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Original Article

Fish Diversity and Water Quality Assessment of the River Damodar in and around Burdwan, West Bengal, India

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Abstract

The ichthyofauna in relation to water quality was studied on monthly basis from March 2014 to February 2015, in the Damodar River, Burdwan district, West Bengal. The result of present investigation reveals the occurrence of 35 species of fishes belonging to 6 Order, 15 families and 23 genera were recorded. Among the collected species Order Cyprinidontiforms constituting 41%, Order Perciformes constituting 37%, Order Siluriformes constituting 16%, of the total fish species. The highest richness was found in sampling site- 1– Krisak Setu. The maximum species richness (33) was recorded in site- 1 and low species richness (27) was recorded in site-2. The highest Shannon value was recorded to be (3.29) in site- 2. The low Shannon value was (2.68) in site- 3. Water parameters such as temperature, pH, alkalinity, dissolved oxygen, hardness, free CO_2, salinity, total inorganic nitrogen, and phosphate were recorded and found suitable for fish production. Conductivity, transparency, and high chloride level are minor limiting factor that may needs rectification for improved fisheries management.

Keywords: Fish Diversity; Water Parameters; Biodiversity Indices; Damodar River; Burdwan; West Bengal.

Introduction

The aquatic ecosystem is highly dependent on water quality and biological diversity. Physicochemical parameters of water play a significant role in the biology and physiology of fish (Dhawan and Kaur, 2002). Fish is very rich source of protein as well as vitamins and other minerals. In addition, to this nutrient values fishes are used in several medical treatments, provide aesthetic beauty in aquariums. Due to these multiple uses of fisheries resources, fishing has become a major industry in country like India and provided livelihood for several families. These important biological resources are under threat of extinction due to habitat and environmental degradation has critically affected the fauna of fishes. Knowledge on available information and the biological characters of fish species are provide the first hand information for further conservation aspects.

Important work has been done on fish diversity during the last few decades (Day, 1958; Jayaram, 1981; Menon, 1992; Shaji, 1995; Arunachalum, 2000; Daniel, 2001; Sarkar and Banarjee, 2000; Bhat, 2002; Mishra et al. 2003; Bossuyt et al. 2004; Rajalakshmi and Sreelatha 2006; Saha and Patra 2013; Bera et al. 2014).

The river Damodar, the prominent tributary of the holy river Ganges, is the synergistic life-line of the coal belt dwellers (1.2 million approx.) of Jharkhand and West Bengal at an elevation of about 7-10 m above mean sea level (MSL). The river is the main water source to the industries that produces 310 million tonnes of coal, 80 million tonnes of steel and 2,000 MW of thermal and hydel power, which together distribute substantially to the country's economy. Aquatic ecosystem is facing also the distorting effect as they are used as waste releasing source as well as the assimilating sink of them. The river water is the source for agriculture, community and industrial activities, power generation, fisheries, mining activity, navigation and different activities

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including sand mining and disposal of industrial and domestic wastes. At present indiscriminate anthropogenic activity has disturbed the global natural ecosystem in the name of developmental activities. Aquatic organisms are strongly influenced by physicochemical properties and a majority of them play a role of good ecological indicators of water quality. The productivity of aquatic systems including the production of fish which depends on the quality and quantity of planktonic organisms present may be influenced. Many factors such as dissolved oxygen, transparency, salinity, pH and temperature influence the occurrence, abundance and distribution of planktonic organisms. The Damodar is seasonal and flood prone mainly on account of different reasons, which are physiographic and meteorological in nature. Frequent floods ravage the lower valley area, which is not only very fertile owing to its alluvial plain suitable for irrigation and agriculture but also used for various industrial activities. Modifications of river course always bring about a variation in the hydrobiology and fishery of the river concerned, both upstream and downstream. In most of the cases, its effect on fishery of the river is adverse. Construction of barrage and dam has adversely affected the fishery of river. Damodar in its upstream is especially recognized for the migrant fish population. But the fishery of downstream has shown a continued upsurge after the commissioning of the barrage. Freshwater is the major determining factor for hydrology and fishery of any freshwater riverine system. The increased flushing of the river Damodar, and consequently the Barakar, has naturally resulted in major changes in ecology and associated chemistry of water body. The total area of Burdwan district is 7028 sq. Km and the area of Damodar basin is 2113.61 sq. Km. The 30.07% area of the district in the basin of Damodar River (About the Region – Damodar Basin, 2012).

Our main aim was to evaluate the suitability of water to nurture fishery activity. We describe the fish diversity in Damodar along Burdwan district, in connection with the physicochemical parameters of water, in order to formulate future planning for the development of the socioeconomic status of fishermen.

Materials and Methods

Study Site

Samplings are done from three sites around Burdwan. They are Site I: Krisak setu (23°12′N and 87°51′E); Site II: Barsul (23°10′N and 87°58′E) and Site III: Palla (23°09′N and 87°59′E).

Collection of Fish Samples

The study was conducted every last week of each month, between 6.00 and 8.00 a.m. The fish samples were captured with the help of local skilled fishermen in three pre selected sampling sites. Dragnet, cast net, Scoop net, Basket trap, and so forth were used for capturing fish. Fish species available at the local market and caught by local fishermen. All fish species were preserved in 10% formaldehyde solution for identification to genus and species level using taxonomic keys and standard literatures (Day, 1958; Talwar and Jhingran, 1991; Jayaram, 1981, 1999). In addition various morphological characters, shape, colors etc were recorded. The IUCN red list of threatened species was followed to assign the conservation status. The species richness was simply estimated by variety of fish species in 3 different sampling stations.

Collection of Water Samples

Samples of subsurface water were collected monthly in clean plastic air tight bottles at three above mentioned sites from March 2014 to February 2015, from 8 to 9.30 a.m. The water and air temperature were recorded by hydrothermometer and minimum-maximum thermometer, respectively; pH recorded by digital pH meter (Cystronics model 335); conductivity analyzed by conductivity meter (Labtronics model LT 16); dissolved oxygen examined by Winkler's method; photic depth measured by Secchi disc method; free CO_2, alkalinity, chlorinity, phosphorus, total inorganic nitrogen and hardness were calculated as standard laboratory protocol (APHA, 2008).

Biodiversity Indices

Margalef richness index (M), Simpson's index (D), Simpson's Index of Diversity (1-D), Simpson's Reciprocal Index (1/D), Shannon's diversity index (H) and Pielou's evenness index (J), biodiversity indices were calculated.

Statistical Analysis

Pearson Correlation matrix was calculated together with scatterplots and histograms were done using *XLSTAT* (Addinsoft 2010).

Results

The seasonal variation of physicochemical parameters of the water in the Damodar River,

Table 1: Fish species collected, their local names, Human use, feeding habit and conservation status in Damodar River around Burdwan

Order	Family	S. No	Scientific Name	Local Name	IUCN Status	Human Use	Feeding Habit	Abundance			
								Site 1	Site 2	Site 3	Total
Beloniformes	Belonidae	1	*Xenentodon cancila*	Kenkle	LC	Ornamental	Omnivore	02	00	01	03
Cyprinidontiformes	Aplocheilidae	2	*Aplocheilus panchax*	Kanpona	DD	Commercial	Herbivore	00	02	00	02
	Cyprinidae	3	*Amblypharyngodon mola*	Mourola	LC	Ornamental Commercial	Herbivore	03	01	01	05
		4	*Danio rerio*	Techokha	NT	Ornamental	Herbivore	08	09	05	22
		5	*Puntius ticto*	Punti	LC	Ornamental Commercial	Herbivore	24	35	25	84
		6	*Puntius sophore*	Punti	LC	Ornamental Commercial	Herbivore	14	19	11	44
		7	*Puntius conchonius*	Punti	VU	Ornamental Commercial	Herbivore	09	05	02	16
		8	*Labeo calbasu*	Kalbose	LC	Ornamental Commercial	Herbivore	00	05	01	06
		9	*Labeo bata*	Bata	LC	Aquaculture Commercial	Herbivore	05	09	06	20
		10	*Labeo rohita*	Rui	LC	Aquaculture Commercial	Herbivore	02	05	09	16
		11	*Cirrhinus mrigala*	Mrigel	LC	Commercial Aquaculture	Omnivore	05	00	06	11
		12	*Catla catla*	Katla	NE	Aquaculture Commercial	Herbivore	08	06	01	15
		13	*Amblypharyngodon mola*	Mourola	LC	Commercial	Herbivore	35	31	25	91
	Cobitidae	14	*Lepidocephalichthys guntea*	Guntey	LC	Ornamental Commercial	Omnivore	01	04	06	11
Clupeiformes	Clupeidae	15	*Gudusia chapra*	Khaira	LC	Commercial	Herbivore	15	09	12	36
Osteoglossiformes	Notopteridae	16	*Notopterus chitala*	Chital	EN	Ornamental Commercial	Omnivore	05	00	01	06
		17	*Notopterus notopterus*	Pholui	LC	Ornamental Aquaculture	Carnivore	01	05	02	08
Perciformes	Ambassidae	18	*Chanda ranga*	Chanda	NE	Ornamental Commercial	Omnivore	02	06	02	10
		19	*Chanda nama*	Chanda	LC	Ornamental Commercial	Omnivore	09	05	04	18
	Channidae	20	*Channa punctata*	Lata	LC	Ornamental Aquaculture	Carnivore	19	14	24	57
		21	*Channa marulias*	Sal	LC	Ornamental Aquaculture	Carnivore	05	00	03	08
		22	*Channa gachua*	Chang	LC	Ornamental Commercial	Carnivore	05	02	00	07

Table 1: Fish species collected, their local names, human use, feeding habit and conservation status in Damodar River around Burdwan

		23	*Channa striatus*	Sol	NE	Ornamental Commercial	Carnivore	01	03	01	05
	Gobiidae	24	*Glossogobius giuris*	Bele	LC	Ornamental Commercial	Omnivore	09	18	12	39
	Nandidae	25	*Nandus nandus*	Bheda	LC	Ornamental Commercial	Carnivore	04	00	01	05
	Osphronemidae	26	*Colisa fasciata*	Khalisa	LC	Ornamental	Omnivore	25	35	30	90
		27	*Colisa lalia*	Khalisa	NE	Ornamental	Omnivore	30	25	20	75
Siluriformes	Bagridae	28	*Mystus cavassius*	Tengra	LC	Commercial	Carnivore	25	10	19	54
		29	*Mystus aor*	Aard	VU	Ornamental Commercial	Carnivore	12	06	09	27
		30	*Mystus seenghala*	Tangra	NE	Commercial Aquaculture	Carnivore	02	00	01	03
	Clariidae	31	*Clarias batrachus*	Magur	LC	Ornamental Commercial	Carnivore	13	08	11	32
	Siluridae	32	*Heteropneustes fossilis*	Singi	LC	Ornamental Commercial	Carnivore	04	05	02	11
		33	*Wallago attu*	Boal	NT	Commercial	Carnivore	02	00	01	03
	Mastacembelidae	34	*Macrognathus pancalus*	Pankal	NT	Ornamental Commercial	Omnivore	02	02	00	04
		35	*Macrognathus armatus*	Ban	LC	Commercial	Carnivore	02	00	01	03
			Total					308	284	255	847

IUCN Red list: DD: Data Deficient, LC: Least Concern, VU: Vulnerable, NE: Not Evaluated, EN: Endangered, NT: Near Threatened.

Table 2: Biodiversity Indices of fish species at three different sites of the river Damodar around Burdwan

Index	Site I	Site II	Site III
Total No. of Species (S)	33	27	32
Total No. of Individuals (N)	308	284	255
Natural Log of Species (ln S)	3.49	3.29	3.46
Natural Log of Individuals (ln N)	5.73	5.64	5.54
Margalef's Index (M)	5.56	4.60	5.59
Simpson's Index (D)	0.05	0.06	0.06
Simpson's Index of Diversity (1-D)	0.95	0.94	0.93
Simpson's Reciprocal Index (1/D)	20	16.6	15.87
Shannon Index (H)	2.98	3.29	2.68
Pielou's Index (J)	0.856	0.82	0.77

Table 3: Correlation matrix (Pearson) representing the relationship of the environmental variables observed during study period (March 2014 to February 2015) study period. Note the values in bold represents significance at P < 0.001 level

Variables	at	wt	h	r	TR	con	pH	DO	ALK	CHOL	PHOS	In N	hard	SAL
at	**1**	**0.867**	-0.219	0.015	-0.345	**0.887**	0.278	-0.307	0.433	**0.704**	0.106	0.203	0.258	**0.703**
wt	**0.867**	**1**	0.097	0.362	-0.348	**0.786**	0.225	-0.357	0.270	**0.578**	0.313	0.479	0.397	**0.585**
h	-0.219	0.097	**1**	**0.722**	-0.015	-0.174	-0.265	-0.031	-0.144	0.007	0.333	**0.607**	0.331	-0.001
r	0.015	0.362	**0.722**	**1**	-0.231	-0.126	-0.294	-0.478	-0.389	0.056	-0.063	0.327	0.019	0.019
TR	-0.345	-0.348	-0.015	-0.231	**1**	-0.341	**0.728**	**0.860**	0.474	-0.060	0.143	0.235	0.544	-0.059
con	**0.887**	**0.786**	-0.174	-0.126	-0.341	**1**	0.203	-0.217	**0.599**	**0.750**	0.261	0.262	0.331	**0.752**
pH	0.278	0.225	-0.265	-0.294	**0.728**	0.203	**1**	**0.713**	**0.636**	0.186	0.315	0.403	**0.655**	0.213
DO	-0.307	-0.357	-0.031	-0.478	**0.860**	-0.217	**0.713**	**1**	0.492	-0.188	0.461	0.370	**0.608**	-0.152
ALK	0.433	0.270	-0.144	-0.389	0.474	**0.599**	**0.636**	0.492	**1**	**0.733**	0.236	0.279	**0.635**	**0.741**
CHOL	**0.704**	**0.578**	0.007	0.056	-0.060	**0.750**	0.186	-0.188	**0.733**	**1**	-0.111	0.081	0.310	**0.988**
PHOS	0.106	0.313	0.333	-0.063	0.143	0.261	0.315	0.461	0.236	-0.111	**1**	**0.850**	**0.655**	-0.081
In N	0.203	0.479	**0.607**	0.327	0.235	0.262	0.403	0.370	0.279	0.081	**0.850**	**1**	**0.770**	0.082
hard	0.258	0.397	0.331	0.019	0.544	0.331	**0.655**	**0.608**	**0.635**	0.310	**0.655**	**0.770**	**1**	0.345
SAL	**0.703**	**0.585**	-0.001	0.019	-0.059	**0.752**	0.213	-0.152	**0.741**	**0.988**	-0.081	0.082	0.345	**1**

at: Air Temperature (°C), wt: Water Temperature (°C), h: humidity (%), r: rainfall (mm), tr: Transparency (cm), con: Conductivity (µmho/cm), pH, DO: Dissolved Oxygen (mg/L), alk: Alkalinity (mg/L), chol: Chloride (mg/L), phos: Phosphate (mg/L), inN: Inorganic Nitrogen (mg/L), hard: Hardness (ppm), sal: Salinity (ppt)

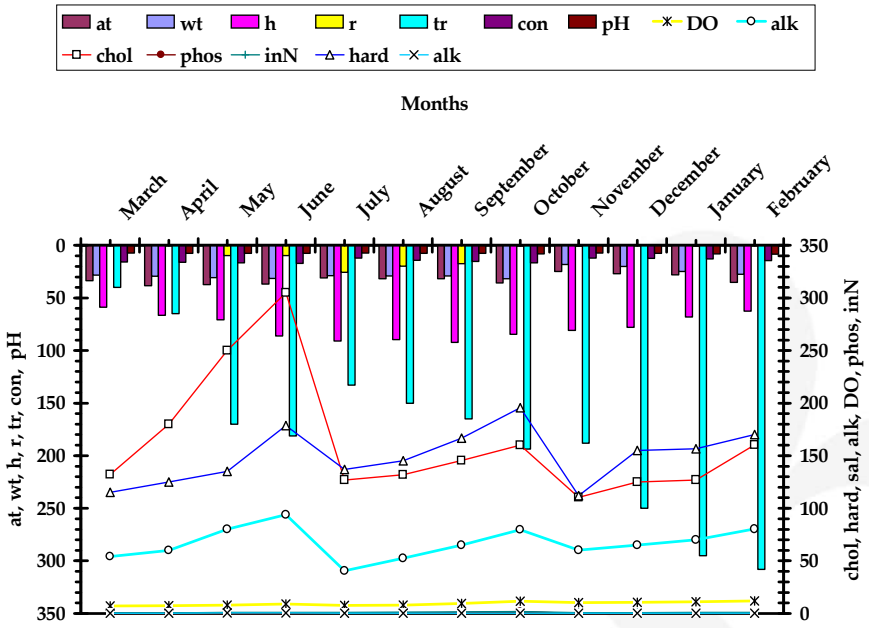


Fig. 1: Seasonal variation of physicochemical parameters of the water in the Damodar River, Burdwan district, West Bengal, March 2014 to February 2015

at: Air Temperature (°C), wt: Water Temperature (°C), h: humidity (%), r: rainfall (mm), tr: Transparency (cm), con: Conductivity (µmho/cm), pH, DO: Dissolved Oxygen (mg/L), alk: Alkalinity (mg/L), chol: Chloride (mg/L), phos: Phosphate (mg/L), inN: Inorganic Nitrogen (mg/L), hard: Hardness (ppm), sal: Salinity (ppt).

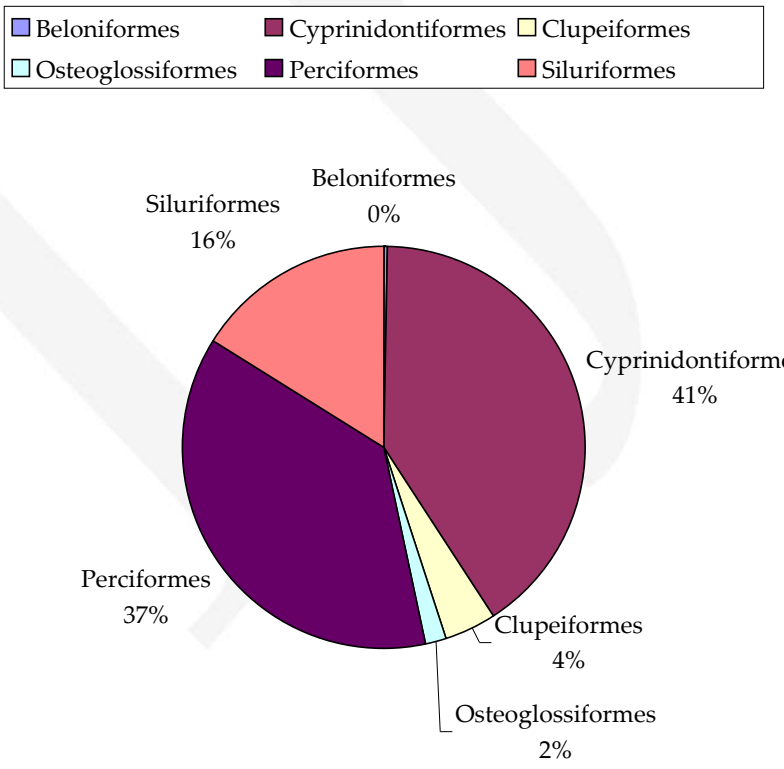


Fig. 2: Percentage representation of species at Order level in the exploited fishery in River Damodar (March 2014 to February 2015)

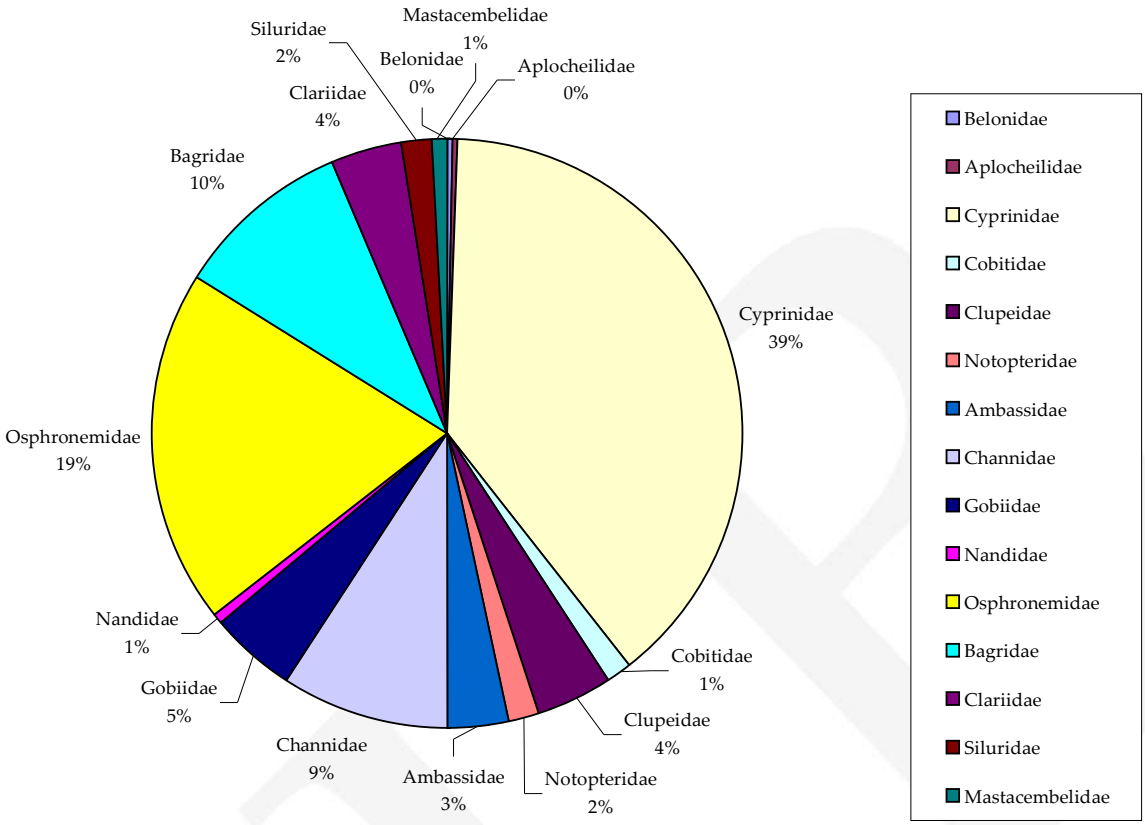


Fig. 3: Percentage representation of species at family level in the exploited fishery in River Damodar (March 2014 to February 2015)

Burdwan district, West Bengal, March 2014 to February 2015 is depicted in Figure 1, and the data on the fish community of the river Damodar is presented in Table 1. The periodical survey of the ichthyofauna revealed the occurrence of 35 species of fishes belonging to 6 Order, 15 families and 23 genera were recorded over a period of one year, from March 2014 to February 2015 (Figure 2 and Figure 3). Among the collected species Order Cyprinidontiforms constituting 41%, Order Perciformes constituting 37%, Order Siluriformes constituting 16%, of the total fish species. The data of Diversity Indices are presented in Table 2. Pearson Correlation matrix was calculated (Table 3) and scatterplots and histograms were plotted (Figure 4) which shows the correlations between environmental parameters affected in distribution of fish species. The highest richness was found in sampling site- 1– Krisak Setu. The maximum species richness (33) was recorded in site- 1 and low species richness (27) was recorded in site-2. The highest Shannon value was recorded to be (3.29) in site- 2. The low Shannon value was (2.68) in site- 3. Habitat loss and environmental degradation has seriously affected the fish fauna. Recent data regarding fish diversity of the study site, aiming to contribute a better knowledge of the fish diversity and a tool for conservation planning of aquatic environments in this region. To maintain fish biodiversity has an immense importance as it is not always possible to identify individual species critically to sustain aquatic ecosystem.

Discussions

Ichtyofaunal diversity is affected by aquatic habitat and water quality parameters. Temperature is the important factor for the aquatic biota. According to FAO report (FAO, 2010), the increase of temperature directly or indirectly impacts species distribution and the seasonality of production in fishes. According to the guidelines for water quality management for fish culture, the suitable water temperature for carp culture ranges between 24°C and 30°C. So, the water temperature of the river Damodar was suitable, except a minute fall during the winter season. Transparency helps to assess the quality of water. According to (Bhatanagar et al. 2004) a turbidity ranging from 30 to 80 cm is good for fish health. High transparency value means that enough light penetrates and encourages macrophytes growth, so that less plankton is available as food for fish. Water transparency in the study sites was not completely satisfactory.

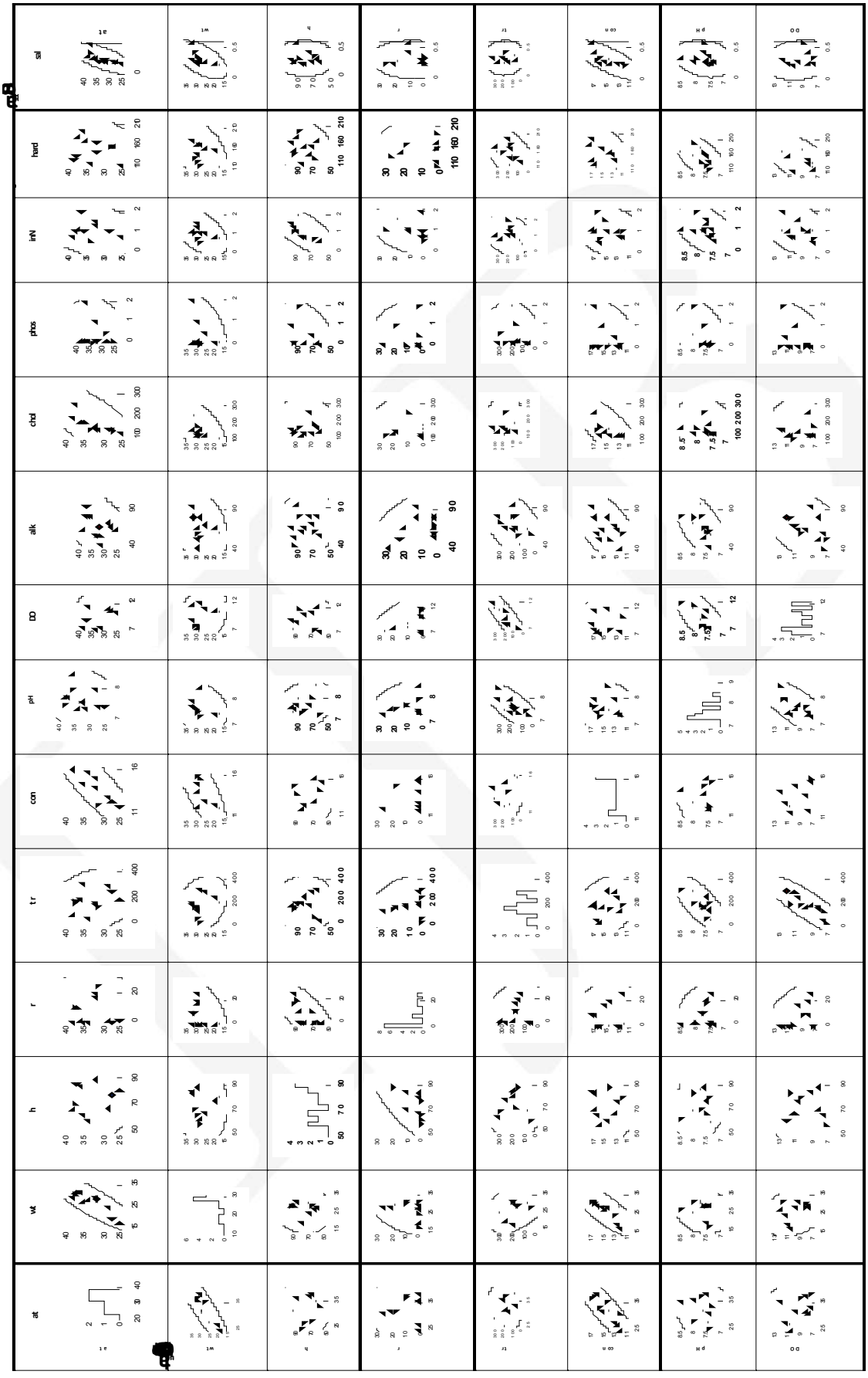
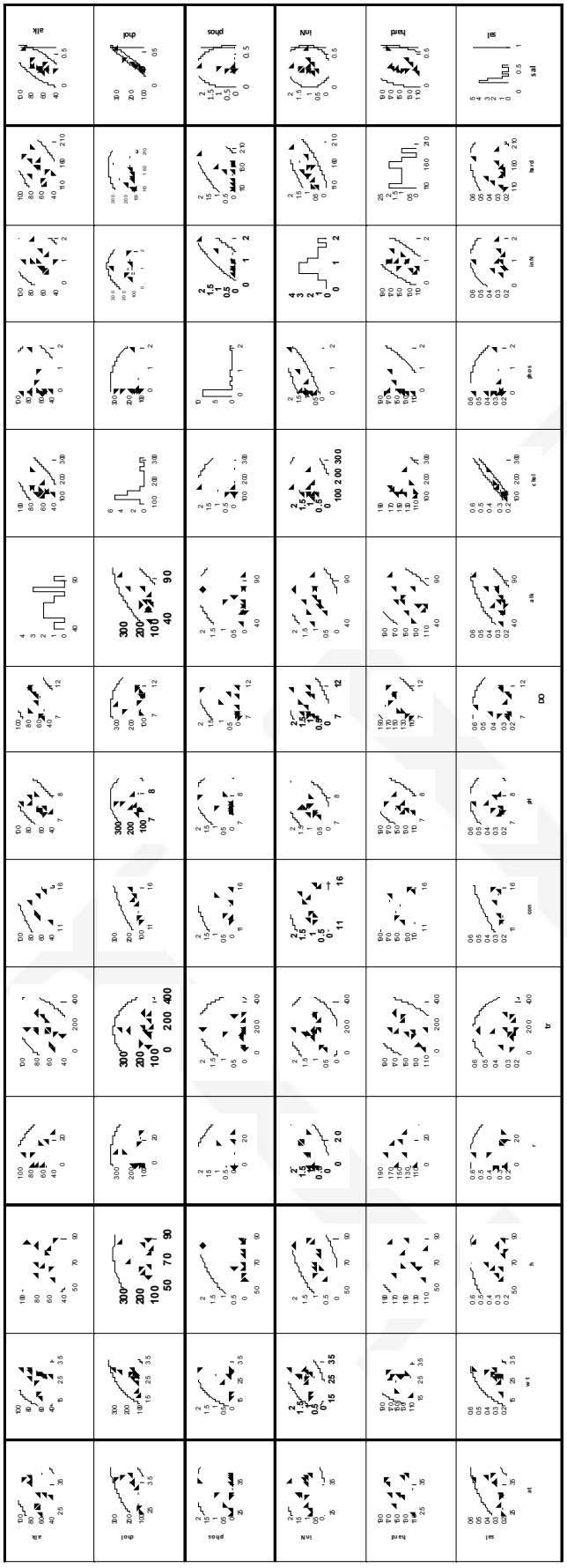


Fig. 4: The scatterplots, histogram representing the relationship of the environmental variables atmospheric as well as water parameters observed during one year study period (March 2014 to February 2015) in the Damodar River, Burdwan district, West Bengal, India



at: Air Temperature (°C), wt: Water Temperature (°C), h: humidity (%), r: rainfall (mm), tr: Transparency (cm), con: Conductivity (µmho/cm), pH, DO: Dissolved Oxygen (mg/L), alk: Alkalinity (mg/L), chol: Chloride (mg/L), phos: Phosphate (mg/L), inN: Inorganic Nitrogen (mg/L), hard: Hardness (ppm), sal: Salinity (ppt)

Electrical conductivity, comprising the total dissolved ions, is a good indicator of water chemistry. A certain level of ions in water is essential as nutrients for aquatic life (Galbrand et al. 2008). According to the report of Southern Regional Aquaculture Centre (SRAC) (Stone et al. 2013), the desirable range of conductivity for fish culture is 60–2000 µmho/cm. Our results showed values that were lower than the optimal limit. SRAC also reported that fresh water fish generally thrive over a wide range of electrical conductivity and that the upper range of tolerance varies with fish species.

pH is another important parameter for fish culture. According to the report of Northeastern Regional Aquaculture Centre (NRAC) (Buttner 1993), fish survive and grow best in waters with a pH between 6 and 9. The pH values we recorded in the river Damodar remained within such safe range.

Dissolved oxygen is one of the most important parameters and a primary limiting factor controlling fish growth and survival (Qayyum et al. 2005). According to Banerjea 1967, D.O. should be above 5.0 mg/L for average or good production. Besides, Bhatnagar and Singh, 2010 also reported that D.O. level > 5.0 mg/L is essential to support good fish production. The D.O. content in the river Damodar was very satisfactory for fish culture.

Alkalinity of water is a measure of its capacity to neutralize acids. According to the guidelines for water quality management for fish culture in Tripura, the ideal value of alkalinity for fish culture is 50–300mg/L. According to the report of SRAC, the desirable limit for fish culture is 50 to 150mg/L, and the acceptable range is from 20 to 400 mg/L. So, the alkalinity range of river Damodar permits the fisheries activity.

According to SRAC, more than 100mg/L is the desirable range for commercial catfish production. So, the chloride value of the river Damodar was very high and stressful for fish culture. Higher chloride content may be due to contamination through large quantity of sewage input (Yousuf et al. 2012). Higher concentration of chloride in water is an indicator of

eutrophy (Kausik et al. 1992). The higher concentration of chloride in the river Damodar may be due to agricultural and sewage run-off during rain from the surrounding area of the reservoir and higher evaporation rate. In most fresh waters, total hardness is mainly due to calcium and magnesium ions. According to the guidelines for water quality management for fish culture in Tripura, the ideal value of hardness for fish culture is 30–180mg/L. Bhatnagar et al. 2004 opined that 75–150mg/L is optimum for fish culture. The hardness in river Damodar was slightly outside the desirable limits but did not reach harmful values. Some euryhaline species may have high tolerance limits to hardness (Bhatnagar and Devi, 2013).

Carbon dioxide is produced in water as a result of respiration of the aquatic organisms. According to the report of NRAC, the preferred range of free $CO_2 \leq$ 10mg/L. Besides, the guidelines for water quality management for fish culture in Tripura also mentioned that water supporting abundant fish populations should contain ≤ 5mg/L free carbon dioxide.

Phosphorus is very critical in maintaining aquatic productivity. SRAC recommend desirable phosphate level for fish culture of 0.06mg/L, and the typical range for surface water is 0.005–0.5mg/L. Bhatnagar and Devi, 2013 reported an optimum range for phosphorus of 0.01–3.0mg/L. The value of phosphate in river Damodar matched the ranges given above.

Nitrogen element is a vital component of protein and is essential for fish growth. FAO recommends desirable limit of total dissolved nitrogen for fish culture of 0.2 ppm. On the other hand, Banerjea 1967 reported TDN values of 0.2–0.5 ppm as favourable for good productivity in ponds. Other than during the rainy season, the total level of inorganic or dissolved nitrogen in the river Damodar is acceptable for fish culture and does not hamper the fish production. Throughout the year, water level in the river Damodar falls from April to June but still remains in adequate amount for fish cultivation.

Therefore, each water quality parameter in the river Damodar remains within the limits suitable for fish production (Stone et al. 2013; Buttner 1993;Banerjea 1967; Bhatnagar and Devi, 2013). The end of the rainy season and the whole winter are the best and the healthier periods for fish growth.

We conclude that water quality in the river Damodar favours for fish cultivation and allows for a high ichthyofaunal diversity, with a value of highest Shannon value was recorded to be (3.29) in site- 2. The low Shannon value was (2.68) in site- 3. We recommend the adoption of scientific fishery management, in order to regulate transparency and chloride level.

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