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A Study on Physico-Chemical Characteristics of Water in Three Floodplain Wetlands of Central Assam, India

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Abstract

A systematic study has been carried out to evaluate physico- chemical characteristics of water in the selected wetlands of central Assam from September 2014 to August 2015. Three wetlands which come across central Assam (Kamrup Metro and Kamrup Rural district) have been selected for the study. The wetlands selected for the study are (a) one is situated between 26°04′59″-26°03′49″ N and 91°26′45″ -91°26′43″ E and connected to the Kulsi River, which is a tributary of River Brahmaputra (b) another is situated between 26°10′-26°8′N and 92°11′-92°8′ E and having a connection to the Kolong river (c) the other is situated between 26°13′20″- 26°05′30″ N and 92°5′ -92°1′30″ E and connected to the Digaru river. Altogether fourteen physico-chemical water quality parameters which include atmospheric temperature (ranges between 16°c-31°c), water temperature (ranges between 17°c-32°c), pH (ranges between 5.67-6.73), conductivity (ranges between 37.6 µs/cm-609.24 µs/cm), transparency (ranges between 31.75cm-42.58cm), dissolved oxygen (ranges between 3.38 mg/l-8.19 mg/l), BOD (ranges between 3.86 mg/l-11.12 mg/l), COD (ranges between 28.19 mg/l-57.32 mg/l), Free CO_2 (ranges between 4.02 mg/l-5.37 mg/l), P-Alkalinity (Nil), Total Alkalinity (ranges between 19.16 mg/l-63.20 mg/l), Total Suspended Solids (ranges between 49.15 mg/l-52.08 mg/l), Total Dissolved Solids (ranges between 20.83 mg/l-357.25 mg/l), Total Hardness (ranges between 8.42 mg/l- 103.67 mg/l) have been analyzed from September, 2014 to August, 2015 on a monthly basis.

Keywords: Wetland, Water, Physico-Chemical, Central Assam

Introduction

Wetlands are part of all biomes, and although they often make up only a small proportion of the total surface area, they account for much of the productivity and provide essential ecosystem services (Millennium Ecosystem Assessment 2005). The most comprehensive definition of "wetland" in current usage is the one used by the Ramsar Convention (1971): Article 1.1. provides that "wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." Article 2.1. adds that wetlands "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands" (Ramsar Convention COP8 2002). It thus covers all wetland ecosystems found on the continents and includes shallow marine areas. Although these areas have in common that they are in some way characterized by the presence of water at least temporarily, they differ vastly in their ecological conditions.

India has extensive floodplain wetlands, defined as low lying areas bordering large rivers, which are seasonally inundated by the overspill from main river channel. These wetlands are an integral component of the Ganga and Brahmaputra river basin, covering an area of 0.2 million hectares. They also exist in Manipur and Tripura as well as in the foothills of Arunachal Pradesh and Meghalaya. They can be typical oxbow lakes (i.e. cut off portions of river meander bends), sloughs, meander scroll depressions, back swamps, residual channels or tectonic depressions, though it is often difficult to establish their identity due to natural and man-made modifications to the environment. These water bodies are locally known as *beels* (Assam, West Bengal, Arunachal Pradesh, Meghalaya and Tripura), maun, chaurs and dhars (Bihar), pats (Manipur), charhas and boars (northern and south eastern West Bengal respectively) (Sugunan & Bhattacharya 2000)

Floodplain wetlands are characteristic features along the rivers Ganga, Brahmaputra and Barak basin, especially along their middle and lower stretches in the eastern and north-eastern parts of India. Most of the tributaries of Ganga River support floodplain wetlands in Uttar Pradesh, Bihar and West Bengal. Similarly, tributaries of river Brahmaputra and Barak river basin also support floodplain wetlands in Assam, Meghalaya, Manipur, Mizoram, Nagaland and Tripura. Assam has 1,392 floodplain wetlands spread over 1, 00,000 ha area. These include 322 wetlands along the river Barak which constitute 8,000 ha. (Sugunan & Bhattacharya 2000)

In Assam, there are 690 lakes and ponds as recorded. These lakes /ponds cover an area of 15494.00 ha which constitutes 0.20 percent of the total geographical area of the state and 15.30 percent of the total area under wetlands. The smallest of them measures 2.50 ha while the largest one has 882.50 ha of areal coverage. Majority of this type of wetlands have water with low turbidity. District- wise 3513 numbers of wetlands are identified in Assam by Assam Remote Sensing Application Centre, Assam.

Water is the one of most important compound to ecosystem. Good quality of water described by its physical, chemical and microbial characteristics. But some correlations were possible among these parameters and the significant one would be useful to indicate quality of water (Kamble et al. 2009). The most important step for conservation of wetlands is to maintain a proper water quality (Smitha & Shivashankar 2013). The water quality is directly related to the health of the water body. So, proper management in water quality of aquatic environment is very much essential. Some of the most recent works on water quality of various aquatic environments was those of, Sarkar & Upadhyay (2013) assessed the variations in physico-chemical characteristics of water quality of the wetlands in District Mainpuri (U.P.), India. Pramod et al. (2011) conducted a study on physico-chemical characteristics of water in wetlands of Hebbe Rannge in Bhadra Wildlife Sanctuary, Mid Western ghat Region, India. Islam et al. (2014) conducted a study on physico-chemical properties of water in some selected sites of Deepor *Beel* (Ramsar site), Assam, India. Jagadeshappa et al. (2011) conducted a study on seasonal variation of physicochemical characteristics of water in two wetlands of Tiptur Taluk, Karnataka.

Materials and Methods

Study area

The present study was carried out in a wetland of Kamrup Rural District and two wetlands of Kamrup Metro District of Central Assam. The wetlands that are selected for the present study are (a) Sol *beel* situated at the global position 26°4′00.5″- 26°3′55″N and 91°26′44.4″-91°26′19.9″E of Kamrup Rural District and connected during the monsoon season at the Kulsi River. (b) Etila *beel* is situated at the global position 26°10′- 26°08′ N and 92°11′ -92°08′ E of Kamrup Metro district and connected to the Kolong, a tributary of mighty Brahmaputra River. (c) Duani *beel* is situated at the global position 26°13′20″-26°05′30″ N and 92°05′-92°1′30″ E and connected to the Digaru river tributary.

Data collection and analysis: For the analysis of water, samples were collected at random basis from each site, in five liter plastic gallons previously rinsed with distilled water at about 25cm depth in the morning at 7am to 11am. Water samples were collected from three selected wetlands to conduct physico-chemical study on a monthly basis from five sampling stations of each wetland. The study was carried out for a period of 12 months from September, 2014 to August 2015. Atmospheric and water temperature, PH, transparency, conductivity were determined on the sampling sites. BOD and DO were fixed on the site , while COD, Free CO2, Phenolphthalein Alkalinity, Total Alkalinity, Total Hardness, Total Suspended Solids, Total Dissolved Solids were analyzed in the laboratory by standard methods (APHA 2005).

Results and discussion

The average values and standard deviations of the three studied wetlands are presented in Table 1, Table 2 and Table 3. Average (Mean) values and standard deviations of all the three wetlands are presented altogether in the Table 4. The water temperature is one of the essential parameter, since it influences the growth and distribution of flora and fauna. Majority of aquatic species are cold blooded and easily affected by changes in temperature (Ormerod 2009). The average water temperature observed during the study period was recorded as 24.37^{0}c ± 5.07 in the Sol *beel*, 24.74°c ± 5.13 in the Etila *beel* and 24.74°c ± 5.13 in the Duani *beel* respectively. The atmospheric temperature of the three studied wetlands was recorded as 24.49°c ± 5.15 in Sol *beel*, 24.91^{0}c ± 5.33 in Etila *beel* and 24.91°c ± 5.33 in Duani *beel* respectively. PH is the concentrations of hydrogen ions (H+) present in water and is a measure of acidity or alkalinity. The pH of the studied wetlands was recorded as 5.67 ± 0.17 in Sol *beel*, 6.73 ± 0.44 in Etila *beel* and 6.24 ± 0.08 in Duani *beel* respectively. It was found that the pH of water of all the three selected wetlands were slightly acidic. The natural range of pH is 7. PH of less than 7 indicates the acidic nature of water and PH greater than 7 indicate basic nature of water. The water PH of Sol *beel* was found more acidic in comparison to the other two studied wetlands. It was recorded as 5.67 ± 0.17 in Sol *beel*. Usually acidity is not a direct or specific pollutant; it is merely a measure of the effects of a combination of substances and conditions in the water. The normal range of PH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. The water PH of Sol *beel* and Duani *beel* were found slightly below the normal range. The water PH of Etila *beel* was found in between the normal range. The desirable range of water PH for fish production is 6.5 to 9.0. Conductivity is a measure of waters capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. Conductivity increases as the concentration of ions increase. During the study period, significant differences of conductivity were observed in the three studied wetlands. The mean conductivity was recorded as 37.66 ± 2.16 µs/cm in Sol *beel*, 609.24 ± 15.5 µs/cm in Etila *beel* and 409.75 ± 5.66 µs/cm in Duani *beel*. Freshwater streams and rivers ideally should have conductivity between 150 to 500 µs/cm to support diverse aquatic life, while most streams and rivers range between 50 to 1500 µs/cm. High conductivity (1000 to 10,000 µs/cm) is an indicator of saline conditions. Waters that have been heavily impacted by industry can fall into this range. Lowest electric conductivity was recorded in the Sol *beel*, this may due to the addition of some organic compounds from the nearby agricultural fields. Conductivity of Etila *beel* and Duani *beel* was found in between the ideal range (150 to 500 µs/cm) for support diverse aquatic life. Transparency of water relates to the depth that light will penetrate water. The transmission of light into a body of water is extremely important since the sun is the primary source of energy for all biological phenomena. During the study period, the mean water transparency of Sol *beel* was recorded as 31.75 ± 5.68 cm, in Etila *beel*, 42.58 ± 4.41 cm and in Duani *beel*, 41.08 ± 2.31 cm. In general, low transparency reflects excessive sediment or other suspended material (e.g. algae) in the water. Transparency of less than 20 cm in freshwater bodies is considered as poor transparency. Transparency of 20 cm to 40 cm of freshwater ecosystem (rivers, streams) is considered as fair transparency. Sol *beel* has the fair transparency that means its transparency is in between 20 cm to 40 cm (31.75 ± 5.68 cm). Transparency in the range of 41 cm to 60 cm is considered as good transparency for freshwater ecosystems like streams, rivers etc. Etila and Duani *beel* has the transparency in between the range of 41 cm to 60 cm. Hence the transparencies of the two wetlands are considered as good transparency. Streams and rivers with transparencies greater than 60 cm are considered as excellent transparency in terms of water quality. Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. Just as we need air to breathe, aquatic organisms need dissolved oxygen to respire. It is necessary for the survival of fish, invertebrates, bacteria, and underwater plants. Dissolved Oxygen is also needed for the decomposition of organic matter. Dissolved Oxygen is considered as the best parameter for showing the effect of pollution on water bodies. During the study period, the mean DO of Sol *beel* was recorded as 8.19 ± 0.5 mg/l, in Etila *beel* as 3.38 ± 0.59 mg/l and in Duani *beel* as 7.4 ± 0.22 mg/l. A low level of DO was recorded in Etila *beel* (3.38 mg/l) in comparison to the other two wetlands. Dissolved Oxygen level of Etila *beel* was found very low according to the standards laid down by WHO (World Health Organization). Low DO levels can be attributed to low flow rate causing stagnant conditions thereby reducing natural aeration. The low DO concentration of the *beel* water has decreased the self-purification power resulting in emission of offensive odor. Dissolved Oxygen content for fish and other aquatic organisms should normally be at 5 mg/l. Dissolved Oxygen of Sol *beel* and Duani *beel* were found in the normal range. During the study period, the mean BOD of Sol *beel* was recorded as 3.86 ± 0.57 mg/l, in Etila *beel* 11.12±0.75 mg/l and in Duani *beel* 9.86 ± 1.05 mg/l respectively. Biological Oxygen Demand approximates the amounts of oxidizable organic matter in water. Water with BOD levels less than 4.00 mg/l are seemed reasonably clean. Water with BOD levels greater than 10.00 mg/l are considered polluted since they contain large amount of degradable organic matter. It was found that Etila *beel* has the highest BOD level (11.12±0.75 mg/l) in comparison to the other two studied wetlands. The high BOD level is considered to be an indication of increasing pollution in the *beel* water. Etila *beel* is highly affected by the discharge of industrial effluent of paper industry (Hindustan Paper Corporation, Nagaon). This may be the reason of its high BOD value. It was found slightly high BOD in the Duani *beel*. This may be due to high macrophytes infestation. BOD of Sol *beel* was found in between the normal range as the water is reasonably clean. COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality. The mean COD was found as 28.19 ± 4.09 mg/l in Sol *beel*, 57.32 ±2.33 mg/l in Etila *beel* and 46.81 ± 2.62 mg/l in Duani *beel* respectively. Free CO_2 in a water body may be derived from the atmospheric sources, biotic respiration, inflowing groundwater which seep into pond, decomposition of organic matter due to bacteria and may also from within the water body itself in combination of other substances mainly calcium, magnesium etc. The mean free CO_2 in the three studied wetlands were recorded as 4.27±0.25 in Sol *beel*, 4.02±0.29 in Etila *beel* and 5.37±0.65 in Duani *beel* respectively. Measuring alkalinity is important in determining a streams ability to neutralize acidic pollutant from rainwater or wastewater. It is one of the best measures of the sensitivity of the stream to acid inputs. There can be long term changes in the alkalinity of streams and rivers in response to human disturbances. During the study period, in all the three studied wetlands, P-Alkalinity (as $CaCO_3$) was found Nil. The mean Total Alkalinity obtained as 19.16±2.51 mg/l in Sol *beel*, 63.2±9.96 mg/l in Etila *beel* and 55.75±7.81 mg/l in Duani *beel*. The highest value of Total Alkalinity was found in Etila *beel* and lowest was recorded in Sol *beel*. Hardness of water is mainly due to the presence of Ca^{2+} and Mg^{2+} salts like sulphate, chloride, bicarbonate etc. Hardness of water has no known adverse affects on health; however it has some role in heart diseases. During the period of the study, the highest mean value of total hardness was recorded as 103.67 ± 10.01 mg/l in Etila *beel*, which is very high, this may be due to the discharge of industrial effluent of paper industry, as they contain high amount of bicarbonates, chlorides of Ca^{2+} and Mg^{2+} and the lowest value of mean total hardness was recorded in the Sol *beel* which was 8.42±0.9 mg/l. It may due to the *beel* is effluent free. Total Hardness of Duani *beel* was recorded as 73.41±5.68 mg/l. Suspended solids are present mainly due to impurities and accumulated gases and are caused by clay, silt, bits of bark, phytoplankton and other microscopic organisms. During the period of the study, Total suspended Solids were recorded as 49.83 ± 23.19 mg/l in Sol *beel*, 52.08±14.09 mg/l in Etila *beel* and 49.15±10.19 mg/l in Duani *beel*. According to standard laid down by CPCB the total suspended solid concentration must be within 100mg/l in fresh water and during the period of the study total suspended solid concentration were recorded within this standard in all the three studied wetlands. Excess dissolved solid imparts physiological effects and unpalatable mineral tastes on water and have corrosive properties. Fish and other aquatic animals have a large degree of tolerance but they are indirectly affected due to elimination of desirable food plants by excess dissolved solid. Water with dissolved solid content of more than 500 mg/l is not recommended for use in irrigation (NTAC 1968). During the period of the study, the total dissolved solids were recorded as 20.83±3.63 mg/l in Sol *beel*, 357.25±68.77 mg/l in Etila *beel* and 228.58± 30.16 mg/l in Duani *beel* respectively. It was observed that Etila *beel* has the highest concentrations of total dissolved solids it may due to the industrial effluent discharged by nearby paper industry (Hindustan Paper Corporation).

Conclusion

From the present study, it was found that the values of physico-chemical parameters of water analyzed during the study period, mostly exceeds the permissible limits in the wetland, which receive industrial effluent. The physico-chemical parameters of water of other two wetlands which were effluent free were under the permissible limits laid down by different agencies and water was free from pollution.

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Table 1. Monthly average variations in physico-chemical parameters of Sol *beel* of Kamrup Rural District, Assam, India (five sites)

	Month	AT	WT.	*PH*	*Conductivity.*	Transparency	DO	BOD	COD	*Free CO_2*	*p-Alkalinity*	*Total Alkalinity*	*Total Hardness*	*TSS*	*TDS*
		^{0}c	^{0}c		*(µs/cm)*	cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Post Monsoon	*SEP, 2014*	27.5	26.5	5.6	42	25	8.55	3.25	26.5	4.85	Nil	17	7.95	60	27
Post Monsoon	*OCT, 2014*	25	24	5.8	38	30	7.75	4.75	27.9	4.96	Nil	16	7.88	50	20
Post Monsoon	*NOV, 2014*	22	21	5.3	36	34	8.35	3.55	29.6	4.06	Nil	19	7.67	40	19
Post Monsoon	*Average*	24.83	23.83	5.57	38.67	29.67	8.22	3.85	28	4.62	Nil	17.33	7.83	50	22
Winter	*DEC, 2014*	19	18	5.1	32	38	8.75	3.05	25.7	4.15	Nil	15	7.75	30	13
Winter	*JAN, 2015*	16	17	5.6	37	40	8.5	4	26.5	4.17	Nil	18	8.1	30	18
Winter	*FEB, 2015*	17	18	5.9	36	42	8.5	3.25	28.6	4.57	Nil	19	8.25	30	18
Winter	*Average*	17.33	17.66	5.53	35	40	8.58	3.43	26.93	4.3	Nil	17.33	8.03	30	16.33
Pre-Monsoon	*MAR, 2015*	25	26	5.8	33	36	7.05	4.85	32.4	3.95	Nil	19	9.9	28	14
Pre-Monsoon	*APR, 2015*	26.5	27	5.7	42	22	7.55	4.55	34	4.25	Nil	21	9.85	37	27
Pre-Monsoon	*MAY, 2015*	27.5	26	5.8	36	33	7.85	4.65	35	3.98	Nil	18	9.6	46	19
Pre-Monsoon	*Average*	26.33	26.33	5.77	37	30.33	7.48	4.68	33.8	4.06	Nil	19.33	9.78	37	20
Monsoon	*JUN, 2015*	29	28	5.9	38	28	8.25	3.38	20.5	4.07	Nil	20	8.7	65	21
Monsoon	*JULY, 2015*	30	31	5.9	41	26	8.5	4	26.4	4.14	Nil	22	8	88	26
Monsoon	*AUG, 2015*	29.5	30	5.5	41	27	8.75	3.15	25.2	4.16	Nil	26	7.5	94	28
Monsoon	*Average*	29.5	29.66	5.9	40	27	8.5	3.51	24.03	4.12	Nil	22.67	8.07	82.33	25
Total Grand Average		24.50	24.37	5.67	37.67	31.75	8.20	3.87	28.19	4.28	Nil	19.17	8.43	49.83	20.83
Standard Deviation (SD) (±)		5.16	5.07	0.17	2.16	5.68	0.5	0.57	4.09	0.25	Nil	2.51	0.9	23.19	3.63

Table 2. Monthly average variations in physico-chemical parameters of Etila *beel* of Kamrup Metro District, Assam, India (five sites)

	Month	AT	WT.	*P^H^*	*Conductivity.*	Transparency	DO	BOD	COD	*Free CO_2*	*p-Alkalinity*	*Total Alkalinity*	*Total Hardness*	*TSS*	*TDS*
		^{0}c	^{0}c		*(µs/cm)*	cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Post Monsoon	*SEP, 2014*	28	27.5	6.3	572	35	2.88	13.07	55.4	4.25	Nil	54	98	58	438
Post Monsoon	*OCT, 2014*	25	24	6.5	580	40	3.41	9.56	56.6	4.36	Nil	51	96.6	49	358
Post Monsoon	*NOV, 2014*	22.5	21	6.6	610	44	3.98	9.96	58.5	3.85	Nil	50	100.5	38	290
Post Monsoon	*Average*	25.16	24.16	6.47	587.33	39.67	3.42	10.86	56.83	4.15	Nil	51.67	98.37	48.3	362
Winter	*DEC, 2014*	19	18	6.6	598	46	3.56	9.88	53.2	3.94	Nil	55	102.34	36	235
Winter	*JAN, 2015*	16	17	6.7	618	49	4.02	10.74	53.85	3.98	Nil	61	99.56	36	325
Winter	*FEB, 2015*	17.5	18.5	7.1	615	52	3.78	12.25	56.6	4.05	Nil	65	106.48	35	305
Winter	*Average*	17.5	17.83	6.8	610.33	49	3.79	10.96	54.55	3.99	Nil	60.33	102.79	35.7	288.33
Pre-Monsoon	*MAR, 2015*	26	27	7.4	605	42	4.46	12.05	58.4	4.1	Nil	65	110	53	305
Pre-Monsoon	*APR, 2015*	27	28	7.4	630	34	3.96	11.28	60.2	3.68	Nil	69	124	56	245
Pre-Monsoon	*MAY, 2015*	28	27	7.2	614	43	2.98	9.75	62	3.64	Nil	66	120	56	436
Pre-Monsoon	*Average*	27	27.33	7.33	616.33	39.67	3.8	10.03	60.2	3.81	Nil	60.67	118	55	328.67
Monsoon	*JUN, 2015*	29	28	6.8	618	41	2.97	11.6	64	4.15	Nil	71	94	68	444
Monsoon	*JULY, 2015*	31	32	6.1	626	42	2.25	11.5	55.1	4.12	Nil	76	96	68	448
Monsoon	*AUG, 2015*	30	29	6.1	625	43	2.41	12.55	54	4.16	Nil	80	96.58	72	458
Monsoon	*Average*	30	29.66	6.33	623	42	2.54	11.88	57.7	4.14	Nil	75.67	95.53	69.3	450
Total Grand Average		24.91	24.74	6.73	609.25	42.58	3.39	11.12	57.32	4.02	Nil	63.21	103.67	52.1	357.25
Standard Deviation (SD) (±)		5.33	5.13	0.44	15.5	4.41	0.59	0.75	2.33	0.29	Nil	9.96	10.01	14	68.77

Table 3 . Monthly average variations in physico-chemical parameters of Duani *beel* of Kamrup Metro District, Assam, India (five sites)

	Month	AT	WT.	P^H	*Conductivity.*	Transparency	DO	BOD	COD	*Free CO_2*	*p-Alkalinity*	*Total Alkalinity*	*Total Hardness*	*TSS*	*TDS*
		^{0}c	^{0}c		*(µs/cm)*	cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Post Monsoon	SEP, 2014	28	27.5	6.1	401	38	7.55	12.05	45	5.6	Nil	46	70	52	254
Post Monsoon	OCT, 2014	25	24	6.3	400	40	6.5	9.55	43.65	5.1	Nil	48	66	46	230
Post Monsoon	NOV, 2014	22.5	21	6.3	406	42	7.6	8.45	46.5	5.4	Nil	42	74	40	220
Post Monsoon	Average	25.16	24.16	6.233	402.33	40	7.22	10.02	45.05	5.37	Nil	45.33	70	46	234.7
Winter	DEC, 2014	19	18	6.2	398	44	7.25	8.25	42	4.8	Nil	51	76	38	195
Winter	JAN, 2015	16	17	6.4	416	48	7.15	8.15	44	3.85	Nil	56	68	38	180
Winter	FEB, 2015	17.5	18.5	5.9	411	41	7.65	8.56	48.5	4.75	Nil	57	77	36	200
Winter	Average	17.5	17.83	6.167	408.33	44.33	7.35	8.32	44.83	4.47	Nil	54.66	73.66	37.3	191.7
Pre-Monsoon	MAR, 2015	26	27	6.1	408	36	7.75	11.25	48	5.5	Nil	55	80	50	205
Pre-Monsoon	APR, 2015	27	28	6.5	432	41	6.55	11.56	51.5	6.4	Nil	60	82	51	210
Pre-Monsoon	MAY, 2015	28	27	6.5	402	40	7.6	8.85	52	5.8	Nil	64	82	54	255
Pre-Monsoon	Average	27	27.33	6.37	414	39	7.3	10.55	50.5	5.9	Nil	59.66	81.33	51.6	223.3
Monsoon	JUN, 2015	29	28	6.6	405	42	7.7	10	53	6.2	Nil	64	70	58	260
Monsoon	JULY, 2015	31	32	6	420	41	7.8	10	44.6	6.5	Nil	60	68	62.9	262
Monsoon	AUG, 2015	30	29	6	418	40	7.7	11.65	43	4.65	Nil	66	68	64	272
Monsoon	Average	30	29.66	6.2	414.33	41	7.7	10.55	46.87	5.78	Nil	63.33	68.66	61.6	264.7
Total Grand Average		24.91	24.74	6.242	409.75	41.08	7.4	9.86	46.81	5.38	Nil	55.75	73.41	49.1	228.6
Standard Deviation (SD) (±)		5.33	5.13	0.08	5.66	2.31	0.22	1.05	2.62	0.65	Nil	7.81	5.68	10.19	30.16

Table 4 Average (Mean) values of physico-chemical parameters of Three different Water Bodies belonging two different districts viz., Kamrup Metro & Kamrup Rural Districts of Assam, India during 2014-15

Parameters	**Sol *beel***	**Etila *beel***	**Duani *beel***
	(Mean ± SD)	***(Mean ± SD)***	***(Mean ± SD)***
Atmospheric Temperature *(°c)*	24.497 ± 5.159	24.91 ± 5.33	24.91 ± 5.33
Water Temperature *(°c)*	24.37 ± 5.07	24.74 ± 5.13	24.74 ± 5.13
pH	5.67 ± 0.17	6.73 ± 0.44	6.24 ± 0.08
Conductivity *(µs/cm)*	37.66 ± 2.16	609.24 ± 15.5	409.75 ± 5.66
Transparency *(cm)*	31.75 ± 5.68	42.58 ± 4.41	41.08 ± 2.31
DO *(mg/l)*	8.19 ± 0.5	3.38 ± 0.59	7.4 ± 0.22
BOD *(mg/l)*	3.86 ± 0.57	11.12 ± 0.75	9.86 ± 1.05
COD *(mg/l)*	28.19 ± 4.09	57.32 ± 2.33	46.81 ± 2.62
Free CO_2 *(mg/l)*	4.27 ± 0.25	4.02 ± 0.29	5.37 ± 0.65
p-Alkalinity *(mg/l)*	Nil	Nil	Nil
Total Alkalinity (mg/l)	19.16 ± 2.51	63.20 ± 9.96	55.75 ± 7.81
Total Hardness (mg/l)	8.42 ± 0.9	103.67 ± 10.01	73.41 ± 5.68
TSS *(mg/l)*	49.83 ± 23.19	52.08 ± 14.09	49.15 ± 10.19
TDS *(mg/l)*	20.83 ± 3.63	357.25 ± 68.77	228.58 ± 30.16

Atm. = Atmospheric
DO = Dissolved Oxygen
BOD = Biochemical Oxygen Demand
COD =Chemical Oxygen Demand
p-Alkalinity = Phenolphthalein Alkalinity
TSS = Total Suspended Solids
TDS =Total Dissolved Solids
BDL =Below Detectable Limit

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Phytosociological Study of the wetland macrophytes of Barpeta District and its Neighbouring areas of Assam

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Abstract

The present study has been made on the occurrence and distribution of certain aquatic plants in certain wetland areas of Barpeta District. During the investigation 67 different species of wetland macrophytes have been recorded from the wetland of the District. The number of free floating, rooted floating leaved, submerged and emergent plant species are found variable from place to place. The most common species are found as *Eichhornia crassipes*, *Nelumbo nucifera*, *Hydrilla verticillata Ipomoea aquatica*, *Ageratum conyzoides, Alternanthera phylloxeroides, Commelina benghalensis, Hygroryza aristata, Polygonum glabrum, Marsilia quadrifolia.* The IVI Value is found variable from species to species and sites to sites. The highest IVI found in case of *Eichhornia crassipes* and the lowest IVI value found in *Marsilia quadrifolia* in the study sites both in summer and winter season.

Keywords: Barpeta, Macrophytes, Importance Value Index (IVI), Dominant species.

Introduction

Phytosociology is the study of vegetation occurring in a particular ecosystem (Ambasht 1969). The phytosociological studies are very much needed for proper understanding the structure and dynamics of the vegetation. It is pre requisites to understand the ecological aspects of the plants in an ecosystem (Devi 1998). The phytosociological studies have been made by several workers in India from time to time as Tripathi (1965) reported an ecological study of weed of wheat and gram crops of Varanasi, Gupta & Srivastava (1983) of rice field weeds of Ranchi. Ananthakrishnan & Vishwanathan, (1976) consider community as any assemblage of ecologically related Organisms composed of two or more species, Pandey and Shah (1966) reported the phytosociology of seasonal weed succession of paddy field of Raipur, Gupta et al. (2008) reported the phytosociology of weed communities of wheat fields in Don valley. Ray & George (2009) have studied phytosociology of roadside communities, Singh and Singh (2010) studied the plants around the municipal drains in Jaunpur. Bora & Sarma (2012) studied phytosociological investigation visa vis human impact on to wetland of Sanitpur District and Deka & Sarma (2014) reported ecological studies on aquatic macrophytes of two major wetlands of Nalbari District of Assam.

The overall picture of ecological importance of a species in relation to all the community structure can be obtained from the importance value index (IVI). Curtis & McIntose (1950) first showed the importance value index and complete picture of sociological characters of species in community was indicated as IVI. Many authors in India reported phytosociology of different weed species such as Sen (1966), Pandey (1961), Tripathi (1965), Tripathi & Misra (1971), Laloo (1979), and others.

Several workers have done ecological studies on different wetlands of Assam so far there is no phytosociological study has been made on the occurrence of certain wetland macrophytes of Barpeta District and its neighbouring areas. Hence the present investigation is carried out to study the phytosociology of wetland macrophytes of three wetlands of Barpeta District, Assam along with the habitat characters of these wetlands.

Materials and methods

Study area

The investigation was conducted in three wetlands Kapla *beel*, Manash *beel* and Amguri *beel* respectively.

Kapla *beel*: It is a closed wetlands located in between 26°19// N to 26°20// N latitude and 91° 12// E to 91°15// E longitude. The *beel* covers an area of 91 hectare of land. The minimum and maximum depth of the *beel* is 5 to 9 meter.

Manash *beel*: It is a open wetland situated 26°36// N to 26°38// N latitude and 91°12// E to 91°13// E longitude. The *beel* is an oxbow type of lake originates from Palla River. The area of the *beel* is 65 hectare. The minimum and maximum depth of the *beel* is 3 to 7 meter.

Amguri *beel*: The *beel* lies 26°21// N to 26°20// N latitude and 90°56// E to 90°54// E longitude. The area of the *beel* is 58 Hectre. The minimum and maximum depth of the *beel* is 7 to 10 meter. It originates from Beki river.

Fig. 1 Kalpa *beel*, Amguri *Beel* and Manash *beel* respectively

Methodology

The present investigation was carried out on physical observation of the plants in the three study sites such as Kapla *beel*, Amguri *beel* and Manash *beel* in the Barpeta District and the aquatic plants were recorded from the year 2013-2014. The phytosociological study was made in the wetlands as per the method of Misra (1968).To study the Phytosociology of the wetlands, in each study sites 20 quadrates (1 x1 m^2) in every months were sampled randomly in two seasons i.e., summer and winter. The individuals of different species were recorded which are found in each quadrat. The relative frequency, relative density, relative abundance and IVI of wetland macrophytes were

As per Forester "Public hearings" began in "Enclosure Process" of land that occurred in Britain in the 18th and 19th centuries. In 1845, the General Enclosure Act created permanent commissioners who sent all bills to Parliament, and one publicly appointed commissioner who presided over the public meetings to hear citizen concerns. This use of commissions to hear public concerns over the enclosure of lands was one of the first examples of a public hearing, and emphasizes how most public hearings today are used when dealing with public lands as well as private properties.

PH process started in India with the river valley project but statutory introduced on 10.4.97 vide which Ministry of Environment & Forest, Govt. of India, now Environment & Forest & Climate Change, Govt. of India, the SPCBs were entrusted to conduct public hearing to get the views and concerns of the affected community and interested parties for the proposed project. It was also entrusted with forming an EPH committee to ensure fair representation in the public hearing process. Since then about 27 orders in this regard have been issued by MoEF in the form of notification and office memorandum [1997 (1), 2002 (1), 2003 (1), 2006 (1), 2008 (1), 2009 (4), 2010 (6), 2011 (1), 2012 (2), 2013 (1), 2014 (8)].

determined by adding the above three as per the following formulas.

$$\text{Relative Frequency} = \frac{\text{Frequency of a Species}}{\text{Frequency of all the species}} \times 100\%$$

$$\text{Relative Density} = \frac{\text{Density of a Species}}{\text{Density of all the species}} \times 100\%$$

$$\text{Relative Abundance} = \frac{\text{Abundance of a Single Species}}{\text{Abundance of all the species}} \times 100\%$$

$$\text{Importance Value Index(IVI)} = RD\% + RF\% + RA\%$$

The three study sites were separated widely from one to another and each study sites was considered as an individual stand of the associated community. The IVI of the wetland macrophytes are presented in tabular form in two seasons accordingly as summer and winter. The IVI values were calculated and all the species and their IVI are shown in the Table 1.1 and 1.2.

Results and discussion

On the basis of the important value index, the dominance of the plant species among the different growth forms of the wetlands of the study sites are described as follows

In Kapla *beel*, *Eichhornia crassipes* showed highest IVI value (IVI=27.05) among all the life forms during the summer seasons of the study period. This is followed by *Azolla pinnata* (IVI=12.64), *Imperata cylindrica* (IVI=11.64) and *Leersia hexandra* (IVI=10.82) respectively. On the other hand, *Marsilea quadrifolia* showed the lowest IVI value (IVI=0.85) among all the life forms during summer season of the study period which is followed by *Echinochloa stagnina* (IVI=0.89), *Vetiveria zizanoides* (IVI=1.42) and *Scoparia dulcis* (IVI=1.44) respectively (Table 1.1)

Table 1.1: Importance value Index (IVI) of aquatic macrophytes during the summer season

Species Name	**Study sites**											
	Kapla *beel*				Manash *beel*				Amguri *beel*			
	RD	RF	RA	IVI	RD	RF	RA	IVI	RD	RF	RA	IVI
Free Floating(FF)												
Azolla pinnata R.Br	6.34	3.43	2.87	12.64	3.07	1.92	3.15	8.14	1.87	2.55	3.02	7.44
Eichhornia crassipes(Mart.) Solms	7.4	1.29	18.36	27.05	9.21	1.44	12.61	23.26	7.41	1.56	10.51	19.48
Lemna minor(sensx)kurz	0.65	0.67	1.46	2.78	0	0	0	0	0.67	0.65	1.43	2.75
Pistia stratiotes L.	2.96	1.94	1.46	6.36	3.68	1.92	3.78	9.38	4.65	2	4.81	11.5
salvinia cuculatus Roxb.	1.23	2.15	0.58	3.96	0.69	1.44	0.94	3.07	1.3	2.3	0.5	4.1
salvinia natans L.	1.06	1.93	2.33	4.86	1.84	2.89	1.26	5.99	3.16	1.98	1.63	6.67
Spirodela polyrhiza(L.) schleid	0.34	1.4	0.8	2.54	0	0	0	0	0	0	0	0
Total (FF)				60.19				49.84				51.8
Submerged(s)												
ceratophyllum demersum L.	0.59	1.29	0.7	2.58	1.15	2.41	0.94	4.5	0.5	1.2	0.8	2.5
Hydrilla verticillata(L.f.)Royale	1.39	1.74	1.76	4.91	2.68	3.37	1.57	7.62	1.3	1.7	1.72	4.72
Utricularia stellaris L.	0.2	1.4	0.3	1.9	0	0	0	0	0	0	0	0
Valliesnaria spiralis L.	2.05	1.74	2.61	6.4	0.23	3.37	1.26	4.85	0.24	3.3	1.21	4.75
Total(SH)				15.79				16.97				12
Rooted floating leaved (RFL)												
Euryale ferox salisb.	3.39	2.46	1.46	7.31	0	0	0	0	0	0	0	0
Hygroryza aristata(Retz.) Nees.ex wight & Arn.	1.55	1.93	1.22	4.7	5.37	3.37	3.15	11.89	5.63	3.38	3.1	12.1
Ipomoea aquatic Forxk.	1.18	1.72	1.05	3.95	1.53	2.41	1.26	5.2	2.15	1.98	2.52	6.65
Ludwigia adscendens(L.) H.Hara	2.29	1.93	1.81	6.03	3.68	3.85	1.89	9.42	2.68	3.16	2.1	7.94
Nelumbo lotus(L.) HK.f & Thoms	1.31	1.72	1.16	4.19	0	0	0	0	0	0	0	0
Nymphaea nouchali Bum.f	0.86	1.15	0.77	3.23	1.84	1.92	1.89	5.65	2.84	1.93	2.68	7.45
Nymphaea alba L.	0.69	1.15	1.34	3.53	0.32	1.68	0.37	2.37	1.35	3.68	1.3	6.33
Nymphaea rubra Roxb.ex Andrews	0	0	0	0	0.37	1.92	0.75	3.4	1.4	3.5	1.46	6.36
Trapa natans L.	0.24	0.64	0.58	1.46	0	0	0	0	0.3	0.81	0.72	1.83
Trapa bispinosa(Roxb.)Makino	0.21	0.89	0.59	1.69	0	0	0		0	0	0	0
Total(RFL)				36.03				37.93				48.7
Emergent, Swampy & Marshy(E+SM)												

Ageratum conyzoides(L.)L.	0.69	1.29	0.81	2.8	0.3	0.96	0.63	1.89	0.65	1.89	1.3	3.84
Alternanthera phylloxeroides(Mart.) Griseb	1.65	1.51	2.34	5.5	1.22	1.92	1.26	4.4	1.75	1.63	2.54	5.92
Alternanthera sessilis(L.) R.Br. ex,DC	2.45	1.58	1.04	5.07	2.07	2.16	1.89	6.12	1.89	2.38	1.9	6.17
Amaranthus spinosus L.	0.32	0.43	1.16	1.91	0.16	0.33	0.94	1.43	0.33	0.48	1.18	1.99
Axonopus compressus(SW.)P. Beauv.	1.58	0.43	5.61	7.62	1.47	0.57	5.04	7.08	1.4	0.6	4.98	6.98
Cassia tora L.	1.48	1.29	1.75	4.52	0.46	0.96	0.94	2.36	1.02	1.47	0.95	3.44
Centella asiatica(L.)Urb	3.29	2.15	2.33	7.77	3.68	3.86	1.89	9.43	3.25	2.16	2.3	7.71
Colocasia esculenta(L.) Schoot.	0.98	2.58	0.58	4.14	0.67	2.65	0.5	3.82	0.6	1.98	0.48	3.06
Commelina benghalensis L.	1.48	1.93	1.68	5.09	1.38	1.44	1.89	4.71	1.68	2.28	1.6	5.56
Cynodon dectylon(L.) Pers.	0.83	1.29	0.99	3.11	1.53	0.96	3.15	5.64	1.48	1.2	3.12	5.8
Cyperus compressus L.	0.98	0.77	1.93	3.67	0	0	0	0	0	0	0	0
Cyperus rotundusL.	0.71	1.55	0.71	2.96	1.84	1.44	2.52	5.8	0.78	1.61	0.78	3.17
Cyperus corymbosus Rottb.	0.54	1.29	0.64	2.47	0.61	1.92	0.63	3.16	0	0	0	0
Cyperus playtistylis R.Br,	0.29	0.64	0.77	1.63	0.42	0.96	0.88	2.26	0.38	0.8	0.72	1.9
Eclipta prostrata(L.)L.	0	0	0	0	3.14	2.41	2.58	8.13	0	0	0	0
Echinochloa stagnina Beauv.	0.03	0.16	0.70	0.89	0	0	0	0	0.05	0.20	0.72	0.97
Elephantopus scaber L.	0.83	1.29	0.99	3.11	0.61	1.92	0.63	3.16	0.78	2.1	0.8	3.68
Enhydra fluctuans DC	2.22	1.93	1.75	5.9	1.38	2.89	0.94	5.21	2.61	1.98	2.16	6.75
Eragrostris nigra Nees ex steud,	0.21	0.81	0.4	1.452	0	0	0	0	0.23	0.86	0.3	1.39
Euphorbia hirta L.	0.46	0.81	0.4	1.67	0.47	1.49	0.63	2.59	0.68	1.78	0.83	3.29
Fimbristylis dichotoma Vhal.,	1.13	1.29	1.34	3.76	0	0	0	0	0	0	0	0
Hydrocotyle rotundifolia Roxb	2	1.5	1.89	5.39	2.76	1.92	2.83	7.51	2.78	1.94	2.85	7.57
Imperata cylindrica(L.)Raeusch.	4.74	1.29	5.61	11.64	1.07	0.33	6.3	7.7	4.88	1.2	6.61	12.7
Ipomoea carnea Jaeq.	0.44	0.68	0.99	2.11	4.29	3.37	2.52	10.18	0.48	0.7	1.2	2.38
Jussiaea repens .L	1.14	1.15	1.16	3.8	0	0	0		0	0	0	
Kyllinga brevifolia Rottb.	1.64	2.15	1.16	4.95	0.92	2.89	0.63	4.44	0.9	2.85	0.6	4.35
Leersia hexandra SW	5.18	3.01	2.63	10.82	3.07	2.41	2.52	8	4.08	2.5	2.83	9.41
Leucas aspera Link.	0.49	0.64	1.68	2.29	0.23	0.48	0.95	1.65	0.31	0.58	1.58	2.47
Marsilea quadrifolia(L)wild	0.09	0.30	0.46	0.85	0.05	0.10	0.60	0.75	0.08	0.2	0.44	0.72
Mikania micrantha Wild	0.74	0.64	0.87	2.25	0.49	1.92	0.5	2.41	0.4	1.98	0.56	2.94
Mimosa pudica L.	0.96	1.93	0.76	3.64	0	0	0	0	0.89	1.9	0.8	3.59
Monochoria hastate(L)Solms	3.22	1.93	1.75	5.9	1.22	0.96	2.52	4.7	1.38	0.8	2.68	4.86
Monochoria vaginalis(Burm.f.)c.presl.	0.32	1.72	0.29	2.33	0.18	0.96	0.37	1.51	0	0	0	0
Oldenlandia corymbosa L	0.57	2.15	0.4	3.12	0.55	1.44	0.75	2.74	0	0	0	0
Oxalis corniculata L.	1	1.55	0.99	3.54	0.76	2.41	0.63	3.8	0.8	2.48	0.68	3.96
Paspalum compactus Roth.	2.76	1.5	2.8	7.06	0.54	1.44	0.75	2.73	0.5	1.4	0.7	2.6
Polygonum chinense L	1.32	1.5	1.34	4.16	0.82	1.44	0.5	2.76	0.8	1.42	0.58	2.8
Polygonum glabrum Wild	1.33	1.29	1.57	4.19	6.14	4.82	2.52	13.48	6.15	4.8	2.54	13.5
polygonum hydropiper L	2.22	1.93	1.75	5.9	9.67	4.33	4.41	18.41	9.47	5.33	4.48	19.28
Phragmites karka(Retz)Trin.ex steud.	0	0	0	0	0.55	1.44	0.75	2.74	0	0	0	0
Saccharum spontaneum L	1.04	0.3	5.26	6.6	0	0	0	0	0	0		0
Sagittaria sagittifolia L	1.02	0.93	3.03	4.98	0.83	1.44	1.13	3.4	1.01	0.92	1.99	3.92
Schoenoplectiella articullatus(L)	2.71	1.29	3.21	7.21	4.6	1.44	6.3	12.34	5.68	1.44	6.5	13.5
Scoparia dulcis L	0.23	0.51	0.7	1.44	0.07	0.24	0.63	0.94	0.3	0.5	0.68	1.48
Vetiveria zizanoides(L.) Nash	0.13	0.3	0.99	1.42	0	0	0	0	0.14	0.31	1	1.45
Xanthium strumarium L	0.82	1.88	0.89	3.59	0.93	2.26	0.81	4	0.98	2.28	0.84	4.1
Total(E+SM)				187.6				195.27				188.45
Total of (FF) +(SH)+(RFL)+(E+SM)				299.6				300.01				300.89

During the winter season also *Eichhornia crassipes* showed highest IVI value (IVI=60.1) among all the life forms in the Kapla *beel*. This is followed by *Lemna minor* (IVI=22.12), *Azolla pinnata* (IVI=21.18), and *Ipomoea aquatica* (IVI=11.85) respectively. On the contrary, *Marsilea quadrifolia* showed the lowest IVI value (IVI=0.76) among all the life forms during the winter season of the study period which is followed by *Amaranthus spinosus* (IVI=1.24), *Alternanthera phylloxeroides* (IVI = 1.32) and *Scoparia dulcis* (IVI=1.42) respectively. (Table 1.2)

Similarly in Manash *beel*, *E.* crassipes showed highest IVI value (IVI= 23.26) among all the forms during the summer seasons of the study period. This is followed by *Polygonum hydropiper* (IVI=18.41), *P. glabrum* (IVI= 13.68) and *Schoenoplectella articulatus* (IVI=12.34). Whereas *Marsilea quadrifolia* showed the lowest IVI value (IVI=0.75) among the all life forms during summer seasons of the study period which is followed by *Scoparia dulcis* (IVI= 0.94), *Amaranthus spinosus* (IVI=1.43) and *Monochoria vaginalis* (IVI=1.51) respectively. (Table-1.2)

During the winter season *E. crassipes* showed the highest IVI value (IVI=42.93) among all the life forms in the Manash *beel*. This is followed by *Azolla pinnata* (IVI=13.4), *Ipomoea aquatica* (IVI=12.76) and *Hygroryza aristata* (IVI=11.79) respectively. On the other hand *Marsilea quadrifolia* showed the lowest IVI value (IVI=0.87) among all the life forms during winter seasons of the study period. This is followed by *Scoparia dulcis* (IVI=1.54), *Leucas aspera* (IVI=1.62) and *Euphorbia hirta* (IVI=1.68) respectively. (Table-1.2)

Likewise in Amguri *beel*, *E. crassipes* showed the highest IVI value (IVI=19.48) among all the life forms during the summer seasons of the study period. This is followed by *P. hydropiper* (IVI=19.28), *Schenoplectella articulatus* (IVI=13.54) and *P. glabrum* (IVI=13.49) respectively. Whereas, *Marsilea quadrifolia* showed the lowest IVI value among all the life forms during the summer seasons of the study period. This is followed by *Eragrostris nigra* (IVI=1.39), *Vetivaria zizanoides* (IVI=1.45) and *Scoparia dulcis* (IVI=1.48) respectively. (Table-1.2)

During winter seasons also *E. crassipes* showed highest IVI value (IVI=39.78) among all the life forms in the Amguri *beel*. This is followed by *Axonopus compressus* (IVI=16.08), *Polygonum glabrum* (IVI=13.09) and *Ipomoea aquatica* (IVI=12.88) respectively. On the other hand *Marsilea quadrifolia* showed the lowest IVI value (IVI=0.65) among all the life forms during the winter seasons of the study period which is followed by *Scoparia dulcis* (IVI=1.41), *Euphorbia hirta* (IVI=1.84) and *Elephantopus scaber* (IVI=2.01) respectively. (Table-1.2)

Among all the free floating wetland macrophytes, *E. crassipes* was found to be most dominant species in all the three wetlands of the study sites during summer season of the study periods. Highest IVI Value of this species was found 27.05 in Kapla *beel*. This is followed by Manash *beel* (IVI=23.26) and Amguri *beel* (IVI=19.48) respectively. (Table-1.2)

During winter seasons also *E. crassipes* showed the highest IVI value in the three wetlands of the study sites. Maximum IVI value of this Species was found (IVI=60.01) in Kapla *beel*. This is followed by Manash *beel* (IVI=42.93) and Amguri *beel* (IVI=39.78) respectively.

Submerged hydrophytes were the least dominant plant species in terms of IVI values in all the three wetlands of the study sites. During the summer seasons, *Hydrilla verticillata* exhibits the highest IVI value (IVI=7.62) in Manash *beel*. This is followed by *Vallisnaria spiralis* (IVI=6.40, IVI=4.75) in Kapla & Amguri *beel* respectively. (Table-1.2).

During the winter seasons, the *Hydrilla verticillata* shows the highest IVI value (IVI=9.78, IVI=7.72 and IVI=7.66) in Kapla *beel*, Amguri *beel* and Manash *beel* respectively.

Table 1.2 Importance value Index (IVI) of aquatic macrophytes during the winter season

Species Name	**Manash *beel***				**Kapla *beel***				**Amguri *beel***			
	RD	RF	RA	IVI	RD	RF	RA	IVI	RD	RF	RA	IVI
Free Floating(FF)												
Azolla pinnata R.Br.	9.6	3.22	8.36	21.18	7.3	3.4	2.7	13.4	6.3	3.14	2.74	12.2
Eichhornia crassipes(Mart.)Solms	24.3	2.4	33.4	60.1	18.2	2.4	22.3	42.93	17.2	2.38	20.2	39.8
Lemna minor(snsex) kurz	9.6	9.72	2.8	22.12	0	0	0	0	0.68	0.69	1.45	2.82

Pistia stratiotes L.	2.64	3.12	2.46	8.22	4.72	3.2	2.8	10.72	3.7	2.2	2.83	8.73
salvinia cuculatus Roxb.	2.46	3.3	1.16	6.92	2.4	3.12	1.2	6.72	2.38	3.11	1.18	6.67
salvinia natans L	2.12	3.86	4.66	10.64	2.1	3.5	4.2	9.8	2.09	3.48	4.18	9.75
Spirodela polyrhiza(L.)Schleid	0	0	0	0	0.3	1.4	1.3	3	0	0	0	0
Total (FF)				129.18				86.57				79.9
Submerged (SH)												
Ceratophyllum demersum L	0.5	1.2	0.79	2.49	1.16	2.4	0.95	4.51	1.15	2.38	0.97	4.5
Hydrilla verticillata(L.f.)Royale.	2.28	3.48	3.52	9.78	2.78	3.3	1.58	7.66	2.8	3.32	1.6	7.72
Utricularia stellaris L	0	0	0	0	0	0	0	0	0	0	0	0
Vallisnaria spiralis L	0	0	0	0	2.4	1.7	2.6	6.34	2	1.7	2.65	6.35
Total(SH)				12.27				18.51				18.6
Rooted floating leaved(RFL)												
Euryale ferox salisb.	1.39	1.46	1.46	4.31	0	0	0	0	0	0	0	0
Hygroryza aristata(Retz) Nees. ex. Wight &Arn.	3.1	3.86	2.44	8.4	5.3	3.32	3.17	11.79	4.3	2.32	2.16	8.78
Ipomoea aquatic Forsk.	3.54	5.16	3.15	11.85	4.5	5.1	3.16	12.76	4.58	5.12	3.18	12.9
Ludwigia adscendens (L) H.Hara	2.2	1.9	1.92	6.02	3.6	3.79	1.82	9.21	2.21	1.91	1.91	6.03
Nelumbo lotus(L)HK.f&Thoms	2.62	3.44	2.32	8.38	0	0	0	0	2.61	3.4	2.3	8.31
Nymphaea nouchaliBum.f	1.72	3	1.54	6.26	0	0	0	0	1.7	2.98	2.13	6.8
Nymphaea alba L.	0.6	1.5	1.36	3.46	0.7	1.72	1.58	4	0.71	1.73	1.6	4.04
Nymphaea rubra Roxb.ex. Andrews.	0	0	0	0	1.13	2.36	1.5	4.99	1.12	2.3	1.48	4.9
Trapa natans L.	0.48	1.28	1.16	2.92	0	0	0	0	0.45	1.25	1.15	2.85
Trapa bispinosa(Roxb.)Makino	0.2	0.8	0.6	1.6	0	0	0	0	0	0	0	0
Total(RFL)				53.2				42.75				54.6
Emergent, Swampy & Marshy(E+SM)												
Ageratum conyzoides(L.)L	0.6	1.2	0.8	2.6	0.58	1.22	1.16	2.96	0.68	2.25	1.1	4.03
Alternanthera phylloxeroides(Mart.)Griseb	0.12	0.42	0.78	1.32	1.23	1.98	1.27	4.48	00	00	00	00
Alternanthera sessilis(L.)R.Br.ex DC	0.14	0.62	0.8	1.56	0	0	0	0	0	0	0	0
Amaranthus spinosusL.	0.13	0.43	0.68	1.24	0.32	0.66	1.26	2.24	0.03	0.66	1.25	2.21
Axonopus compressus(SW)P.Beauv.	0.54	0.4	1.7	2.68	1.4	0.52	5.02	6.94	3.4	1.56	11.12	16.1
Cassia tora L	0	0	0	0	1.7	1.2	1.7	4.6	1.7	1.2	1.72	4.64
Centella asiatica(L.)Urb	1.02	0.93	3.3	4.98	1.07	0.98	5.1	7.15	1.16	0.98	5.8	7.15
Colocasia esculenta(L)schoot	0.3	0.98	0.43	1.71	0.5	1.2	0.48	2.18	0.52	1.22	0.48	2.22
Commelina benghalensis L	1.1	1.5	1.6	4.2	1.56	1.46	2.18	5.2	1.13	1.54	1.61	4.28
Cynodon dectylon(L.)pers.	0.7	1.12	0.9	2.72	1.6	0.98	4.15	6.73	1.95	1.12	3.98	7.05
Cyperus Compressus L	0	0	0	0	0.98	0.76	1.92	3.65	0	0	0	0
Cyperus rotundus L	0.6	1.45	0.6	2.65	0.7	1.52	0.7	2.92	0.71	1.52	0.71	2.94
Cyperus corymbosus Rottb.	0	0	0	0	0	0	0	0		0	0	0
Cyperus playtistylis R.Br,	0	0	0	0	0.43	0.98	0.89	2.3	0	0	0	0
Eclipta prostrate(L.)L.	0	0	0	0	3.15	2.4	2.5	8.05	0	0	0	0
Echinochloa stagnina Beauv.	0.02	0.14	0.68	0.84	0	0	0	0	0	0	0	0
Elephantopus scaber L.	0.43	0.98	0.72	2.13	0	0	0	0	0.4	0.9	0.71	2.01
Enhydra fluctuans DC	1.22	1.9	1.7	4.82	3.6	4.82	2.69	11.11	3.68	4.92	2.7	11.3
Eragrosrtis nigra Nees ex steud.	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbia hirta L.	0.42	78	0.3	1.5	0.48	0.8	0.4	1.68	0.5	0.82	0.52	1.84
Fimbristylis dichotoma vahl.,	0	0	0	0	0	0	0	0	0	0	0	0
Hydrocotyle rotundifolia Roxb.	1.13	0.9	0.8	2.83	1.98	2.84	2.87	7.69	1.91	2.8	2.87	7.58
Imperata cylindrical (L)Raeusch.	3.7	1.2	4.6	9.5	0	0	0	0	4.7	2.21	5.65	12.6
Ipomoea carnea Jaeq.	0	0	0	0	0.45	0.69	1	2.14	0	0	0	0
Jussiaea repens L.	1.1	1.4	1.17	367	0	0	0	0	0	0	0	0
Kyllinga brevifolia Rttb.	1.6	2.1	1.1	4.8	0.93	2.9	0.64	4.47	0	0	0	0
Leersia hexandra Sw	2.18	2.01	1.6	5.79	3.08	2.43	2.58	7.09	2.07	2.43	2.6	7.1
Leucas aspera Link.	0	0	0	0	0.2	0.44	0.98	1.62	0	0	0	0
Marsilea quadrifolia(L) wild	0.08	0.2	0.48	0.76	0.03	0.15	0.69	0.87	0.15	0.20	0.30	1.65
Mikania micrantha Wild	0	0	0	0	0.43	1.9	0.58	2.91	0	0	0	0
Mimosa pudica L.	0.52	0.98	1.12	2.62	0	0	0	0	1.00	1.40	1.11	3.51
Monochoria hastate(L.)solms.	3.12	1.9	0.7	5.72	1.23	0.98	2.58	4.79	3.1	1.9	0.72	5.72
Monochoria vaginalis(Burm.f.)c.presl.	0.34	1.73	0.3	2.37	0	0	0	0	0	0	0	0

Oldenlandia corymbosa L.	0	0	0	0	0.34	1.4	0.7	2.44	0	0	0	0
Oxalis corniculata L.	0	0	0	0	0	0	0	0	0	0	0	0
Paspalum compactus Roth	0	0	0	0	0	0	0	0	0	0	0	0
Polygonum chinense L.	1.3	1.42	286	5.58	1.32	1.51	4.17	7	1.34	1.52	4.18	7.04
Polygonum glabrum Wild	4.44	3.86	3.5	11.8	3.98	3.55	3.3	10.83	4.9	3.89	4.3	13.1
polygonum hydropiper L.	1.33	1.29	1.58	4.2	2.33	1.29	2.57	6.19	2.3	1.28	2.58	6.16
Phragmites karka(Retz) Trin.ex. steud.	0	0	0	0	0.54	1.33	0.72	2.59	0	0	0	0
Saccharum spontaneum L.	0	0	0	0	0	0	0	0	0	0	0	0
Sagittaria sagittifolia L.	0	0	0	0	0.62	1.4	1.1	3.12	0	0	0	0
Schoenoplectiella articullatus(L)	2.7	1.28	3.2	7.18	4.16	1.4	5.3	10.86	5.1	1.4	5.25	11.8
Scoparia dulcis L.	0.22	0.5	0.7	1.42	0.24	0.58	0.72	1.54	0.21	0.5	0.7	1.41
Vetiveria zizanoides(L.) Nash	0	0	0	0	0	0	0	0	0	0	0	0
Xanthium strumarium L.	0.58	1.36	0.92	2.86	0.92	2.28	0.84	4.04	0.9	2.2	0.85	3.95
Total(E+SM)				1065.1				152.38				147
Total of (FF) +(SH)+(RFL)+(E+SM)				300.7				300.92				300

Abbreviation-
[SM=Swampy and Marshy, E= Emergent, FF= Free Floating, RFL= Rooted with Floating Leaved, SH= Submerged Hydrophytes, R.D= Relative Density, R.F= Relative Frequency, R.A. = Relative Abundance*]*

Among the rooted with floating leaved hydrophytes, *Hygroryza aristata* exhibits the highest IVI value (IVI=12.11, IVI=11.89) in Amguri *beel* and Manash *beel*. This is followed by *Euryale ferox* (IVI=7.31) in Kapla *beel* respectively and was found to be the dominant species during the summer seasons. (Table-1.2)

Similarly during the winter season also, *Ipomoea aquatica* shows highest IVI value (IVI=12.88, IVI=12.76 and IVI=11.85) in Amguri *beel*, Manash *beel* and Kapla *beel* and was found in the dominant species during winter seasons of the study period. (Table-1.2)

Among the emergent, swampy and marshy hydrophytes, *P. hydropiper* shows the highest IVI value (IVI=19.28, IVI=18.1) in Amguri and Manash *beel* during summer seasons and was found to be the most dominant species in these wetlands. While in Kapla *beel Imperata cylindrica* shows the highest IVI value (IVI=11.64) and was found dominant species during the summer seasons of the study sites.

Likewise in the winter seasons also, *Axonopous compresus* shows the highest IVI value (IVI=16.08) in Amguri *beel*. This is followed by *P. glabrum* (IVI=11.80) and *Enhydra fluctuans* (IVI=11.11) in Kapla *beel* and Manash *beel* respectively and was found to be the most dominant species during the winter season of the study sites.

At present the study sites of the district are degrading due to various anthropogenic activities likes encroachment, siltation due to flood, modern agricultural activities, development of commercial fisheries, lack of efficient inlet and outlet and excessive growth of *E. crasipes*.

The study sites remain covered by water along with its aquatic vegetation almost throughout the year except Manash *beel* because it is a seasonal wetland. It is directly linked to the river Manash and Palla Which carry heavy silt load and get deposited in wetland areas of the Manash *beel*, as a result of which many of the areas of the wetland with its aquatic macrophytes submerged by the heavy silt load. Development of commercial fisheries inside the wetland areas results blockage of the inlet and outlet channel of the kapla *beel* that result excessive growth of *Eichhornia crasipes*. The modern agricultural practices causing threats to the Amuguri *beel* along with its aquatic vegetation. In all the study sites the aquatic vegetation are found in heterogeneous mode

Conclusion

Phytosociological study of wetland macrophytes is one of the important aspects as because; it gives the overall picture of the ecologically important areas in relation to the community structure and dynamics. In the present investigation on the study sites the highest IVI value found in case of *E. crassipes* and the IVI value found lowest in case of *Marsilea quadrifolia* both in summer as well as in winter season.

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Biological Resources of Dora *Beel* in Kamrup Rural District of Assam

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Abstract

A systematic study has been carried out to evaluate biological resources of Dora beel in Kamrup Rural District of Assam. Dora beel is an important wetland, in the global position between $26^{o}04^{/}43.3^{//}$ N latitude and $091^{o}26^{/}41.8^{//}$ E longitude, covering an approximate area of 13 hectares. The biological resource, which includes –fishes, birds, macrophytes and Physico-chemical properties of water were investigated during February 2016 to July 2016. During the study period different Physico-chemical parameters of water such as Temperature, PH, Transparency, Conductivity, Total Alkalinity, Free CO2, DO, BOD, COD, TDS, TSS, Total Hardness, Fluoride, Calcium, Magnesium, Chloride were analyzed. A total of 54 fish species belonging to 25 families and 8 orders have been recorded from Dora beel. A total of 25 bird species belonging to 11 families and 7 orders has been recorded. During the study period, a total of 48 species of macrophytes belonging to 27 families and 15 orders were recorded. From the investigation, it is come into light that the beel is gradually degrading by some natural and anthropogenic activities. The major anthropogenic activities that influence the beel are agricultural activities, waste disposal, overgrazing, human settlement, over extraction of fish etc.

Keywords: Biological Resource, Physico-Chemical, Fish, Bird, Macrophytes, Degraded

Introduction

Wetlands are unique ecosystems which provide water and habitat for a diverse range of plants and animals. It is considered the most biologically diverse of all ecosystems, serving as home to a wide range of plants and animals life. The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydric soil. Many species of birds, fishes, mammals, reptiles, amphibians, mollusks and microorganism depend on the wetland habitat for breeding, foraging and for their shelter supported by diverse plant species. Wetlands offer various environmental benefits such as cycling of nutrient, carbon sinks, energy flow, water purification, flood protection, ground water recharge, climate control, soil erosion control etc. Apart from these, other benefits associated with wetlands are food, fodder, medicine, drinking water etc., for local communities, recreation, aesthetics and commercial benefits. Above all, wetlands provide habitat for many economically important flora. Unfortunately, increasing world population, urbanization and overexploitation of wetlands has resulted in degradation and shrinkage of wetlands globally. It is therefore felt to be an imperative need to conserve the wetlands and protect their unique biodiversity.

India has extensive floodplain wetlands, defined as low lying areas bordering large rivers, which are seasonally inundated by the overspill from main river channel. These wetlands are an integral component of the Ganga and Brahmaputra river basin, covering an area of 0.2 million hectares. They also exist in

Manipur and Tripura as well as in the foothills of Arunachal Pradesh and Meghalaya. They can be typical oxbow lakes (i.e. cut off portions of river meander bends), sloughs, meander scroll depressions, back swamps, residual channels or tectonic depressions, though it is often difficult to establish their identity due to natural and man-made modifications to the environment. These water bodies are locally known as beels (Assam, West Bengal, Arunachal Pradesh, Meghalaya and Tripura), maun, chaurs and dhars (Bihar), pats (Manipur), charhas and boars (northern and south eastern West Bengal respectively). (Ecology and Fisheries of Beels in Assam, 2000)

Materials and Methods

Study Area:

The present study was conducted in the floodplain wetland Dora beel of South Kamrup district of Assam, India. Dora beel is a very important floodplain wetland of South Kamrup district of Assam, India at the global position between 26°04′43.3″ N latitude and 091°26′41.8″ E longitude, covering an area of 116 ha. It is situated on the south bank of the river Brahmaputra and located nearby the Kulsi (locally known as Kolohi) river under Palashbari Revenue Circle. In the monsoon period the beel is connected to the Kulsi River. The National Highway No.37 lie on the south of the beel and the distance from the NH-37 to the beel is less than 1 km.

Data Collection and Analysis:

The study was carried out for a period of six months from February to July, 2016. For the analysis of water, samples were collected at random basis from each site, in five liter plastic gallons previously rinsed with distilled water at about 25cm depth in the morning at 7am to 11am. Water samples were collected from the studied wetland to conduct Physico-chemical study on a monthly basis from five sampling stations of the wetland. Water Temperature, PH, Transparency, Conductivity were determined on the sampling sites. BOD and DO were fixed on the site , while COD, Free CO2, , Total Alkalinity, Total Hardness, Total Suspended Solids, Total Dissolved Solids, Chloride, Fluoride, Calcium, Magnesium were analyzed in the laboratory by standard methods (APHA,2005)

Fish estimation methods:

Fish samples were collected through experimental fishing by using caste nets of various sizes, gill nets (vertical height 1.0 m- 1.5 m; length 30 m -100 m), drag nets (vertical height 2.0 m), fish hooks of various sizes and a variety of gears like polo, juluki, sepa, jakoi etc by local fisherman. The documentation of present study was carried out with the help of local fishermen, having more than 25 years of experience in fishing technologies. Collected fish species were preserved in 10% formaldehyde in the field itself. Fish species have been identified following the literature of Talwar & Jhingran (1991) and Vishwanath (2000).

Bird estimation methods:

For the study of the bird species, the study site Dora beel was surveyed twice in a week and different data and information were collected. In addition, the local communities have been interviewed and different books and scientific journals have been followed for collecting secondary data. Photographs of the different bird species were taken from the observation point by digital camera for further identification. The bird species were identified as per Ali (2002).

Macrophytes estimation methods:

Field survey was conducted in the studied wetland at least twice in a month during February 2016 to July 2016. The aquatic plant species were collected from the studied wetland and critically studied them in their natural habitat, packed in the plastic bags with newspaper for making dry herbarium and taken to the laboratory for further identification. Photograph of the plant species also have been taken in its natural habitat as it is very helpful for its identification. The collected specimens were identified by standard literatures (Hooker, 1872-1897; Choudhury, 2005)

Results and Discussion

Physico-chemical parameters:

The average water temperature of Dora beel was recorded as 28.83oC during the study period. PH of water was recorded slightly acidic which was 6.14. The pH level of the studied wetland is within the reference limit, it is safe for the aquatic life. Transparency of water was recorded as 40.86 cm in Dora beel. Conductivity of water in Dora beel was recorded as 61.33 µs/cm. Total alkalinity of water in Dora beel was recorded as 25.83 mg/l .Free CO2 of water is 39.99 in Dora beel .Dissolved oxygen (DO) of water is in Dora beel (5.75 mg/l). BOD of water is slightly higher in Dora beel (5.13mg/l). COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality. The average COD of Dora beel was recorded as 24.39 mg/l. During the period of the study, the average Total Dissolved Solids was recorded as (50.66 mg/l) in Dora beel which was slightly higher but in between the reference limit. Suspended solids are present mainly due to impurities and accumulated gases and are caused by clay, silt, bits of bark, phytoplankton and other microscopic organisms. The average Total Suspended Solids of water is in Dora beel was recorded as 37.66 mg/l. Hardness of water is basically caused by the elements like calcium, magnesium, sodium and occasionally by iron, aluminum and potassium. Hardness of water in Dora beel was recorded as 26.83 mg/l .Fluoride is the simplest anion of fluorine. Fluoride can either inhibit or enhance the population growth of algae, depending upon fluoride concentration, exposure time and algal species. Aquatic plants seem to be effective in removing fluoride from contaminated water under laboratory and field conditions. In aquatic animals, fluoride tends to be accumulated in the exoskeleton of invertebrates and in the bone tissue of fishes. The toxic action of fluoride resides in the fact that fluoride ions act as enzymatic poisons, inhibiting enzyme activity and, ultimately, interrupting metabolic processes such as glycolysis and synthesis of proteins. During the study period, Fluoride was recorded as 0.33 mg/l in Dora beel. Calcium of water in Dora beel was found as 4.68 mg/l .Magnesium of water in Dora beel was recorded as 3.52 mg/l .The conductivity of water was found as 61.33 µs/cm in Dora beel. Chloride ion is one of the most abundant anions found in waste water and is a good indicator of pollution sources. Chloride content in Dora beel was recorded as 2.78 mg/l (Table 1 & 2).

Fishes

During the present study, a total of 54 fish species belonging to 25 families and 8 orders have been recorded from the Dora beel (Table 3) .In Dora beel, out of 8 orders the Cypriniformes order was the most dominant, which includes 20 species. This is followed by Perciformes order, which includes 15 species, Siluriformes order, which includes 10 species, Synbranchiformes order, which includes 4 species, Osteoglossiformes order, which includes 2 species whereas Tetraodontiformes, Beloniformes and Clupeiformes orders represents 1 species each (Table 3). A total of 25 families of fishes were recorded from the Dora beel, during the present investigation. Cyprinidae was the most dominant family in the beel, which includes 17 species of fishes. This is followed by Channidae with 4 species, Ambassidae, Bagridae and Mastacembelidae with 3 species each, Cichlidae, Notopteridae, Osphronemidae and Siluridae having 2 species each and the rest of the families such as Anabantidae, Badidae, Balitoridae, Belonidae, Botiidae, Clariidae, Clupeidae, Cobitidae, Gobiidae, Heteropneustidae, Horabagridae, Nandidae, Tetraodontidae, Schilbeidae, Sisoridae and Synbranchidae were observed as single species in the beel (Table 3).

Birds

During the present study, a total of 25 bird species belonging to 11 families and 7 orders have been recorded from the Dora beel (Table 4). In the Dora beel, out of 7 orders the Passeriformes and the Pelecaniformes orders were the most dominant in the beel with 7 species each. This is followed by Ciconiiformes and Coraciiformes with 3 species each, Anseriformes and Charadriiformes with 2 species and Suliformes with 1 species (Table 4). A total of 11 families of birds were recorded from the Dora beel, during the present investigation. Ardeidae was the most dominant family in the beel, which includes 7 species of birds. This is followed by Alcedinidae , Ciconiidae and Motacillidae with 3 species each, Anatidae and Sturnidae with 2 species each and the rest of the families such as Charadriidae, Dicruridae, Locustellidae, Phalacrocoracidae and Scolopacidae were observed as single species in the beel (Table 4).

Macrophytes

A total of 48 species of macrophytes belonging 27 families and 15 orders were recorded from the Dora beel, during the present investigation. Out of 15 orders the Alismatales order was the most dominant in the beel with 10 species. This is followed by Poales with 8 species, Caryophyllales and Asterales with 5 species, Salviniales with 4 species, Solanales and

Myrtales with 3 species, Commelinales and Brassicales with 2 species each. The remaining orders such as Apiales, Ceratophyllales, Fabales, Lamiales, Nymphaeales and Ranunculales represent 1 species each. Out of 27 families the Poaceae family was the most dominant in the beel with 7 species. This is followed by Hydrocharitaceae, Asteraceae with 4 species, Amaranthaceae with 3 species, Alismataceae, Convolvulaceae, Polygonaceae, Pontederiaceae, Potamogetonaceae, Onagraceae and Salviniaceae with 2 species each whereas the Araceae, Apiaceae, Azollaaceae, Ceratophyllaceae, Cleomaceae, Fabaceae, Lamiaceae, Lythraceae, Lemnaceae, Brassicaceae, Marsileaceae, Menyanthaceae, Cyperaceae, Nymphaeaceae, , Ranunculaceae and Solanaceae were observed as single species in the beel.

Adverse impact on Dora beel

During the present study of Dora beel of South Kamrup district (Assam), it is come into light that the beel is impacted adversely by some natural and anthropogenic factors. Some of the major threats to Dora beel are :

Sedimentation is a very serious threat to the beel. Deforestation, agricultural activity etc. are the major cause of increase sedimentation in the study area. Due to sedimentation process the beel is lowering its bed.

The local peoples of the studied wetland practice agricultural activities on the adjacent land. They use various pesticides and fertilizers in the agricultural field and these pesticides and fertilizers enter in the wetland in runoff and affect the entire wetland.

Due to increasing population pressure some of the local people are filling the catchment areas of the wetland for their settlementOver extraction of the fishes and macrophytes by the local people is one of the most serious threats to the studied wetland.

Hunting of birds illegally within the wetland and in adjoining areas also decreasing the entire biodiversity.Unscientific fishing methods and gears are also the causes of degradation of wetland environment.

Throwing of household waste and garbage into the wetland also creates a serious threat to the aquatic ecosystem.The unscientific construction of roads, growing of brick industries etc. which cause deterioration of the wetland environment.

Conservation Measures

The following measures have been suggested to protect and conservation of Dora beel.

The depth of the beel should be increased by digging, so that the beel can hold water all year round . Effort should be made to create awareness among the local people of Dora beel about the importance and need of conservation of the wetlands. Alternative livelihood should be generated for them, who depend on the beel for their survival.Over grazing, over extraction of the wetlands resources, use of unscientific net etc. should be strictly prohibited within the beel.Strict laws should be implemented for protection of the wetland from any illegal encroachment.

Dora beel is a very important wetland of South Kamrup district, Assam, India. It plays a vital role in maintaining the healthy environmental condition. Besides this many local peoples are dependent on the beel for their livelihood. Wetlands are very productive. They are very rich in biodiversity. During the present investigation, a total of 54 fish species belonging to 42 genera, 25 families and 8 orders; 25 bird species belonging to 23 genera, 11 families and 7 orders and 48 species of macrophytes belonging to 27 families and 15 orders have been recorded from Dora beel . But the beel is gradually degraded by some natural and anthropogenic activities. The major anthropogenic activities that influence the beel ecosystem are agricultural activities, throwing of wastes, overgrazing, deforestation, settlement, over extraction of fishes and Macrophytes, hunting of birds, construction of road etc. Therefore proper conservation measures should be taken for sustainable livelihood and existence of this important wetland.

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Table1: Monthly average variation of physical parameters of Dora beel, South Kamrup district, Assam, India (2016)

		Months						
Parameters	Units	Feb	Mar	Apr	May	Jun	Jul	Average
Temperature	°C	23	24	26	32	33	35	28.83
P^H	P^H	6.28	6.32	6.26	6.22	5.14	6.32	6.14
Transparency	cm	7.7	5	40	62.5	64	66	40.86

Table2: Monthly average variation of Chemical parameters of Dora beel, South Kamrup district, Assam, India (2016)

		Months						
Parameters	Units	Feb	Mar	April	May	June	July	Average
Total alkalinity	mg/l	25	30	27	23	26	24	25.83
Free CO_2	mg/l	44.1	37.8	40.2	34.9	41.9	41.08	39.99
DO	mg/l	6.2	6.9	6.1	6	5.8	3.5	5.75
BOD	mg/l	4.3	3.5	4.7	5.3	6	7	5.13
COD	mg/l	24	22	24.5	23	25.9	26.99	24.39
TDS	mg/l	62	44	53	66	39	40	50.66
TSS	mg/l	28	48	37	28	61	24	37.66
Total hardness	mg/l	24	27	30	34	22	24	26.83
Fluoride	mg/l	O.24	O.44	0.29	0.26	0.32	0.46	0.33
Calcium	mg/l	4.1	3.8	4.2	5.6	4.8	5.6	4.68
Magnesium	mg/l	3.30	3.67	4.42	4.88	2.44	2.44	3.52
Conductivity	µs/cm	62	58	68	61	53	66	61.33
Chloride	mg/l	2.3	2.6	3.5	4	2.3	2	2.78

Table3: Seasonal occurrence of fish species recorded from Dora beel, South Kamrup district, Assam, India (2016)

Local Name	**Scientific Name**	**Family**	**Order**	**Pre-monsoon**	**Monsoon**
Aari	*Aorichthys seenghala*	Bagridae	Siluriformes	-	+
Basa	*Eutropiichthys vacha*	Schilbeidae	Siluriformes	-	+
Bami	*Mastacembelus armatus*	Mastacembelidae	Synbranchiformes	+	+
Bhakua	*Catla catla*	Cyprinidae	Cypriniformes	-	+
Bhangone	*Labeo bata*	Cyprinidae	Cypriniformes	-	+
Bariala	*Aspidoparia morar*	Cyprinidae	Cypriniformes	+	+

Botia	*Lepidocephalichthys guntea*	Cobitidae	Cypriniformes	+	+
Bali botia	*Noemacheilus botia*	Balitoridae	Cypriniformes	+	+
Borali	*Wallago attu*	Siluridae	Siluriformes	+	+
Bortingra	*Mystus cavasius*	Bagridae	Siluriformes	+	+
Common carp	*Cyprinus carpio*	Cyprinidae	Cypriniformes	-	+
Chanda	*Chanda nama*	Ambassidae	Perciformes	+	+
Chanda	*Parambassis baculis*	Ambassidae	Perciformes	+	+
Chanda	*Parambassis ranga*	Ambassidae	Perciformes	+	+
Cheng	*Channa gachua*	Channidae	Perciformes	+	+
Chital	*Chitala chitala*	Notopteridae	Osteoglossiformes	-	+
Darikona	*Esomus danricus*	Cyprinidae	Cypriniformes	+	+
Dum Vacheli	*Badis badis*	Badidae	Perciformes	+	+
Grass carp	*Ctenopharyngodon idella*	Cyprinidae	Cypriniformes	-	+
Gedgedi	*Nandus nandus*	Nandidae	Perciformes	+	+
Gangatope	*Tetradon cutcutia*	Tetraodontidae	Tetraodontiformes	+	+
Gethu	*Botia derio*	Botiidae	Cypriniformes	+	+
Goroi	*Channa punctatus*	Channidae	Perciformes	+	+
Java puthi	*Puntius javanicus*	Cyprinidae	Cypriniformes	+	+
Japani kawoi	*Oreochromis mossambica*	Cichlidae	Perciformes	+	+
Keni puthi	*Puntius ticto ticto*	Cyprinidae	Cypriniformes	+	+
Kuchia	*Monopterus cuchia*	Synbranchidae	Synbranchiformes	+	+
Kurhia	*Labeo gonius*	Cyprinidae	Cypriniformes	-	+
Kokila	*Xenentodon cancila*	Belonidae	Beloniformes	-	+
Korati	*Gudusia variegata*	Clupeidae	Clupeiformes	-	+
Kawoi	*Anabas testudineus*	Anabantidae	Perciformes	+	+
Kholihona	*Trichogaster lalius*	Osphronemidae	Perciformes	+	+
Kholihona	*Trichogaster fasciata*	Osphronemidae	Perciformes	+	+
Kandhuli	*Notopterus notopterus*	Notopteridae	Osteoglossiformes	-	+
Keyakatta	*Gagata cenia*	Sisoridae	Siluriformes	+	+

Laupati	*Danio devario*	Cyprinidae	Cypriniformes	+	+
Mirika	*Cirrhinus mrigala*	Cyprinidae	Cypriniformes	-	+
Moa	*Amblypharyngodon mola*	Cyprinidae	Cypriniformes	+	+
Magur	*Clarias magur*	Clariidae	Siluriformes	+	+
Pabhoh	*Ompok pabo*	Siluridae	Siluriformes	-	+
Patimutura	*Glossogobius giuris*	Gobiidae	Perciformes	+	+
Rou	*Labeo rohita*	Cyprinidae	Cypriniformes	-	+
Silver carp	*Hypophthalmichthys molitrix*	Cyprinidae	Cypriniformes	-	+
Senduri puthi	*Puntius sophore*	Cyprinidae	Cypriniformes	+	+
Seni puthi	*Systomus sarana*	Cyprinidae	Cypriniformes	+	+
Selkona	*Salmostoma bacaila*	Cyprinidae	Cypriniformes	+	+
Singi	*Heteropneustes fossilis*	Heteropneustidae	Siluriformes	+	+
Sal	*Channa marulius*	Channidae	Perciformes	+	+
Sol	*Channa striata*	Channidae	Perciformes	+	+
Tingorah	*Mystus vittatus*	Bagridae	Siluriformes	+	+
Turi	*Macrognathus aral*	Mastacembelidae	Synbranchiformes	+	+
Turi	*Macrognathus pancalus*	Mastacembelidae	Synbranchiformes	+	+
Tilapia	*Oreochromis mossambicus*	Cichlidae	Perciformes	+	+
Total	54	25	8	39	54

Table4: Species of birds recorded in Dora beel during February, 2016 to July 2016

Sl No	Common Name	Scientific Name	Family	Order
1	Asian openbill-stork	*Anastomus oscitans*	Ciconiidae	Ciconiiformes
2	Asian pied starling	*Gracupica contra*	Sturnidae	Passeriformes
3	Black drongo	*Dicrurus macrocercus*	Dicruridae	Passeriformes
4	Cattle egret	*Bubulcus ibis*	Ardeidae	Pelecaniformes
5	Ferruginous pochard	*Aythya nyroca*	Anatidae	Anseriformes
6	Grey heron	*Ardea cinerea*	Ardeidae	Pelecaniformes
7	Indian pond-heron	*Ardeola grayii*	Ardeidae	Pelecaniformes

8	Jungle myna	*Acridotheres fuscus*	Sturnidae	Passeriformes
9	Large egret	*Casmerodius albus*	Ardeidae	Pelecaniformes
10	Lesser adjutant-stork	*Leptoptilos javanicus*	Ciconiidae	Ciconiiformes
11	Lesser pied kingfisher	*Ceryle rudis*	Alcedinidae	Coraciiformes
12	Lesser whistling-duck	*Dendrocygna javanica*	Anatidae	Anseriformes
13	Little cormorant	*Microcarbo niger*	Phalacrocoracidae	Suliformes
14	Little egret	*Egretta garzetta*	Ardeidae	Pelecaniformes
15	Median egret	*Mesophoyx intermedia*	Ardeidae	Pelecaniformes
16	Oriental tree pipit	*Anthus hodgsoni*	Motacillidae	Passeriformes
17	Purple heron	*Ardea purpurea*	Ardeidae	Pelecaniformes
18	Red-wattled lapwing	*Vanellus indicus*	Charadriidae	Charadriiformes
19	Small blue kingfisher	*Alcedo atthis*	Alcedinidae	Coraciiformes
20	Striated marsh-warbler	*Megalurus palustris*	Locustellidae	Passeriformes
21	White wagtail	*Motacilla alba*	Motacillidae	Passeriformes
22	White-breasted kingfisher	*Halcyon smyrnensis*	Alcedinidae	Coraciiformes
23	White-necked stork	*Ciconia episcopus*	Ciconiidae	Ciconiiformes
24	Wood sandpiper	*Tringa glareola*	Scolopacidae	Charadriiformes
25	Yellow wagtail	*Motacilla flava*	Motacillidae	Passeriformes

Table5: Macrophyte species found in Dora beel of South Kamrup District, Assam during the period of February, 2016 to July, 2016

Sl. No.	Scientific Name	Family	Order	Pre-Monsoon	Monsoon
1	*Azolla pinnata* R.Br.	Azollaceae	Salviniales	+	+
2	*Eichhornia crassipes* (Mart.) Solms	Pontederiaceae	Commelinales	+	+
3	*Lemna minor* L.	Lemnaceae	Alismatales	+	-
4	*Pistia stratiotes* L.	Araceae	Alismatales	+	+
5	*Salvinia natans* L.	Salviniaceae	Salviniales	+	+
6	*Salvinia cucullata* Roxb.	Salviniaceae	Salviniales	+	-
7	*Calaadesia parnassifolia* (L.) Parl.	Alismataceae	Alismatales	+	+

8	*Hygroryza aristata* (Retz.) Nees	Poaceae	Poales	+	+
9	*Ludwigia adscendens* (L.) H.Hara	Onagraceae	Myrtales	+	+
10	*Nymphaea nouchali* Burn. f.	Nymphaeaceae	Nymphaeales	+	-
11	*Nymphoides indica* (L.) Kuntze	Menyanthaceae	Asterales	+	-
12	*Ottelia alismoides* (L.) Pers.	Hydrocharitaceae	Alismatales	+	+
13	*Trapa natans* L.	Lythraceae	Myrtales	+	+
14	*Ceratophyllum demersum* L.	Ceratophyllaceae	Ceratophyllales	+	+
15	*Hydrilla verticillata*(L.f.) Royle	Hydrocharitaceae	Alismatales	+	+
16	*Najas indica* (Willd.) Cham.	Hydrocharitaceae	Alismatales	+	+
17	*Potamogeton octandrus*	Potamogetonaceae	Alismatales	+	+
18	*Vallisneria spiralis* L.	Hydrocharitaceae	Alismalales	+	_
19	*Ageratum conyzoides* L.	Asteraceae	Asterales	_	_
20	*Alternanthera sessilis* (L.) R.Br.	Amaranthaceae	Caryophyllales	+	+
21	*Alternanthera philoxeroides* Griseb	Amaranthaceae	Caryophyllales	+	+
22	*Amaranthus viridis* L.	Amaranthaceae	Caryophyllales	+	+
23	*Barbarea vulgaris* R.Br.	Brassicaceae	Brassicales	_	+
24	*Cassia tora* L.	Fabaceae	Fabales	+	+
25	*Cyperus pilosus* Vahl	Cyperaceae	Poales	_	_
26	*Centella asiatica* (L.) *Urban*	Apiaceae	Apiales	+	_
27	*Cleome rutidosperma* DC.	Cleomaceae	Brassicales	+	+
28	*Cynodon dactylon* (L.) Pers.	Poaceae	Poales	+	+
29	*Enhydra fluctuans* Lour	Asteraceae	Asterales	+	+
30	*Hymenechne assamica* (Hook.f.) Hitchc.	Poaceae	Poales	+	+
31	*Ipomoea aquatica*	Convolvulaceae	Solanales	+	-
32	*Ipomoea carnea* Jace.	Convolvulaceae	Solanales	+	-
33	*Leersia hexandra* Sw.	Poaceae	Poales	+	+
34	*Ludwigia octovalvis*	Onagraceae	Myrtales	-	+
35	*Marsilea quadrifolia* L.	Marsileaceae	Salviniales	+	+

36	*Matricaria discoidea* DC.	Asteraceae	Asterales	+	+
37	*Monochoria hastata* (L.) Solms	Pontederiaceae	Commelinales	+	+
38	*Persicaria barbata* (L.) H. Hara	Polygonaceae	Caryophyllales	+	-
39	*Potamogeton octandrus*	Potamogetonaceae	Alismatales	+	-
40	*Persicaria hydropiper* (L.) Spach	Polygonaceae	Caryophyllales	+	+
41	*Ranunculus sceleratus* L.	Ranunculaceae	Ranunculales	+	+
42	*Sagittaria sagittifolia* L.	Alismataceae	Alismatales	+	+
43	*Solanum nigrum* L.	Solanaceae	Solanales	+	+
44	*Spilanthes paniculata* Wall.	Asteraceae	Asterales	-	+
45	*Leucas aspera*	Lamiaceae	Lamiales	+	+
46	*Saccharum ravennae* L.	Poaceae	Poales	+	+
47	*Saccharum spontaneum* L.	Poaceae	Poales	+	+
48	*Vetiveria zizanioides* (L.) Nash	Poaceae	Poales	+	+