Ecological studies of macrophytes of two major wetlands of Nalbari district of Assam , India

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Abstract: The present study deals with the investigation of the macrophytic diversity of Borbilla beel and Borali beel which are two largest wetlands of Nalbari district of Assam covering an area of 55 hectares and 40 hectares respectively and its ecological status, particularly among the plant communities. While Borali beel is regularly affected by river flood water, the other one faces no such disturbances and are very rich in resources which are utilized by the people living in its vicinities. The study was carried out for a period of two years i.e. from January 2012 to December 2013. Altogether 92 macrophytic species belonging to 77 genera and 34 families have been reported from these wetlands. Of these species, monocotyledons are represented by 43 species under 37 genera and 15 families while dicotyledons are represented by 49 species under 40 genera and 19 families. Various diversity indices of the wetland plant communities were calculated to show the species richness (Margalef, 1964), Shannon – Weiver Diversity Index (Shannon and Weiver, 1963), Simpson's Dominance Index (Simpson, 1949), Evenness Index (Pielou, 1966) and Similarity index (Sorensen, 1948). During the study period maximum values of species richness, diversity and dominance index, and evenness of the macrophytic communities were shown at Borbilla beel during the summer season and similarity index was also found to be maximum during the summer season (0.686) between the two wetlands. The study shows that the two wetlands although situated away from one another yet so far as species contents are concerned, the two wetlands have similarities in their plant species composition.
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Key Words: Wetland, Macrophytic species, Species richness, Diversity and Dominance Index, Evenness Index, Similarity Index.

1. Introduction

Wetlands are highly productive ecosystems, comparable to rain forests and coral reefs. They act as bio-filter, as they intake large amount of organic as well as inorganic nutrients from the eutrophic water bodies or nutrient enriched pollutant through various dynamic processes like water cycle, nutrient cycle and food chain. Therefore, they are known as 'Kidney of the Landscape'. They are also known as 'Biological Super Market' as they support all life forms through extensive food webs and biodiversity (Mitsch and Gosselink, 1993).

A Wetland is an environment "at the interface between truly terrestrial ecosystems and aquatic systems making them inherently different from each other yet highly dependent on both" (Black, 1986).

The macroscopic forms of aquatic vegetation denoted as aquatic macrophytes (Wetzel,1983) include macroalgae, some species of ferns and angiosperms inhabiting a wetland. It is one of the basic components characterizing the wetland habitat. Muenscher (1944) considered aquatic plants as "those species which normally stand in water and must grow for at least a part of their life cycle in water, either completely submerged or emerged".

Macrophytes serve as a link between the sediment, water, and sometimes atmosphere in wetlands, lakes, and rivers. However, macrophytes are also involved in ecosystem processes such as biomineralization, transpiration, sedimentation, elemental cycling, materials transformation, and release of biogenic trace gases into the atmosphere (Carpenter and Lodge, 1986).

Since the beginning of the industrial revolution, increasing human population, economic activities as well as shortcomings in their management have resulted in more pollutants being introduced into watercourses. An increasing number of surface water bodies have come under serious threat of degradation.

Most of the wetlands of Nalbari district of Assam, India are also degrading due to various natural and anthropogenic activities like the starting of the process of eutrophication due to the decay of aquatic weed mainly highly abundant *Eichhornia crassipes* and some other aquatic macrophytes which are growing extensively over the past few years, encroachment due to construction of houses, cultivation, siltation as a result of flood, construction of roads through one of the wetlands, development of commercial fisheries inside one of the wetland, lack of efficient inlet and outlet of the wetlands and excessive growth of exotic weed *Eichhornia crassipes*.

While the larger of the two wetlands i.e. Borbilla beel is facing disturbances of both natural as well as of man induced, the relatively smaller one i.e. Borali beel confronts mainly natural disturbances of very high

intensity in the form of floods during the summer of every year caused by the river Pagladia with which it is connected. The flood caused by the river during the year 2001 and 2012 was of devastating form when the flood water caused heavy siltation in the wetland. The recurring flood has resulted in the noticeable change in the macrophytic community structure in the form of purely aquatic vegetation some years back to patches of alluvial grasslands during the last 10-15 years.

Wetlands have attracted the attention of botanists since early 20th century. Several works relating to aquatic and wetland flora have been carried out by several workers in various parts of the country including in the state of Assam (Mirashi, 1954; Subramanyam, 1962; Unni, 1971; Srivastava *et al*., 1987; Billore and Vyas, 1981; Biswas and Calder, 1936; Baruah and Baruah 2000; Kar and Barbhuiya, 2007).

Many workers have conducted experiments on the physicochemical characteristics of different freshwater bodies of India (Billore and Vyas, 1981; Biswas and Calder, 1984; Cottam and Curtis,1956; Crowder *et. al*. 1977; Dey and Kar,1989; Kar and Barbhuiya, 2000; Mishra,1974). Limited studies of wetlands of Assam have been done so far by various workers. Baruah *et.al*. (2011) carried out a simple diagnostic tool for measuring Subansiri river health. Borah and Sarma (2012) carried out the phytosociological investigation visa vis human impact on two wetlands of Sonitpur district of Assam. Dutta *et.al*. (2010) carried out statistical overview of certain physicochemical parameters of river Subansiri in North East India. Dutta *et. al*. (2011) also carried out the Influence of riparian flora on the river bank health of Subansiri river. Dutta *et.al*. (2010) conducted an experiment on Pre-impact Studies of the 2000 MW Lower Subansiri Dam on Certain Aquatic Environmental Aspects of Downstream of the River Subansiri with Special Reference to Plankton and Fishes. Saikia and Sarma (2010) carried out the utilization of wetland resources by the rural people of Nagaon district of Assam.

2. Study area:

The study was conducted at two wetlands i.e. Borbilla beel and Borali beel of Nalbari district of Assam during January 2012 to December 2013. Borbilla beel is situated at the global position at latitude 26^0 $21^/$ $20.4^{//}$ and 91^0 $17^/$ $18.2^{//}$ longitude. It covers an area of more than 55 hectares. The Borbilla beel is a compact type of wetland and it remains covered by water along with its aquatic vegetation almost throughout the year. The wetland is surrounded by four villages namely, Karakuchi in the south, Borbilla village in the east, Lokhopur in the north and Gomra in the west. The wetland is connected with the river Buradia with an inlet on the eastern side of the wetland. On the otherhand it has two outlets on south and south western sides. Both the outlets merge with each other after travelling a small distance which ultimately meet the river Buradia, a tributary of the river Brahmaputra again. Other wetland, Borali beel is situated in the eastern part of Nalbari district at the global position at latitude $N26^0$ $42^/$ $18.7^{//}$ and $E91^0$ $05^/$ $31.0^{//}$ longitude, covering an area of 40 hectares. Borali beel is connected with an inlet Satha channel on the north side flowing throughout the centre of the wetland and ultimately merge with the river Pagladia a tributary of the river Brahmaputra.

3. Materials and Methods:

Both the wetlands were surveyed for its macrophytic composition at least twice in a month during January 2012 to December 2013. The plant species were collected and herbarium sheets were prepared by following usual laboratory procedure. Collected species were identified with the help of standard literatures and also by matching the species at the herbariums of department of Botany, Gauhati university, Guwahati.

To study the phytosociological characters of the two wetlands, quadrats of 1m x 1m size were used within the communities. Every month 20 quadrats each were randomly placed in both the wetlands during the summer as well as in winter season to find out the Importance Value Index (IVI) of species, by following the methods as described by Misra (1969).

Different diversity indices like Species richness (Margalef, 1964), Shannon-Weaver Diversity Index (Shannon and Weaver, 1963), Simpson Dominance Index (Simpson, 1949), and Species evenness index (Pielou, 1966), Similarity index (Sorensen, 1948) and Dissimilarity index of the wetland plant communities were used to obtain various analytical data of the communities by using the following formulas:

1. Species richness (d):

$d = S/\sqrt{N}$

where, S=Total number of species, and N =Total number of individuals of all the species.

2. Shannon–Weaver index of diversity (H'):

$H' = -\sum pi \ln pi$

Where, pi = the proportion of Importance Value of the ith species (pi = ni / N, ni is the Importance Value of ith species and N is the Importance Value of all the species).

3. Simpson's index of Dominance (D):

$D = \sum (pi)^2$

Where, pi = the proportion of Important Value of the ith species (pi =ni / N, ni is the Importance Value of ith species and N is the Importance Value of all the species).

4. Evenness index (E):

E= H'/logs

H' = Shannon–Weaver diversity, and

log S= Natural log of the total number of species recorded.

5. Similarity Index (SI):

SI = 2C/ A+ B

Where, C = Number of species common in both the wetlands

A = Number of species present in Borbilla beel

B = Number of species present in Borali beel

6. Dissimilarity Index (DI) :

DI = 1- *SI*

4. Results:

During the survey, 92 macrophytic species belonging to 77 genera under 34 families were recorded from both the wetlands found to grow at different seasons of the year. Of these species monocotyledons are represented by 43 species under 37 genera and 15 families while dicotyledons are represented by 49 species under 40 genera and 19 families. [Table1]

Table 1: Macrophytic species of Borbilla beel and Borali beel wetlands: (H=Herb, Sh= Shrub, Us= Undershrub, Cl= Climber, Fl= Flowering, Fr= Fruiting, W.L.= Wetland, √= Present, x= Absent)

Sl no	Species name	Borbilla W.L.	Borali W.L.	Family	Habit	Phenophases Fl, Fr
1	*Acorus calamus* L.	√	X	Araceae	H	Fl = Oct-Jan Fr= Oct- Feb
2	*Adenostoma levinae* L.	√	X	Asteraceae	H	Fl= Aug-Dec Fr= Sep- Jan
3	*Aeschynomene aspera* L.	√	√	Papilionaceae	Us	Fl= Jul- Nov Fr= Aug- Dec
4	*Aeschynomene indica* L.	√	X	Papilionaceae	Us	Fl & Fr= Oct- Jan
5	*Ageratum conizoides* L.	√	√	Asteraceae	H	Fl & Fr= Jan-Dec
6	*Alisma plantago* L.	√	√	Alismaceae	H	Fl & Fr= Jul-Nov
7	*Alocasia indica* (Lour.) Koch.	√	√	Araceae	H	Fl & Fr= Sep-Nov
8	*Alpinia allughas* (Retz.) Rosc.	X	√	Zingiberaceae	H	Fl & Fr=Jan-Mar
9	*Alternanthera phyloxeroides* (Mar) Grisep.	√	√	Amaranthaceae	H	Fl= Sep- Apr Fr= Oct- May
10	*Alternanthera sessilis (L.)* R.Br.ex DC.	√	√	Amaranthaceae	H	Fl= Oct- Feb Fr= Oct- Feb
11	*Amaranthus virides* L.	√	X	Amaranthaceae	H	Fl & Fr= Nov-Feb
12	*Amaranthus spinosus* L.	√	√	Amaranthaceae	H	Fl & Fr= Oct- May
13	*Aponogeton appendiculatus* L.	√	X	Aponogetonaceae	H	Fl & Fr= Sept-Dec
14	*Aurundo donax* L.	X	√	Poaceae	H	Fl & Fr= Jun- Nov
15	*Auxonopus compressus* (Sw.) P. Beauv.	√	√	Poaceae	H	Fl & Fr= Dec- May
16	*Azolla pinnata* R.Br.	√	√	Azollaceae	H	NA
17	*Bacopa monnieri* (L.) Penn.	√	X	Scrophulariaceae	H	Fl & Fr= Nov-Feb
18	*Carex spp.*	√	X	Cyperaceae	H	Fl & Fr= May-Nov
19	*Casia tora* L.	√	√	Caesalpiniaceae	H	Fl & Fr=Jun-Dec

20	*Caytonis spp.*	X	√	Poaceae	H	Fl & Fr= May-Nov
21	*Centella asiatica* (L.) Urban	√	√	Apiaceae	H	Fl & Fr=Nov-Mar
22	*Ceratophyllum demersum* L.	√	√	Ceratophyllaceae	H	Fl & Fr=Aug-Dec
23	*Sagittaria sagittifolia* L.	√	X	Alismaceae	H	Fl & Fr=Nov-Feb
24	*Schoenoplectus articulatus* (L.)	√	√	Cyperaceae	H	Fl & Fr=Oct-Mar
25	*Colocasia esculenta* (L.) Schott.	√	√	Araceae	H	Fl & Fr= Aug-Nov
26	*Commelina benghalensis* L.	√	√	Commelinaceae	H	Fl & Fr= Jun-Dec
27	*Cynodon dactylon* (L) Pers.	√	√	Poaceae	H	Fl & Fr= Feb-May
28	*Cynoglossum zeylanicum* (Vahl.) Thunb.ex Lehm.	√	X	Boraginaceae	H	Fl & Fr= Feb-Jun
29	*Cyperus bulbosus* Vahl.	√	X	Cyperaceae	H	Fl & Fr=Jul-Jan
30	*Cyperus compressus* L.	√	X	Cyperaceae	H	Fl & Fr= Aug- Jan
31	*Cyperus corymbosus* L.	√	√	Cyperaceae	H	Fl= Aug- Nov Fr=Aug-Dec
32	*Schoenoplectus grossuss* (L.fil.)	√	√	Cyperaceae	H	Fl & Fr=Jun- Dec
33	*Eclipta prostrata* (L.) L.	√	√	Asteraceae	H	Fl & Fr= Aug- Dec
34	*Eichhornia crassipes* (Mart.) S.L.	√	√	Pontederiaceae	H	Fl & Fr= Apr-Jun, Aug-Jan
35	*Enhydra fluitans* Lour.	√	√	Asteraceae	H	Fl & Fr= Jun-May
36	*Euryale ferox* Salisb.	√	X	Nymphaeaceae	H	Fl=Apr-Jun Fr=Jun-Jul
37	*Scirpus articulatus* L.	√	X	Cyperaceae	H	Fl & Fr= Sept-Feb
38	*Euphorbia hirta* L.	√	√	Euphorbiaceae	H	Fl & Fr=Oct-Feb
39	*Fimbristylis bisumbellata*	√	X	Cyperaceae	H	Fl=May-Jun Fr= Jul-Oct
40	*Granga maderaspatana* (L.) Poir.	√	√	Asteraceae	H	Fl & Fr= Aug-Nov
41	*Hydrilla verticillata* (L.f.) Royle.	√	√	Hydrocharitaceae	H	Fl=Sep- Dec Fr=Oct-Jan
42	*Hydrocotyl sibthorpoides* Lmmk.	√	√	Apiaceae	H	Fl & Fr=Oct-Apr
43	*Hygroryza aristata* (Retz.) Nees.	√	√	Poaceae	H	Fl & Fr=Nov-Feb
44	*Hymenachne acutigluma (*Steud) Gill.	√	√	Poaceae	H	Fl & Fr=Aug-Dec
45	*Ipomoea aquatica* Forssk.	√	√	Convolvulaceae	H	Fl=Oct-Mar Fr=Oct-Apr

46	*Ipomoea carnea* Jaeq.	√	√	Convolvulaceae	H	Fl & Fr= Jul-Jan
47	*Ischemum albens*	√	X	poaceae	H	Fl & Fr=Aug-Nov
48	*Jussiea repens* L.	√	X	Onagraceae	H	Fl & Fr=Oct-Apr
49	*Kyllinga monocephela* Roxb.	√	X	Cyperaceae	H	Fl & Fr=Jun-Oct
50	*Leersia hexendra* Sw.	√	√	Poaceae	H	Fl & Fr=Aug-Dec
51	*Lemna minor* L.	√	√	Lemnaceae	H	NA
52	*Limnophylla aromatica* (Roxb.) Ben	√	X	Scrophulariaceae	H	Fl & Fr=Aug-Dec
53	*Limnophylla heterophylla* (Roxb.) Ben	√	√	Scrophulariaceae	H	Fl=Apr-Sept Fr=May-Oct
54	*Luduwigia adscandens* (L.) Hara	√	√	Onagraceae	H	Fl & Fr=Jun-Nov
55	*Luduwigia parviflora* Roxb.	√	X	Onagraceae	H	Fl & Fr=May-Jan Fr=Oct-May
56	*Luduwigia perennis* L.	X	√	Onagraceae	H	Fl & Fr= Sept- Jan
57	*Ludwigia octavalis* L.	√	√	Onagraceae	H	Fl & Fr= Aug- Jan
58	*Mikenia micrantha* Willd.	√	√	Asteraceae	H	Fl & Fr= Jun- Jan
59	*Monochoria hastata* Presl.	√	√	Pontederiaceae	H	Fl=Apr- Nov Fr=Apr-Dec
60	*Monochoria vaginalis* C.Presl.	√	X	Pontederiaceae	H	Fl & Fr=Apr-Nov
61	*Murdania nudiflora* L.	X	√	Commelinaceae	H	Fl & Fr=Sept-Dec
62	*Myriophyllum tuberculatum*	√	X	Haloragaceae	H	Fl=Apr-Sept Fr=Jan-Mar
63	*Nelumbo nucifera* (Gaertn).	√	X	Nymphaeaceae	H	Fl& Fr= Mar-Oct
64	*Nymphaea alba* L.	√	√	Nymphaeaceae	H	Fl& Fr=Jul-Jan
65	*Nymphaea nouchali* Burm.f.	√	√	Nymphaeaceae	H	Fl & Fr=Jul-Jan
66	*Nymphoides cristata* (Roxb.)Kuntze	√	X	Nymphaeaceae	H	Fl=Jan-Oct Fr=Jan-Nov
67	*Nymphoides indica* (L.) Kuntze	√	√	Nymphaeaceae	H	Fl & Fr=Apr- Nov
68	*Oldenlindia corymbosa* L.	√	X	Rubiaceae	H	Fl & Fr=Aug-Sept
69	*Ottelia alismoides* (L.) Pers.	√	√	Hydrocharitaceae	H	Fl & Fr=Aug-Dec
70	*Oxlis corniculata* L.	√	√	Oxalidaceae	H	Fl & Fr=Jan-May
71	*Pandanus fascicularis* Lamk.	X	√	Pandanaceae	Sh.	Fl & Fr=Apr-Jul

72	*Parthenium hysterophorus* L.	X	√	Asteraceae	H	Fl & Fr= May-Apr
73	*Pistia stratoides* L.	√	√	Araceae	H	Fl=Apr-May Fr=Apr-Oct
74	*Phragmites karka* L	X	√	Poaceae	H	Fl & Fr= Sept-Mar
75	*Polygonum barbatum* L.	√	X	Polygonaceae	H	FL & Fr=Aug-Oct
76	*Polygonum glabrum* Willd.	√	X	Polygonaceae	H	Fl & Fr=Dec-Mar
77	*Polygonum hydropipper* L.	√	√	Polygonaceae	H	Fl &Fr=Jun-Sept
78	*Potomogeton crispus* L.	√	X	Potamogetonaceae	H	Fl & Fr=Jan-Mar
79	*Pouzolzia zeylanica* (L.)Benn.	√	X	Urticaceae	H	Fl & Fr=Aug- Nov
80	*Rotala densiflora* Koehne	√	X	Lythraceae	H	Fl & Fr= Sept-Feb
81	*Rumex dentatus* L.	√	X	Polygonaceae	H	Fl & Fr=Oct-Feb
82	*Rumex nepalensis* Spreng.	√	√	Polygonaceae	H	Fl & Fr= Oct-Feb
83	*Rungia parviflora* (Retz.) Nees.	√	√	Acanthaceae	H	Fl & Fr=Jun-Dec
84	*Saccharum spontaenum* L.	X	√	Poaceae	H	Fl & Fr=Sep-Feb
85	*Salvinia molesta* Mitchell	√	√	Salviniaceae	H	NA
86	*Setaria verticillata* (L.) P.Beauv.	√	X	Poaceae	H	Fl & Fr=Oct-Feb
87	*Tetrastigma obovatum* L.	√	X	Papilionaceae	Cl	Fl & Fr=Nov-Mar
88	*Trapa bispinosa* (Roxb.) Makino	√	X	Trapaceae	H	Fl & Fr=Jun-Aug
89	*Trapa natans* L.	√	√	Trapaceae	H	Fl & Fr= Jul-Oct
90	*Valisnaria spiralis* Linn.	√	√	Hydrocharitaceae	H	Fl & Fr= Aug-Dec
91	*Vernonia cinerea* (L.) Lees.	√	X	Asteraceae	H	Fl & Fr=Jul-Dec
92	*Xanthium strumarium* L.	√	X	Asteraceae	H	Fl & Fr= Dec- Apr

Table 2: Diversity indices of macrophytes of Borbilla beel and Borali beel :

Sl no	Diversity Indices	Borbilla beel		Borali beel	
		Summer	Winter	Summer	Winter
1	Shannon–Weaver Diversity Index	3.316	2.802	3.01	2.379
2	Simpson Index of Dominance	0.088	0.064	0.042	0.169
3	Species richness	24.025	11.52	19.988	11.15
4	Evenness Index	0.995	0.872	0.896	0.737

Table 3: Similarity and Dissimilarity Index between the two wetlands during summer and winter season:

Season	Similarity Index	Dissimilarity Index
Summer	0.686	0.314
Winter	0.586	0.414

Species diversity is a useful parameter for the comparison of communities under the influence of disturbances of any kind or to know the state of succession and stability in the community. Shannon-Weaver diversity Index was found to be maximum in Borbilla beel which is relatively less disturbed wetland during the summer and winter season as compared to Borali beel, a highly naturally disturbed wetland. Simpson's Index of dominance was highest in Borali beel during the winter season, as it contains the lowest species diversity as compared to Borbilla beel. Species richness Index was maximum in Borbilla beel both in summer and winter seasons. Species richness Index showed the lowest values in Borali beel. Evenness Index was found to be maximum in Borbilla beel in both summer and winter seasons. Similarity Index between the wetlands shows which are positive in both the seasons are however maximum during the summer than during the winter.[Table 2,3]

5. Discussion:

The study indicates that although normal human interferance in the form of use of wetland water for day to day necessities, collection of fish and fodders by the people of its surrounding areas exist in both the wetlands. The natural disturbance in the form of annual flood by the river Pagladia badly affects the macrophytic community structure of the Borali beel where the purely aquatic plant communities are replaced by some patches, supporting alluvial grasslands. On the other hand heavy grazing by domestic buffaloes during certain periods of the year also seasonally affects the aquatic plant community structure of Borbilla beel.

The present investigation reveals that out of 92 macrophytic plants recorded from the Borbilla beel and Borali beel, population of few economically important species like *Euryale ferox , Trapa natans,* and *Nelumbo nucifera* are becoming very rare in these two wetlands.This is due to the aggressive growth of invasive exotic aquatic weed *Eichhornia crassipes* and luxuriant growth of *Leersia hexandra* in both the wetlands. Significantly heavy siltation after flood by the river Pagladia in Borali beel wetland is causing shrinkage of the population sizes of *Nelumbo nucifera* and *Euryale ferox*. It is also clear from the different diversity indices of plant communities that summer season shows the greatest species diversity in comparison to winter season due to the availability of sufficient water during the season which is the prime medium for the growth of the macrophytes. Likewise Similarity Index of the two wetlands also show higher values in summer because of the fact that in winter differences in species contents between the two wetlands are clearly visible. Besides the high organic contents leached from the surrounding areas of human habitations and agricultural fields in the form of remains of detritus and cow and buffalo dung by rain water enhances the nutrient contents of the habitat for the growth of macrophytes.

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