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# EVALUATION OF PRODUTIVITY OF RIVER GANGA NEAR BARAUNI(BIHAR).

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**Abstract:**

In the present investigation, an attempt was made to assess the productivity of river Ganga near Barauni. Water sample collected from four different sites in every month were analysed for productivity over a period of two consecutive year and average mean value were computed to know the overall productivity of river water.The study showed variation in GPP (0.30 -- 0.44 gc/$m^3$/hr), NPP (0.16--0.29gc/$m^3$/hr),CR(0.14--0.15gc/$m^3$/hr),NPP/GPP(0.51-0.66),%ofGPP(.46.55—33.89),and NPP/CR(1.84—2.50).

(**Keywords**: Productivity, GPP, NPP, CR,)

## Introduction

The productivity of an ecosystem refers to the rate of production i.e. the amount of organic matter accumulated in any unit time. The ultimate outcome of photosynthesis i.e. primary productivity forms the basis of ecosystem function since it makes the chemical energy and organic matter available to consuming organisms. Gross productivity in an ecosystem reflects the rate of transmission of radiant energy to chemical energy while net productivity is determined by the rate of community respiration (CR). In the present study, the productivity of river system has been studied with reference to specific group of biomass – the phytoplankton. Since the plankton population vary greatly in size and distribution, their production can not be calculated alone by counting them, most reliable method of its determination is either through dry weight or through measuring its metabolic activities or through ascertaining the metabolic products. Since the photosynthesis is an inherent quality of entire phytoplankton, the change in $O_2$ and $Co_2$ concentration can be taken as reliable parameter for assessing their production and hence it was adopted. Productivity is also considered as a reliable index of pollution assessment (Wetzel and Linkens 1979, Christi et al. 2011). It is the back-bone of all food chains and food webs and generates 70% of world atmospheric oxygen (Reynold 1984). The photosynthetic production by primary transducer can be expressed as Gross primary productivity (G.P.P) or Net primary productivity (N.P.P). The difference between the two basically is that during photosynthesis, algae synthesize organic matter, a part of which is simultaneously used up for this work. G.P.P can't be determined. Since productivity is the result of multiple physico-chemical and biological factors (indices of phytoplankton community structure), it would be possible to evaluate it by studying the metabolism of river water. This has been also proved important and most reliable parameter for depicting trophic status of water body in question. Several workers (Krishnamoorthy and Vishwanathan (1960), Manzel and Ryther (1961), Sreenivasan (1963), Goldman and Wetzel (1963), Sreenivasan (1964, 1965, 1970), Ganapati and Sreenivasan (1970), Patralekh (1971), Vijayraghwan (1971), Khan and Siddiqui (1971), Hickman (1973), Nasar (1975), Nasar and Munsi (1975), Bilgrami et al. (1979), Hosmani and Bharati (1980),

Karan and Joh (1980), Singh and Swarup (1981), Dutta and Chaudhary (1984), Gopalkrishna (1985), Saha et al. (1985), Pradeep and Gupta (1986), Yadav et al. (1987), Valecha and Bhatnagar (1989), Saha and Pandit (1990), Patralekh (1990), Singh and Singh (1996), Khan et al. (1998), Singh and Singh (1999), Mishra and Tripathy (2000), Yeragi and Shaik (2003), Supriya Das (2012) etc have studied the productivity of different ponds, lakes, rivers and reservoir and depicted the pollution status of water bodies. In the present investigation, productivity of river water was estimated at regular monthly intervals for two consecutive years.

## Materials and Methods:

The river Ganga flowing near Barauni (Bihar) was selected for the present study. Within a stretch of 10 kms. 2 different spots were selected. From each spot, water from upstream and downstream side were collected in plastic Jug. All the water were mixed thoroughly and were taken to the laboratory. .Primary productivity was calculated through light and dark bottle methods as discussed by Gaarder and Gran (1927).

### Results and discussion

The NPP and GPP of both sites of river water was determined and result has been presented in Table I and II respectively

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### Net Primary Productivity

The net primary productivity of river water system varied significantly during the course of investigation. The annual mean average value was ascertained as 0.16 ± 0.033 gc / $m^3$/ hr at site- I and 0.29 ± 0.028 gc/$m^3$/hr at site- II. At site- I its value varied from 0.06 gc/$m^3$/hr (March) to 0.24 gc/$m^3$/hr (December – January) and at site- II it varied from 0.15 gc/$m^3$/hr (October) to 0.38 gc/$m^3$/hr (May and July) as evident in Table- 5.1 and 5.2. Annual trend of variations at site- I showed its minimum value in March (0.06 gmc/$m^3$/hr) which showed an increasing trend upto June (0.22 gc/$m^3$/hr) after which its value decreased upto August. A slightly increased value was noticed during September which again decreased in October and thereafter increased. Two peaks were observed, primary in January and secondary in June. Similarly at site- II, the NPP showed an increasing trend from January (0.26 gc/$m^3$/hr) to May (0.38 gc/$m^3$/hr) which decreased slightly in June and again increased in July (0.38 gc/$m^3$/hr). From July it exhibited a decreasing trend up to October and then increased again. Here two distinct peaks were not observed.

### Gross primary productivity

The average of annual mean value of GPP was ascertained as 0.30 ± .031 gc/$m^3$/hr at site- I and 0.44 ± 0.03 gc/$m^3$/hr at site- II (Table- 5.1 and 5.2). At site- I, the minimum (0.12 gc/$m^3$/hr) was observed in the month of March and maximum (0.45 gc/$m^3$/hr) in January while at site- II, the minimum (0.12 gc/$m^3$/hr) was observed in September and maximum (0.58 gc/$m^3$/hr) in April. No significant annual trend of variations was observed at site- I but at site- II its value showed an increasing trend from January to April after which it exhibited a decreasing trend till September and thereafter it increased again. As a whole higher value of GPP was observed during summer and winter months and lower during monsoon and post monsoon months at site- I while at site- II, higher values were observed during summer months, lower during monsoon and post monsoon period and moderate during winter months.

### COMMUNITY RESPIRATION

The average of annual mean value of community respiration was computed as 0.14 ± 0.031 gc/$m^3$/hr at site- I and 0.15 ± 0.028 gc/$m^3$/hr at site- II (Table- 5.1 and 5.2). At site- I, the minimum (0.06 gc/$m^3$/hr) was observed during March and July and maximum (0.21 gc/$m^3$/hr) during January and May. At site- II, the minimum (0.04 gc/$m^3$/hr) was observed in August and maximum (0.24 gc/$m^3$/hr) in March. No generalized annual trend of variations was observed at both sites. Higher values of community respiration was observed during January, May and December, lower during March,

July and October and moderate during rest of months at site- I while at site- II, higher values were observed during March – April, lower during July to September and moderate during rest of Months.

**DISCUSSION**

N.P.P and G.P.P of river water was studied in every months of the year for two consecutive years. Much works have been done on this line in ponds / lakes / reservoirs / rivers in different parts of the country (Sreenivasan 1963, 64, 65, 70, Ganpati and Sreenivasan 1970, Khan and Siddiqui 1971, Vijayraghwan 1971, Nasar 1975, Nasar and Munshi 1975, Nasar and Nasar 1976 – 78, Munawar 1974, Hosmani and Bharati 1980, Dutta and Chaudhary 1984, Ayappam and Gupta 1985, Pradeep and Gupta 1986, Yadav et al. 1987, Valecha and Bhatnagar 1989, Saha and Pandit 1990, Patralekh 1990, Yeragi and Shaik 2003).

The average of annual mean value of NPP and GPP was ascertained as 0.16 ± 0.03 gc/$m^3$/hr and 0.30 ± 0.03 gc/$m^3$/hr at site- I and 0.29 ± 0.03 gc/$m^3$/hr and 0.44 ± 0.03 gc/$m^3$/hr at site- II. Some of the workers have studied the productivity of different rivers. According to report by CIFRI,Barrackpur, Kolkatta about the river Ganga, GPP varies between 20.8 – 202.5 mgc/$m^{-3}$/$hr^{-1}$ in upper stretch, 15.0 – 632.8 mgc/$m^{-3}$/$hr^{-1}$ in the middle stretch and 33.3 – 142.0 mgc/$m^{-3}$/$hr^{-1}$ in the lower stretch. Supriya Das (2012) found GPP varying from 0.075 ± 0.009 gmc/$m^{-3}$/$hr^{-1}$ to 0.938 ± 0.103 gmc/$m^{-3}$/$hr^{-1}$, NPP from 0.012 ± 0.001 to 0.832 ± 0.087 gmc/$m^{-3}$/$hr^{-1}$ and C.R from 0.026 ± 0.002 to 0.496 ± 0.043 gmc/$m^{-3}$/$hr^{-1}$ with maximum and minimum values during summer and winter season in river Kharasrota in Orissa. Verma et al (2012) while studying the productivity of river Pandu at Kanpur found NPP varied from 0.028 – 0.564 mgc/ l / day, GPP ranged from 0.015 – 0.844 mgc/ l / day. Rajyalaxmi and Premswarup (2012) while studying the productivity of river Godavari found GPP varying from 240 – 1058 mgc/$m^3$/hr /day, NPP from 113 – 660 gmc/$m^{-3}$/12hr/day at station I, II and III. Bishnoi et al. (2013) found GPP varying from 0.075 – 0.175 gmc/$m^3$/hr , NPP from 0.05 – 0.125 gc/$m^3$/hr and C.R from 0.025 – 0.062 gc/$m^3$/hr at four station of Gang canal in Rajasthan and stated that primary productivity of river system is influenced by velocity of water flow and its variations in different portion of the river system. It is well known that the rate and extent of organic production in a water body are normally controlled by several factors and it is collective action of all these that results in primary production.

The annual cycle of the productivity in the river water was observed on bimodal pattern as reported earlier in a clear lake at California (Goldman and Wetzel; 1996), in Okhakadai pond of south India (Vijayraghwan; 1971), in sewage fed ponds at Bhagalpur (Nasar and Munshi; 1975, Nasar and Nasar; 1978). Bimodal fluctuation in the primary productivity is the characteristics of fresh water bodies. As regards the maxima and minima, there has been variable reports on it. Bishnoi et al. (2013) observed the maximum production in February at station I and II and in April at station III and IV in Gang Canal, Rajasthan. Rajyalaxmi and Premswarup (2012) observed two peaks of GPP, one in winter months (November and December) and other in June in river Godavari. Supriya Das (2012) also observed maximum and minimum value of productivity during summer and winter months in river Kharasrota in Orissa. Verma et al. (2012) found maximum value of GPP in the month of April and minimum during September. In the present investigation maximum value of productivity was observed in summer and winter months at site- I and in summer at site- II, which is in accordance with the observations of previous workers. Several other workers also found higher values during summer months (Supriya Das; 2012, Verma et al.; 2012). Sreenivasan (1964), Vijayraghwan (1971), Hickman (1973), Nasar and Munshi (1975), Nasar and Nasar (1978), Ayappan and Gupta (1985) are of the opinion that the recorded variations in the months of maxima of productivity may be assumed due to variations in physico-chemical and biological factors of the water. The climatic as well as the seasonal variations may also be considered as the possible cause of the aforesaid variations (Krishnamurthy and Vishwanathan; 1960, and Kumaron and Rao; 1975). The seasonal variations in the peak of primary productivity have also been attributed the season and specific dominance of different groups of algae (Pradeep and Gupta; 1986). Lowest values of GPP were found during the month of March at site- I and during September at site- II. Verma et al. (2012) is of the opinion that several physico-chemical factors exerts a negative pressure on the growth development and population of primary producers.

The magnitude of annual fluctuation in the primary productivity is supposed to be direct reflection of the seasonal impact. More the effect of seasonal variations more will be fluctuation in the primary productivity. In the present investigation, the productivity was observed lowest during March (0.12 gc/$m^3$/hr) and increased about 3.7 times during January (0.45 gc/$m^3$/$hr^1$) at site- I and at site- II, it increased about 2.4 times form lowest (0.24 gc/$m^3$/hr) in September to maximum (0.58 gc/$m^3$/hr) in April. Vijayraghwan (1971) reported the ratio of maximum /minimum as 10 times in Othakadai pond, 4 times in Teppakulum tank, 5 times in Yanamulai pond of south India. Nasar (1975) recorded the aforesaid ratio as only 3 times in Bharawa as well as in T.N.B college pond, Bhagalpur. Supriya Das (2012) found this ratio as 12 times in Kharasrota river in Orissa. According to report published by CIFRI, Barrackpur, Kolkatta on Ganga, this ratio was observed as about 10 times in upper stretch, 42 times in middle stretch and 4 times in lower stretch. Verma et al. (2012) found this ratio as 6 – 7 times in river Pandu at Kanpur. Several workers (Hulbert et al.; 1960, Menzel and Ryther; 1961, Prasad and Nair; 1963, Nasar and Munshi; 1975, and Nasar and Nasar; 1978) pointed out that in tropical fresh water, production is moderate throughout the year with little oscillation. Barauni (Bihar) which falls under tropical region, the river water showed little oscillation in productivity.

The net/gross ratio in the river water varied from 0.40 to 0.72 at site- I and 0.44 to 0.90 at site- II. Previous workers have reported variations as from 0.06 to 0.73 in a sewage fed pond (Nasar and Nasar; 1978), from 0.1 to 071 in river Pandu at Kanpur (Verma et al.; 2012), from 0.60 – 0.75 in a stretch of Gang canal, Rajasthan (Bishnoi et al.; 2013). Ketchem et al (1958) stated that net/gross ratio should approach to unity in healthy condition if the respiration is 5 to 10% of gross. If this ratio is zero, it may indicate physiological state of phytoplankton arising due to nutrients deficiency. In the present investigation this ratio is greater than zero but less than one hence it may be concluded that river water never exhibited nutrient deficiency. NPP/CR ratio in the present investigation varied from 0.8 – 2.66 at site- I and 0.58 – 3.8 at site- II. Yeragi and Shaik (2003) stated that NPP/CR ratio exceeding one is an indication of gross pollution. Taking this value into account it may be concluded that river water as whole is polluted.

As regard community respiration (CR) it showed minimum value (0.06) during March and July and maximum (0.21) during January and May at site- I, whereas the minimum (0.04) and maximum (0.24) was observed during August and March respectively at site- II. The annual trend of variations showed the bimodal pattern at both sites as reported earlier by Nasar and Nasar (1978) in sewage fed pond showing annual range of variations between 0.12 (February) – 2.66 (December) gc/$m^3$/day. The two maxima were recorded in June and December by Nasar and Nasar (vide infra) but in the present investigation it was recorded during January and May at site- I and during March and June at site- II. Valecha and Bhatnagar (1989) while studying the primary productivity of a eutropic lower lake at Bhopal found the maximum community respiration in April (5.65 gc/$m^3$/day) during 1980 and in March (6.3 gc/$m^3$/day) during 1981. Yadav et al (1987) detected the lowest community respiration as nil during August – December, February and highest as 0.71 gc/$m^3$/day. Ayappan and Gupta (1985) while studying the productivity of Ramasamudra tank found maximum community respiration (CR) in April (107.91 mgc/$m^3$/hr) at station-I, in February (110.20 mgc/$m^3$/hr) at station-II, in February (114.89 mgc/$m^3$/hr) at station-III and in June (258.38 mgc/$m^3$/hr) at station-IV. Verma et al. (2012) while studying the primary productivity of river Pandu at Kanpur found the minimum value of CR in September and maximum during March – May at station-I, in April at station-II, in February at station-III and in March at station-IV. From the above discussion it is clear that the maximum community respiration was found in different months by different workers.

Comparatively lower respiration rate in the present study suggest that destruction rate at both the sites is not so high. Amongst the two sites the destruction rate is slightly higher at site- II than site- I. As regard the respiration as percentage of gross productivity in the present investigation was found varying from 27.27 – 55.55% at site- I and from 10.0 – 55.88% at site- II. Annual range of such fluctuation was reported between 27.27 – 98.37% by Nasar and Nasar (1978), between 6.25 – 100% by Valecha and Bhatnagar (1989), between 3.2 – 66% by Singh (1992) and between 43.9 – 79.09% by Kumar (1998). The present observations are in conformity with the observations made by previous workers (Vide infra). Moderate value of respiration as percentage of GPP suggest that destruction rate in the river water are not so high as compared to productivity. However a substantial quantum of the synthesized organic matters is utilized during the respiratory

activities of phytoplankton leaving the net production at low level. The fluctuation in different months of the year in the present study suggests the influence of seasonal variations as well as physico-chemical factors of the water.

**TABLE- 1**

**Monthwise Variations in Phytoplankton Primary Productivity (gc/m$^3$/hr) of river water**

**(Site- I)**

| | GPP | NPP | CR | NPP/GPP | % of GPP | NPP/R |
|---|---|---|---|---|---|---|
| **Jan** | 0.45 | 0.24 | 0.21 | 0.53 | 46.66 | 1.14 |
| **Feb** | 0.30 | 0.15 | 0.15 | 0.50 | 50.1 | 1.0 |
| **Mar** | 0.12 | 0.06 | 0.06 | 0.50 | 50 | 1.0 |
| **Apr** | 0.18 | 0.08 | 0.10 | 0.44 | 55.55 | 0.8 |
| **May** | 0.40 | 0.19 | 0.21 | 0.47 | 52.5 | 0.9 |
| **Jun** | 0.40 | 0.22 | 0.18 | 0.55 | 45 | 1.22 |
| **Jul** | 0.22 | 0.16 | 0.06 | 0.72 | 27.27 | 2.66 |
| **Aug** | 0.30 | 0.12 | 0.18 | 0.40 | 60 | 0.66 |
| **Sep** | 0.36 | 0.18 | 0.18 | 0.50 | 50 | 1.0 |
| **Oct** | 0.16 | 0.08 | 0.08 | 0.50 | 50 | 1.0 |
| **Nov** | 0.38 | 0.16 | 0.12 | 0.42 | 31.57 | 1.33 |
| **Dec** | 0.40 | 0.24 | 0.16 | 0.60 | 40 | 1.5 |
| **M.V** | 0.30 | 0.16 | 0.14 | 0.51 | 46.55 | 1.84 |
| **S.E.±** | 0.031 | 0.033 | 0.031 | 0.024 | 2.734 | 0.149 |

**GPP:-** Gross Primary Productivity

**NPP:-** Net Primary Productivity

**CR:-** Community Respiration

**% of GPP:-** Percentage of Gross Primary Productivity

**NPP/R:-** Ratio of Net Primary Productivity with Respiration

**TABLE- 2**

**Monthwise Variations in Phytoplankton Primary Productivity (gc/m$^3$/hr) of river water**

**(Site- II)**

| | GPP | NPP | CR | NPP/GPP | % of GPP | NPP/R |
|---|---|---|---|---|---|---|
| **Jan** | 0.42 | 0.26 | 0.16 | 0.62 | 38.09 | 1.62 |
| **Feb** | 0.45 | 0.28 | 0.17 | 0.62 | 37.78 | 1.64 |
| **Mar** | 0.54 | 0.30 | 0.24 | 0.55 | 44.44 | 1.25 |
| **Apr** | 0.58 | 0.35 | 0.23 | 0.60 | 39.65 | 0.58 |
| **May** | 0.55 | 0.38 | 0.17 | 0.69 | 30.90 | 2.23 |
| **Jun** | 0.54 | 0.35 | 0.19 | 0.65 | 35.18 | 1.84 |
| **Jul** | 0.48 | 0.38 | 0.10 | 0.79 | 20.83 | 3.8 |
| **Aug** | 0.4 | 0.36 | 0.04 | 0.90 | 10.0 | 9 |
| **Sep** | 0.24 | 0.19 | 0.05 | 0.79 | 20.83 | 3.8 |
| **Oct** | 0.34 | 0.15 | 0.19 | 0.44 | 55.88 | 0.79 |
| **Nov** | 0.36 | 0.22 | 0.14 | 0.61 | 38.88 | 1.57 |
| **Dec** | 0.38 | 0.25 | 0.13 | 0.66 | 34.21 | 1.92 |
| **M.V** | 0.44 | 0.289 | 0.15 | 0.66 | 33.89 | 2.50 |
| **S.E.±** | 0.029 | 0.028 | 0.029 | 0.035 | 3.490 | 0.657 |

**GPP:-** Gross Primary Productivity

**NPP:-** Net Primary Productivity

**CR:-** Community Respiration

**% of GPP:-** Percentage of Gross Primary Productivity

**NPP/R:-** Ratio of Net Primary Productivity with Respiration

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