PRODUCTIVITY SCENARIO DEPICTS AN IMPORTANT RELATION WITH PHYTOPLANKTON – A CASE STUDY OF KABAR WETLAND

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ABSTRACT

Wetlands have nurtured the development of many important cultures around the world. Kabar wetland has ecological significance as it has been a home for several associated biodiversities. A study was carried out to the productivity status of Kabar wetland. Primary productivity of particular water body gives quantitative information about the amount of energy available to support the bioactivity of the system. The value of Gross Primary Production (GPP) ranged from 0.562 to 4.05 gC/l/d. Maximum GPP was recorded in summer and minimum GPP was recorded in monsoon. GPP showed positive correlation with community respiration (r = 0.968). Net primary production varied from 0.337 to1.35 g C/l/d. NPP values were lower during monsoon and maximum during summer. NPP showed positive correlation with ambient and water temperature and Cyanophycean density (r = 0.887) significant at 5%. Community respiration varied between 0.225 to 3.375 g C/l/d. Community respiration showed negative correlation with Chlorophycean density (r = -0.938).

P/R ratio was found to vary from 0.181 to1.98 g C/l/d. The range of P/R ratio is an excellent functional index of unpolluted (P/R > 1) and polluted (P/R < 1) condition of aquatic system. In the present study the P/R ratio indicated that the wetland was progressing towards eutrophication.

Key words: Kabar wetland, GPP, NPP, Community respiration, Phytoplankton, Productivity

Introduction

Wetlands are highly productive systems. Primary productivity of particular water body gives quantitative information about the amount of energy available to support the bioactivity of the system. The most important input of energy into the freshwater ecosystem is by photosynthesis and phytoplankton constitutes the major segment of primary producers in aquatic ecosystems. The primary productivity of many wetlands is quite high especially when compared with other natural communities or even to agricultural land. Primary productivity is the rate of plant growth during a certain period of time. It is often measured by harvesting and weighing dried plants and it is reported in grams dry weight per square meter per year (g m^{-2} $year^{-1}$). Wetlands with emergent herbaceous vegetation are often more productive than other wetland types. The productivity of wetland ecosystems is strongly affected by changes in water table depth (WTD). However, these effects are complex and site-specific because they arise from numerous interactions among physical and biological processes that control carbon and nutrient transformations in soils.

Wetland primary productivity depends upon the type of wetland and the vegetation found there as well as on hydrology, climate and environmental variables such as soil type and nutrient availability. Wetlands that receive nutrients either naturally from flooding or from farm rum off tend to be more productive than those that receive nutrients only from rainwater, such as scrub cypress swamps or raised bogs. The total rate of solar energy conversion into carbohydrates (total photosynthesis) is gross primary productivity. However, a portion of gross primary productivity must be expended by the plant through the metabolic processes that are necessary for maintenance, growth and reproduction, and is lost as heat through respiration. The net rate at which energy is stored as plant biomass is net primary productivity. The energy stored in net primary production (NPP) becomes available to heterotrophs. Primary productivity, turnover, and standing crop biomass are governed by a number of factors that differ among successional stages and between terrestrial and aquatic ecosystems. Photosynthetic rates and NPP are sensitive to environmental conditions. Photosynthetic rate and NPP increase with precipitation up to a point, after which they decline, due to low light associated with cloudiness and reduced nutrient availability associated with saturated soils .

Primary productivity is an assessment of the amount of carbon fixed in unit time which has been converted into organic matter through the process of photosynthesis (Russel, 1954). Net production is the amount of organic substances remaining in plant bodies after respiratory loss (Ryther, 1956). Total assimilation or gross primary productivity (GPP) is the total rate of photosynthesis including the organic matter used in respiration during the measurement period. The variation trend of primary production is of great interest in tropical biotypes as it provides information about the amount of energy available to support the bioactivity of the system (Ohle, 1956).

The present study has been made to evaluate the phytoplankton productivity and P/R ratio of the Kabar wetland. The data were collected during two years of investigations (2011-2013). Several investigators have studied the primary production of ponds, lakes, reservoirs and rivers (Singh and Sinha, 1994; Suresh and Mathew, 1999; Mandal, 2002; Kumar and Choudhary, 2007; Sinha and Choudhary, 2019).

Study area

Kabar wetland is situated about 22 km North-west from the district headquarter of Begusarai town. It is situated at a latitude of 25^0 35'N and a longitude of 86^0 10' E. The boundaries of Kabar wetland close the entire wetland from North (Garhpura, Parora, Narainpur road), South (Sripur-Manjhoul road) and West (Narainpur - Sripur road). The ecological areas of the Kabar are estimated on the extent of water spread over areas. Total area of Kabar and adjacent lakes are 91.66 km². According to the data available from the Landsat imageries, the decadal changes (1999 – 2009) show that the total surrounding area submerged under water remarkably decreased from 34.16 km² to 26.73 km² and land area increased from 57.50 km² to 64.93 km² (http://glovis.usgs.gov).

The climate of Kabar wetland is typically tropical with extremes of low and high temperature in the winter and summer months respectively. The seasons are the same as in other parts of the state of Bihar. The Wetland supports a rich and diverse aquatic flora such as *Potamogeton nodosus, Hydrilla verticillata, Nymphaea stellata, Nelumbo nucifera, Polygonum barbatum* etc.

MATERIALS AND METHODS

For estimating the rate of primary production 'light and dark bottle' method was employed as suggested by Gaarder and Gran (1927). After the incubation period, dissolved oxygen in both light and dark bottles was measured by modified Winkler's method (Ellis et al, 1948).

Result and Discussion

Gross Primary Productivity (GPP)

Gross Primary Productivity is the rate of photosynthesis, and includes the organic matter used up in the respiration during the measurement period. Gross primary production value ranged from 0.562 g C/l/d to 4.05 g C/l/d. Maximum gross production was recorded in summer (4.05 g C/l/d). However, minimum amount of GPP was recorded in monsoon (0.562 g C/l/d). It showed that light intensity and temperature appeared to have a direct impact on gross production. Low value of GPP in monsoon is due to addition of rain water. The observations on gross production in the present study are similar to findings of Bilgrami *et al.* (1979), Singh (1981), Kumar and Singh (2006) and Sinha (2009).

GPP showed positive correlation with community respiration (r = 0.968) which was significant at 1% level.

Net Primary Production (NPP)

Net Primary Production is the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by the producers during the period of measurement. The seasonal value of Net production varied from 0.337 g C/l/d to 1.35 g C/l/d. Net primary productivity values were lower during monsoon (0.337 g C/l/d) and maximum during summer. The net primary productivity was possibly governed by some environmental factors such as light, DO, composition and density of phytoplankton. Lower value of net production during rainy season was possibly due to increase in water level and dilution of nutrient concentration. No significant correlation could be established between NPP and other productivity variables. NPP showed positive correlation with ambient and water temperature, and Cyanophycean density at 5% significant level.

Net and Gross Primary Production ratio (NPP/GPP)

The ratio of net and gross primary production ranged from 0.153 to 0.66. It was found that minimum ratio was recorded during winter (0.153), Lower values of net and gross productivity ratio resulting in enhanced respiratory value in the present study, probably was due to organic matter supplied to the system during monsoon. Higher value of net and gross production ratio was recorded during monsoon (0.66). Kumar (2008) found the similar findings of net and gross production ratio in the range of 0.09 to 0.85 and Sinha (2009) in the range of 0.38 to 0.77.

Community Respiration (CR)

In the present study, community respiration values fluctuated from 0.225 to 3.375 g C/l/d. Community respiration concept covers the process of oxygen consumption during the mineralization of non-living organic matter and during the metabolic process of

plants and animals. Higher values were obtained during summer (3.375 g C/l/d) whereas, lower values during rainy season (0.225 g C/l/d). Abundance of phytoplankton in summer season was probably responsible for high value of community respiration. The result was similar to those of Saha and Pandit (1986) and Jaiswal (2006). The range of community respiration has been earlier reported as 0.09 to 1.08 mgC/l/d by Saha and Pandit (1986), 0.02 to 0.81 mg C/l/d and 0.42 -0.75 mgC/m^2/d by Jaiswal (2006).

Community respiration showed negative correlation with Chlorophycean density (r = -0.938) which was significant at 5% level.

Photosynthesis and Respiration ratio (P/R ratio)

The range of P/R ratio is an excellent functional index of unpolluted (P/R> 1) and polluted (P/R <1) condition of aquatic system. The P/R ratio was found to vary between 0.181 to 1.98. Maximum average value of P/R ratio was observed during monsoon (1.98), while minimum value during winter (0.181). The range of P/R ratio has been earlier reported to vary between 0.64 to 2.28, by Jaiswal (2006) and between 0.09 to 6.0 g C/l/d by Kumar (2008).

Respiration as percentage of Gross Production

It varied from 33.33% to 84.62% in the present investigation. Lower value was recorded during summer season, whereas higher average value of respiration as percent of gross production was recorded during winter. Higher value of respiration as percent of gross production was because of high microbial activities. Sinha (2009) recorded the value of respiration as percentage of gross production in the range of 22.26% to 61.84%. Kumar (2008) recorded its value in the range of 14.26 to 92.33%.

From the result of ANOVA analysis, the value of F.R. (3.173) is more than the critical value (3.055) at 5% significant level in the first year of investigation and the F.R. (7.617) is more than critical value (1.852) in the second year also. This suggests that the values of productivity and water variables for seasons are not equal.

In the present study, NPP showed positive correlation with temperature and GPP showed positive correlation with CR. Community respiration exhibits no significant correlation with water factors. From the NPP, GPP and CR values it may be suggested that wetland is progressing towards eutrophication. The physiographic, land use, flushing rates and high rate of light penetration also affect the productivity of wetland.

The range of P/R ratio is an excellent functional index of unpolluted (P/R > 1) and polluted (P/R < 1) condition of aquatic system. In the present study the P/R ratio indicate that the wetland is progressing towards eutrophication. It needs immediate remedial measures as the wetland is the source of livelihood for thousands of local people

Table 1: Seasonal variations in Phytoplankton productivity in Kabar Wetland (2011 – 2013)

Parameters	Gross Primary Productivity (G.P.P)	Net Primary Productivity (N.P.P)	N.P/G.P (P)	Community Respiration (C.R)	Respiration(R) as % of G.P	P/R ratio
Seasons (2011-12)						
Winter	2.925	0.45	0.153	2.475	84.62	0.181
Summer	3.60	1.35	0.375	2.25	62.5	0.60
Monsoon	0.562	0.337	0.599	0.225	40.03	1.496
Seasons (2012-13)						
Winter	1.35	0.45	0.33	0.90	66.67	0.496

Summer	4.05	0.675	0.167	3.375	83.33	0.20
Monsoon	0.675	0.45	0.66	0.225	33.33	1.98

Production and Respiration value Expressed in gC/l/d.

Table 2: Correlation between Physico-chemical characteristics of water, Density of Phytoplankton and Productivity of Kabar Wetland, Begusarai District, Bihar (2011 – 2013)

	G.P.P	N.P.P	C.R
G.P.P	1		
N.P.P	0.640	1	
C.R	0.968 **	0.430	1
Water depth(ft.)	-0.522	-0.284	-0.522
Ambient Temp.(˚C)	0.382	0.919 *	0.152
Water Temp. (˚C)	0.416	0.829 *	0.221
Turbidity (NTU)	0.374	-0.042	0.454
TDS	0.599	0.440	0.562
TSS	-0.678	-0.871 *	-0.516
Conductivity	0.570	0.452	0.524
pH	-0.071	0.554	-0.263
DO	-0.626	-0.182	-0.677
TH	-0.192	0.595	-0.417
Cl-	0.236	0.351	0.164
NO3 – N	0.439	0.863 *	0.237
PO4 – P	0.551	-0.285	0.739
COD	0.398	-0.070	0.491
BOD	-0.068	-0.442	0.061
Cyanophyceae	0.256	0.887 *	0.014
Chlorophyceae	-0.935	-0.498	-0.938 *
Bacillariophyceae	-0.117	0.679	-0.356
Euglenophyceae	-0.752	-0.564	-0.702

(*) significant at 5%, (**) significant at 1%

Table 3: One way analysis of variance (ANOVA) for different physico-chemical parameters of water and productivity of Kabar Wetland (2011-12)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1548944	19	81523.39	13.64253	5.89E-12	1.852892
Within Groups	239027.1	40	5975.677			
Total	1787971	59				

*Significant at 5% level

Table 4: One way analysis of variance (ANOVA) for different physico-chemical parameters of water and productivity of Kabar Wetland (2012-13)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2188183	19	115167.5	7.617397	4.08E-08	1.852892
Within Groups	604760.5	40	15119.01			
Total	2792943	59				

*Significant at 5% level

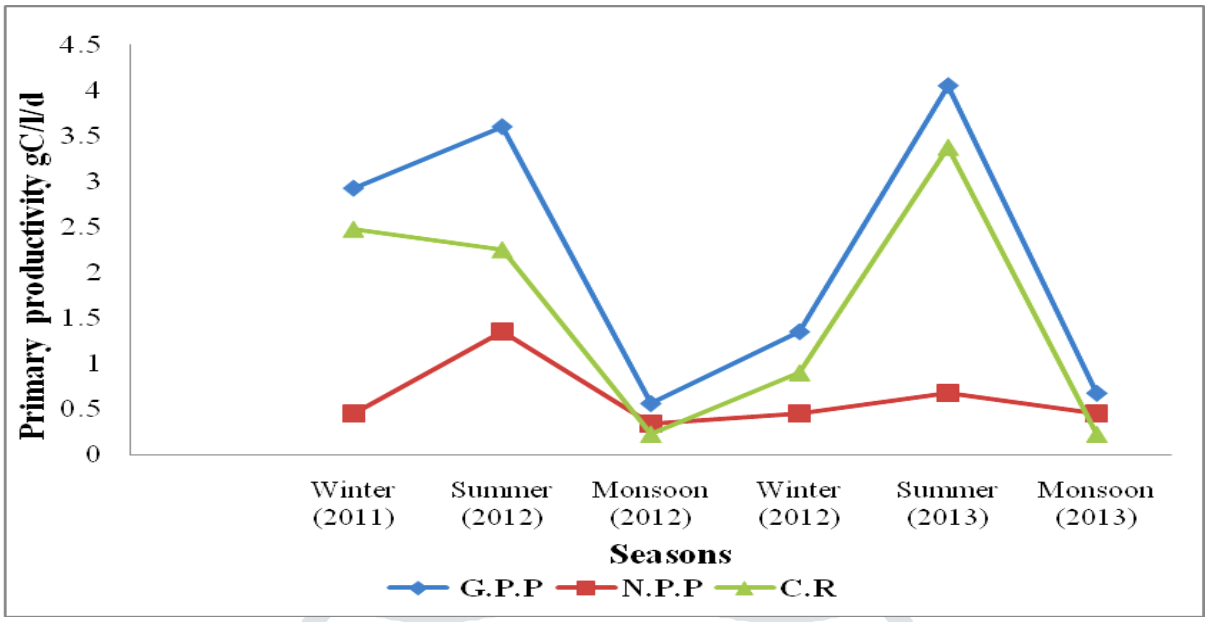

Fig 1: Primary Productivity of Phytoplankton of Kabar Wetland (2011- 2013)

Acknowledgement

The authors are thankful to DST, Govt. of India for awarding INSPIRE Fellowship to the first author and providing financial support. We also thank to the Head, University Department of Botany for providing Laboratory and Library facilities.

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