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Article

Ecology and water quality parameters of Balla *beel* in Moulovibazar district of Bangladesh

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Abstract: A study was carried out to assess the ecological aspects of Balla *beel* ecosystem in Moulavibazar district and the affectivity of the ongoing biodiversity restoration program from July 2011 to June 2012. Seventy-four fish species belonging to 21 families were identified during the study period. About nine types of fishing methods and one type of fish aggregating device were identified in the surveyed beel. Increasing pressure of illegal current jal (gill net), ber jal (seine net) and FAD (Fish Aggregating Device) was detected as the reduction of almost all type of species. About 24 aquatic weeds were found in the Balla *beel*, among them both emergent and spreading were 29%, followed by floating 21%, 13% were rooted plants with floating leaves and 8% were submerged. The dissolved oxygen content 5.22±1.60 mg/l inside and 5.70±1.38 mg/l outside of the Balla *beel* sanctuary were found to be congenial for aquatic life. pH of the *beel* water both inside and outside of the sanctuary were slightly acidic to moderately alkaline (7.0±0.68 inside and 6.88±0.43 outside the sanctuary). Lower values of alkalinity and hardness indicating *beel* water to be less nutrient enriched. The contribution of phytoplankton (79%) was larger than zooplankton (21%). The diversity of phytoplankton both inside and outside of the sanctuary was dominated by three group Chlorophyceae, Myxophyceae and Bacillariophyceae.

Keywords: ecology; water quality parameter; Balla *beel*

1. Introduction

Bangladesh is blessed with enormous open water fisheries resources with an area of 4.90 million hectors. The inland open water fisheries resources of Bangladesh are the third richest in the world after China and India. These vast Inland open water fisheries resources composed of river and estuaries, *beel*s (natural depression) and baors (Dead River) flood lands (seasonal floodplain) and a man-made Kaptai lake. A large number of fish species and aquatic flora inhabit in its extensive inland open water bodies. Over the last four decades the production from inland open water have been facing gradual declension due to many natural calamity and anthropogenic reasons like use of chemicals in agricultural fields; unplanned construction of roads, embankments and dams; over fishing; use of harmful fishing gears and systems; siltation of water bodies etc. Decrease in fish catch increasingly threatens the livelihoods of more than 12 million fishers in Bangladesh (Tsai and Ali, 1997). According to a study, 42 fish species are endangered and 12 are critically endangered (IUCN, 2000). To mitigate the prevailing situation it is necessary to design effective interventions, policies, and management options.

Hail Haor is a large wetland in Sreemongol Upazilla under Moulavibazar District, in northeastern of Bangladesh. This haor covers an area of 1400 hectares in the wet season, but in the dry season, it shrinks to become about 130 *beel*s and narrow canals covering a total area of less than 400 hectares. More than 172,000 peoples in 30,000 households were involved in fishing in the haor, many as regular professionals (Chakraborty *et al*., 2005).

A total area of *beel*s in Bangladesh has estimated to be 114,161 ha, occupying 27.0% of the inland freshwater area. Bernacsek *et al*. (1992) has reported that the number of *beel*s in the Northeast region between 3,440 (covering 58,500 ha with a mean size of 7ha) and 6,149 (covering 63,500 ha with a mean size of 10ha). About 58% of the *beel*s in the northeast region are permanent and the rest is seasonal. Balla *beel* is a part of the Hail Haor. It currently supports about 90 species of fish and is important as a bird sanctuary. Every year in winter season, hundreds of bird species come here and tourists from home and abroad visit this place for its natural beauty and biological diversity (Mahbub, 2012). Balla *beel* sanctuary has designed to conserve and restore fish. The Bangladesh Government declared Balla *beel* as a permanent sanctuary on July 1, 2003 and set about 100 hectares aside. This site was managed through a project called Management of Aquatic Ecosystem through Community Husbandry (MACH). After the end of MACH project in 2008, the sanctuary continued to operate a wide range of protected areas in Bangladesh, including the hail haor wetland of which Balla *beel* is a part. Objective of the declaration of Balla *beel* as a sanctuary was to improve wetland habitat for existing flora and fauna and to protect wetland biodiversity.

2. Materials and Methods

2.1. Study site and duration

The study was conducted in the Balla *beel* under Moulavibazar District from July 2011 to June 2012 (Figure 1). Balla *beel* was about 70.74 ha of wetlands in the eastern part of Hail haor near Sreemongal, a tea-growing town in Moulavibazar district. Balla *beel* includes three sub-*beel*s Chapra, Maguara and Jaduria with surrounding marshy areas known as Balla *beel* sanctuary.

2.2. Data collection

Detail survey on flora and fauna of the Balla *beel* was conducted with particular emphasis on water quality, biological productivity and biotic communities and status of fishery exploitation. Operationalized research was carried out through collection of both primary and secondary data, comprehensive literature review and extracts of local knowledge and information. Field observation and different experimentation viz. experimental fishing within the *beel* ecosystem outside the sanctuary, survey of fish market adjacent to *beel*, survey of katha and kua fishing, monitoring of water quality, recording of water level and fisher's perception were made for primary data. Secondary data were collected from *Beel* Management Committee (BMC), Local administrations, Water Development Board (WDB), Department of Fisheries, Meteorological Department and related NGOs.

2.3. Measurements of water quality parameters

Hydrological, meteorological, physico-chemical and biological characteristics of *beel* ecosystem have been monitored monthly basis. In each sampling day, water quality data was collected from both inside and outside of the *beel* sanctuary separately. A bamboo made meter scale measured water depth. A seechi-disc measured transparency. A centigrade thermometer measured temperature of air and water. Free CO_2 content was determined by phenolphthalein indicator method (Welch, 1948). Total alkalinity was estimated by using phenolphthalein and methyl orange indicator method (Welch, 1948). Total hardness was determined by EDTA titrimetric method (APHA, 1995). HACH test kit (Model-FF-2, USA) was used to measure pH, dissolved oxygen (DO), ammonia and nitric acid only. For plankotonic study, water (50L) was collected from euphotic zone of the *beel* and passed through bolting silk plankton net of 55µ. The filtrates were preserved in Luglo's solution.

2.4. Sampling for fish species

An organized sampling program was run for a long time to get a true picture of the catch and catch composition of surveyed *beel*. The experimental *beel* were sampled during winter (mid November to mid February), pre monsoon (mid February to April), monsoon (May to August) and post monsoon (September to mid November) for assessment of aquatic lives' abundance and availability. Identification of resident as well as migratory fishes was done through collection of different species directly from fisher's catch, experimental fishing, fishing

through enclosure bana (made by bamboo), Kua fishing and surveying local fish markets. Resident fish species were recorded through experimental fishing in the deep pool areas in the *beel* and manmade kuas where water remains during dry season (early January- mid April). Local knowledge as well as fisher's perception has been considered for conceptual knowledge regarding the identification of resident fishes.

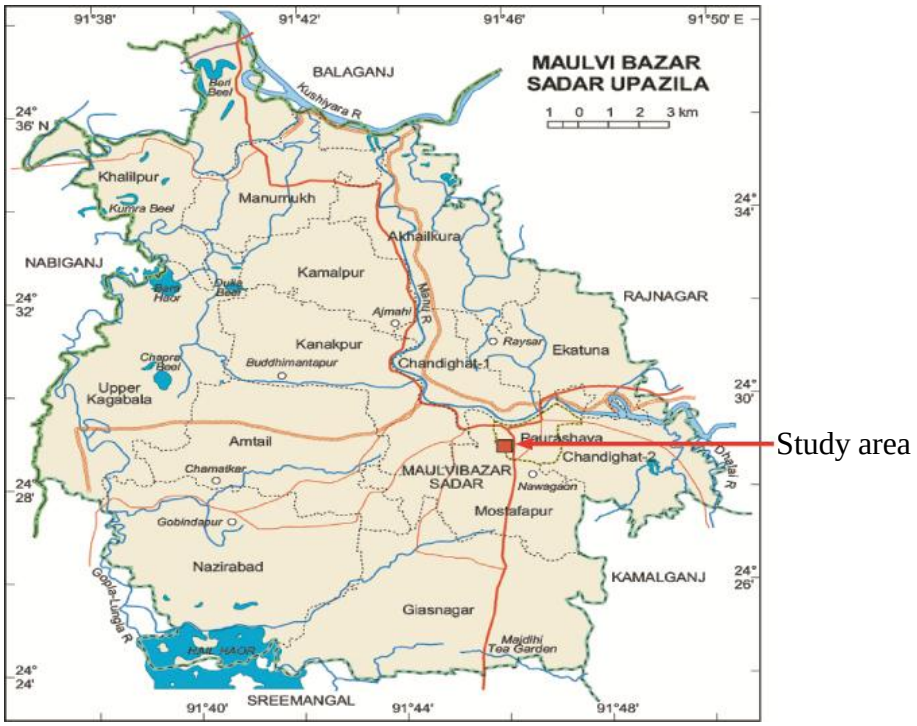

Figure 1. Map of the study area.

2.5. Fishing method

Detail survey on fishing method of the Balla *beel* was conducted with particular emphasis on number of different gears. Fishermen used boat for transport of nets and related materials and used ber jal (seine net), thela jal (push net), lift net, cast net, current jal (gill net), hook and lines etc. according to season and availability of different species of fish. During monsoon and post monsoon, fisher's used lift net, current jal, cast net, hook and lines (barsi, jhupi, aikra, etc.) to catch fishes. They also operated katha fishing by sein net in winter and spring season.

2.6. Study of plankton and aquatic weeds

The plankton sample was collected fortnightly from the euphotic zone using 0.55 blotting silk plankton net and later analyzed numerically with the help of Sedgewick-Rafter counting cell (SR-cell) under a compound microscope according to Clesceri *et al*. (1989). Qualitative and quantitative analysis of both phytoplankton and zooplankton were done following drop count method (APHA, 1995). Microscopic identification was performed up to genera. Each sample was tired smoothly just before microscopic analysis. One ml of agitated sample was poured in a Sedgwick-Rafter (S-R) cell counter. A binocular microscope was used (10×0.25 magnification) for identification and enumeration of samples. Qualitative studies were done according to Prescott (1962) and Needham (1962). Different types of aquatic weeds (floating, spreading, emergent, rooted plants with floating leaves) were collected from the *beel*s and identification was made in the laboratory.

3. Results and Discussion

3.1. Water quality parameters

The physico-chemical factors and plankton were found more or less in normal range in the surveyed *beel* (Table 1), which was agreed by APHA (1995). Transparency was consistently higher in deeper portion of the *beel*, possibly due to stagnancy of water. Rahman (1992) stated that the transparency of productive water bodies should be 40 cm or less. The uniformly average value of oxygen range in inside 5.14±1.45 mg/l and outside 5.70±1.56 mg/l as noted in the *beel* agreed well with the findings of APHA (1998). pH value in inside

7.01±0.71 and outside 6.89±0.34 of the *beel* was more or less similar with the findings of Rahman (2003), Kohinoor *et al*. (1994) and Chakraborty *et al*. (2003). Alkalinity levels indicate medium to higher level of productivity. An alkalinity level of the *beel* was medium to high that also agreed with the findings of Clesceri *et al*. (1989). The temperature of the survey area was within the acceptable range that agreed well with the findings of Haque *et al*. (1993). Transparency was more or less similar in the *beel* due to the availability of the plankton population Haque *et al*. (1993). The dissolve oxygen was in acceptable range compared to ponds stocked with a same density. Boyd (1982) observed similar results. Fluctuation of dissolve oxygen concentration may be attributing to photosynthetic activity and variation in the rate of oxygen consumption by fish and other aquatic organisms (Boyd, 1982).

3.2. Fish species diversity

The fish species diversity of the *beel* was virtually enriched along with the presence of large number of indigenous species. During June 2012, 74 fish species were found in the Balla *beel*. Among 74 fish species, maximum 32 species belonged to the family Cyprinidae followed by Bagridae (6 species), Chanidae (4 species) and Siluridae (4 species). Rest of the species belonged to another 17 families (Table 2). The status of the 74 fish species of Balla *beel* was ranked as different status. Important 12 fish species such as *Amblypharyngodon mola, Chela laubuca, Puntius chola, Puntius conchonius, Puntius puntio, Puntius ticto, Rasbora daniconius, Salmostoma phulo, Chanda nama, Chanda beculis, Chanda ranga* and *Colisa fasciata* were found very common (+++) in the sanctuary area of the Balla *beel* . On the other hand 25 fish species such as *Xenentodon cancila, Corica soborna, Botia Dario, Esomus danricus, Labeo gonius, Puntius gelius, Puntius sarana, Puntius sophore, Notopterus notopterus, Anabas testudineus, Badis badis , Channa orientalis, Channa punctata, Channa striata, Colisa lalia, Glossogobius giuris, Clarius batrachus, Clupisoma garua, Heteropneustes fossilis, Mystus bleekeri, Mystus tengara, Mystus vittatus, Macrognathus aculeatus, Macrognathus pancalus* and *Tetraodon cutcutia* were found in common (++) phenomena in the sanctuary and rest 37 fish species such as *Anguilla bengalensis, Monopterus cuchia, Gudusia chapra, Barbonymus goninotus, Catla catla, Cirrhinus cirrhosus, Crossocheilus latius, Ctenopharyngodon idella, Cyprinus carpio var. communis, Cyprinus carpio var. specularis, Hypophthalmichthys molitrix, Aristichthys nobilis, Labeo bata, Labeo boga, Labeo calbasu, Labeo nandina, Labeo rohita, Puntius gonionotus, Raiamas bola, Crossocheilus latius, Osteobrama cotio, Chitala chitala, Anabas cobojius, Channa marulius, Ailia coila, Bagarius bagarius, Batasio batasio, Eutropiichthys vacha, Gagata gagata, Ompok bimaculatus, Ompok pabda, Sperata aor, Sperata seenghala, Wallago attu, Mastacembelus armatus, Monopterus cuchia* and *Ophisternon bengalense* were found in rare (+) condition in the sanctuary area of the Balla *beel*. It was also observed that, 11, 16 and 47 fish species were found in very common (+++), common (++) and rare (+) in the Balla *beel* outside the sanctuary area (Table 2). According to IUCN (1998), in Bangladesh about 56 freshwater fish species is critically endangered some are still found in Balla *beel* to a little extent *viz.* Chital, Rita, Baga air, Chepchela, Tatkini, Kaliboush, Gonia, Sharpunti, Rani, Modupabda, Napit Koi, Gozar etc. The total catch statistics of aquatic lives in the surveyed *beel* indicated that percentage of different groups of aquatic live was sharply decrease within the year, which was very similar to the study of Chakraborty (2009 and 2010). Due to over-exploitation and various ecological changes in natural aquatic ecosystem, commercially important aquatic lives were in the verge of extinction, which was in agreement with the findings of Sarker (1993). Intervention to control floods, adoption of new agricultural technologies and construction of road networks was altered the ecology of *beel* significantly which supported the views of Khan (1993) and Ali (1991). Stock of the wildlife brood fishes in their breeding ground was also suffered significant damages resulting in a reduction of biodiversity as noted by Nishat (1993) and Chakraborty (2010).

3.3. Fishing gears

In Balla *beel*, various types of fishing gears were found to operate for fish catching. Traditional fishing gears, different nets, wounding gears, fish aggregating devices (kua/katha) were also found in this *beel.* It was revealed that, maximum time required for catching fish by current jal and long line where minimum in thela jal. The largest CPUE was found in katha and lowest in thela jal respectively (Table 3). The fishing effort with various types of fishing methods such as seine net (especially ber jal), gill net (current jal) and FAD (kua/katha) was increased during the study period. As a result, an average number of fishes and other aquatic lives declined in the surveyed *beel*. Cast net (Jhaki jal) was used whole year in the *beel*. It is a very popular fishing method and used in all over the Bangladesh (Ahmad, 1962). Suganan and Bhattacharjya (2000) found a wide variety of

fishing methods (passive gear, active gear, FAD, falling gear, dewatering) employed in the beels of Assam, which are very similar to the present findings.The study clearly indicated that the aquatic lives of the *beel* were subjected to over fishing resulting in gradual decline in aquatic population. Indiscriminate killing of fish occurred due to the use of pesticides in improper doses, use of forbidden chemicals, and aerial spray of chemicals as used in paddy field which was very much similar to the observation of Mazid (2002) and Chakraborty (2010). Haroon *et al*. (2002) reported eighteen types of fishing gears recorded from the Sylhet sub-basin and thirteen types from Mymensingh sub-basin. They also recorded many kinds and sizes of bamboo made traps.

3.4. Planktonic biomass

Abundance of plankton in sanctuary and non-sanctuary areas showed a wide range of variation. Average total plankton density (Nos./l) outside the sanctuary areas of Balla *beel* was higher (28,552±7,486) than the sanctuary areas (25,117 ±8,114) (Table 4). Among the planktonic algae, 45 genera of phytoplankton under 6 families which was more or less similar to the observation of Sugunan and Bhattacharjea (2000) and 12 genera of zooplankton under 9 families were recorded inside the sanctuary areas of Balla *beel*, which were closer to the study of Ahmed *et al*. (1997) and Sugunan and Bhattacharjea (2000). In the study area, the phytoplankton abundances were consistently higher than that of zooplankton. Similar results also recorded in various food habits of fish, fry and fingerling rearing in ponds (Chakraborty *et al*., 2003). Higher phytoplankton concentrations in water normally indicate higher productivity. The higher abundance of phytoplankton compared to zooplankton might be due to regular fertilization and excess uneaten feed that is agreed by Sugunan, Bhattacharjea, (2000) and Keshavanath *et al*., 2002.

In case of outside the sanctuary Balla *beel*, about 36 genera of phytoplankton under 6 families and 12 genera of zooplankton under 10 families were found (Table 5). The presence of higher content of fish biomass inside the sanctuary might exert a significant role on the presence of lower amount of planktonic algae over there, because higher the amount of fish higher the predation over the planktonic mass.

Table 1. Physico-chemical parameters of Balla *beel* (inside and outside the sanctuary).

Parameters	Inside	Outside
Water depth (m)	2.10±0.92	1.99±0.81
Air temperature (^{0}C)	30.95±3.48	30.30±3.91
Water temperature (^{0}C)	29.57±4.16	28.14±4.91
Water colour	Brownish	Brown
Bottom Type	Soft and muddy	Hard and muddy
Transparency (m)	66.77±39.61	90.50±28.55
Dissolve O_2 (mg/l)	5.14±1.45	5.70±1.56
Free CO_2 (mg/l)	6.86±2.23	6.72±2.10
pH	7.01±0.71	6.89±0.34
NH_3 (mg/l)	0.10±0.23	0.11±0.00
Total alkalinity (mg/l)	33.71±19.38	33.94±10.67
Total hardness (mg/l)	33.79±15.93	35.84±9.87

Table 2. Fish species diversity of Balla *beel.*

Sl. No.	Order	Family	Local name	*Scientific Name*	Sanctuary	Non-sanctuary
1.	Anguilliformes	Anguillidae	Banehara	*Anguilla bengalensis*	+	+
2.	Anguilliformes	Anguillidae	Kuchia	*Monopterus cuchia*	+	+
3.	Beloniformes	Belonidae	Kakila	*Xenentodon cancila*	++	+
4	Clupeiformes	Clupeidae	Kachki	*Corica soborna*	++	+++
5.	Clupeiformes	Clupeidae	Chapila	*Gudusia chapra*	+	+
6.	Cypriniformes	Cyprinidae	Mola	*Amblypharyngodon mola*	+++	++
7.	Cypriniformes	Cyprinidae	Rajputi	*Barbonymus goninotus*	+	+
8.	Cypriniformes	Cobitidae	Bou mach	*Botia dario*	++	+
9.	Cypriniformes	Cyprinidae	Katol	*Catla catla*	+	+
10.	Cypriniformes	Cyprinidae	Chep chela	*Chela laubuca*	+++	++

Sl. No.	Order	Family	Local name	*Scientific Name*	Sanctuary	Non-sanctuary
11.	Cypriniformes	Cyprinidae	Mrigal	*Cirrhinus cirrhosus*	+	+
12.	Cypriniformes	Cyprinidae	Minor carp	*Crossocheilus latius*	+	+
13.	Cypriniformes	Cyprinidae	Grass carp	*Ctenopharyngodon idella*	+	+
14.	Cypriniformes	Cyprinidae	Common carp	*Cyprinus carpio var. communis*	+	+
15.	Cypriniformes	Cyprinidae	Mirror carp	*Cyprinus carpio var. specularis*	+	+
16.	Cypriniformes	Cyprinidae	Darkina	*Esomus danricus*	++	+++
17.	Cypriniformes	Cyprinidae	Silver carp	*Hypophthalmichthys molitrix*	+	+
18.	Cypriniformes	Cyprinidae	Big head carp	*Aristichthys nobilis*	+	+
19.	Cypriniformes	Cyprinidae	Bata	*Labeo bata*	+	+
20.	Cypriniformes	Cyprinidae	Bhangan	*Labeo boga*	+	+
21.	Cypriniformes	Cyprinidae	Kalibaus	*Labeo calbasu*	+	+
22.	Cypriniformes	Cyprinidae	Shada ghonia	*Labeo gonius*	++	++
23.	Cypriniformes	Cyprinidae	Nandil	*Labeo nandina*	+	-
24.	Cypriniformes	Cyprinidae	Rui	*Labeo rohita*	+	+
25.	Cypriniformes	Cyprinidae	Rajpunti	*Puntius gonionotus*	+	+
26.	Cypriniformes	Cyprinidae	Punti	*Puntius chola*	+++	+++
27.	Cypriniformes	Cyprinidae	Kanchan punti	*Puntius conchonius*	+++	+++
28.	Cypriniformes	Cyprinidae	Gilipunti	*Puntius gelius*	++	++
29.	Cypriniformes	Cyprinidae	Punti	*Puntius puntio*	+++	+++
30.	Cypriniformes	Cyprinidae	Shorpunti	*Puntius sarana*	++	+
31.	Cypriniformes	Cyprinidae	Bhadi punti	*Puntius sophore*	++	+
32.	Cypriniformes	Cyprinidae	Tit punti	*Puntius ticto*	+++	+++
33.	Cypriniformes	Cyprinidae	Bhol	*Raiamas bola*	+	+
34.	Cypriniformes	Cyprinidae	Darkina	*Rasbora daniconius*	+++	+++
35.	Cypriniformes	Cyprinidae	Chela	*Salmostoma phulo*	+++	+++
36.	Cypriniformes	Cyprinidae	Tatkini/Kalabata	*Crossocheilus latius*	+	+
37.	Cypriniformes	Cyprinidae	Dhela	*Osteobrama cotio*	+	+
38.	Osteoglossiformes	Notopteridae	Chital	*Chitala chitala*	+	+
39.	Osteoglossiformes	Notopteridae	Foli	*Notopterus notopterus*	++	+
40.	Perciformes	Anabantidae	Kawai'in	*Anabas testudineus*	++	++
41.	Perciformes	Anabantidae	Koi	*Anabas cobojius*	+	+
42.	Perciformes	Badidae	Napte koi	*Badis badis*	++	+
43.	Perciformes	Ambassidae	Lomba chanda	*Chanda nama*	+++	+++
44.	Perciformes	Ambassidae	Gol chanda	*Chanda beculis*	+++	+++
45.	Perciformes	Ambassidae	Ranga chanda	*Chanda ranga*	+++	+++
46.	Perciformes	Channidae	Gozar	*Channa marulius*	+	+
47.	Perciformes	Channidae	Gachua	*Channa orientalis*	++	++
48.	Perciformes	Channidae	Taki	*Channa punctata*	++	++
49.	Perciformes	Channidae	Shol	*Channa striata*	++	++
50.	Perciformes	Osphronemidae	Khailsha	*Colisa fasciata*	+++	++
51.	Perciformes	Osphronemidae	Lal kholisha	*Colisa lalia*	++	++
52.	Perciformes	Gobiidae	Bele	*Glossogobius giuris*	++	++
53.	Siluriformes	Schilbeidae	Kajuli	*Ailia coila*	+	+
54.	Siluriformes	Sisoridae	Baghair	*Bagarius bagarius*	+	+
55.	Siluriformes	Bagridae	Tengra	*Batasio batasio*	+	+
56.	Siluriformes	Clariidae	Magor	*Clarius batrachus*	++	+
57.	Siluriformes	Schilbeidae	Muribacha	*Clupisoma garua*	++	+
58.	Siluriformes	Schilbeidae	River catfish	*Eutropiichthys vacha*	+	+
59.	Siluriformes	Sisoridae	Catfish	*Gagata gagata*	+	+
60.	Siluriformes	Heteropneustidae	Shingi	*Heteropneustes fossilis*	++	+

Sl. No.	Order	Family	Local name	*Scientific Name*	Sanctuary	Non-sanctuary
61.	Siluriformes	Bagridae	Tengra	*Mystus bleekeri*	++	+
62.	Siluriformes	Bagridae	Stripped dwarf catfish	*Mystus tengara*	++	++
63.	Siluriformes	Bagridae	Tengra	*Mystus vittatus*	++	++
64.	Siluriformes	Siluridae	Kani pabda	*Ompok bimaculatus*	+	+
65.	Siluriformes	Siluridae	Madhu pabda	*Ompok pabda*	+	+
66.	Siluriformes	Bagridae	Air	*Sperata aor*	+	+
67.	Siluriformes	Bagridae	Guizza	*Sperata seenghala*	+	+
68.	Siluriformes	Siluridae	Boal	*Wallago attu*	+	+
69	Synbranchiformes	Mastacembelidae	Tara baim	*Macrognathus aculeatus*	++	++
70.	Synbranchiformes	Mastacembelidae	Pankal baim	*Macrognathus pancalus*	++	++
72.	Synbranchiformes	Mastacembelidae	Baim	*Mastacembelus armatus*	+	+
73.	Synbranchiformes	Synbranchidae	Kuchia	*Monopterus cuchia*	+	+
74.	Synbranchiformes	Synbranchidae	Bamosh	*Ophisternon bengalense*	+	+
75.	Tetraodontiformes	Tetraodontidae	Tepa	*Tetraodon cutcutia*	++	++

+++ Very common; ++ common; + rare; and - absent

Table 3. Catch per unit effort of major fishing gears of Balla *beel.*

Name of fishing device		Time of unit effort (min)	Effort/day	Average CPUE (kg/day)
Fishing gear	Teta/koach	120-180	4-5	5.93
	Veshal jal	30-45	30-40	11.33
	Thela jal	10-15	40-50	2.84
	Ber jal	120-150	2-3	22.37
	Current jal	360-720	1-2	7.40
	Long line	360-720	1-2	7.38
	Koi jal	120-150	2-3	6.12
	Sutar jal	120-180	1-2	10.32
	Dharma jal/lift net	20-30	40-50	9.60
Kua/katha	Katha	337.31	1-2	398.32

Table 4. Plankton biomass inside and outside the sanctuary of Balla *beel* .

Phyto-plankton (nos/L)		Zoo-plankton (nos/L)	Total plankton	Phytoplankton (%)	Zooplankton (%)
Inside	24,510 ±7,922	607±109	25,117 ±8,114	97.60±0.22	2.40±0.24
Outside	27,683 ±7,273	869±173	28,552 ±7,486	96.90 ±0.17	3.10±0.18

Table 5. List of different group of plankton found in Balla *beel.*

Plankton	Family	Genera	
		Sanctuary area	**Non-sanctuary area**
Phytoplankton	Chlorophyceae	*Ankistrodesmus, Chlamydomonas, Chlorella, Closterium, Crucigenia, Mougeotia, Pediastrum, Scenedesmus, Selenestrum, Staurastrum, Spirogyra, Spirotaenia, Volvox*	*Ankistrodesmus, Chlamydomonas, Chlorella, Closterium, Cosmarium, Crucigenia, Mougeotia, Palmellococcus, Pediastrum, Scenedesmus, Selenestrum, Spirogyra, Staurastrum, Volvox, Zygnema*
	Myxophyceae	*Anabaena, Anacystis, Aphanocapsa, Coelospharium, Chlorococcus, Gomphosphaeria, Merismopedia, Microcystis, Nostoc, Oscillatoria, Spirulina, Tetrapedia*	*Anabaena, Anacystis, Chlorococcus, Merismopedia, Microcystis, Oscillatoria, Tetrapedia*
	Bacillariophyceae	*Amphora, Asterionella, , Cyclotella, Coscinodiscus, Diatoma, Gyrosigma, Melosira, Navicula, Nitzschia, Synedra, Stephanodiscus*	*Amphora, Cyclotella, Diatoma, Melosira, Navicula, Nitzschia, Synedra, Tabellaria*
	Euglenophyceae	*Euglena, Phacus*	*Euglena, Phacus*
	Xanthophyceae	*Chloranllanthus, Tribonema*	*Tribonema*
	Dinophyceae	*Mesotaenium, Netrium, Protococcus, Tetraspora, Ulothrix*	*Netrium, Tetraspora, Ulothrix*
Zooplankton	Brachionidae	*Brachionus, Keratella*	*Brachionus, Keratella*
	Bosminidae	*Bosmina*	*Bosmina*
	Cyclopidae	*Cyclops*	*Cyclops*
	Diaptomidae	*Diaptomus*	*Diaptomus*
	Daphnidae	*Daphnia, Nauplius*	*Daphnia, Nauplius*
	Polycystidae	-	*Polycystis*
	Sididae	*Sida*	*Sida*
	Synchaetidae	*Cypris, Polyarthra*	*Polyarthra*
	Testudinellidae	*Filinia*	*Filinia*
	Trichocercidae	*Trichocerca*	*Trichocerca*

Table 6. Aquatic weeds of the Balla *beel.*

Sl. No.	Local Name	Scientific Name	Type	Sanctuary	Non-sanctuary
1.	Kachuripana	*Eichhornia crassipes*	Floating	+++	++
2.	Topapana	*Pistia stratiotes*	Floating	+	++
3.	Edurkanipana	*Wolffia arrhiza*	Floating	++	+
4.	Khudipana	*Lemna minor*	Floating	+	+
5.	Kutipana	*Azolla pinnata*	Floating	+	++
6.	Dal	*Hydroryza aristota*	Emergent	+	+++
7.	Amrul shak	*Oxalis corniculata*	Emergent	-	-
8.	Shusnishak	*Marsilea quadrifolia*	Emergent	-	+
9.	Bishkatali	*Polygonum hydropiper*	Emergent	-	+
10.	Kachu	*Colocasia esculenta*	Emergent	-	+
11.	Najas	*Najas najas*	Submerged	++	++
12.	Arail	*Leersia hexandra*	Spreading	+	+++
13.	Helencha	*Enhydra flucktuans*	Spreading	+	+
14.	Kalmilata	*Ipomoea aquatica*	Spreading	-	+
15.	Kanaibashi	*Commelina bengalensis*	Spreading	-	+
16.	Malancha	*Ehhydra sp*	Spreading	+	++
17.	Arrowhead	*Sagitaria sagitifollia*	Emergent	+	++
18.	Keshordam	*Jussiaea ripens*	Spreading	+	++

Sl. No.	Local Name	*Scientific Name*	Type	Sanctuary	Non-sanctuary
19.	Lalshapla	*Nymphaea rubna*	Rotted plants with floating leaves	+	++
20.	Shapla	*Nymphaea nouchali*	Rotted plants with floating leaves	+	++
21.	Padma	*Nelumbo nucifera*	Rotted plants with floating leaves	+	++
22.	Shakata chechra	*Scirpus actus*	Emergent	+	++
23.	Panikola	*Ludwigia adscendens*	Submerged	++	++
24.	Dhol Kalmi	*Ipomoea fistulosa*	Spreading	-	+

+++ Very common; ++ common; + rare; and - absent

3.5. Aquatic weeds

About 24 aquatic weeds were found in the Balla *beel*, among them both emergent and spreading were 29% followed by floating 21%; 13% were rooted plants with floating leaves and 8% were submerged (Table 6), which are comparable with the finding of Sugunan and Bhattacharjea (2000) in case of floodplain of Brahmaputra basin. The weeds usually grow along the *beel* margins and absent in the deeper regions. In the sanctuary area of the *beel*, *Eichhornia crassipes* was found as very common (+++) species where *Wolffia arrhiza, Najas najas, Ludwigia adscendens* were found in common (++) and the rest were in rare condition. The weeds were used as human consumption, cattle food and main food of buffalo. These weed also used as feed, shelter and breeding place for the resident species. FAP-16 (1992) reported less abundant macrophytes from Surma-Kushiyara floodplain project. Rahman (1992) could not find any find floating aquatic vegetation from the spawning location of Halda, the Jamuna, and the Brahmaputra river and no significant relationship existed between the aquatic and the spawning of major carps. A unique feature of floodplain wetlands was the rich growth of marginal and submerged macrophytes due to allochthonous and autochthonous nutrient loading, which often tends to replace plankton community and hastens the pace of eutrophication.

4. Conclusions

In floodplain wetland, water quality influenced largely by inflow of water from the connecting river, the run-off water mainly due to silt and organic debris carried the turbidity in *beel* water. The basin and aquatic soil can influence the value of pH. The variation in the concentration of DO and CO_2 were mainly due to the rate of photosynthetic activity by aquatic vegetation and variation in the organic matter contents in the basin soil. The DO levels of *beel* water were not high but within the acceptable limit for the growth of fishes. Balla *beel* was found to be conducive to enhanced fisheries, capture fisheries and biological production as well. In order to promote biodiversity, the deep area of the *beel* must be declared as sanctuaries to protect the aquatic lives in all season. Strict enforcement of fish Act-1950, forbidding unplanned digging and sedimentation; avoid unplanned construction of flood control, embankments, drainage system and sluice gates, conversion of inundated land to cropland (reducing water area); and controlling use of pesticides and agrochemicals in the *beel* and flood plain area would be some recommendations to protect the *beel* biodiversity. The above issue will be lead to ensure the food security of the people of Bangladesh.

Conflict of interest

None to declare.

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