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Research article

ECOLOGY OF TWO RIVERINE WETLANDS OF GOALPARA DISTRICT, ASSAM IN RELATION TO PLANKTON PRODUCTIVITY

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ABSTRACT: Ecological investigation of two riverine wetlands of Goalpara district, Assam, India was carried out in relation to planktonic productivity from 2006 to 2008. The physico chemical parameters were found fluctuating with the growth of both phytoplankton and zooplankton. Both the beel was dominated by Chlorophyceae throughout the year amongst which *Ulothrix* and *Spirogyra* were found as dominating species. Among the Copepods, C*yclops* was over all dominating species and amongst the Cladoceran groups; *Daphnia, Bosmina* and *Moina* were found in the wetlands throughout the studied period. Phytoplankton community of Urpod beel constituted 58.82% to 65.52%, while zooplankton community constituted 34.48% to 41.18% of the total plankton hauled throughout the studied period. Chlorophyceae fluctuates between the range of 47% to 58%, Bacillariophyceae 20% to 27% and Myxophyceae fluctuates between the ranges of 20% to 30%. Mean value of GPP in Hasila beel was estimated between the range of 2.88 gC/ m^2/day and 4.66 gC/ m^2/day, while in Urpod beel it was between 2.75g $Cm^{-2}day^{-1}$ and 4.27g $Cm^{-2}day^{-1}$.

Key words: Productivity, Phytoplankton, Zooplankton, Wetland, Goalpara district

INTRODUCTION

Wetlands are considered as priceless gems of the earth. Known as 'Simsar (sim = low-grade land; sar = water)' in Nepali, wetlands are those areas which lie between the land and deepwater and remain waterlogged or submerged under water, seasonally or throughout the year (Jha, 2004). According to Black (1984), 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. Wetlands are the most productive important part of global ecosystem, which because attention has been turned recently to using the wetland systems and the plant species occurring therein as bio-energy sources and also for use in pollution abatement projects to filter sewage, agricultural run-off, leachate from landfills, and acid mine drainage mitigation (Brooks, 1989, Oliver and Hill, 1998). In the functioning of aquatic ecosystems both the productivity and the efficiency of ecosystem operations are governed by many constraints. Major environmental regulations include physical factors and the availability of resources required at various physiological ranges. Wetland hydrology, a primary driving force influencing wetland ecology, development, and persistence, is as yet poorly understood. The biological productivity of any water body is influenced by climatic factors like air temperature; wind velocity and rainfall have a great bearing on wetland fisheries (Natarajan and Pathak, 1987). 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 (Sarma and Dutta, 2012). The expanding human population and the growing need of the organic matter have necessitated the evaluation of the primary productivity of the different ecosystems, which provide food to the consumers of the higher trophic level (Adoni and Vaishya 1985). The study of diel fluctuation in the phytoplankton productivity is very essential to know the actual photosynthetic capacity of the aquatic systems and to assess its trophic dynamics (Adoni and Vaishya, 1985). The plankton community is a heterogeneous group of tiny plants (phytoplankton) and animals (zooplankton) adapted to suspension in the sea and fresh waters (Battish, 1992). Zooplanktons support the economically important fish population (Kiran et al., 2007). They are the major mode of energy transfer between phytoplankton and fish (Howick and Wilhm, 1984). Plankton has immense value as food, in the disposal of sewage, in the natural purification of polluted waters etc. A number of workers such as Dwivedi et al., 2000; Prasad et al., 2002; Chakraborty and Chakraborty, 2003; Rout *et al*., 2003; Nath and Das, 2004; Sarma *et al*., 2007; Gogoi, 2007 have reported on different aspects of ecology, limnology, fisheries and conservation of wetlands in India including Assam. Keeping in view of the aforesaid importance, present investigation is made with an objective to study ecology and its relation to plankton diversity in two riverine wetland of Goalpara district of Assam.

MATERIALS AND METHODS

The study area *i.e.* Goalpara district is located approximately 25^0 $33^/$ to 26^0 $12^/$ N latitude and 90^0 $7^/$ to 91^0 $5^/$ E longitude. The climate is hot and humid in summer and dry cool season in winter (Deka et al., 2011). The Hasila wetland (beel) is located very near to the Goalpara town of Goalpara District of Assam (latitude $26^0 15^/$ N and longitude $90^0 14^/$ E). It is a riverine wetland and considered to be dynamic system in which living plants and animals not only interact but also influence the habitat profoundly. The other wetland, Urpod beel lies between the latitude and longitude of 25^0 $15^/$ N and 90^0 $14^/$ E respectively. It is also riverine in origin and covers an area of about 1000 hectare of land. The wetland has already been included in wetland directory (Scot, 1989) due to its aquatic avifaunal diversity. The study has been carried out for a period of two years from 2006 to 2008 based on both primary and secondary data. The primary data were collected from the field through survey and spot observation. Secondary data were also collected through observation and interview with fishers through questionnaire. The information regarding the aquatic flora and fauna were collected from the field. Water samples for physico-chemical parameters were collected from five pre-selected sampling sites in each season (*i.e.* in premonsoon, monsoon, retreating monsoon and winter). Plankton collections were also made in the same site and in the same season. Diversity of fishes determined from landing center and observing fishing (once in every month). Physico-chemical parameters were analyzed adopting the method of APHA (1989), Trivedi and Goel (1986). Temperature and pH were measured on the spot at the time of sample collection using portable kit. Primary productivity was estimated by "light and dark bottle" oxygen method followed after Vollenweider (1975) and Dutta Munshi and Dutta Munshi (1995). Productivity of the wetland was estimated in terms of carbon in gram as per the methods of Trivedi and Goel (1986). Identification of planktons were followed after Edmonson (1959); Tonapi (1980); Needham and Needham (1986).

RESULTS AND DISCUSSION

Water quality parameters

pH estimation:

All the water quality parameters were found within permissible limit throughout the year (Table 1. & 2). In Hasila wetland, pH values were estimated between 8.0 and 8.5. It was lowest in winter and highest in Premonsoon. The lower pH during winter season was due to high turbidity as well as the uniform temperature during that season might have enhances microbial activity, causing excessive production of CO_2 and reduced pH also in conformity of the findings Khan & Khan (1985). Wetzel (1975) who reported that the value of pH ranges between 8 and 9 attributing increased primary productivity. The present findings were also in conformity with the above.

Table 1: Mean Value (± SD) of water quality parameters of Hasila wetland in four seasons

Parameters	Seasons			
	Pre-monsoon	Monsoon	Retreating monsoon	Winter
pH	8.5 ± 0.4	8.3 ± 0.3	7.9 ± 0.5	8.0 ± 0.2
Water temperature (^{0}C)	24.9 ± 1.2	27.0 ± 2.4	25.4 ± 2.0	20.0 ± 1.1
Transparency (cm)	46.5 ± 3.4	65.0 ± 3.3	45.0 ± 3.4	40.2 ± 3.5
Dissolved oxygen (mg l^{-1})	8.2 ± 0.8	9.0 ± 0.6	6.8 ± 0.5	5.3 ± 0.4
Free CO_2 (mg l^{-1})	4.3 ± 0.4	5.8 ± 0.6	6.6 ± 1.1	2.8 ± 0.8
Alkalinity (mg l^{-1})	57.5 ± 9.6	67.0 ± 8.8	58.0 ± 8.5	60.5 ± 9.1
Hardness (mg l^{-1})	29.5 ± 1.6	24.2 ± 1.7	20.0 ± 1.2	30.0 ± 1.7
Chloride (mg l^{-1})	15.83 ± 0.44	15.35 ± 0.51	16.41 ± 0.52	18.11 ± 0.68

Table 2: Mean Value (± SD) of water quality parameters of Urpod wetland in four seasons

Parameters	Seasons			
	Pre-monsoon	Monsoon	Retreating Monsoon	Winter
pH	6.9 ± 0.8	7.6 ± 1.0	7.1 ± 1.3	8.1 ± 0.5
Water temperature (^{0}C)	22.9 ± 1.8	29.3 ± 2.6	24.3 ± 2.4	20.5 ± 1.6
Transparency (cm)	44.6 ± 3.5	53.6 ± 3.7	45.7 ± 3.8	40.2 ± 3.1
Dissolved oxygen (mg l^{-1})	8.1 ± 0.8	6.2 ± 1.2	12.5 ± 1.5	8.8 ± 1.1
Free CO_2 (mg l^{-1})	6.6 ± 0.6	6.9 ± 0.8	2.2 ± 1.5	11.6 ± 1.1
Alkalinity (mg l^{-1})	93.7 ± 1.8	46.2 ± 1.5	100.0 ± 1.9	120.0 ± 2.0
Hardness (mg l^{-1})	39.5 ± 0.9	25.3 ± 1.0	46.0 ± 1.7	60.1 ± 1.9
Chloride (mg l^{-1})	14.0 ± 0.33	13.5 ± 0.89	22.9 ± 0.96	24.0 ± 1.1

The pH level of water of the Urpod wetland was estimated between the range of 6.9 and 8.1. Lowest was in premonsoon, while highest value of pH observed in winter season. According to Buttner et al. (1993), pH between 6 and 9 is desirable for fish survival and growth. Highest value of pH in winter season might have resulted due to the presence of polyvalent metal ion, e.g. Calcium and magnesium coming from inorganic fertilizer used in paddy field in the vicinity. Dodds (2003) described a secondary source of H^+ ions from periphytic photosynthesis which locally increases pH of the system by up to 1 unit. The present findings are also in conformity with the above.

Water temperature:

Water temperature is one of the most important ecological factors, which controls the physiological behavior and distribution of organisms (Moundiotiya et al., 2004). The water temperature of the Hasila beel observed between 20^0C to 27^0C lowest being in winter and highest being in Monsoon. The level of water temperature found to correlate with the Air temperature. However, the water temperatures were observed conducive for aquatic animals in the site. Water temperature recorded in the Urpod beel was between the range of 20.5^0C and 29.3^0C in which highest was in monsoon and lowest observed in the winter season. This is range corresponds to the temperature range in the works of Gras et al. (1997) which reported in their immunological investigation of lake Chad. Lowest value of winter season might have resulted due to receding water couple with heavy accumulation of organic wastes. This observed value also agrees with the findings of Ezra (1999).

Water trancparency:

The level of water transparency in both the wetlands was also found favorable for photosynthetic organism, as sunlight able to reach up to the bottom in the site. In Hasila beel, transparency ranges between 45cm to 65cm, lowest being in Retreating Monsoon and highest being in Monsoon. However, in the Urpod beel, maximum transparency value was found in Monsoon and minimum in winter. Maximum transparency in Monsoon season was due to influx of rain water. It becomes lowest in winter due to increase organic matter as well as due to increase in fishing activity. The lowest level of water transparency in the site might also have resulted due to anthropogenic activities besides fishing. Local inhabitants are using water of the beel for washing clothes, cattle etc. Paddy cultivation was also practiced in winter season in dried out area of the beel where huge amount of inorganic fertilizer were also used.

Dissolved Oxygen (DO):

DO value ranges between 5.3 mg l^{-1} and 9.0 mg l^{-1} in Hasila beel of which maximum were observed in Monsoon and minimum in winter. In winter DO level became lowest due to less rainfall and increasing fishing activity. The levels of DO were observed in the Urpod beel between 6.2 mg l^{-1} and 12.5 mg l^{-1}. Maximum value estimated in retreating monsoon and minimum in monsoon. DO level throughout the studied period showing an orthograde profile as in conformity with the finding of Reid and Wood (1976). The entire water body of the beel had more than 50% saturation of oxygen and provided a suitable habitat of fish. Many factors are related to the complex daily and seasonal variation in the oxygen content of water (Heckman, 1979). Accumulation of hospital waste along with organic wastes might be the factor for declining trend of DO. The addition of a variety of biodegradable pollutants from domestic and industrial sources stimulates the growth of micro-organisms, which consume the dissolved oxygen (Moundiotiya et al., 2004).

Free CO_2 (FCO_2):

FCO_2 values estimated between 2.8 mg l^{-1} to 6.6 mg l^{-1} in the Hasila beel of which highest being in Retreating Monsoon and lowest being in winter. The level of FCO_2 is inversely proportional to the level of DO level. Present findings are also conformity with the above. The level of free CO_2 in Urpod beel was estimated between the range of 2.2 mg l^{-1} and 11.6 mg l^{-1}. Maximum range of free CO_2 in the beel was recorded in winter might be due to high rate of decomposition of organic matters by the microbes resulting in rapid production of free CO_2 (Sinha, 1986).

Total Alkalinity:

Alkalinity measures the acid-neutralizing capacity of water. It is attributed to the presence of hydroxide, carbonate, and bicarbonate ions in the sample. Weak bases such as phosphates, silicates and borates may also contribute to alkalinity. In the Hasila beel, the level of alkalinity was found within permissible limit. It was found between 58 mg l^{-1} and 67 mg l^{-1} highest being in monsoon and lowest in retreating monsoon. Slight increment in the level of alkalinity might be due to organic decomposition of aquatic vegetation. In Urpod beel, the alkalinity values were found between the range of 46.2 mg l^{-1} and 120 mg l^{-1}. In winter season due to greater accumulation of nutrient as well as receding water, the level of alkalinity enhanced in the beel. Biological organisms may exploit such productive aquatic environment (Boyd, 1981).

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The present findings are also in conformity with the above. Alkalinity and pH are the factors responsible for determining the amenability of water to biological treatment (Manivasakam, 1980). The low alkalinity in Urpod beel during the monsoon might be due to dilution. Bishop (1973) and Jain et al. (1996) also reported similar findings in their study on Malayan rivers and the Halali Reservoir.

Total Hardness

The hardness in water is derived largely from contact with the soil and rock formations. Rain water as it falls upon the earth is incapable of dissolving the solids found in natural waters. Hardness value in Hasila beel was recorded between 20 mg l^{-1} and 30 mg l^{-1} lowest estimated in Retreating monsoon and highest being in winter. On the other hand in Urpod beel it was estimated within the range of 25.3 mg l^{-1} and 60.1 mg l^{-1}. The levels of hardness of both the beels were estimated within permissible limit. According to Baruah et al. (1993), hardness of water is not a pollution parameter, but indicates water quality mainly in terms of Ca^{2+} and Mg^{2+}.

Chloride

In Hasila beel, highest value of chloride was estimated in winter and lowest value in monsoon. Highest value in winter is due to anthropogenic activity. The enhancement of chloride level in aquatic medium is due to animal origin. However, in Urpod beel the range of chloride was between 13.5 mg l^{-1} and 24.0 mg l^{-1}. The highest value of chloride was estimated during winter and lowest in monsoon. Munwar (1972) suggested that high value of chloride is an indication of pollution of animal origin. Similar observation was also made by Thresh et al. (1994). It has been suggested that chloride content also increased with degree of eutrophication (Sinha, 1986). Present findings are also agree with the above statement.

Plankton population:

Phytoplankton:

Phytoplankton community in the both the beels showed bi-modal pattern of distribution *i.e.* two peaks in one annual cycle. Increasing trend of in Phytoplankton population showed in pre monsoon and in retreating monsoon. It has been observed in both the beel that member of Chlorophyceae dominant throughout the year (Figure 1). Amongst the Chlorophyceae, *Ulothrix* and *Spirogyra* were dominating species throughout the studied period in Hasila beel. However, their occurrence was more during premonsoon. The growth, occurrence and the distribution of algae are affected by a great number of physical and chemical factors (Gotting et al., 1982). The Phytoplankton community of Urpod beel constituted 58.82% to 65.52% of the total plankton collected throughout the studied period. Out of the collected Phytoplankton population, Chlorophyceae fluctuates between the range of 47% to 58%, Bacillariophyceae 20% to 27% and Myxophyceae 20% to 30%. Dominance of Chlorophyceae throughout the year indicates indicates excess of nutrient such as Nitrogen and Phosphorus (Round, 1973). Algal blooms and eutrophication often noticed in the Urpod beel. 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. Bhowmik and Singh (1985) reported that during rainy season there was a sharp fall in the phytoplankton density which showed upward trend from November onward.

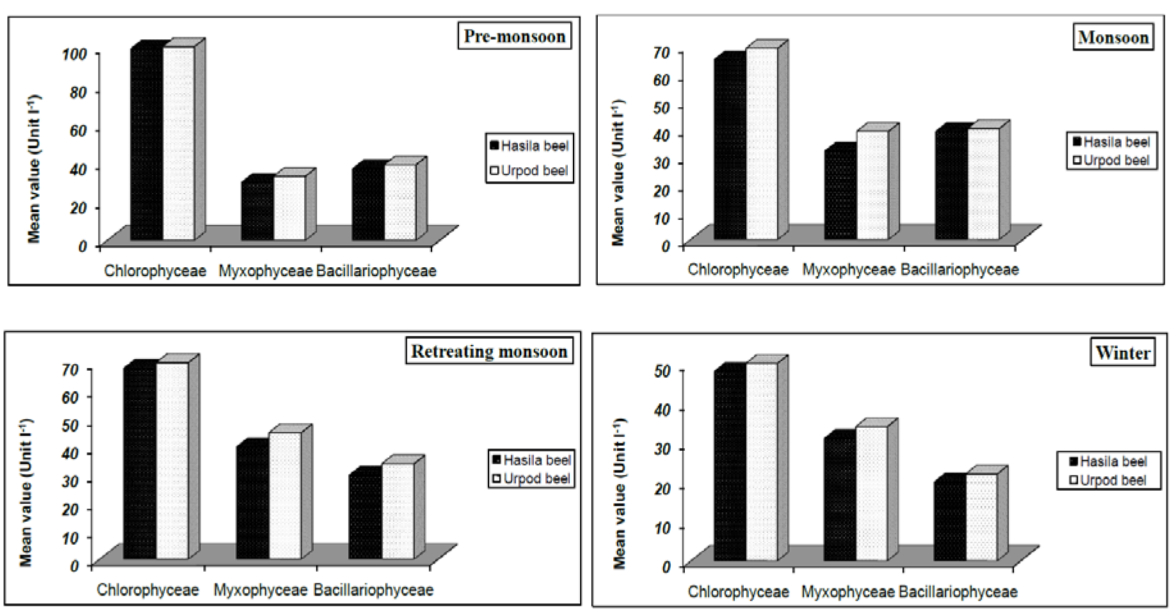

Figure-1: Mean Value (unit l^{-1}) of Phytoplankton population of Hasila and Urpod wetland.

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Zooplankton

Density of zooplankton and their population was less than phytoplankton population and growth was slow in the Hasila beel. Zooplankton community in Urpod beel constituted 34.48% to 41.18% of the total plankton hauled. It shows bimodal pattern of distribution in both the beel. Increasing trend of zooplankton population was seen in pre-monsoon and monsoon. Amongst the Copepods, C*yclops* was over all dominating species found throughout the annual cycle (Fig 2). Similar results are also recorded in Urpod beel. Adholia and Vyas (1991) reported that the abundance of C*yclops* throughout the year is due to high level of nutrient concentration. The present finding is also in conformity with the above. Amongst the Cladoceran groups, *Daphnia*, *Bosmina* and *Moina* were found throughout the studied period. Amongst them, *Daphnia* was dominant during monsoon. Amongst the Rotifers *Brachionus* and *Keratella* were abundant throughout the year. The factors like temperature, transparency, turbidity, conductivity and dissolved oxygen play an important role in regulating diversity and seasonal population densities of cladoceran species (Patil and Auti, 2005). Similar observation was made in case of Urpod beel.

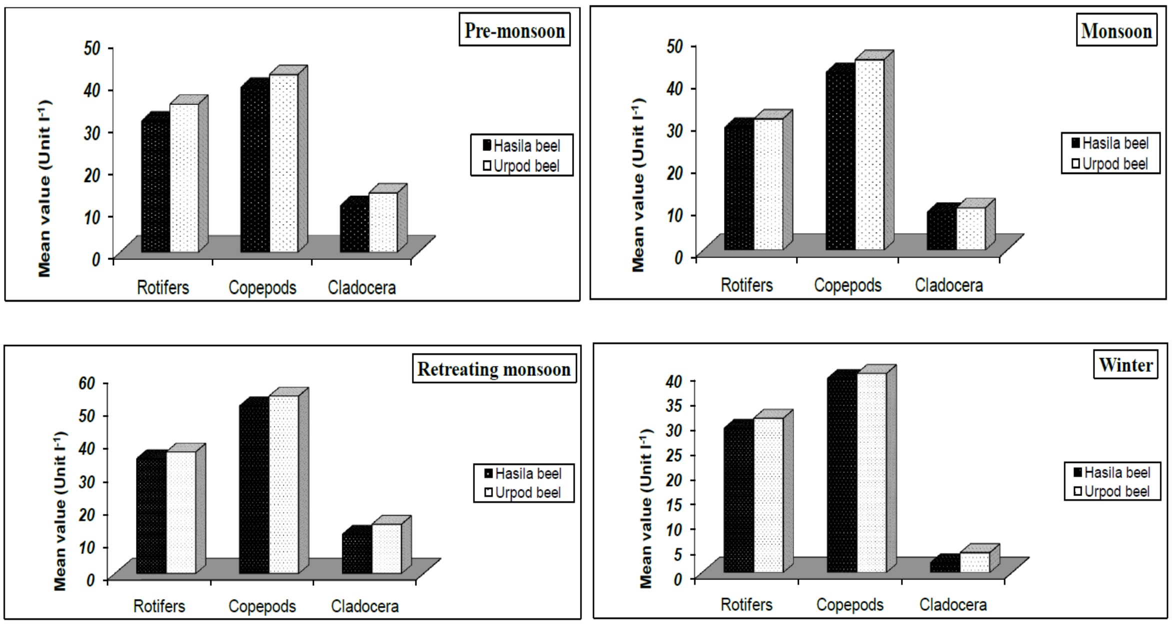

Figure-2: Mean Value (unit l^{-1}) of Zooplankton population of Hasila and Urpod wetland.

Primary productivity

So far primary productivity is concern; in Hasila beel, mean value of GPP was estimated between the range of 2.88 gC/ m^2/day (in monsoon) and 4.66 gC/ m^2/day (in premonsoon). Annual fluctuation trend were Premonsoon > Retreating Monsoon > winter > monsoon. Mean Value of NPP was estimated between the range of 1.72 gC/ m^2/day (in premonsoon) and 2.94 gC/ m^2/day (in monsoon). Annual fluctuation trend were Monsoon > winter > Retreating Monsoon > Premonsoon. The mean value of community respiration was found fluctuate between the range of 0.83 gC/m^2/day (in winter) and 2.01 gC/m^2/day (in premonsoon). Annual fluctuation trend were premonsoon > Retreating monsoon > Monsoon > winter. Production efficiency of Hasila beel conducive for wetland ecosystem but influence phytoplankton community along with infestation of macrphytes especially *Eicchornia* *v*egetation have clearly indicated as Mean value of NPP was comparatively higher than that of the Community Respiration (CR). According to Sen et al. (1992), available nutrients set a basic limit to phytoplankton productivity. Therefore, it can be presumed that organic load of the sampling site are in increasing trend leading to eutrophication.

However, in Urpod beel annual Gross primary productivity fluctuation range was found between 2.75g $Cm^{-2}day^{-1}$ and 4.27g $Cm^{-2}day^{-1}$. Higher range of primary productivity observed in premonsoon and in retreating monsoon. However, lower limit was observed in monsoon. According to Sarma and Dutta (2012), higher range of primary productivity in premonsoon and retreating monsoon might have resulted due to less amount of rainfall and high density of phytoplankton population. Adoni and Vaishya (1985) reported the GPP maximum during summer season and minimum during winter season. Munawar (1972) reported that turbidity by influencing light penetration acts as a limiting factor to affect phytoplankton abundance. The net primary production was also higher in summer season and lowest in rainy season but did not follow any regular diel pattern (Adoni and Vaishya 1985). Almost similar observation was also found in the present investigation in both the beel.

Community respiration rate was maximum during pre monsoon and minimum during winter season. However, in monsoon season due to high turbidity, lower density of phytoplankton coupled with dilution of nutrient resulted in low primary production. Net Primary Production values fluctuate between the ranges of 2.05 g $Cm^{-2}day^{-1}$and 2.80 g $Cm^{-2}day^{-1}$. Maximum range of net primary production was observed in premonsoon season. Maximum range of net production in premonsoon might have resulted due to proliferation of phytoplankton as fresh rain helps in accumulation of organic matter from decomposed macrophytic vegetation. Similar observations were also made by Sarma and Dutta (2012) in two riverine wetlands. Community respiration of Urpod beel showing positive correlation with GPP (0.88) and NPP (0.95) throughout the annual cycle.

Statistical analysis

Statistical interpretation of primary productivity, plankton community and physico-chemical parameters showed high positive and significant correlation between GPP and Chlorophyceae (0.90), GPP and Myxophyceae (0.91) and GPP and Bacillariophyceae (0.70) in Hasila beel. However, Phytoplankton and Zooplankton showed highly negative correlation between Chlorophyceae and Cladocera (-0.77), Chlorophyceae and Rotifers (-0.69).

In Urpod beel also, statistical interpretation of primary productivity, plankton community and physico-chemical parameters showed highly positive and significant correlation between GPP and Chlorophyceae (0.964), GPP and Myxophyceae (0.743) and GPP and Bacillariophyceae (0.802). However, Phytoplankton and Zooplankton showed highly negative correlation between Chlorophyceae and Cladocera (-0.743), Chlorophyceae and Rotifers (-0.790).

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