Research Article

Ichthyofaunal Diversity and Water Quality in the Kangsabati Reservoir, West Bengal, India

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The ichthyofauna in relation to water quality was studied on monthly basis from March, 2010 to February, 2011 in the Kangsabati Reservoir, West Bengal. The study revealed that physicochemical parameters of Kangsabati Reservoir were congenial for 39 fish species of commercial importance, belonging to 7 orders, 15 families, and 26 genera. The Cypriniformes were dominant with 17 species, followed by Siluriformes and Perciformes, with 7 species each, Channiformes with 3 species, Osteoglossiformes and Synbranchiformes with 2 species each, and Anguilliformes with 1 species. Regarding their conservation status, 27 species were of least concern, 1 species was vulnerable, 6 species were near threatened, 1 species was data deficient, and 4 species were not evaluated (IUCN-Version 2014.1). Economical values have also been evaluated. Water parameters such as temperature, pH, alkalinity, dissolved oxygen, hardness, free CO₂, 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.

1. 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 [1]. Lakes and reservoirs contribute to the single largest inland fishery resources in terms of both size and production potential. Fishes are the important indicator of aquatic ecosystem and occupy a remarkable position from a socioeconomic point of view. Fish is very rich source of protein as well as vitamins and other minerals. Kangsabati Reservoir is situated between 22°55'16.53"N–23°2'30.41"N latitude and 86°37'55.30"E–86°47'23.35"E longitude, about 67 Km southwest from the Bankura District Town, West Bengal, India. The reservoir is used not only for irrigation but also for fish production by Fishery Department, Government of West Bengal, through the involvement of local fishermen communities. The structure of fish community, fish distribution, and ichthyofauna diversity has been reported by various workers in the different lakes and reservoirs [2–19]. But comprehensive information of Kangsabati Reservoir

(Figure 1) on fish diversity in relation to water quality is inadequate to frame a tangible fisheries programme.

In the present study, our main aim was to evaluate the suitability of water to nurture fishery activity, by recording water parameters. We describe the fish diversity in Kangsabati reservoir, in connection with the physicochemical parameters of water, in order to formulate future planning for the development of the socioeconomic status of fishermen.

2. Materials and Methods

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 preselected sampling sites. Dragnet, Castanet, Scoop net, Basket trap, and so forth were used for capturing fish. Fish species available at the local market and caught by local fishermen from the reservoir were also purchased. All fish species were preserved in 10% formaldehyde solution for identification to genus and species level using taxonomic keys and standard literatures [20–23].

FIGURE 1: View of the Kangsabati Reservoir (blue shaded area indicating reservoir area in inset).

Samples of subsurface water were collected monthly in clean plastic air tight bottles at three stations (local names: Sadarghat, Aparajitghat, and Peerlessghat) from March 2010 to February 2011, 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, calcium, magnesium and hardness were calculated as standard laboratory protocol [24]. The diversity was calculated on number of species, while the orders were used to calculate the Shannon-Wiener index.

3. Results

The value of water parameters is depicted in Table 1, and the data on the fish community of the Kangsabati Reservoir are presented in Tables 2, 3, and 4. The periodical survey of the ichthyofauna revealed the occurrence of 39 species belonging to 15 families, 26 genera, and 7 orders. On the basis of species composition, Cypriniformes were dominant (17 species) followed by Siluriformes and Perciformes (each of 7 species), Channiformes (3 species), Osteoglossiformes and Synbranchiformes (each of 2 species), and Anguilliformes (1 species).

4. Discussion

Among the studies on ichthyofaunal diversity previously conducted for our region in large aquatic bodies like the Kangsabati Reservoir, [25] reported the occurrence of 26 fish species belonging to 5 orders, 7 families, and 15 genera in Godavari river at Mudgal. The order Cypriniformes was dominant with 15 species, followed by Siluriformes with 5 species, Channiformes with 4 species, and Mastacembeliformes and Perciformes with 1 species each. Similar results, a total of 29 fish species belonging to 10 families, 7 orders, and 15 genera were reported for the Halali Reservoir, Vidisha, Madhya Pradesh [26].

The aquatic habitat and water quality parameters affect the fish growth and development and ichthyofaunal diversity. Temperature is the important factor for the aquatic biota. According to FAO report [31], 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 in Tripura, the suitable water temperature for carp culture ranges between 24°C and 30°C . So, the water temperature of Kangsabati Reservoir was very suitable, except a minute fall during the winter season.

Transparency helps to assess the quality of water. According to [32] a turbidity ranging from 30 to 80 cm is good for fish health. On the other hand, according to guidelines for water quality management for fish culture in Tripura [33],

TABLE 1: Seasonal variation of physicochemical parameters of the water in Kangsabati Reservoir, March 2010–February 2011.

Parameters (units)	Summer season (March–June)	Rainy season (July–October)	Winter season (November–February)
Air temperature (°C)	33.58–36.83	31.06–35.83	25.0–35.25
Water temperature (°C)	28.16–31.50	28.80–31.66	18.33–27.83
Transparency (cm)	40.83–181.66	133.0–193.6	188.1–308.5
Conductivity ($\mu\text{mho/cm}$)	15.73–17.11	12.14–16.43	11.95–14.47
pH	7.32–7.72	7.38–7.98	7.42–8.45
D.O. (mg/L)	7.20–9.00	7.60–11.60	10.40–12.00
Alkalinity (mg/L)	54.33–94.00	40.67–79.66	60.33–80.34
Chloride (mg/L)	132.91–305.3	127.4–160.93	110.9–160.40
Phosphate (mg/L)	0.014–0.041	0.098–0.199	0.037–0.062
Total inorganic nitrogen (mg/L)	0.50–1.08	1.06–1.96	0.74–1.02
Hardness (ppm)	115.18–178.6	137.00–195.36	112.60–170.60
Salinity (ppt)	0.26–0.57	0.25–0.31	0.22–0.31
Photic depth (cm)	32.66–170.00	117.00–176.60	163.00–287.00
Free CO ₂ (ppm)	3.66–4.00	3.33–7.00	3.66–9.66
Water level (ft)	396.00–399.00	405.00–432.80	409.20–415.80
Rainfall (average in mm)	4.30–138.20	90.80–213.60	0.00–34.80
Plankton population			
Plankton density (ind/L)	1362–2183	965–1681	1253–2240

transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture. 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 Kangsabati Reservoir was not completely satisfactory.

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 [34]. According to the report of Southern Regional Aquaculture Centre (SRAC) [35], the desirable range of conductivity for fish culture is 60–2000 $\mu\text{mho/cm}$. 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) [36], fish survive and grow best in waters with a pH between 6 and 9. The pH values we recorded in the Kangsabati Reservoir remained within such safe range.

Reference [37] experimentally proved that dissolved oxygen is one of the most important parameters and a primary limiting factor controlling fish growth and survival. According to [38], D.O. should be above 5.0 mg/L for average or good production. Besides, [39] also reported that D.O. level > 5.0 mg/L is essential to support good fish production. The D.O. content in Kangsabati Reservoir 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 50–300 mg/L. According to the report of SRAC, the desirable limit for fish culture is 50 to 150 mg/L, and the acceptable range is from 20 to 400 mg/L. So, the alkalinity range of Kangsabati Reservoir permits the fisheries activity.

According to SRAC, more than 100 mg/L is the desirable range for commercial catfish production. So, the chloride value of the Kangsabati Reservoir was very high and stressful for fish culture. Higher chloride content may be due to contamination through large quantity of sewage input [26]. Higher concentration of chloride in water is an indicator of eutrophy [40]. The higher concentration of chloride in the Kangsabati Reservoir 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 30–180 mg/L. Reference [32] opined that 75–150 mg/L is optimum for fish culture. The hardness in Kangsabati Reservoir was slightly outside the desirable limits but did not reach harmful values. Some euryhaline species may have high tolerance limits to hardness [41].

Carbon di oxide is produced in water as a result of respiration of the aquatic organisms. According to the report of NRAC, the preferred range of free CO₂ $\leq$ 10 mg/L. Besides, the guidelines for water quality management for fish culture in Tripura also mentioned that water supporting abundant fish populations should contain $\leq$ 5 mg/L free carbon dioxide.

TABLE 2: Fish species in Kangsabati Reservoir from March 2010 to February 2011 [27–30].

Sl. number	Order	Family	Scientific name	Common name	Local name	Lucr status	Seasonal abundance	Economic value
1	Cypriniformes	Cyprinidae	<i>Labeo rohita</i> (Ham.)	Rohu	Rui	LC	TY	Food fish
2			<i>Labeo calbasu</i> (Ham.)	Black rohu/karnataka labeo	Kalbose	LC	TY	Food fish
3			<i>Labeo bata</i> (Ham.)	Bata labeo/minor carp	Bata	LC	SM	Food fish
4			<i>Puntius ticto</i> (Ham.)	Ticto barb	Tit punti	LC	SM	Ornamental, food fish
5			<i>Puntius sophore</i> (Ham.)	Pool barb	Jatpunti	LC	SM	Ornamental
6			<i>Puntius gelius</i> (Ham.)	Golden dwarf barb	Dor punti	LC	SM	Ornamental
7			<i>Catla catla</i> (Ham.)	Catla	Catla	LC	TY	Food fish
8			<i>Amblypharyngodon mola</i> (Ham.)	Mola carplet	Mourala	LC	SM	Ornamental
9			<i>Amblypharyngodon microlepis</i> (Bleeker)	Indian carplet	Mourala	LC	SM	Ornamental
10			<i>Rasbora daniconius</i> (Ham.)	Slender rasbora	Siram punti	LC	TY	Ornamental
11			<i>Cirrhinus mrigala</i> (Ham.)	Mrigal	Mrigal/Mrig	LC	RS	Food fish
12			<i>Cirrhinus reba</i> (Ham.)	Reba carp	Bhangonbata	LC	SM	Food fish
13			<i>Cyprinus carpio</i> (Linn.)	Wild common carp	Cyprinus	VU	TY	Ornamental/food fish
14			<i>Esomus danricus</i> (Ham.)	Flying barb	Darkya	LC	TY	Ornamental
15			<i>Salmostoma bacaila</i> (Ham.)	Large razorbelly minnow	Chela	LC	SM	Food fish/ornamental
16			<i>Hypophthalmichthys molitrix</i> (Val.)	Silver carp	Silver carp	NT	TY	Food fish
17			<i>Ctenopharyngodon idella</i> (Val.)	Grass carp	Grass carp	NE	TY	Food fish
18	Perciformes	Ambassidae	<i>Chanda ranga</i> (Ham.)	Indian glassy fish	Ranjanchanda	LC	WN	Ornamental
19			<i>Chanda nama</i> (Ham.)	Elongate glass-perchlet	Kanta chanda	LC	TY	Ornamental
20			<i>Oreochromis niloticus</i> (Linn.)	Nile tilapia	Nilontica	NE	TY	Food fish
21		Cichlidae	<i>Oreochromis mossambicus</i> (Peters)	Mozambique tilapia	Tilapia	NT	TY	Food fish
22			<i>Trichogaster lalius</i> (Ham.)	Dwarf gourami	Khoira	LC	SM	Ornamental
23		Anabantidae	<i>Anabas testudineus</i> (Bloch)	Climbing perch	Koi	DD	TY/RS	Ornamental
24		Gobiidae	<i>Glossogobius giuris</i> (Ham.)	Bareye goby	Bele	LC	WN	Ornamental/food fish
25		Siluridae	<i>Ompok pabda</i> (Ham.)	Pabda catfish	Pabda	NT	SM	Food fish
26			<i>Wallago attu</i> (Bl. & Schn.)	Fresh water shark	Boal	NT	WN	Food fish/ornamental
27			<i>Clarias batrachus</i> (Linn.)	Air breathing catfish	Magur	LC	WN	Ornamental/food fish
28		Heteropneustidae	<i>Heteropneustes fossilis</i> (Bloch)	Stinging catfish	Singhi	LC	SM	Ornamental/food fish
29			<i>Mystus vittatus</i> (Bloch)	Striped dwarf catfish	Tangra	LC	WN	Ornamental/food fish
30		Bagridae	<i>Mystus tengara</i> (Ham.)	Tengara catfish	Tangra	LC	WN	Food fish/ornamental
31		Schilbeidae	<i>Eutropiichthys vacha</i> (Ham.)	Bacha	Bacha	LC	WN	Food fish

TABLE 2: Continued.

Sl. number	Order	Family	Scientific name	Common name	Local name	Iucn status	Seasonal abundance	Economic value
32	Synbranchiformes	Mastacembelidae	<i>Macrogynathus pancalus</i> (Ham.)	Barred spiny eel	Pacal	LC	WN	Food fish
33			<i>Macrogynathus aculeatus</i> (Bloch)	Lesser spiny eel	Pacal	NE	WN	Ornamental/food fish
34	Channiformes	Channidae	<i>Channa punctata</i> (Bloch)	Spotted snakehead	Lata	LC	SM	Food fish/ornamental
35			<i>Channa striata</i> (Bloch)	Stripped or Snakehead murrel	Shol	LC	SM	Food fish/ornamental
36			<i>Channa orientalis</i> (Bl. & Schn.)	Walking snakehead	Cheng	NE	SM	Food fish
37	Osteoglossiformes	Notopteridae	<i>Notopterus notopterus</i> (Pallas)	Bronze featherback	Folui	LC	WN	Ornamental/food fish
38			<i>Notopterus chitala/Chitala chitala</i> (Ham.)	Humped featherback	Chital	NT	WN	Ornamental/food fish
39	Anguilliformes	Anguillidae	<i>Anguilla bengalensis</i> (Gray)	Indian mottled eel	Ban fish	NT	RS	Ornamental

LC = least concern, VU = vulnerable, NT = near threatened, NE = not evaluated, DD = data deficient; WN = winter, SM = summer, TY = throughout the year, and RS = rainy season.

TABLE 3: Composition of the fish community by order.

Sl. number	Taxa	Number of species	Percentage (%)
1	Order: Cypriniformes	17	43.58
2	Order: Perciformes	7	17.95
3	Order: Siluriformes	7	17.95
4	Order: Channiformes	3	7.69
5	Order: Osteoglossiformes	2	5.13
6	Order: Synbranchiformes	2	5.13
7	Order: Anguilliformes	1	2.57
Total		39	

TABLE 4: Composition of the fish community by family.

Sl. number	Taxa/families	Number of Species	Percentage (%)
1	Family: Cyprinidae	17	43.58
2	Family: Ambassidae	2	5.12
3	Family: Cichlidae	2	5.12
4	Family: Osphronemidae	1	2.57
5	Family: Anabantidae	1	2.57
6	Family: Gobiidae	1	2.57
7	Family: Siluridae	2	5.13
8	Family: Claridae	1	2.57
9	Family: Heteropneustidae	1	2.57
10	Family: Bagridae	2	5.13
11	Family: Schilbeidae	1	2.57
12	Family: Channidae	3	7.69
13	Family: Notopteridae	2	5.12
14	Family: Mastacembelidae	2	5.12
15	Family: Anguillidae	1	2.57
Total		39	

Reference [41] clearly indicated an acceptable range of 0–10 mg/L and a desirable range of <5, 5–8 mg/L of free CO₂ for high fish yield. The CO₂ values we recorded for the Kangsabati Reservoir can strongly support fish culture.

Salinity limits may vary from species to species of fish [41]. According to the report of NRAC, the preferred ranges for fresh water fish culture are <0.5–1.0 ppt. Our results fall within the limits given by NRAC.

Phosphorus is very critical in maintaining aquatic productivity. SRAC recommend desirable phosphate level for fish culture of 0.06 mg/L, and the typical range for surface water is 0.005–0.5 mg/L. Reference [41] reported an optimum range for phosphorus of 0.01–3.0 mg/L. The value of phosphate in Kangsabati Reservoir matched the ranges given above. Reference [38] reported 0.05–0.20 ppm range for medium to high productivity in fish ponds.

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, [38] 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 Kangsabati Reservoir is acceptable for fish culture and does not hamper the fish production.

Throughout the year, water level in the Kangsabati Reservoir falls from April to June but still remains in adequate amount for fish cultivation.

Plankton is the chief food source for fish. According to [41], the desirable range of plankton density is 3000–4500 individual/L, and acceptable values are ≥2000 individual/L. Both the zooplankton and the phytoplankton density together enhance the fisheries programme in our reservoir.

Therefore, each water quality parameter in the Kangsabati Reservoir remain within the limits suitable for fish production [33, 35, 36, 38, 41]. Most of the local workers reported that D.O., pH, alkalinity, temperature, and hardness are the main factors which showed satisfactory results for fish culture in Kangsabati Reservoir. Salinity, phosphate, and free CO₂, with the only exception of transparency and chloride level, also are favourable for good fish production. Conductivity was slightly variable throughout the study period and not completely favourable for pisciculture. A slight increase in planktonic density, as fish food, would be advisable. 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 Kangsabati Reservoir favours for fish cultivation and allows for a high ichthyofaunal diversity, with a value of 1.71 as per Shannon-Wiener index. We recommend the adoption of scientific fishery management, in order to regulate transparency and chloride level.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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