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THE STUDY OF THE IMPACT OF FLOOD IN THE WETLANDS OF ASSAM, NORTH EASTERN REGION OF INDIA

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Flood

Wetlands

Plankton

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ABSTRACT

It is a matter of concern that every year the state of Assam and the valley of the hill states suffer extensively from floods and river bank erosion. The Brahmaputra basin is an acutely flood prone region. The total flood prone area here is 32 lakh hectares accounting for 57% of the Brahmaputra valley. 85% of population of Assam lives here. The unique physiographic setting along with heavy rainfall is the main cause of flood hazards of this region. Geomorphologically and geophysically the alluvial plain of Assam the wetlands, shallow lakes are frequently located by the side of the rivers and rivulets. Oxbow lakes are characteristic features of this region. During flood these wetlands become connected with the rivers and aquatic lives migrate to the wetland area for reproduction. River Brahmaputra covers 72% of the total area of the state, extends in east-west direction for about 720kms with an average width of 80 km and is drained by the mighty Brahmaputra long with its thirty-two north and south tributaries. Numerous wetlands are scattered in this region covering about 1 lakh hectare area. The flood hazards began after the devastating earthquakes of 1869, 1897, 1923, 1943 and 1950. Despite the immense destruction of cropland, livestock, roads and household assets, it has some constructive side also. Along with the deposition of silt, it also enhances the fertility of the soil. It makes the paddy field suitable for crops. Monsoon is the breeding season for various aquatic inhabitants like fish, amphibians, birds and other aquatic inhabitants. So it is extremely important that the lakes and wetlands should be reclaimed, restored and inundated by flood water every season. This paper deals with the two wetlands of the region. The physico-chemical analysis of flood water shows that it is suitable for the breeding of fish and other aquatic animals. The wetlands also restore flood water and act as filter. So flooding is essential for constructive factors also.

INTRODUCTION

It is a matter of concern that every year the state of Assam and the Valleys of the Hill-States suffer extensively due to floods and river bank erosion. Floods are becoming problem in terms of area and duration of submergence.

Because of certain human activities, the intensity of natural hazards is becoming problem towards the conservation of biodiversity and ecosystem. Among them are the tremendous growths of population, extension of agricultural activities, into forest lands, destruction of forest for timber, commerce, unplanned construction of dams and embankments for irrigation, power, regular water supply to towns and cities and big industries, construction of roads, cutting of hill-top, slopes etc. have accelerated the problem of ecological imbalance in the region and the surrounding states.

But in the past the scenario was not that much pathetic. The Brahmaputra may be called the great drain of Assam. The numerous tributaries, streams of which swell it to a river of the very fast rate magnitude. The country at all seasons generally swampy and intersect with half-filled channels and stagnant lakes. During rainy season the flood water periodically inundate the land. But it is strange that the inhabitants do not avail themselves of the provision of nature to raise themselves above the reach of the floods, when they might do so without trouble, expense or in convenience (Topography of Assam, John M'Cosh). During the dry season it is very susceptible of cultivation and amply repays any labour, expense bestowed upon it by producing abundant crops.

The flood hazards began when there were devastating earthquakes relatively between short intervals. The high intensity earthquakes (8.6 to 8.7 in Richter scale) of 1869, 1923, 1943 and August 15th 1950, badly affected the region. Many roads, bridges and buildings were destroyed. There were rise of some areas and sinking of some other areas. For example, afforested foot-hill area of about 40 kms the South West of Guwahati sank down to give rise to the present Chandubi Lake. Many river beds like the Brahmaputra, Subansiri, Buridihing, Jia Bhorali etc were found to have risen and many rivers changed their routes. As a result of which the area transformed into a flood prone zone (Environmental Degradation in Assam and other North Eastern States in India- Gautam Purkayastha, Environmental Economics. Page 143-161).

The National Commission on Floods has calculated that the land area prone to flood in India has doubled from 20 million hectares within ten years (1971-1981). The worst hit states were Assam, Bihar, Orissa and Uttar Pradesh. North-Easter Region accounts for about 7-10% of the total National loss due to floods. Now the flood of 2007 incurred a loss of 36 thousand crore (Amar Asom 6th Dec.2007).

In Assam 17 districts were affected by recurrent floods, which is responsible for large scale soil erosion and siltation affecting the agriculture. Flooding of the plains and valleys during rainy season is a common hazard in North-East. Despite the immense destruction of crop land, live stock, roads and household assets it has some other constructional side also. Along the deposition of silting also enhances the fertility of soil. It makes the field suitable for "Baodhan" a variety of rice crop grown in the lower lands during the monsoon season. Assam is rich in fish variety; but it is fast disappearing due to loss of habitat and unrestricted fishing during breeding season. The disappearance of Wetland areas due to mismanagement is one of the reasons for depletion of fish variety. Besides these many of the

Wetland birds have completely disappeared in Myanmar, Vietnam and Sundarbans are becoming extinct in Assam as well. So it is extremely important that the lakes and wetlands should be reclaimed restored and inundated by flood waters every year. The flood water is suitable physico-chemically for breeding of the fish particularly.

The analysis of the flood water has been done in the Wetlands present in and around Dibrugarh district during flooding season i.e from June to August 2008. It shows that despite of the destructive properties, flooding is essential for continuation of the aquatic species including fish. A recent study in U.S.A estimated that 0.4 hectares of the wetland could store over 6000 cubic meters of flood water. Vegetation in and around the low-lying areas also slow down the flow of water current. The aquifers are recharged from the lakes and wetlands. Fishes change their colouration from pale to dark during flooding season.

MATERIALS AND METHOD

Study area: The investigation was conducted in two wetlands - Kotoha Borbeel and Maijan beel.

Kotoha borbeel: It is a Closed Wetland with 27°15' N latitude and 94°55' E longitudes. Length and breath of the beel is 800m and 200m respectively. The area is 1600 sq m *i.e.* 0.16 hectare. The depths recorded are 4.8 m (in summer) 2.7 m (in winter). Origin of the beel is change of river Buri- Dihing. The shape of the wetland is straight.

Maijan beel: It is an open Wetland with 27°32 ' N latitude and 94°58 ' E longitude. The breadth of the connecting channel to river Brahmaputra is 600 m and the area is 87.07 hectares. The minimum and maximum depths are 3.8 m and 6.4 m respectively.

Methodology

Analytical Method: Chemical composition of water influences the ecological properties of a system. So it is essential to study the physico-chemical features of a system to understand the ecological behaviour of the ecosystem.

The analytical procedures were followed after APHA (2005). Dutta Munshi (2006) Aquatic macrophytes were collected using square shaped quadrant sampler having 0.25 sq m area (Jhingran *et al.*, 1988). The identification of ichthyofauna was done following K.C. Jayaram(2002), V.G. Jhingran (1991) and W. Vishwanath (2002).

RESULTS AND DISCUSSION

The water quality, hydrobiology and fishery of the Kotoha Borbeel and Maijan beel were analyzed for the flooding period of 3 months from June 2008 to August 2008 and studied from June 2008 to May

Table 1: Seasonal variation of different parameters in comparison to flooding season: Kotoha borbeel

Sl.no.	Parameters	Monsoon/ flooding season	Autumn	Winter	Pre- monsoon
1	Air temperature (°C)	26.8	25.2	21	25.16
2	Water temperature (°C)	26.6	22.83	15.83	22.5
3	pH	8.2	7.0	8.0	8.9
4	Humidity (%)	65.83	60.16	57.33	52.83
5	Dissolved O_2 (mg/L)	7.7	7.2	7.6	6.2
6	Free CO_2 (mg/L)	13.1	7.3	4.3	3.8
7	Alkalinity (mg/L)	107.33	102	78	69.66
8	Total Hardness (mg/L)	94.66	85.33	81.33	66
9	Calcium hardness (mg/L)	38.66	16	17	24
10	Magnesium hardness (mg/L)	54.33	66	64.33	51.33
11	Chloride (mg/L)	19.9	19.23	10.9	17.4
12	Fluoride (mg/L)	2.7	1.75	1.33	1.5
13	Phosphate (mg/L)	0.5	0.56	0.2	0.33
14	Ammonia (mg/L)	0.36	0.23	0.1	0.15
15	Total iron (mg/L)	0.4	0.33	0.2	0.36
16	Nitrate	5	5	5	5
17	GPP mg C/m^3/hr	0.659	0.129	0.847	0.374
18	NPP (mg O_2/m^3/hr)	0.486	0.798	0.182	0.409
19	Respiration(mg O_2/m^3/hr	0.608	0.616	0.752	0.533
20	TDS (ppt)	0.341	0.09	0.076	0.07
21	Conductance (mS)	0.131	0.14	0.11	0.123
22	Turbidity (NTU)	15.33	13.3	26.83	42

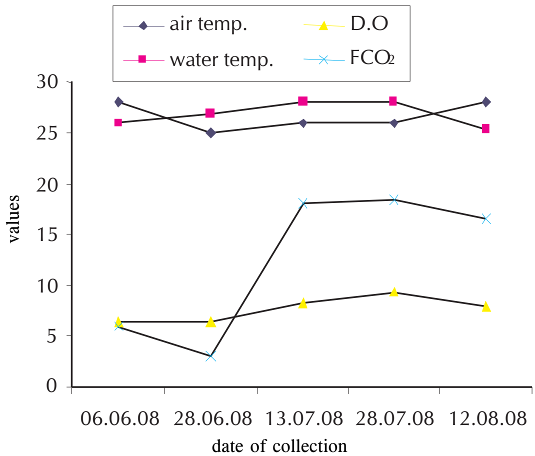

Figure 1: Fluctuation of Air temperature, water temperature, dissolved oxygen and free CO_2 against date of collection: Kotoha

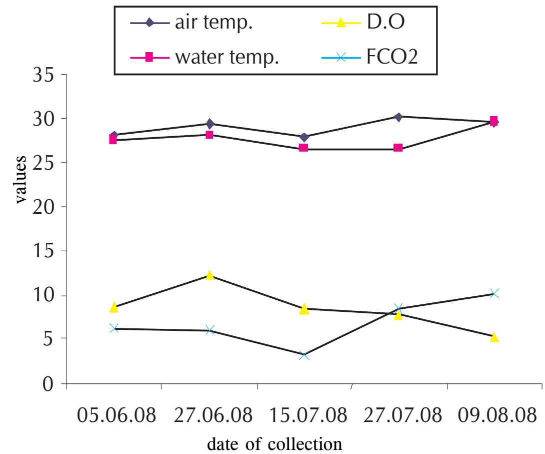

Figure 2: Fluctuation of Air temperature, water temperature, dissolved oxygen and free CO_2 against date of collection: Maijan

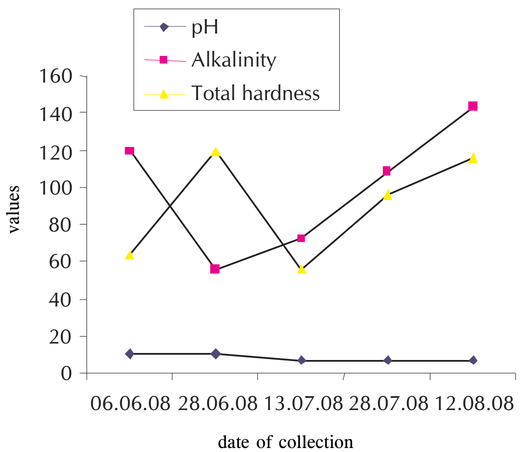

Figure 3: Fluctuation in pH, Alkalinity and Total hardness against date of collection: Kotoha

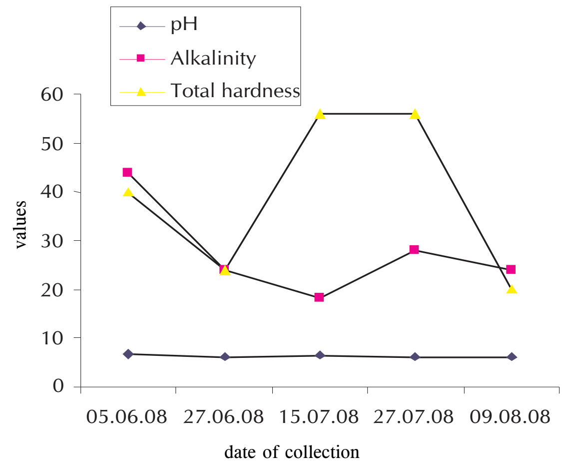

Figure 4: Fluctuation in pH, Alkalinity and Total hardness against date of collection: Maijan

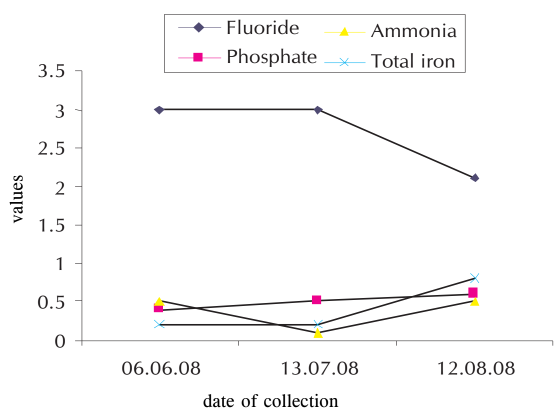

Figure 5: Fluctuation of Minerals against date of collection in Kotoha

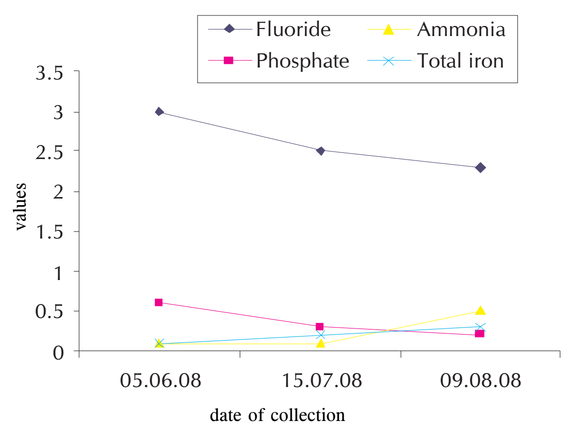

Figure 6: Fluctuation of Minerals against date of collection in Maijan

2009. The physico-chemical parameters of the investigated beel and their variation due to seasons were recorded and are presented in Tables 1, 2, 3 and Figures 1 to 10.

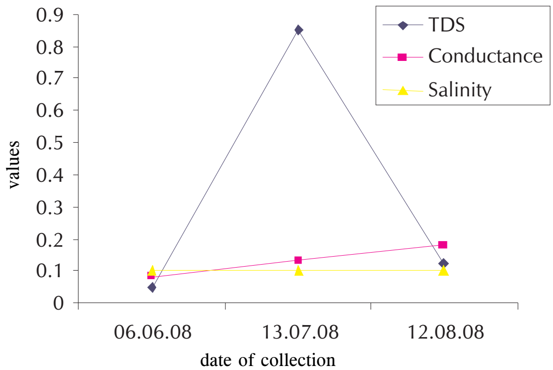

Figure 7: Graphical representation showing fluctuation of Total dissolved Solids, Conductance and Salinity against date of collection Kotoha

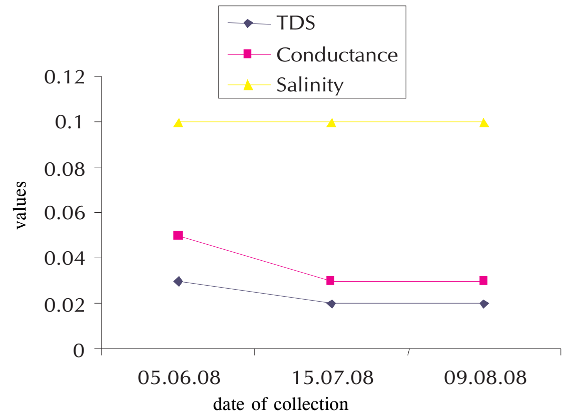

Figure 8: Graphical representation showing fluctuation of Total dissolved Solids, Conductance and Salinity against date of collection Maijan

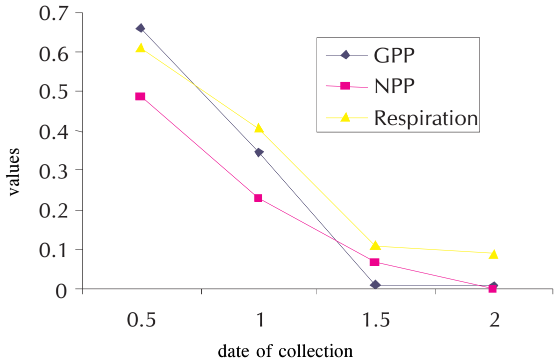

Figure 9: Graphical representation showing depth-wise fluctuation in Kotoha

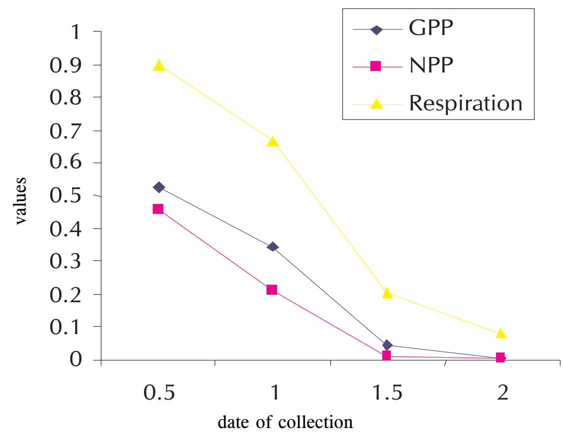

Figure 10: Graphical representation showing depth-wise fluctuation in Maijan:

a) **Water temperature:** The average water temperature of Kotoha borbeel varied from 26.5°C in June to 25.3°C in August and that of Maijan beel varied from 27.7°C in June to 29.5°C in August.

b) **Air temperature:** The average air temperature of Kotoha borbeel varied from 26.5°C in June to 28.1°C in August and that of Maijan beel varied from 28.7°C in June to 29.6 °C in August.

c) **pH:** pH of Kotoha borbeel varied from 10.4 in June to 6.9 in August and that of Maijan beel varied from 6.5 in June to 6.1 in August.

d) **Dissolved oxygen:** Monthly averages of dissolved oxygen (DO_2) of Kotoha borbeel varied from 6.4 mg/L in June to 7.9 mg/L in August and that of Maijan beel varied from 10.9 mg/L in June to 5.2 mg/L in August.

e) **Free carbon dioxide:** Monthly average pattern of free CO_2 concentration of Kotoha borbeel varied from 4.5 mg/L in June to 16.6 mg/L in August and that of Maijan beel varied from 6.1 mg/L in June to 10.2 mg/L in August.

f) **Total Alkalinity:** The value fluctuated of Kotoha borbeel varied from 88 mg/L in June to 144 mg/L in August and that of Maijan beel varied from 34 mg/L in June to 24 mg/L in August.

Table 2: Seasonal variation of different parameters in comparison to flooding season: Maijan beel

Sl.no.	Parameters	Monsoon/ flooding season	Autumn	Winter	Pre- monsoon
1	Air temperature (°C)	29	22.5	20	26.6
2	Water temperature (°C)	27.9	22.6	16.6	21.9
3	pH	6.3	6.8	7.4	8.0
4	Humidity (%)	73.33	67.33	45.5	44.83
5	Dissolved O_2 (mg/L)	8.0	5.8	8.8	6.4
6	Free CO_2 (mg/L)	7.3	9.4	5.6	3.8
7	Alkalinity (mg/L)	27	40	50.33	51
8	Total Hardness (mg/L)	36	38	50.66	62
9	Calcium hardness (mg/L)	18.6	14.66	32.66	40
10	Magnesium hardness (mg/L)	18.6	23.33	21.33	22
11	Chloride (mg/L)	16.9	18.23	15.4	13.5
12	Fluoride (mg/L)	2.6	1.5	1.5	1.4
13	Phosphate (mg/L)	0.36	0.36	0.16	0.26
14	Ammonia (mg/L)	0.23	0.46	0.1	0.15
15	Total iron (mg/L)	0.21	0.4	0.2	0.2
16	Nitrate	5	5	5	5
17	GPP mg C/m^3/hr	0.527	0.643	0.618	0.484
18	NPP (mg O_2/m^3/hr)	0.456	0.659	0.249	0.253
19	Respiration(mg O_2/m^3/hr	0.897	0.400	0.704	0.441
20	TDS (ppt)	0.023	0.04	0.056	0.056
21	Conductance (mS)	0.030	0.06	0.07	0.08
22	Turbidity (NTU)	7	9	7.2	10.8

g) **Total Hardness:** The value fluctuated of Kotoha borbeel varied from 92 mg/L in June to 116 mg/L in August and that of Maijan beel varied from 32 mg/L in June to 20 mg/L in August.

h) **Calcium Hardness:** The value fluctuated of Kotoha borbeel varied from 44 mg/L in June to 40 mg/L in August and that of Maijan beel varied from 24 mg/L in June to 12 mg/L in August.

i) **Magnesium Hardness:** The value fluctuated of Kotoha borbeel varied from 43 mg/L in June to 76 mg/L in August and that of Maijan beel averaged 8 mg/L from June to August.

j) **Mineral Content:** The average value of minerals such as **chloride** was found to be 19.9 mg/L, **Fluoride** 2.7 mg/L, **Phosphate** 0.5 mg/L, **ammonia** 0.36 mg/L and **iron** 0.4 mg/L, was found in Kotoha borbeel. In Maijan beel the average values of Chloride is 16.9 mg/L, phosphate 0.36 mg/L, Fluoride 2.6 mg/L, ammonia 0.23 mg/L and total iron 0.21 mg/L.

k) **Total dissolved solids (TDS):** Average value of TDS was found as 0.023 in Maijan and 0.341 in Kotoha.

l) **Conductance:** Average conductance of Kotoha is 0.131 mS and that of Maijan beel is 0.036 mS.

m) **Turbidity:** Turbidity of Kotoha is 15.33 NTU and Maijan is 7 NTU.

The air and water temperature were recorded highest during the monsoon period in both the beels as compared to other seasons (Kotoha 28.8°C, 26.6°C; Maijan 29°C, 22.5°C), with lowest recorded in winter (Kotoha 21°C, 15.8°C; Maijan 21°C, 16.6°C).

But pH was recorded lowest during the flooding season in Maijan (6.3) and highest in pre-monsoon (8) whereas in Kotoha pH was high in flooding season (8.2) highest in pre-monsoon (8.9) and lowest in autumn (7).

Humidity was observed highest in monsoon in both the beels (Kotoha 65.8%; Maijan 73.33%) and lowest in pre-monsoon (Kotoha 52.8%; Maijan 44.8%).

D.O and FCO_2 was also found to be highest in Kotoha (7.7 mg/L, 13.1 mg/L) in the flooding period with lowest value recorded in Pre-monsoon (6.2 mg/L, 3.8mg/L). In Maijan,

Table 3: List of fish species

Order/family	Fish species	Local name	Maijan	Kotoha	Conservation status
Order: Anguilliformes Family: Angruilidae	*Anguila bengalensis* (Gray and Hardwicke)	Nadal bami	+	-	VU
Order: Beloniformes Family: Belonidae	*Xenentodon cancilla* (Hamilton)	Kokila	+ + +	+ + +	LRnt
Order Clupeiformes Family: Clupeidae	*Gudusia chapra* (Hamilton-Bloch)	Koroti	+	-	VU
Family: Engruilidae	*Setipinna phasa* (Hamilton-Buchanan)	Salo	+ +	-	NE
Order: Cypriniformes	*Amblypharyngodon mola* (Hamilton)	moa	+ + +	+ + +	LRnt
Family: Cyprinidae	*Aspidoparia morar* (Hamilton)	boriala	+ + +	+ +	LRnt
	A.jaya (Hamilton)	boriala	+ + +	+ +	LRnt
	Barilius barna(Hamilton)	Jikiri/ozola	+ +	-	NE
	Brachydanio rerio (Hamilton-Buchanan)	——	+ +	+ +	NE
	Catla catla (Hamilton-Buchanan)	Bahu/bhokua	+ + +	+ + +	LRlc
	Cirrhinus mrigala (Hamilton-Buchanan)	Mirika	+ + +	+ + +	LRlc
	C.reba (Hamilton)	Laseem	+ + +	+ +	VU
	Ctenopharyngodon idella (Valenciennes)	Grass carp	-	+ +	LRlc
	Cyprinus carpio (Linnaeus)	Common carp	-	+ +	LRlc
	Chela cachius (Hamilton)	Dorikona	+ + +	+ +	NE
	C.laubuca (Hamilton)	Dorikona	+ + +	+ +	NE
	*Danio aequipinnatus (*McClelland)	Dorikona	+ + +	+ +	NE
	D.devario (Hamilton)	Dorikona	+ + +	+ +	NE
	Esomus danricus (Hamilton-Buchanan)	Dorikona	+ + +	+ +	NE
	Hypopthalmichthys molitrix (Valenciennes)	Silver carp	-	+ +	LRlc
	Labeo rohita (Hamilton-Buchanan)	rohu	+ + +	+ + +	LRlc
	L.gonius (Hamilton)	Kurhi	+ + +	+ + +	LRlc
	L.bata (Hamilton)	Bhangan	+ + +	+ +	LRnt
	L.calbasu (Hamilton)	Kaliajora/mali	+ + +	+ + +	LRlc
	L.dero (Heckel)	Naro	+ +	+	LRnt
	Osteobrama cotio (Hamilton)	Hafo	+ + +	+ + +	LRnt
	Puntius ticto (Hamilton)	Puthi	+ + +	+ + +	LRnt
	P.sophore (Hamilton)	Puthi	+ + +	+ + +	LRnt
	P.chonchonius (Hamilton)	Puthi	+ + +	+ + +	LRnt
	P.phutonio (Hamilton)	Puthi	+ + +	+ + +	LRnt
	P.chola (Hamilton)	Puthi	+ + +	+ + +	LRnt
	P.sarana sarana (Hamilton)	Seni puthi	+ + +	+ +	NE
	Rasbora daniconius (Hamilton-Buchanan)	Dorikona	+ + +	+ + +	VU
	R,rasbora (Hamilton-Buchanan)	Dorikona	+ + +	+ + +	VU
	Salmostoma bacaila (Hamilton-Buchanan)	Selkona	+ + +	+ +	VU
Family Cobitidae	*Botia dario* (Hamilton)	Gethu	+ + +	-	NE
	Botia rostrata (Gunther)	Botia	+ + +	-	NE
	Lepidocephalus guntea (Hamilton)	Bali botia	+ + +	-	NE
	L.berdmorei (Blyth)	Bali botia	+ + +	-	NE
	Somileptes gongota (Hamilton)	——————	+	-	NE
	Noemacheilus arunachalensis (Dutta and Barman)	Botia	+ +	-	E
Family: Psilorhynchidae	*Psilorhynchus sucatio* (Hamilton)	————-	+	-	NE
Order: Mastacembeformes	*Mastacembelus armatus* (Lacepede)	Bami	+ + +	+ +	LRnt
	M.aculeatus (Bloch)	Bami	+ + +	+ +	LRnt
Family: Mastacembellidae	*Macrognathus pancalus* (Hamilton-Buchanan)	Tura	+ + +	+ +	LRnt
	*Macrognathus aral (*Bloch- Schneider)	Tura	+ + +	+ +	LRnt
Order: Osteoglossiformes	*Chitala chitala* (Fowler)	Chitol	+ +	-	E
Family: Notopteridae	*Notopterus notopterus* (Pallas)	Kanduli	+ + +	+ + +	VU
Order: Perciformes	*Chanda nama* (Hamilton-Buchanan)	Chanda	+ + +	+ + +	LRnt

Cont….Table 3: List of fish species

Order/family	Fish species	Local name	Maijan	Kotoha	Conservation status
Family: Chandidae	*C.ranga* (Hamilton-Buchanan)	Chanda	+ + +	+ + +	LRnt
	C.baculis (Hamilton)	Chanda	+ + +	+ + +	LRnt
Family: Nandidae	*Badis badis* (Hamilton-Buchanan)	Randhoni	+ + +	+ + +	LRnt
	Nandua nandus (Hamilton-Buchanan)	Gadgedi	+ + +	+ +	VU
Family: Gobiidae	*Glossogobius giuris* (Hamilton-Buchanan)	Patimutura	+ + +	+ + +	LRnt
Family: Anabantidae	*Anabas testudineus* (Bloch)	Kawoi	+ + +	+ + +	NE
Family: Belontidae	*Colisa fasciatus* (Schneider)	Kholihona	+ + +	+ + +	NE
	C.lalia (Hamilton-Buchanan)	Kholihona	+ + +	+ + +	NE
	C.sota (Hamilton-Buchanan)	Vesseli	+ + +	+ + +	NE
Family:Channidae	*Channa marulius* (Hamilton-Buchanan)	Sal	+ + +	+ + +	LRnt
	C.straitus (Bloch)	Sol	+ + +	+ + +	LRnt
	C.punctatus (Bloch)	Goroi	+ + +	+ + +	LRlc
	C.orientalis (Schneider)	Cheng	+ + +	+ + +	Lrlc
	C.gachua(Hamilton-Buchanan)	Cheng	+ + +	+ + +	LRnt
	C.stewarti (Playfair)	————-	+ + +	+ + +	NE
Order: Siluriformes	*Mystus cavasius* (Hamilton)	Bor-Hingori	+ + +	+ +	LRnt
Family Bagridae	*M.bleekeri* (Day)	Hingori	+ + +	+ +	VU
	M.vittatus (Bloch)	Hingori	+ + +	+ +	LRnt
	M.tengra(Hamilton-Buchanan)	Tengra	+ + +	+ +	LRnt
	M.montana (Jerdon)	Hingori	+ +	-	VU
	M.menoda (Hamilton-Buchanan)	Gagol	+ +	-	VU
Family: Siluridae	*Ompok bimaculatus* (Bloch)	Pavo	+ + +	-	E
	O.pavo (Hamilton-Buchanan)	Pavo	+ + +	-	E
	O.pabda (Hamilton-Buchanan)	Pavo	+ + +	-	E
	Wallago attu (Schneider)	Borali	+ + +	+ + +	LRnt
Family Schilbeidae	*Ailia coila* (Hamilton-Buchanan)	Kajoli/bahpatia	+ + +	+ + +	VU
	Clupisoma garua (Hamilton-Buchanan)	Neria	+ + +	-	VU
	Eutropiichthys vacha (Hamilton-Buchanan)	Bosa	+ + +	+ +	NE
	Pseudotropius atherinoides (Bloch)	Bordua	+ + +	+ + +	LRnt
Family: Claridae	*Clarius batrachus* (Linnaeus)	Magur	+ + +	+ + +	LRlc
Family: Heteropneustidae	*Heteropneustes fossilis* (Bloch)	Hingi	+ + +	+ + +	VU
Family: Chacidae	*Chaca chaca* (Hamilton-Buchanan)	Kurkuri	+ +	-	VU
Order: Synbrachiformes Family: Synbranchidae	*Monopterus cuchia* (Hamilton-Buchanan)	Cuchia	+ + +	+ + +	NE
Order: Tetraodontiformes Family: Tetraodontidae	*Tetraodon cutcutia* (Hamilton-Buchanan)	Gongatop	+ + +	+ + +	LRnt

D.O and FCO_2 values were high (8 mg/L, 7.3 mg/L) but highest D.O (8.8 mg/L) was recorded in winter and highest FCO_2 (9.4mg/L) in autumn with low values of D.O in autumn (5.8mg/L) and FCO_2 in pre-monsoon (3.8mg/L).

The values of Alkalinity (107.3 mg/L), total hardness (94.6 mg/L) including Calcium hardness (38.6 mg/L) were recorded highest in the flooding season with lowest values of alkalinity and hardness was observed in pre-monsoon (69.6 mg/L, 66mg/L) and for calcium hardness lowest value was seen in autumn (16mg/L) in case of Kotoha borbeel. The magnesium hardness of Kotoha was moderate during flooding month (54.3mg/L) with highest in autumn (66mg/L) and lowest in pre-monsoon (51.3mg/L). While in Maijan beel, lowest values were recorded in flooding period of alkalinity (27mg/L), total hardness (36mg/L), calcium hardness (18.6mg/L) and magnesium harness (18.6mg/L) and highest values are recorded in pre-monsoon of alkalinity (51mg/L), total hardness (62mg/L), calcium hardness (40mg/L) and magnesium hardness highest was seen in autumn (23.3mg/L).

In Kotoha borbeel, the values of Chloride (19.9mg/L), fluoride (2.7mg/L), phosphate (0.5mg/L), ammonia (0.36mg/L) and total iron (0.4mg/L) were all recorded highest in the monsoon period and lowest in the winter season (10.9 mg/L, 1.33mg/L, 0.2mg/L, 0.1mg/L, 0.2mg/L). In Maijan beel, chloride showed high value in monsoon (16.9mg/L) but highest was recorded in autumn (18.2mg/L) and lowest in (13.5mg/

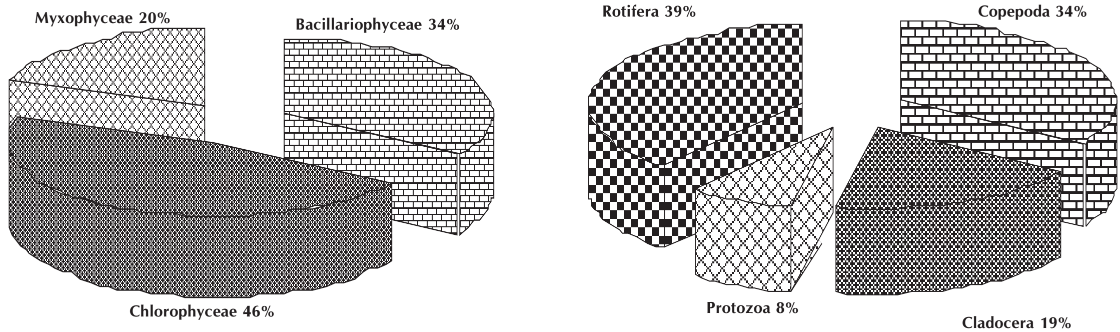

Figure 11: Percentage composition of Phyto and zooplankton of the Kotoha borbeel

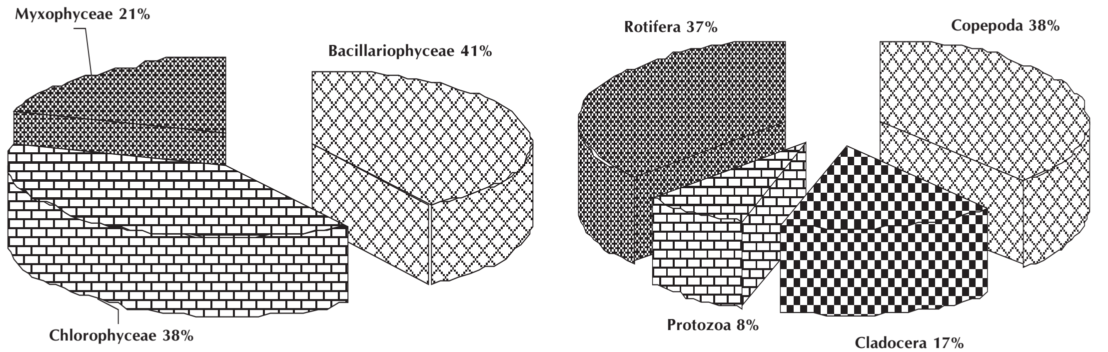

Figure 12: Percentage composition of phyto and zooplankton of Maijan beel

L). Fluoride and phosphate recorded highest values in flooding months (2.6mg/L, 0.36mg/L) and lowest values in pre-monsoon (1.4mg/L) for fluoride and winter for phosphate (0.16mg/L). Ammonia and total iron showed moderate values (0.23mg/L, 0.21mg/L) in the flooding months with highest in autumn (0.46mg/L, 0.4mg/L) and lowest in winter (0.1mg/L, 0.2mg/L).

Nitrate was recorded constant throughout all the seasons in both the beels (Kotoha 5mg/L; Maijan 5mg/L).

GPP, NPP and respiration are moderate during flooding season (0.659 mg C/m^3/hr, 0.486 mg C/m^3/hr, 0.608 mg C/m^3/hr) while highest values of GPP and respiration was recorded in winter (0.847 mg C/m^3/hr, 0.752 mg C/m^3/hr) and NPP in autumn (0.798 mg C/m^3/hr) in Kotoha borbeel. In Maijan beel also, GPP and NPP showed moderate values (0.527 mg C/m^3/hr, 0.456 mg C/m^3/hr) in flooding period with highest values in autumn (0.643 mg C/m^3/hr , 0.659 mg C/m^3/hr) and lowest in pre-monsoon (0.484 mg C/m^3/hr, 0.253 mg C/m^3/hr). However, respiration is seen highest in monsoon (0.897 mg C/m^3/hr) and lowest in autumn (0.4 mg C/m^3/hr).

TDS was recorded highest in flooding season (0.341ppt.) and lowest in pre-monsoon (0.07ppt.), Conductance showed high value in flooding season (0.131 mS) but highest was seen in autumn (0.14mS and lowest in winter (0.11mS), Turbidity was observed low in flooding period (15.3NTU) with highest in pre-monsoon (42NTU) and lowest in autumn (13.3NTU) in Kotoha borbeel. Whereas in Maijan, TDS, Conductance and turbidity were lowest in monsoon period (0.023ppt, 0.03mS, 7NTU) with highest values in pre-monsoon (0.056ppt, 0.08mS, 10.8NTU).

Fish species composition of both the beels

In Maijan **80** species of fishes belonging to **23** families and 10 orders were found and in Kotoha **64** species of fishes belonging to **18** families and 8 orders were recorded and presented inTable3.

*Based on CAMP report, 1998

E- Endangered; VU- Vulnerable; LRnt- Low risk near threatened; LRlc- Low risk least concerned; NE-Not evaluated.

Fish species: As seen from the various faunal species table the riverine connection of Maijan beel brings much desired auto-stoking in this wetland. The freshwater prawns are also found in large numbers hiding under the submerged macrophytes.

DISCUSSION

Water quality includes all physical, chemical and biological attributes that influences the beneficial use of water (Boyd, 1984). Any characteristic of water affects the production potential of a beel ecosystem. The range and pattern of core physico-chemical parameters of water have briefly been discussed here. The biotic communities were also analysed. Diana *et al*. (1997) has given a detailed account of the relationship between water quality and fish production.

Abiotic factors

Temperature: It is universally accepted density independent factor shaping the biotic communities. Slight change in it may affect the hydrology of the beel ecosystem. The fluctuation of water temperature largely depends on the changes in the solar radiation. During the rainy season the temperature ranges between 25°C to 32°C in which the fish grow the best (Boyd, 1984).

pH: pH is one of the most important characteristic regulating the life processes and nutrient availability in any water body particularly the flood plain lakes with alternate drying and flooding. The fluctuation of pH in water phase of flood plain lakes is a function of basin soil and the dense aquatic vegetation (Yadava *et al*., 1987) besides the inflow of surface run-off. According to Swingle (1967) water having pH range of 6.5 to 9.0 before day break is considered suitable for fish production in fresh water lakes and ponds.

Dissolved oxygen: According to Boyd (1982) fish do not feed or grow well when dissolved oxygen remains continuously below 4 or 5 mg/L. D.O also provides a valuable information on the prevailing biological and biochemical reactions of the system, which affects the aquatic life and the capacity of the water to receive organic matters without causing adverse impacts (Wetzel, 1990).

Free Carbon-dioxide (CO_2): Free CO_2 in water occurs due to respiration of aquatic biota decomposition of organic maters and also due to infiltration through the soil. Fishes can tolerate a higher concentration of free CO_2 upto 66 mg/L with a tendency to avoid as low as 5 mg/L (Hart, 1944).

Transparency: It depends upon the penetration of solar radiation, geographical location of water body, and the presence of dissolved and particulate materials are the interfering factors. The decline of Secchi Disc depth during the study may be due to inflow of silt through surface run-off from the catchment into the beel following heavy monsoon showers experienced during the period.

Total Alkalinity: It is due to presence of carbonate, bicarbonate and hydroxide ions. It is an index of nutrient status of the water body. Water bodies having total alkalinity above 50 mg/L can be considered productive.

Hardness: Hardness of water is due to the compounds of Calcium and Magnesium which exists in the form of carbonate, sulphates, chlorides etc. increase in hardness during summer in both the wetlands is supposed to be due to evaporation of surface water and decompositions of flora and fauna. In winter low hardness may be due to utilization of calcium by mollusca and magnesium by aquatic plants.

Mineral Contents: The minerals like Chloride, Silicate, Phosphate and Nitrate during the rainy season varies.

Chloride: Chloride varied from 12.9 mg/L to 25.9 mg/L in Kotoha and in Maijan from 13.9 to 15.9 mg/L during the flooding season.

Phosphate and Nitrate: Both are low in two beels and remained below 1.0 mg/L in case of phosphate and nitrate 10 mg/L throughout the year. Rapid utilization by dense infestation of submerged macrophytes might be one of the causes for low concentration of these two primary nutrients.

Iron: In both the sites the iron content was minimum 0.1 to maximum 0.4 mg/L at Kotoha and minimum 0.2 to maximum 0.5 mg/L at Maijan. Low concentration in winter and high in summer might have been due to receding level of water during summer.

Biotic factors

Biological Properties (productivity): It is the rate of conversion of solar energy to chemical energy through photosynthesis. The productivity experiment showed maximum production at 0.5 m depth where gross, net and respiration values were 0.527, 0.456, 0.897 mg C/m^3/hr respectively. The lower limit of productivity was at 2.0 m depth where gross, net, respiration values were 0.006, 0.005, 0.081 mg C/m^3/hr at Maijan beel. A minimum productivity suggested the extent of the euphotic zone. The productivity below 2 m is almost nil. The primary productivity was influenced by autotrophs as photosynthesis exceeded the respiration (Odum 1956). In Kotoha the gross, net and respiration values were 0.659, 0.486, 0.608 mg C/m^3/hr respectively at 0.5 m depth and 0.009, 0.001, 0.091 mg C/m^3/hr at 2 m depth.

Plankton: Davis (1955) stated that a number of physico-chemical, biological and environmental factors acting simultaneously should be taken into consideration while studying plankton. The biological processes are so complex that no single ecological factor can be identified to be responsible for the growth and production of plankton community. The nutrient enrichment increases at the onset of monsoon. Further with the sudden rise in water level and turbidity, the submerged macrophytes like *Hydrilla, Ceratophyllum* and *Majas* etc growing abundantly in the beel were decayed due to the obstruction of sunlight in the water. Qualitative and quantitative estimation of planktons showed seasonal variation in species composition as well as fluctuation in the density of phyto- and zoo-plankton particularly in the flooding season.The phytoplankton dominated the zooplankton both in quality and quantity.

The plankton community structure represents the biological productivity of the system. Phytoplankton observed in Kotoha beel are the representative of Myxophyceae (20%), Chlorophyceae (47%) and Bacillariophyceae (37%). Zooplankton observed are representative of protozoa (8%), Rotifera (39%), Cladocera (19%) and Copepoda (34%). Phytoplankton shows their maximum concentration upto 2 m depth which gradually decreases below as their distribution is under the influence of light and water temperature. The phytoplankton in Maijan beel are Bacillariophyceae (45%), Chlorophyceae (42 %) and Myxophyceae (21%). Zooplankton in Maijan beel constitute of Protozoa (8%), Rotifera (37%), Cladocera (17%) and Copepoda (38%). Plankton species diversity shows significant correlation with the species richness and evenness.

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