STUDIES ON SEASONAL VARIATIONS IN PRIMARY PRODUCTION OF MAIN CHANNEL AND SIDE CHANNEL OF RIVER GANGA AT BHAGALPUR

Annie Sinha[1] and Sunil Kumar Choudhary[2]
Research Scholar[1] and Professor[2] & Head of University Department of Botany
Environmental Biology Research Laboratory
University Department of Botany,,
Tilkamanjhi Bhagalpur University, Bhagalpur 812007, Bihar India

Abstract

The phytoplankton constitute a major segment of the primary producers and thus the phytoplankton primary production in the fresh water ecosystems acquire immense importance. The photosynthetic fixation of carbon dioxide and its quantitative measurements is considered a vital index of the productive potential of any aquatic system represented by the weight of organic matters. Present study represents the seasonal variations in productivity of main channel and side channel of River Ganga at Bhagalpur. The light and dark bottle method (Gaarder and Gran, 1927) was used to measure primary production. Gross Primary Production (GPP), Net Primary Production (NPP), Community respiration, respiration as percent and P/R ratio were studied at four sampling sites during pre-monsoon and post-monsoon seasons of 2015 and 2016. Maximum and minimum value of GPP was recorded during pre-monsoon and post-monsoon season at site II. The site wise analysis of NPP indicated maximum (4.05 g C/m^3/d) productivity in the pre-monsoon and minimum (0.08 g C/m^3/d) in post-monsoon season at side-channel i.e., Khirni Ghat. A maximum (2.25 g C/m^3/d) value of community respiration was observed at Hanuman Ghat (side channel) during post-monsoon (2015) and pre-monsoon (2016) and a minimum (0.27 g C/m^3/d) value during pre- and post-monsoon season at mixing zone. Maximum (0.83) value of P/R ratio was observed during post-monsoon and minimum (0.002) during pre-monsoon season. Overall on the basis of observation it may be concluded that whole stretch of the sampling sites are eutrophic in nature.

Keywords- River Ganga, Main and Side channels, Gross primary productivity (GPP), Net primary productivity (NPP)

Introduction

Large river systems constitute the lifeline for the future of human populations. Rivers are complex ecosystems that can be seen as an interaction between five main components: physical habitat, flow regime, the energy or food base of the system, biological interactions and water quality.

The flow of energy and the fixation of sunlight of any ecosystem depend on autotrophic organisms. Phytoplankton is vital and important organisms which act as producer to the primary food supply in any aquatic ecosystem. The direct and indirect alterations in physicochemical parameters of water affect the survival of primary producer and growth of planktons (Gang *et al*., 2006). The physico-chemical parameters are the major factors that control the dynamics and structure of the phytoplankton of aquatic ecosystem (Hulyal and Kaliwal, 2009). Phytoplankton, mainly represented by algae, are the initial biological components from which the energy is transferred to higher organisms through food chain (Tiwari and Chauhan, 2006; Saifullah *et al*., 2014).The primary and secondary productivity of a fresh water ecosystem depends on its surroundings, season and also depend on an array of biotic and abiotic factors. Primary production supports not only higher trophic levels as a food source but also provide physical habitat in the form of aquatic macrophytes and riparian vegetation. In the present study, an attempt has been made to evaluate the phytoplankton productivity to examine the biological status of the main-channel and side channel of the river, and that is essential to predict fish production potential. The study may be helpful in formulating fishery management policies.

Study Area

The river stretch near Bhagalpur city is the part of the Lower Ganga and is characterized by high fluvial volume, meanders, alluvial islands and sandbars. For the present study four sampling sites were selected for the assessment of productivity of River Ganga at Bhagalpur and those included (i) Site I - Main Channel - north of Barari Bridge Ghat (25°17'25.8"N 87°01'18.2"E), (ii) Site II - Mixing zone ((where Jamania channel – an offshoot of River Chanan - meets the mainstream of River Ganga) in between Cremation Ghat and Vikramshila bridge (25°16'27.4"N 87°01'40.8"E), (iii) Site III in Jamania channel (side-channel) near Hanuman Ghat about 8.9 Km downstream of Barari bridge Ghat (25°16'250"N 87°00'754"E and (iv) Site IV: side – channel i.e. part of Jamania channel ((25°15'850"N 86°59'692"E). near Khirni Ghat 8.4 km downstream of Barari Bridge Ghat. The study was conducted in pre- and post-monsoon periods of 2015 and 2016.

Material and methods

The present investigation on seasonal variations in primary productivity of main and side channels of River Ganga at Bhagalpur was conducted at four sampling sites during 2015-2016. For estimating the rate of phytoplankton primary production "light and dark bottle" method was employed as suggested by Gaarder and Gran (1927) with the incubation period of 4 hours. After the incubation period, dissolved oxygen in both light and dark bottles was measured on the spot following modified Winkler's method (Ellis *et al*., 1948).

RESULTS AND DISCUSSION

Seasonal variations of phytoplankton primary productivity i.e., GPP, NPP, Community respiration, respiration and P/R ratio of four sites are depicted in Tables 1 and 2.

Gross Primary Productivity (GPP)

The value of gross primary productivity was ranged from 2.16-4.05, 1.35-2.25, 3.6-4.95, 2.24-5.4 g $C/m^3/d$ at Main channel, mixing zone, Hanuman Ghat and Khirni Ghat respectively. Maximum (5.4 g $C/m^3/d$) and minimum (1.35 g $C/m^3/d$) value of GPP was recorded during pre-monsoon season and post-monsoon season at site IV and site II respectively. Highest value of GPP may be due to intensive sunlight with high temperature and phytoplankton diversity in pre-monsoon season. The results were also supported by Sontakke and Mokashe, 2014. Lower GPP may be attributed to addition of rains and flood water coming through catchment area and a lot of organic matter which makes the water more turbid in post-monsoon season. It has been attributed to the light inhibition due to turbidity and cloudy days and water current (Madhupratap *et al*., 2001).

Net Primary Productivity (NPP)

The seasonal values of net primary production was ranged from 1.6-2.7, 0.45-1.89, 0.9-3.6, 0.08-4.05 g $C/m^3/d$ at Main channel (site I), Mixing zone (site II), Hanuman Ghat (site III), Khirni Ghat (site IV) g $C/m^3/d$ respectively. The site wise analysis of NPP indicated that maximum (4.05 g $C/m^3/d$) productivity in the pre-monsoon season and minimum (0.08 g $C/m^3/d$) in post-monsoon season at side-channel i.e., Khirni Ghat respectively. Present data is accordance to the range (0.02 to 7.8 g $C/m^3/d$) of Gopal and Sharma, 1978. Higher value of NPP in pre-monsoon season might be due to higher density of phytoplankton in side-channel in comparison to other sites and accumulation of organic matter from decomposed from macrophytic vegetation.

NPP and GPP Ratio

Qasim *et al.,* (1969) suggested that the decomposing organic matter demand more oxygen resulting in enhanced respiratory values which in turn gives rise to low NPP and GPP ratio. The ratio of net and gross primary production ranged from 0.43-0.77, 0.2-0.87, 0.28-0.43, 0.4-0.75 at site I (Main channel), site II (Mixing zone), site III (Hanuman Ghat), and site IV (Khirni Ghat) respectively. The ratio of net and gross primary production is essential for the evaluation of the amount of gross production available to the consumers (Singh and Singh, 1999).

Community Respiration

Community respiration was observed in the range of 0.54-2.02, 0.81-2.27, 1.35-2.25 and 1.35 g $C/m^3/d$ at site I, site II, site III and site IV respectively. A maximum (2.25 g $C/m^3/d$) value was during post-monsoon (2015) and pre-monsoon (2016) at Hanuman Ghat and a minimum (0.27g $C/m^3/d$) value during pre and post-monsoon season at mixing zone in the same year of the study.

Decreased rate of CR indicates that CO_2 fixation was quite low and rate of respiration was quite high which could create oxygen deficient condition in river water (Pandey *et al*., 2014).

Respiration as percent

Respiration as percent of GPP was fluctuated in between 22.22-54.55, 12.5-150, 27.27-71.42, 37.78-60.08 percent at site I, site II, site III, site IV respectively. According to Ketchen *et al.,* 1958 for a healthy aquatic ecosystem, respiration should be 5-10% of GPP. Higher (150 %) and lower (12.5 %) values were also recorded in post-monsoon season (2016) and pre-monsoon season (2015) at mixing zone respectively. The reason behind maximum value at mixing zone unit that it receives drainage from side channels. Higher range was almost very similar to finding of Mandal *et al.*, 2010.

P/R ratio

In the present investigation, the ratio of P/R ratio varied from 0.008-0.03, 0.002-0.83, 0.002-0.83, 0.003-0.02, 0.006-0.03 at Main channel, Mixing zone, Hanuman Ghat and Khirni Ghat respectively. Maximum (0.83) value of P/R ratio was observed during post-monsoon and minimum (0.002) during pre-monsoon season. According to Odum (1956) the natural ecosystems usually approach P/R ratio of 1, autotrophic (P/R>1) or heterotrophic (P/R<1). In the present observation the ratio indicated less than 1 i.e., all the four sites of river may be classified as heterotrophic in nature.

GPP established a positive correlation with water temperature and NPP significant at 0.01% and 0.001% level at mixing zone (site II) and Hanuman ghat (site III) respectively. GPP possessed a positive significant value of different variables like water temperature, TDS and NPP at 0.05%, 0.01%, 0.001% level at side channel (Khirni ghat i.e., site IV) respectively. NPP also showed a significant positive correlation with water temperature and TDS at 0.05% and 0.01% level at site IV respectively.

Conclusion

The results obtained in the present study suggest that the side channels are more productive than the main channel of the river. The higher primary productivity (5.4 g C/m^3/d) value was found in the side channel as compared to the main channel (2.16 g C/m^3/d) of the river. This indicates that the phytoplanktonic activity is higher in side channel of the river. It may be due to shallowness of channel and extent of macrophytic growth. As per the classification of water bodies based on gross primary production values given by Vollenwieder (1974) (GPP: 0.065 - 0.3 g C/m^3/day - oligotrophic GPP: 0.25 - 1.0 g C/m^3/day - mesotrophic and GPP: 1.0 - 8.0 g C/m^3/day - eutrophic), the present data on GPP suggest the eutrophic nature of river water at all the sampling sites.

Table 1. Seasonal Primary productivity (g C/m^3/d) of River Ganga at different sites near Bhagalpur (2015)

Sites	Seasons	GPP	NPP	NPP/GPP(P)	CR	R as % of GPP	P/R Ratio
Site I	Pre-monsoon	4.05	2.7	0.66	1.35	33.33	0.01
	Post-monsoon	2.43	1.89	0.77	0.54	22.22	0.03
Site II	Pre-monsoon	2.16	1.89	0.87	0.27	12.5	0.07
	Post-monsoon	1.62	1.35	0.83	0.27	16.66	0.83
Site III	Pre-monsoon	3.13	1.35	0.43	1.78	56.89	0.007
	Post-monsoon	3.15	0.9	0.28	2.25	71.42	0.003
Site IV	Pre-monsoon	3.57	2.22	0.62	1.35	37.78	0.01
	Post-monsoon	2.25	0.9	0.4	1.35	60	0.006

Table: 2 Seasonal Primary productivity of River Ganga at different sites in g C/m^3/d (2016)

Sites	Seasons	GPP	NPP	NPP/GPP(P)	CR	R as % of GPP	P/R Ratio
Site I	Pre-monsoon	2.16	1.62	0.75	0.54	25	0.03
	Post-monsoon	3.71	1.6	0.43	2.02	54.55	0.008
Site II	Pre-monsoon	2.25	0.45	0.2	1.8	80	0.002
	Post-monsoon	1.35	0.54	2.5	0.81	150	0.016
Site III	Pre-monsoon	3.6	1.35	0.37	2.25	62.5	0.006
	Post-monsoon	4.95	3.6	0.7	1.35	27.27	0.02
Site IV	Pre-monsoon	5.4	4.05	0.75	1.35	25	0.03
	Post-monsoon	2.24	0.08	0.35	1.35	60.08	0.006

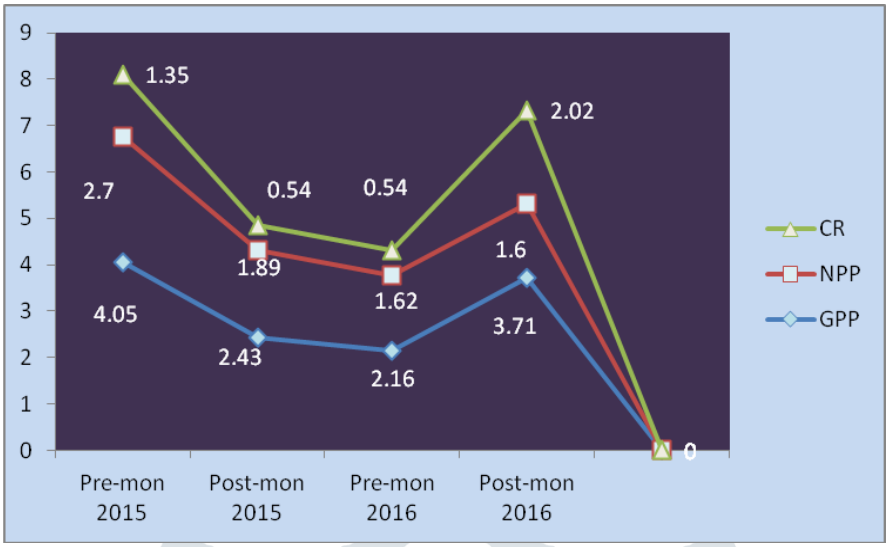

Figure: 1 Primary Productivity of Phytoplankton in different seasons in Main channel

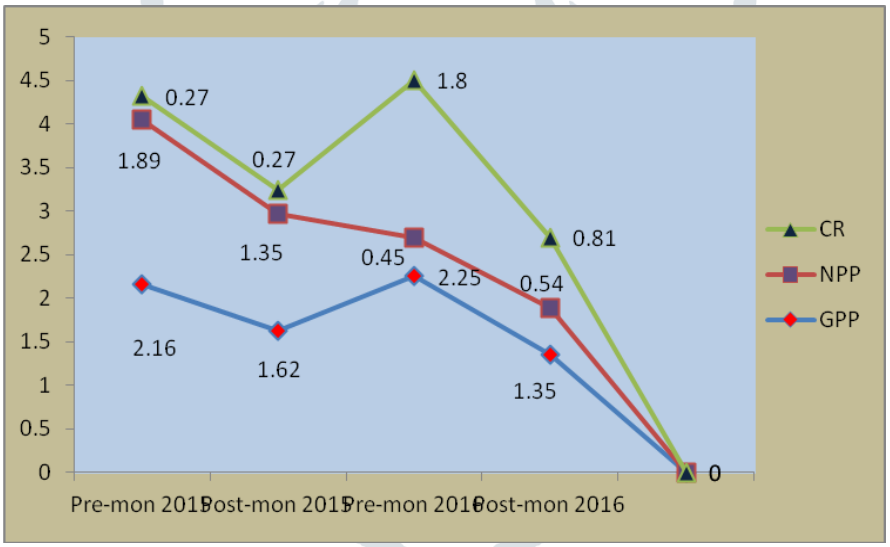

Figure: 2 Primary Productivity of Phytoplankton of different seasons at mixing zone.

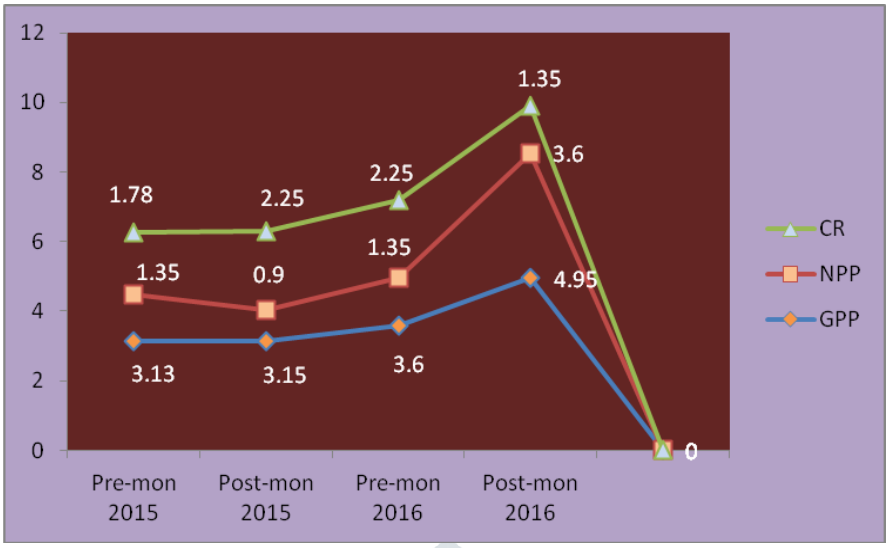

Figure: 3 Primary Productivity of Phytoplankton of different seasons at Hanuman ghat

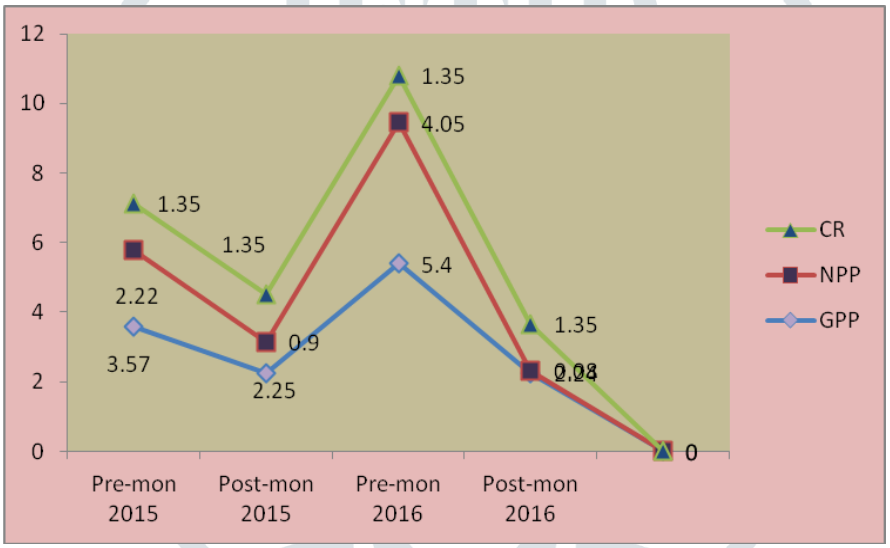

Figure: 4 Primary Productivity of Phytoplankton of different seasons at Khirni ghat

Acknowledgements

The authors would like to thank Head, University Department of Botany, T.M. Bhagalpur University for providing necessary laboratory facilities. The authors also thank to Dr. Braj Nandan Kumar, Post Doctoral Research fellow for help in laboratory.

References

[1] Ellis, M. N., Westfall, B. A. and M. D. 1948. Determination of water quality. Fish and wildlife service, U.S. Dept Interior. Res. Rept. 9: 122.
[2] Gaarder, T. and Gran, H. H. 1927. Investigation of the production of plankton in the Oslofjord. Rapp. et. Proc. Verb. Con. Int. Explor. Mer., 42 : 1-48.
[3] Gang R. K, Saksena DN, Rao R. J. 2006. Assessment of physico-chemical water quality of Harsi Reservoir. District Gwalior, Madhya Pradesh J. Ecophys. Occup. Health. 6:33-40.
[4] Hulyal, S. B., Kaliwal, B. B., 2009. Dynamics of phytoplankton in relation to physico-chemical factors of Almatti reservoir of Bijapur district, Karnataka State. Environ. Monit. Assess. 153, 45–59.
[5] Ketchen, B. H., Ryther, J. H., Yentsch, C. S. and Corwin, N. 1958. Productivity in relation to nutrients. Rapp. P.V. Renu. Cons. Per. Int. Explor. Mer., 144 : 132-140.
[6] Madhupratap, M., Gopalakrishnan, T. C., Haridas, P., Nair, K. K. C. 2001. Mesozooplankton biomass, composition and distribution in the Arabian Sea during fall intermonsoon: implications of oxygen gradients. Deep-Sea Research II 48, 1345-1368.
[7] Mandal, P., Upadhyay, R., Hasan, A. (2010). Seasonal and spatial variation of Yamuna River water quality in Delhi, India. Environ. Monit. Assess.170(1), 661: 670.
[8] Odum, H. T. "Primary production in flowing water." Limnol Oceanogr 1 .1956. 102-117. Print.
[9] Pandey, Ruby, Raghuvanshi, D., Shukla, D. N. (2014). Water quality of river Ganga along Ghats in Allahabad City, U. P. India. Adv. Appl. Sci. Res. 5(4), 181-186.
[10] Qasim, S. Z. S. Wellershaus, P. M. A. Battathiri and Abidi, S. A. H. 1969. Organic production in a tropical estuary. Proc. Indian Acad. Sci., 69 B (2): 51-94
[11] Saifullah, A. S. M., Hena, M. K. A., Idris, M. H., Halimah, A. R., Johan, I., 2014. Diversity of phytoplankton from mangrove Estuaries of Sarawak, Malaysia. World Appl. Sci. J. 31, 915–924.
[12] Singh, A. K., and Singh, D. K. 1999. "A comparative study of the phytoplanktonic primary production of river Ganga and pond of Patna (Bihar)." India J Env Biol 20: 263 – 270.
[13] Sontakke, G. K. and Mokashe, S. S. 2014. Seasonal variation of primary productivity of two freshwater lakes of Aurangabad district, Maharashtra, India. International journal of Fauna and Biological studies, 1(6): 07-10
[14] Tiwari, A., Chauhan, S.V.S., 2006. Seasonal phytoplanktonic diversity of Kitham Lake, Agra. J. Environ. Biol. 27, 35–38.
[15] Vollenweider, R. A. 1974. A Manual on Methods for Measuring Productivity in Aquatic Environment I.B.P, Hand Book, 12, Blackwells Oxford.