Mean variation of transparency*

Multiple correlations between the abiotic factors were presented in Table 1. Air and water temperature was found to be positively correlated with all the parameters except transparency and pH; both the variables showed an inverse relationship with temperature. DO was negatively correlated with transparency (r=-0.892) and pH (r=-0.186); but positively correlated with other parameters studied. Similarly, FCO_2 was positively correlated with all the studied parameters except transparency (r=-0.241). Water velocity was positively correlated with most of the abiotic parameters except transparency (r=-0.871) and pH (r=-0.83). Again, pH was positively correlated with transparency, free CO_2 and TSS but negatively correlated with alkalinity, TDS, DO, water current and temperature. Total alkalinity was found positively correlated with DO (r=0.906), free CO_2 (r=0.319), TDS (r=0.942), TSS (r=0.849), water current (r=0.873) and both atmospheric temperature (r=0.983) and water temperature (r=0.9381) while negatively correlated with pH (r=-0.055) and transparency (r=-0.944). Further, TDS and TSS showed positive correlation with air and water temperature and negatively correlated with transparency. Due to the presence of minimal quantities of suspended matter, the transparency was maximum in February (70.3 ± 3.74 cm) and minimum (11.5 ± 3.04 cm) in August (Figure 5). The transparency was found to be negatively correlated with all studied parameters except pH (r=-0.1742).

TABLE 1
The list of fish species of the dihing river

Order	Family	Vernacular name	IUCN status	Scientific name
Beloni-formes	Beloniformes	Kokila	LC	*Xenentodon cancila* (Ham.-Buch.)
	Belitoridae	Botia	LC	*Acanthocobitis botia* (Ham.-Buch.)
	Cobitidae	Gethu/Rani	LC	*Botia Dario* (Ham.-Buch.)
		Botia	LC	*Lepidocephalichthyes guntea*(Ham.-Buch)
Cyprin-iformes	Cyprinidae	Mowa	LC	*Ambylopharyngodon mola* (Ham.-Buch.)
		Boriola	LC	*Cabdio jaya* (Ham.-Buch.)
		Boriola	LC	*Cabdio morar* (Ham.-Buch.)
		Bahu	VU	*Gibelion catla* (Ham.-Buch.)
		Mirika	LC	*Cirrhinus mrigala* (Ham.-Buch.)
		Darikona	LC	*Esomus danricus* (Ham.-Buch.)
		Mali	LC	*Labeo calbasu* (Ham.-Buch.)
		Bhangon	LC	*Labeo bata* (Ham.-Buch.)
		Kuri	LC	*Labeo gonius* (Ham.-Buch.)
		Rahu	LC	*Labeo rohita* (Ham.-Buch.)
		Puthi	LC	*Pethia conchonius* (Ham.-Buch.)
		Seniputhi	LC	*Systomus sarana* (Ham.-Buch.)
		Kaniputhi	LC	*Puntius ticto* (Ham.-Buch.)
		Puthi	LC	*Puntius sophore* (Ham.-Buch.)
Osteoglo-ssiformes	Notopteridae	Kanduli	LC	*Notopterus notopterus* (Ham.-Buch.)
		Chital	NT	*Chitala chitala* (Pallas)

Perci-formes	Anabantidae	Kawoi	DD	*Anabas testudineus* (Bloch)
	Belontiidae	Kholihona	NE	*Tricogaster labiosus* (Ham.-Buch.)
		Kholihona	NE	*Tricogaster fasciata* (Bloch & Schneider)
		Vecheli	NE	*Tricogaster sota* (Ham.-Buch.)
	Channidae	Rongaseng	NT	*Channa bleheri* (Vierke)
		Goroi	LC	*Channa punctatus* (Bloch)
		Sol	NE	*Channa straitus* (Bloch)
		Sal	LC	*Channa marulius* (Ham.-Buch.)
	Chandidae	Chanda	LC	*Chanda nama* (Ham.-Buch.)
	Gobiidae	Patimutura	LC	*Glossogobius giuris* (Ham.-Buch.)
Siluri-formes	Bagridae	Rongasingora	LC	*Mystus tengara* (Ham.-Buch.)
		Laluasingora	LC	*Mystus cavasius* (Ham.-Buch.)
		Singora	LC	*Mystus bleekeri* (Day)
		Singora	LC	*Mystus vittatus* (Bloch)
		Gutasingora	LC	*Mystus dibrugarensis* (Chaudhuri)
	Heteropneustidae	Singi	LC	*Heteropneustes fossilis* (Bloch)
	Siluridae	Pavo	NT	*Ompok pabo* (Ham.-Buch)
		Pavo	NT	*Ompak pabda* (Hamilton)
		Pavo	NT	*Ompok bimaculatus* (Bloch)
	Claridae	Magur	EN	*Clarias magur* (Linnaeus)
Synbranc-hiformes	Mastacembelidae	Bami	LC	*Mastacembelus armatus* (Lacepede)
		Tura	LC	*Macrognathus pancalus* (Ham.-Buch.)
Tetraod-ontiformes	Tetraodontidae	Gongatop	LC	*Leiodon cutcutia* (Hamilton)

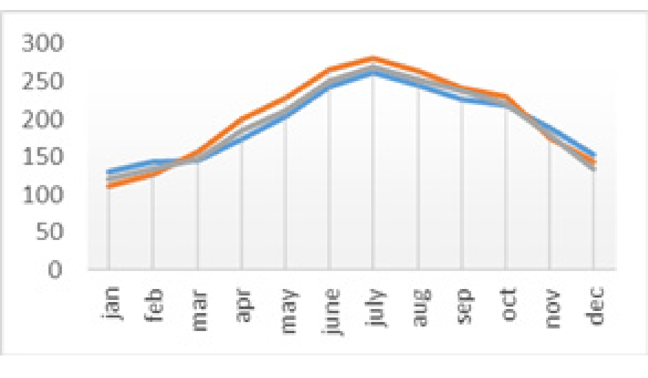

Figure 5) *Mean variation of TDS*

Ecology of the river

In this investigation, a total of 43 species belonging to 7 orders of 16 families were collected from fish landing sites of Dihing River. Fish species were recorded along with their order, family, vernacular name and scientific name (Table 2). Similarly, in rainy months, floating macrophytes like Eichhornia species and Pistia were observed in the river. Other macrophytes like Ipomoea, Ageratum, Commelina, Polygonum, Colocasia and Cynodon were observed in the bank. Among invertebrates, Bosmina species, Cyclops species, Brachionus species, Daphnia species, Tubifex species, Corbicula species, Hippeutis species, Lymnaea species, Indoplanorbis species. were frequently encountered. Checklist and IUCN status of ichthyofaunal diversity in the River Dihing is mentioned. According to the IUCN Red list of threatened species, 31 are least concern, 4 are near threatened, 1 is vulnerable and 1 is endangered. Pie diagrams of IUCN status of fish diversity in percentage are represented in Figure 6.

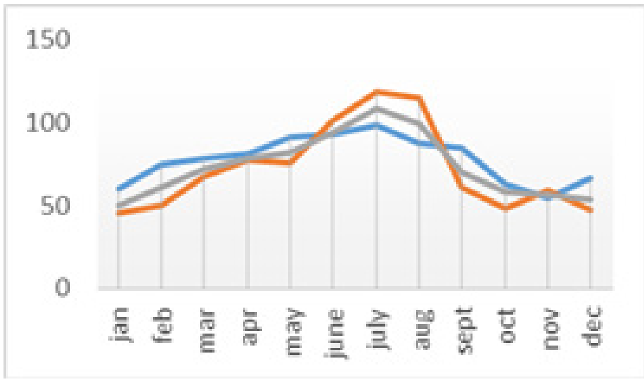

Figure 6) *Mean variation of TSS*

Role of fish diversity as alternative livelihood

Due to the richness of diversity, they have potential value to generate employment opportunities in rural areas. Moreover, unemployed as well as employed people also adopt fishing as a livelihood. During the period of investigation, it was observed that fishermen mainly went to catch fish in the evening and continued till dawn by using different fishing gears. In the morning mahaldar took all those fishes from the fisherman in auction i.e., called daak. After that fishmongers purchased those fishes from the mahaldar, and eventually, the fishes were made available to the local fish markets of Dibrugarh and Tinsukia. Fish has high nutritional value, and hence it is a staple food item in the diet of most of the people. Moreover, they have a great aesthetic value which increases its demand in national and international markets. Local fishes are always in demand among people as a food item. So, fish culture is very much beneficial to all, especially for unemployed people. By selecting it as an alternative livelihood it not only benefits fishermen but also keeps the diversity and population of species rich. Assam is struggling to build its economy through efficient resource utilization [7]. People belonging to rural areas, inhabiting the banks of rivers, mainly adopt fish culture as their livelihood. Different types of fish culture were seen in this river such as fish culture by using water hyacinth, katal fishing, pan culture etc. In the winter season of each year, farmers encircled an area with nets in the river mainly in the meanders and threw bamboo sticks called jang, woody bushes etc. Fishes within that area naturally grow, matured, breed and new batch arises. At post monsoon jangs were removed and fishes were collected (Figure 7).

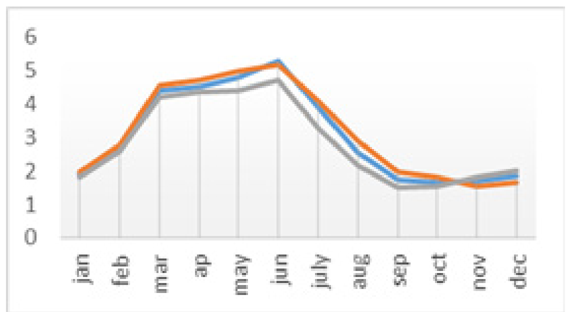

Figure 7) *Mean variation of Free CO_2*

This technique also helps to get rid of fish theft. Fish culture practice by using water hyacinth also provides great success. Here water hyacinths were grown at the periphery of the river and fishes were culture therein. In the monsoon season fishes were harvested in which fishermen first surrounded the water hyacinth by net and then by dragging the net up to the shore fishes were collected (Figure 8).Both katal and water hyacinth fishing were found to be commonly used techniques. In pan culture bamboo boxes are made in the river and fishes are culture in those boxes. This method is costlier than the other two methods. Hence, it was found that fishermen generally prefer the earlier two techniques of fish culture (Figure 9).

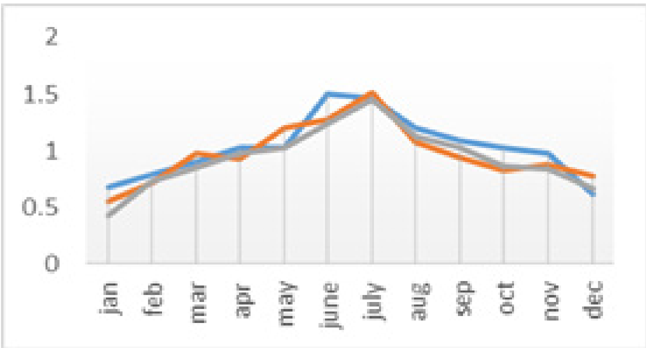

Figure 8) *Mean variation of water current*

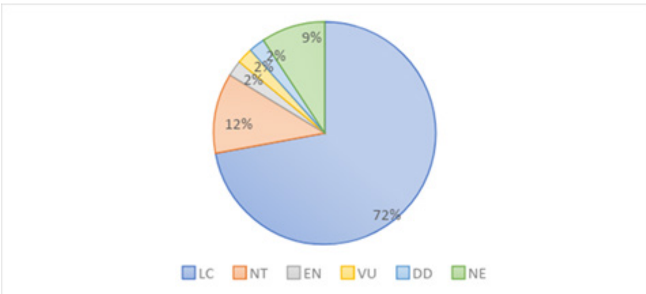

Figure 9) *Graphical representation of percentage of fish diversity order wise*

DISCUSSION

Water quality of the river

Aquatic ecosystem is not only a source of water and resources such as fish and crop for household and agro- industrial uses, but also a vital part of the natural environment for our own survival [8]. Abiotic parameters influenced in the structuring assemblages of fish Mathew et al. Therefore, limnological knowledge and its proper applications is an important tool for better fish yield and management of the ecosystems.

In the present study January was found to be the coldest month. Similar trends of air temperature were also recorded by [9]. In their studies. Higher air temperature in monsoon may be due to high solar radiation whereas low temperature in winter may be due to shorter day length in the Indian subcontinent. Air and water temperature showed a very characteristic annual cycle, with higher during summer and lower during winter. Similar fluctuation pattern of water temperature was reported by several workers in recent years elsewhere in NE India [10]. Changes in the air temperature naturally affect the water temperature [11]. Photoperiod is directly related to temperature. The summer temperature was always found above the winter temperature due to the lack of sunlight [12].

Alkalinity of water is the capacity to neutralize the acid and maintain homeostasis in animals. It is usually taken as an index of the productive potential of the water [13]. Seasonally it was found highest in monsoon and lowest in winter during study period. also reported similar results that it was maximum in summer and minimum in winter due to high photosynthetic rate. Larger quantities of bicarbonates during summer may be due to the liberation of free carbon-di-oxide in the process of decomposition of bottom sediments and domestic waste which probably resulted in conversion of insoluble carbonates to soluble bicarbonates [14]. Total alkalinity range between 20 and 100 mg/L is optimal for primary and secondary production in aquatic ecosystems. Thus, the River might be a good habitat for ichthyofaunal.

Dissolved oxygen is an important parameter which has a direct impact on the survival and distribution of flora and fauna in an ecosystem. In the present study, DO was found to be lowest in January but increased steadily and reached its maximum in August [15]. Reported that long day periods accelerate photosynthesis that resulted in increased DO in summer. Moreover, bright sunlight in summer influences the percentage of soluble gases in water. Dissolved oxygen (DO) concentration is directly related to flow velocity [16]. During non-rainy months, especially in winter, flow rate became feeble and consequently DO level dropped down. The high values in the rainy season might be due to aeration with continuous disturbance of the water from wind storms usually occurring in rainy months. In the present study too, DO values are altered by changing the pattern of the current velocity in the river [17].

High value of TDS and TSS during monsoon due to high sediment load, precipitation, deterioration and mixing run off rainwater. During monsoon, effluents released from nearby collieries and agricultural fields may mix with the river water. With rising temperature, more organic matter decomposes and mixes into the water. Probably this may be the cause of the increase of TDS and TSS along with the increase of temperature. The acceptable limit of TDS in drinking water is 500 mg/l (EPA, 1976; WHO, 1997). The range of TDS (112 to 281 mg/l) fell within the permissible limit. Thus, water is potable and may be utilized for human and animal consumption [18].

Transparency was found low during rainy seasons. This could be increased due to silt, debris, TSS, TDS into the river water. Reduced transparency during the rainy season may be due to reasons like excess sediments carried by runoff from the catchment areas, high water current eroded the bank of the river, suspended matter and dissolved particles. Moreover, R. Dihing has many sub tributaries. The cumulative impact of all the drainages resulted in low transparency in monsoon. Higher transparency during winter (dry season) might be due to settling of particles at the bottom [19].

The pH of an aquatic ecosystem is important because it is closely linked to biological productivity [20]. PH range will allow the fish survivability and its use as drinking water. The pH remained alkaline throughout the study period and its range (7.04 to 8.14) fell within the desirable limits of drinking water and fish culture as it did not exceed 6.5-8.5 (BIS, 1983). Variation of pH is due to the seasonal fluctuation of free CO_2 and carbonate. It was found to be higher in pre-monsoon and monsoon but lower in post-monsoon (Figure 3) [21].

The free CO_2 content of River Dihing was found between 1.52 and 5.79 mg/, well below the permissible limit and is an indicator of good quality of water. It showed an increasing trend along with ambient temperature from winter to monsoon. The higher values of free CO_2 recorded in pre-monsoon and monsoon might have been due to deoxygenation as well as high rate of decomposition of organic matter by the microbes. Natural acidity in rainwater is caused by the dissolution of atmospheric CO_2. The high CO_2 value is due to the entry of organic and inorganic nutrients from the surrounding areas [22-24].

TABLE 2

Multiple correlation of abiotic parameters

	WT	AT	Trans	WC	DO	Free CO_2	pH	Alk	TDS	TSS
WT	1									
AT	0.971^{**}	1								
Trans	-0.897^{**}	-0.949^{**}	1							

WC	0.842**	0.874**	-0.871**	1						
DO	0.795**	0.874**	-0.892**	0.893**	1					
FCO2	0.331	0.283	-0.241	0.558	0.318	1				
pH	-0.223	-0.137	0.174	-0.083	-0.186	0.436	1			
Alk	0.938**	0.983**	-0.944**	0.873**	0.906**	0.319	-0.056	1		
TDS	0.945**	0.966**	-0.967**	0.905**	0.882**	0.259**	-0.263	0.942**	1	
TSS	0.743**	0.797**	-0.819**	0.911**	0.868**	0.621*	0.138	0.849**	0.786**	1

Note: **Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)

The velocity of the river was found to be directly proportional to the 'flood pulse' and also with gradient of the river stretch. The most notable seasonal flooding due to extreme rainfall that triggered the current flow in the tropical river after monsoon rains. It also determines both food supply rates and energetic costs for fishes, affecting their behavior, position choice, and intra- and interspecific interactions [25-27]. The range of abiotic parameters of River Dihing X water was compared with the standard indexes and found within the desirable limit recognized by BIS (1983), WHO (1997), APHA (1998) for drinking water purpose and fish production. Instead of human activity less eutrophication was observed. Excessive fishing in this body was observed which may cause threat to ichthyofauna. There is an urgent need to arrest excessive fishing in the ~river [27-32].

CONCLUSION

From this present investigation it can be concluded that River Dihing has a diverse kind of ichthyofauna. Diversity richness is a measure that people can adopt as alternative livelihood by providing supply to national and international markets, different institutions, hotels etc. through proper channels. Proper scientific technique of fishing and fish culture will upgrade the status of fisherman's life and keep the diversity rich as well.

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