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Studies on seasonal variations in primary production of river Mahanadi, Banki, Odisha, India.

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Abstract: The primary productivity of the river Mahanadi at Banki has been estimated from January 2012 to December 2012 at three different stations. It varies from 0.69 ± 0.062 gC m^{-2} day^{-1} to 2.30±0.281 gC m^{-2} day^{-1} with mean annual production of 494.57 gC m^{-2} yr^{-1}. The seasonal variation of primary productivity revealed that maximum and minimum values of GPP was associated with summer and winter seasons respectively. The minimum values of NPP were recorded during rainy season and maximum during summer or winter for different study stations. The community respiration showed a systematic seasonal pattern where the maximum value was observed during summer and minimum value during winter. The ratio between NPP and GPP was lowest during rainy season and highest in summer.

Key words: Primary Productivity, River Mahanadi, Seasonally

Introduction

Measurement of primary productivity gives information regarding the photosynthetic production of organic matter in an area per unit time and the functional aspects of ecosystem (Odum 1971). It also refers to an assessment about the exact nature of the ecosystem, its trophic status and the availability of energy for secondary producers (Clarke, 1954). Therefore, the measurement of primary production in aquatic environment is of importance not only estimating productivity efficiency but also for aquaculture management. Primary productivity of a water body is its biological production. It plays an important role in an ecosystem as it makes the chemical energy and organic matters for the entire biological community.[3,4] Most of the organic matter of an aquatic ecosystem is produced within the water by phytoplankton. [2,5,6] When conditions are favourable, the organic matter is produced and the net primary productivity has a positive value, but under unfavourable conditions, the rate of net primary production may fall to zero or even become negative when respiratory losses exceed photosynthetic gains.[7] Photosynthesis is the fundamental process involved in primary production.[1] The chlorophyll bearing organisms utilize solar energy and convert it into chemical energy in the form of carbohydrate molecules by taking water and CO_2 from the environment.[8]

Materials and Methods

The primary productivity estimation depicts the relationship between oxygen evolution and carbon fixation. The light and dark bottle technique with the Winkler's titration method was employed in estimating primary productivity in the present study. Water sample were collected in three bottle of equal volume, in the middle of every month between 10.00 Am to 12.00 noon. The water sample in the first bottle was used for determining the initial level of dissolved oxygen content immediately following modified Winkler's volumetric method (APHA, 1988). The second bottle was painted black colour (dark bottle) to prevent light penetration and hence serve as control to measure respiration. The third bottle (light) was treated as test to measure the net primary production. The last two bottles were incubated under water in each euphotic zone for a period of three hours by suspending it in water. After the incubation period, dissolved oxygen content (DO_2) of each bottle was estimated. All O_2 values obtained in the present study were converted to Carbon values by multiplying with the factor 0.375 (Odum, 1956).[5] The hourly rate can be converted to daily rates by multiplying with duration of sunshine on that day. Oxygen values (mgl^{-1}) were converted to carbon values by applying the equation by Thomas *et al.,* (1980).[9]

$$\text{Primary productivity (gC)} = \frac{O_2(mg\ l^{-1})\ X\ 0.375}{PQ}$$

Where PQ = 1.25

PQ represent respiratory quotient = Respiration/ photosynthesis and a comprised value of 1.25 was used which represent metabolism of sugar, fat and proteins. The value 0.375 represent a constant to convert Oxygen value to Carbon value (Thomas *et al.,* 1980).[9] Productivity values were expressed as gC m^{-2} day^{-1}, assuming 9-hour photoperiod and were then converted to gC m^{-2} day^{-1} by multiplying by the average water depth.

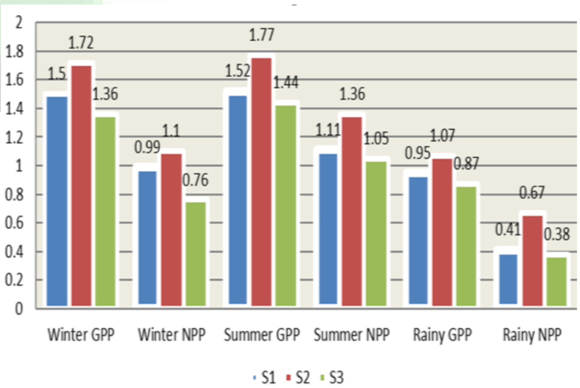

Figure 1: Seasonal variation in Primary Productivity (GPP, NPP) at S_1, S_2 & S_3 Graphical Representation

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Table 1: Monthly variations in Primary Productivity (gC m^{-2} day^{-1}) of river Mahanadi at Sunadei hill (Upstream, S_1) during 2012

Month & Year	GPP gC m^{-2} day^{-1}	NPP gC m^{-2} day^{-1}	CR gC m^{-2} day^{-1}	NPP:GPP	Respiration as % of GPP	Weather condition
January	1.72±0.063	1.04±0.138	0.68	0.60	39.53	Bright
February	1.47±0.150	1.11±0.145	0.36	0.75	24.48	Bright
March	1.79±0.160	1.29±0.217	0.51	0.72	28.49	Bright & Sunny
April	1.90±0.106	1.44±0.101	0.47	0.75	24.73	Bright & Sunny
May	1.36±0.110	1.05±0.105	0.32	0.74	23.52	Bright & Sunny
June	1.05±0.133	0.68±0.162	0.37	0.64	35.23	Cloudy & Rainy
July	0.92±0.086	0.48±0.118	0.44	0.52	47.82	Cloudy & Rainy
August	0.80±0.078	0.25±0.059	0.54	0.31	67.5	Cloudy & Rainy
September	0.95±0.073	0.42±0.037	0.56	0.44	58.94	Cloudy & Rainy
October	1.15±0.149	0.49±0.073	0.65	0.42	56.52	Cloudy
November	1.24±0.278	0.66±0.113	0.59	0.53	47.58	Bright
December	1.59±0.158	1.15±0.133	0.45	0.72	28.30	Bright

Table 2: Monthly variations in Primary Productivity (gC m^{-2} day^{-1}) of river Mahanadi at Ranapur (S_2) during, 2012

Month & Year	GPP gC m^{-2} day^{-1}	NPP gC m^{-2} day^{-1}	CR gC m^{-2} day^{-1}	NPP:GPP	Respiration as % of GPP	Weather condition
January	1.90±0.147	1.13±0.211	0.77	0.59	40.52	Bright
February	1.67±0.135	1.21±0.178	0.46	0.72	27.54	Bright
March	1.84±0.302	1.50±0.150	0.34	0.81	18.47	Bright & Sunny
April	2.30±0.281	1.79±0.216	0.51	0.77	22.17	Bright & Sunny
May	1.63±0.251	1.20±0.125	0.43	0.73	26.38	Bright & Sunny
June	1.34±0.155	0.97±0.061	0.37	0.72	27.61	Cloudy & Rainy
July	1.05±0.067	0.67±0.084	0.38	0.63	36.19	Cloudy & Rainy
August	0.90±0.067	0.85±0.088	0.05	0.94	5.55	Cloudy & Rainy
September	1.05±0.109	0.57±0.071	0.48	0.53	45.71	Cloudy & Rainy
October	1.28±0.169	0.60±0.112	0.68	0.46	53.12	Cloudy
November	1.58±0.327	0.76±0.213	0.82	0.48	51.89	Bright
December	1.76±0.202	1.32±0.168	0.44	0.75	25.00	Bright

Table 3: Monthly variations in Primary Productivity (gC m^{-2} day^{-1}) of river Mahanadi at Harirajpur (Downstream, S_3) during, 2012

Month & Year	GPP gC m^{-2} day^{-1}	NPP gC m^{-2} day^{-1}	CR gC m^{-2} day^{-1}	NPP:GPP	Respiration as % of GPP	Weather condition
2012						
January	1.56±0.226	0.87±0.144	0.69	0.55	44.23	Bright
February	1.30±0.222	0.94±0.097	0.36	0.72	27.69	Bright
March	1.70±0.186	1.33±0.252	0.37	0.78	21.76	Bright & Sunny
April	1.63±0.090	1.28±0.098	0.35	0.78	21.47	Bright & Sunny
May	1.48±0.246	0.98±0.163	0.50	0.66	33.78	Bright & Sunny
June	0.96±0.123	0.62±0.062	0.34	0.64	35.41	Cloudy & Rainy
July	0.86±0.132	0.43±0.036	0.43	0.50	50.00	Cloudy & Rainy
August	0.69±0.062	0.22±0.017	0.47	0.31	68.11	Cloudy & Rainy
September	0.82±0.077	0.32±0.115	0.50	0.39	60.97	Cloudy & Rainy
October	1.12±0.087	0.55±0.205	0.57	0.49	50.89	Cloudy
November	1.18±0.155	0.46±0.159	0.72	0.38	61.01	Bright
December	1.40±0.090	0.80±0.098	0.60	0.57	42.85	Bright

Table 4: Seasonal variations in Primary Productivity (GPP, NPP) at S_1, S_2 & S_3)

Season	S1	S2	S3
Winter GPP	1.53	1.71	1.40
Winter NPP	0.95	1.12	0.80
Summer GPP	1.52	1.77	1.44
Summer NPP	1.15	1.37	1.07
Rainy GPP	1.02	1.14	0.92
Rainy NPP	0.46	0.66	0.40

Results

Primary productivity of river Mahanadi at the three study sites (S_1, Sunadei hill; S_2, Ranapur; S_3, Harirajpur) was evaluated and its seasonal variation is given in Table 4. The annual mean GPP varied from 0.69±0.062 gC m^{-2} day^{-1} (S_3 in August) to 2.30±0.281 gC m^{-2} day^{-1} (S_1 in April). On seasonal basis, maximum GPP was observed during summer season and minimum GPP was obtained in rainy season at all the three sites. The trend reflects a well-defined seasonal pattern. The lowest GPP was noted in August in all the three study sites i.e S_1, S_2 and S_3 (0.80±0.078 gC m^{-2} day^{-1}, 0.90±0.067 gC m^{-2} day^{-1} and 0.69±0.062 gC m^{-2} day^{-1}) respectively. Similarly, the highest value of GPP was noted in March/April in all the three study sites i.e S_1, S_2 and S_3 (1.90±0. 106 gC m^{-2} day^{-1}, 2.30±0.281 gC m^{-2} day^{-1} and 1.70±0.186 gC m^{-2} day^{-1}) respectively. The GPP showed a continuous trend of decrease from January to September, 2012 at all the three study sites.

The annual mean NPP varied from 0.22±0.017 gC m^{-2} day^{-1} (S_3 in August) to 1.79±0.216 gC m^{-2} day^{-1} (S_2 in April). On seasonal basis, maximum NPP was observed during summer season and minimum NPP was obtained in rainy season at all the three sites. The trend reflects a well-defined seasonal pattern. An increasing trend of NPP was recorded from January to April with a mean value of 1.50 gC m^{-2} day^{-1} which then gradually declined. The lowest NPP was noted in August in S_1 and S_3 (0.25±0.059 gC m^{-2} day^{-1} and 0.22±0.017 gC m^{-2} day^{-1}) respectively. Similarly, the highest value of NPP was obtained during March-April in all the three study sites i.e S_1, S_2 and S_3 (1.44±0.101 gC m^{-2} day^{-1}, 1.79±0.216 gC m^{-2} day^{-1} and 1.33±0.252 gC m^{-2} day^{-1}) respectively. The NPP showed a continuous trend of decrease from July to October, 2012 at all the three study sites. The reduced production from July to October coincides with low illumination.[9] Agarwal[12] and Thomas *et al.*,[9] stated that the weather conditions markedly affect productivity in aquatic ecosystem. This was also noted in present study as the highest gross and net production values were obtained on bright days.

The community respiration ranged from 0.05 gC m^{-2} day^{-1} to 0.87 gC m^{-2} day^{-1}. The CR value showed a definite pattern with maximum value during summer and minimum value during winter. The ratio of NPP and GPP was highest in winter and lowest in rainy season.

Discussion

The ratio of NPP and GPP is important for the evaluation of the amount of gross productivity available to the first trophic level consumer.[2] Decreased value of the ratio between NPP and GPP during the rainy season might be due to high suspended solids in the flood water restricting light penetration into the water and thereby results in less photosynthetic activities and productivity. Further the phenomenon of organic matter entering the riverine system, through surface runoff causing increased demand of oxygen for the oxidation of allochthonous organic matter cannot be ruled out. During late summer the productivity value lowers due to high water temperature, decrease in water volume and minimum phytoplankton population in the medium. The minimum productivity during season may be due to dilution of nutrients, greater water depths, decrease of light penetration and lower concentration of phytoplankton in the water column.

The higher value of NPP and GPP during the summer may be due to the penetration of high light intensity which facilitate higher rate of photosynthesis and ultimately the productivity of the riverine system.[1,10] Community respiration is also a good indicator to assess the productivity of the water body. The community respiration values were higher during summer, may be due to increased water temperature that stimulates growth of microbial population which in turn utilize more oxygen for their metabolic activities.[11] The decreased CR value during winter is linked with low water temperature and reduced light which effects the rate of photosynthetic efficiency. [4,10]

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