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Original Research Paper

Ecological Studies of Two Riverine Wetlands of Goalpara District of Assam, India

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ABSTRACT

The ecology in terms of physico-chemical and biological properties of Urpod beel and Kumri beel of Goalpara district of Assam were assessed from 2001 to 2003. Physico-chemical properties of both the wetlands were observed favourable. Biological properties such as plankton population and primary productivity fluctuated within the permissible limits. However, eutrophication tendency appeared in both the wetlands due to autochthonous and allochthonous input.

INTRODUCTION

Wetlands are some of the most biologically productive natural ecosystems in the world. By retaining nutrients, wetlands not only improve water quality, they also play a role in the nutrient recycling process of elements such as nitrogen and phosphorus. Plants absorb and accumulate these elements in their tissues and in the soil and when they die or lose their leaves, the elements are returned to the environment in another form.

Wetland hydrology, a primary driving force influencing wetland ecology, development, and persistence, is as yet poorly understood. The interaction between groundwater and surface water and the discharge-recharge relationships in wetlands affect water quality and nutrient budgets as well as vegetative composition. Hydrological considerations, necessary for an improved understanding of wetland ecology, include detailed water budgets, water chemistry, water regime and boundary conditions. Wetland values are often based on perceived wetland functions.

The biological productivity of any water body is influenced by climatic factors like air temperature, wind velocity and rainfall, which have a great bearing on wetland fisheries (Natarajan & Pathak 1987). As climatic and edaphic factors provide the essential sources of energy and nutrient they may be considered to be of first-order importance.

Allochthonous inorganic particulate matter (e.g. calcium carbonate with adsorbed inorganic and organic nutrients) and particulate organic matter in various stages of decomposition and mineralization settle into wetlands and littoral areas in prodigious amount.

In addition, dissolved inorganic and organic compounds entering the regions with inflowing surface water or percolating groundwater are exposed to intensive metabolic removal by microflora, particularly bacteria and algae associated with sediments and attached to other living and dead surfaces.

Nutrients of limited availability particularly phosphorus and nitrogen tend to be intensively conserved within the macrophytes. Assimilation from the sediments dominate uptake, little is lost to the surrounding water during active growth and most is translocated back to the sediments prior to and during senescence. Release of large amounts of nutrients and dissolved organic matter from senescing macrophyte into the surrounding water is markedly reduced by the effective capture, retention and recycling by the epiphytic microflora.

The impacts of nutrients on fishery resources have been emphasize by several workers (Natarajan & Pathak 1987, Salagar & Hosetti 1990, Sen et al. 1992). Based on the biological productivity of the large seasonal flood plains, the freshwater fishery sector plays an important role in the rural population in Assam. This fishery is a very important source of employment and income generation, as well as a pillar of rural food security and livelihood for rural people of Assam. Therefore, considering the aforesaid importance of nutrient budget of wetlands as well as for effective fishery management practices, present paper has been carried out to evaluate nutrient cycles of two riverine wetlands (locally known as Beel) of Goalpara district of Assam, India for sustainable fishery development.

DESCRIPTION OF THE STUDY AREA

Urpod Beel: The beel lies between the latitude and longitude of 25°15′and 90°14′ E. The beel covers an area of about 1000 hectares of land. The beel is surrounded by 10 villages (about 1000 families) of fishers, whose livelihood depend upon the aquatic resources of the beel. The beel has already been included in Asian Wetland Directory (Scot 1989). Perennially, the beel is fed by Jinziram (outlet of the beel) Jinari (inlet of the beel), both are the tributaries of river Brahmaputra. *Nymphaea* nuts are harvested from the beel for sale. The beel is also a source of *Euryale ferox.*

Kumri Beel: The beel also lies between the latitude and longitude of 26°14′ and 90°13′ E and located near to southern bank of the River Brahmaputra. The beel covers an area of about 200 hectare. The beel is surrounded by 5 villages (about 200 families) of fishers who earn their daily bread from the aquatic resources of the beel. Perennially a small canal coming from the River Brahmaputra feeds the beel.

MATERIALS AND METHODS

Sample collections were made in five pre-selected sampling sites in each beel. Selection of sampling sites was made on the basis of morphometry and physiography of the studied beel. Samples were collected seasonally i.e., twice in a season, for a period of two years (2001-2003).

Physico-chemical parameters of water were analysed by the methods of APHA (1989), Golterman et al. (1978), Trivedy & Goel (1986) and Dutta Munshi & Dutta Munshi (1995). Identification of aquatic biota was followed after Edmonson (1959), Tonapi (1980) and Needham & Needham (1986). Primary productivity and energy flow of the studied ecosystems were determined by the method of Vollenweider (1975) and Dutta Munshi & Dutta Munshi (1995). Biodiversity was determined by the method of U.S. Fish and Wildlife Service (1993).

RESULTS AND DISCUSSION

Population Dynamics of Urpod and Kumri Beels

The important plankton diversity of the two studied beel was identified as follows:

Phytoplankton (Tables 3 and 5)

1. Chlorophyceae	2. Myxophyceae	3. Bacillariophyceae
a. *Spirogyra*	a. *Spirulina*	a. *Fragillaria*
b. *Ulothrix*	b. *Anabaena*	b. *Melosira*
c. *Hydrodictyon*	c. *Nostoc*	c. *Navicula*
d. *Pediastrum*	d. *Oscillatoria*	d. *Nitzschia*
e. *Oedogonium*	e. *Microcystis*	e. *Synedra*
f. *Cladophora*		f. *Pinnularia*
g. *Eudorina*		
h. *Closterium*		

Zooplankton (Tables 4 and 6)

1. Cladocera	2. Rotifers	3. Copepods
a. Daphnia	*a. Brachionus*	*a. Cyclops*
b. Moina	*b. Keratella*	*b. Diaptomus*
c. Bosmina	*c. Nauplius*	
d. Cerodaphnia		

Fish population: A total of 48 dominant species of fishes were recorded in both the beels during the studied period, which are: *Tetradon cutcutia, Labeo rohita, Labeo calbasu, Catla catla, Cirrihinus mrigala, Labeo gonius, Notopterus chitala, Notopterus notopterus, Aorichthys aor, Wallago attu, Channa marulius, Channa striatus, Labeo bata, Cirrihinus reba, Eutropiichthys vacha, Clupisoma garua, Heteropneustes fossilis, Clarias batrachus, Channa punctatus, Channa gachua, Barilius bola, Puntius sarana, Mastacembelus armatus, Mastacembelus puncalus, Macrognathus aculeatus, Anabas testudineus, Xenentodon cancila, Glossogobius giuris, Puntius sophore, Puntius conchonius, Puntius ticto, Gadusia chapra, Rasbora elanga, Rasbora rasbora, Rasbora daniconius, Chela labuca, Amblypharyngodon mola, Aspidoparia morar, Mystus tengra, Mystus cavasius, Mystus bleckeri, Chanda ranga, Chanda nama, Badis badis, Danio devario, Monopterus cuchia, Colisa fasciata, Colisa lalia.*

Macroinvertebrates: Macroinvertebrates of studied beels belong to Annelids, Gastropods, Odonata, Ephemeroptera, Diptera, Hemiptera and Coleoptera. Depending upon the degree of association of macroinvertebrates with aquatic macrophytes, they can be classified into two major groups.

a. The fauna closely associated with submerged macrophytes (Annelids, Chironomids, Odonata, Ephemeroptera).

b. Other comparatively less associated or generally not moving types (Gastropoda, Hemiptera, Coleoptera). Both adults and larval forms of Mayflies (Ephemeroptera), Caddis flies (Trichoptera), Midges (Diptera), Mosquito larvae, Chironomids, water bugs like Notonecta, Nepa, etc.

Aquatic macrophytes: *Salvinia, Trapa, Nymphaea, Lemna, Wolffia, Nitella, Hydrilla, Vallisnaria, Polygonum, Eichhornia, Marsilia, Utricularia.*

Primary Production

Urpod beel: Primary productivity of Urpod beel (Table 1) was found maximum in pre-monsoon. However, lower limit was observed in monsoon. Annual productivity fluctuation range was found between 2.75 g C/m^2/day and 4.27 g C/m^2/day. Higher range of primary productivity was observed in pre-monsoon and in retreating monsoon mainly due to uniform solar radiation, less rainfall and high density of phytoplankton population. According to Sen et al. (1992), available nutrients set a basic limit to phytoplankton production. Other factors can actively influence the growth and reproduction of the producers. Munawar (1972) reported that turbidity by influencing light penetration acts as a limiting factor to affect phytoplankton abundance. These factors could have limited productivity during the present study. However, gross primary production in five sampling stations did not show any significant differences. Productivity value showed bimodal pattern of fluctuation i.e., two peaks in one annual cycle.

Net primary production showed the same pattern of fluctuation as in gross primary production. However, NPP values fluctuate between the ranges of 2.05 g C/m^2/day and 2.80 g C/m^2/day. Maximum range of net primary production was observed in pre-monsoon season. Highest value of net production in pre-monsoon might have resulted due to proliferation of phytoplankton, due to fresh rain and accumulation of organic matter from decomposed macrophytic vegetation.

Community respiration of Urpod beel showed positive correlation with GPP and NPP throughout the annual cycle. Maximum level of community respiration was observed in retreating monsoon and in pre-monsoon. According to Juday (1940) and Lindemann (1942), a value of 33% of fixed gross energy lost through respiration is probably the best available coefficient of lacustrine producers. Present findings are also in conformity with the above.

Kumri Beel: As far primary production is concerned, production capacity of Kumri beel is lower than that of Urpod beel (Table 2). Low range of productivity in Kumri beel might have resulted due to high siltation rate, low macrophytic vegetation and low phytoplankton density. However, annual productivity was fluctuated between 2.75 gC/m^2/day and 3.25 gC/m^2/day. Maximum value of primary productivity was observed in pre-monsoon and in retreating monsoon. According to Sen et al. (1992) if inflow of nutrients is accompanied by high turbidity then the productivity will be low. Present investigation also established that higher value of primary productivity in pre-monsoon might have resulted due to same trend as in Urpod beel. GPP, NPP and CR value of Kumri beel showed same trend as in Urpod beel.

Nitrogen and phosphorus released or enriched through autochthonous and allochthonous sources are main components for governing primary production throughout the year

Table 1: Mean value of GPP, NPP and CR along with standard deviation of Urpod beel.

Seasons	GPP	SD	NPP	SD	CR	SD
Premonsoon	4.27	0.88	2.80	1.10	1.47	0.89
Monsoon	2.75	1.22	1.85	0.55	0.90	0.50
Retreating Monsoon	4.25	1.80	2.71	0.89	1.54	0.90
Winter	3.10	0.91	2.05	1.12	1.05	0.51

Table 2: Mean value of GPP, NPP and CR along with standard deviation of Kumri beel.

Seasons	GPP	SD	NPP	SD	CR	SD
Premonsoon	3.25	0.84	2.80	1.10	1.47	0.89
Monsoon	2.75	1.01	1.85	0.55	0.90	0.50
Retreating Monsoon	3.25	1.20	2.71	0.89	1.54	0.90
Winter	2.75	0.91	2.05	1.12	1.05	0.51

of the two riverine beels because nitrogen in combination with phosphorus often limits primary productivity in many tropical freshwater lakes (Moss 1969, Zaret et al. 1981). Phosphate and nitrogenous compounds are usually released into water either by the decomposition of the organic matter in water and sediments (autochthonous) or by rain and sewage run-off (allochthonous) (Dutta Munshi & Dutta Munshi 1995).

Phytoplankton

Urpod beel: Phytoplankton community of Urpod beel (Table 3) constituted 58.82%-65.52% of the total plankton collected during the year. Phytoplankton community also showed bi-model pattern of distribution i.e., two peaks in one annual cycle. Increasing trend of phytoplankton population was showed in pre-monsoon and in retreating monsoon. Out of the collected phytoplankton, Chlorophyceae fluctuated between the range of 47% and 58%; Bacillariophyceae, 20% and 27%; and Myxophyceae, 20% and 30%.

It has been observed that members of Chlorophyceae were dominant throughout the year, which indicates excess of nutrients such as nitrogen and phosphorus (Round 1973). In rainy season, influx of nutrients is responsible for allochthonous input. However, in other seasons, autochthonous input is attributed.

Vollenweider (1968) reported that excessive loading of nitrogen and particularly phosphorus causes lakes to become eutrophic and often to exhibit noxious algal blooms. Present findings are also in conformity with the above. Algal blooms and eutrophication were often noticed in the Urpod beel. The fertilizers used in paddy, cultivated in the dried out beel during winter season, also enhance influx of nutrient in Urpod beel.

Kumri beel: Density of plankton population of Kumri beel

Table 3: Mean value (unit L^{-1}) and standard deviation of phytoplankton population of Urpod beel in four seasons (2001-2003).

Seasons	Chlorophyceae	SD	Myxophyceae	SD	Bacillariophyceae	SD
Premonsoon	100	3.5	33	1.8	39	2.9
Monsoon	69	3.5	39	2.0	40	2.0
Retreating monsoon	70	2.2	45	1.8	34	2.5
Winter	50	2.3	34	2.1	22	2.0

Table 4: Mean value (unit L^{-1}) and standard deviation of zooplankton population of Urpod beel in four seasons (2001-2003).

Seasons	Rotifers	SD	Copepods	SD	Cladocera	SD
Premonsoon	35	2.2	42	3.0	14	0.88
Monsoon	31	2.1	45	1.5	10	1.22
Retreating monsoon	37	3.1	54	2.5	15	2.33
Winter	31	1.8	40	1.3	04	1.00

Table 5: Mean value (unit L^{-1}) and standard deviation of phytoplankton population of Kumri beel in four seasons (2001-2003).

Seasons	Chlorophyceae	SD	Myxophyceae	SD	Bacillariophyceae	SD
Premonsoon	99	3.2	30	1.4	37	2.4
Monsoon	65	3.0	32	1.9	39	1.9
Retreating monsoon	68	2.0	40	1.1	30	2.1
Winter	48	1.9	31	1.9	20	1.9

Table 6: Mean value (unit L^{-1}) and standard deviation of zooplankton population of Kumri beel in four seasons (2001-2003).

Seasons	Rotifers	SD	Copepods	SD	Cladocera	SD
Premonsoon	31	1.9	39	2.8	11	0.42
Monsoon	29	2.0	42	1.3	09	1.00
Retreating monsoon	35	2.9	51	2.1	12	2.00
Winter	29	1.5	39	1.1	02	0.99

Table 7: Mean value (mg/L) and standard deviation of DO, pH, CO_2, alkalinity, hardness, chloride and phosphate of Urpod beel in four seasons (2001-2003).

Seasons	DO	SD	pH	SD	CO_2	SD	$CaCO_3$	SD	Hardness	SD	Cl	SD	P	SD
Premonsoon	8.1	0.8	6.9	0.8	6.6	0.6	93.7	1.8	39.5	0.9	14.0	0.33	0.80	1.9
Monsoon	6.2	1.2	7.6	1.0	6.9	0.8	46.2	1.5	25.3	1.0	113.5	0.89	0.90	1.6
Retreating monsoon	12.5	1.5	7.1	1.3	2.2	1.5	100.0	1.9	46.0	1.7	22.9	0.96	1.50	1.1
Winter	8.8	1.1	8.1	0.5	11.6	1.1	120.0	2.0	60.1	1.9	24.0	1.1	1.65	1.1

Table 8: Mean value (mg/L) and standard deviations of DO, pH, CO_2, alkalinity, hardness, chloride and phosphate of Kumri beel in four seasons (2001-2003).

Seasons	DO	SD	pH	SD	CO	SD	$CaCO_3$	SD	Hardness	SD	Cl	SD	P	SD
Premonsoon	8.3	0.8	8.3	0.8	6.6	0.6	70.1	1.1	41	0.5	15.2	0.35	0.86	0.6
Monsoon	8.5	1.0	8.5	1.0	6.9	0.8	61	1.5	33.5	0.9	1 14.5	0.79	0.90	0.8
Retreating monsoon	9.1	0.9	8.9	1.0	2.1	1.5	89	1.2	48.5	1.1	22.9	0.56	1.05	1.5
Winter	8.8	1.1	9.1	0.5	6.5	1.1	102	1.8	65.5	12	25.0	1.1	1.65	1.1

is lower than that of Urpod beel (Table 5). Fluctuation trend of plankton population shows same trend as in Urpod beel.

Physico-Chemical Characteristics

Urpod beel: The data on physico-chemical properties of Urpod beel are given in Table 7. The pH level of water of the beel ranged between 6.9 and 8.1. Lowest value of pH was recorded in pre-monsoon, while highest value in winter season. Increment of the pH value in the winter season was resulted due to decomposition of aquatic vegetation. The levels of DO were observed between 6.2 mg/L and 12.5 mg/L. Maximum value was estimated in retreating monsoon, and minimum in monsoon. DO level throughout the study period showed an orthograde profile. The entire water body of the beel had more than 50% saturation of oxygen and provided a suitable habitat of fish. The level of free CO_2 was estimated between the range of 2.2 mg/L and 11.6 mg/L. Maximum range of free CO_2 was recorded in winter due to high rate of decomposition of organic matter by the microbes resulting in rapid production of CO_2. Hardness of the water body was in the range of 25.3 mg/L and 60.1 mg/L.

Chloride was fluctuated between 13.5 mg/L and 24.0 mg/L. The highest value of chloride was estimated during winter, and lowest in monsoon. Munwar (1970) suggested that high value of chloride is an indication of pollution of animal origin. It has been suggested that chloride content also increased with degree of eutrophication. It has also been observed that some regions of the beel were totally infested with weeds.

The water quality of the beel was observed moderately alkaline throughout the year with alkalinity values ranging between 46.2 mg/L and 120 mg/L. However, in winter season due to greater accumulation of nutrients as well as receding water, the level of alkalinity enhanced. Phosphate value was found to fluctuate between 0.90 mg/L and 1.65 mg/L. However, maximum value of phosphate was observed in winter season, and minimum in monsoon season.

Statistical interpretation of primary productivity, plankton community and physico-chemical parameters showed the following results: High positive and significant correlation between GPP and Chlorophyceae ($r = 0.964$), GPP and Myxophyceae ($r = 0.743$) and GPP and Bacillariophyceae ($r = 0.802$). However, phytoplankton and zooplankton showed highly negative correlation between Chlorophyceae and Cladocera ($r = -0.743$) and Chlorophyceae and Rotifers ($r = -0.790$). Relationship between physico-chemical parameters and plankton also showed highly positive correlation: Alkalinity-Cyanophyceae ($r = 0.74$), Alkalinity-Copepods ($r = 0.32$), pH-Copepods ($r = 0.87$) and pH-Rotifers ($r = 0.91$).

Kumri beel: The data on physico-chemical properties of Kumri beel are given in Table 8. The water quality of the Kumri beel was observed in moderately alkaline condition i.e., between 61 mg/L and 102 mg/L with the level of pH between 8.3 and 9.1. Dissolved oxygen of Kumri beel was more or less uniform during the annual cycle. Oxygen value throughout the annual cycle exhibited an orthograde profile. Phosphate value was found to fluctuate between 0.95 mg/L and 1.80 mg/L. However, maximum value of phosphate was observed in winter season, and minimum in monsoon season.

Statistical interpretation of primary productivity, plankton community and physico-chemical parameters showed following results: High positive and significant correlation between GPP and Chlorophyceae ($r = 0.91$), GPP and Myxophyceae ($r = 0.85$) and GPP and Bacillariophyceae ($r = 0.99$). However, phytoplankton and zooplankton showed highly negative correlation between Chlorophyceae and Cladocera ($r = -0.87$), and Chlorophyceae and Rotifers ($r = -0.790$). Relationship between physico-chemica1 parameters and plankton also showed highly positive correlation: Alkalinity-Cyanophyceae ($r = 0.74$), Alkalinity-Copepods ($r = 0.87$), pH -Copepods ($r = 0.87$) and pH-Rotifers ($r = 0.91$).

In recent times due to unauthorized cultivation of paddy during winter season, where inorganic fertilizers are used enormously, allochthonous input of nutrients has increased and as a result eutrophication appeared in both the beels.

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