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RESEARCH ARTICLE

SEASONAL PRIMARY PRODUCTION OF RIVER RUSHIKULYA IN ODISHA, INDIA

[1,*]Ramprasad Panda, [2]Manoj Ku Das and [3]Peetabas Nayudu

[1]Department of Zoology, Anchalik Science College, Kshetriyabarapur, India
[2]Department of Chemistry, T.S.D. College, B.D. Pur, India
[3]Department of Botany, Science College, Kukudakhandi, India

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ABSTRACT

The primary productivity of the river Rushikulya in the district of Ganjam, Odisha has been assessed from January to December during 2013 and 2014 at three different study stations. The lowest (0.19 $g^c m^{-2} day^{-1}$) and (0.21 $g^c m^{-2} day^{-1}$)while the highest 1.79 and 1.76 $g^c m^{-2} day^{-1}$ values of NPP were recorded during August and April of 2013 and 2014 respectively. This is comparable to the production of riverine ecosystem in the tropics. However the rate of primary production is adversely affected by environmental pollutants.

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INTRODUCTION

Measurement of primary productivity givers information regarding the photosynthetic production of organic matter in an area per unit time and functional aspect of ecosystem (odum, 1971, Mishra, 1972). It is also concerned with the capacity of the system to utilize external energy with subsequent transfer to higher system levels (Vollenweider, 1990) james and Moss (2003) and James *et al.* (2006) state the potential capacity of the lakes with respect to nutrient enrichment. In India studies on primary productivity was made by Singh and Mishra (1969), Mishra (1970, 1972), Jain and Mishra (1972), Dash (1981), Gupta and Sharma (1994), Hedge and Kalc (1995) Thomas *et al.* (1980), Agarwal (1980) state that the weather conditions markedly affect productivity in aquatic system. This report will document the primary production of the river Rushikulya in Ganjam District, Odisha.

MATERIALS AND METHODS

The present study was conducted at three different stations (i.e.Sorada,S1, Aska, S2 and Ganja,S3 having an area of approximately 68 kms at Rushikulya in the Ganjam district in Odisha.

Corresponding author: Ramprasad Panda,
Department of Zoology, Anchalik Science College, Kshetriyabarapur, India.

Water samples were collected from 50 cms depth and observations were made for the period of Two years i.e. 2009 and 2010. Estimation of primary productivity have used different techniques i.e. radioactive carbon (C^{14}), Chlorophyll method (Thomas *et al.*, 1980), Oxygen method by light and dark bottle (Garder and Gran, 1927). The later technique is relatively simple and does not require extensive instrumentation, therefore, it was used in the present study. Water samples were collected in triplicate near the middle of every month. Net productivity value plus respiration value gives gross productivity. The light and dark bottles were incubated under water for a period of 24 hours, at 50 cms depth and oxygen concentration was measured following Winkler's volumetric method (Ellis *et al.*, 1984) Oxygen values ($ml.l^{-1}$) were converted to carbon value by applying the equation suggested by Thomas *et al.* (1980)

$$\text{Productivity (mg C)} = \frac{O_2\text{ (ml) } 0.536}{RQ} \quad (RQ=1.25)$$

RQ represents respiration quotient / photosynthesis and that a compromise value of 1.25 was used which represents metabolism of sugars and some fats and proteins. The value 0.536 represents a constant to convert oxygen value ($ml.l^{-1}$) to a carbon value ($g^c l^{-1}$). Productivity values were expressed as $g^c m^{-2} day^{-1}$assuming 12 hours photo period and were then converted to $g^c m^{-2} day^{-1}$ by multiplying with average water depth.

Table 1. Monthly variation in primary productivity ($g^c m^{-2} day^{-1}$) of River Rushikulya at Sorada (Upstream, S_1)

Month & Year	GPP $g^c m^{-2} day^{-1}$	NPP $g^c m^{-2} day^{-1}$	CR $g^c m^{-2} day^{-1}$	NPP/GPP	Respiration as % of GPP	Water temperature	Weather Condition
2013					Calculation		
Jan	1.73±0.063	1.03±0.139	0.70	0.59	40.46	18.6±0.406	Bright
Feb	1.45±0.150	1.12±0.146	0.34	0.78	23.44	20.0±0.624	Bright
Mar	1.77±0.161	1.27±0.219	0.50	0.71	28.24	27.4±0.820	Bright & Sunny
Apr	1.85±0.105	1.63±0.102	0.44	0.78	23.40	28.8±0.284	Bright & Sunny
May	1.34 ± 0.111	1.03±0.106	0.34	0.76	25.37	29.8±0.008	Bright & Sunny
June	1.03±0.137	0.66±0.164	0.38	0.64	36.89	29.4±1.124	Cloudy /Rainy
July	0.91±0.085	0.49±0.119	0.44	0.53	48.35	28.6±0.754	Cloudy /Rainy
August	0.74±0.079	0.21±0.059	0.54	0.31	68.35	29.0±0.832	Cloudy /Rainy
Sept	0.98±0.072	0.41±0.039	0.56	0.43	58.94	28.4±0.856	Cloudy /Rainy
Oct	1.11±0.151	0.48±0.072	0.63	0.43	56.75	27.4±0.670	Cloudy
Nov	1.25±0.279	0.64±0.112	0.61	0.51	48.00	21.6±0.326	Bright
Dec	1.57±0.160	1.12±0.132	0.45	0.72	28.66	17.5±0.444	Bright
2014					Calculation		
Jan	1.16±0.095	0.85±0.061	0.74	0.52	45.96	19.5±0.098	Bright
Feb	1.75±0.161	1.32±0.72	0.42	0.75	24.00	19.2±0.58	Bright
Mar	1.65±0.076	1.39±0.114	0.28	0.84	16.96	24.5±0.554	Bright
Apr	1.84±0.309	1.65±0.197	0.22	0.87	12.29	29.0±0.760	Bright & Sunny
May	1.59±0.42	1.12±0.114	0.48	0.70	30.18	28.8±0.636	Bright & Sunny
June	1.14±0.074	0.71±0.065	0.40	0.63	36.03	3.4±0.978	Cloudy
July	1.03±0.065	0.57±0.034	0.44	0.55	12.71	28.4±0.298	Cloudy /Rainy
Aug	0.72±0.059	0.21+0.063	0.48	0.44	53.93	29.8±1.162	Cloudy /Rainy
Sept	1.9±0.135	0.49±0.068	0.70	0.41	59.82	26.8±0.592	Cloudy /Rainy
Oct	1.26±0.116	0.57±0.212	0.69	0.45	54.76	26.0±0.536	Cloudy
Nov	1.39±0.173	0.53±0.228	0.86	0.38	61.87	24.2±0.470	Bright
Dec	1.55±0.215	1.01±0.362	0.54	0.65	34.83	16.8±0.749	Bright

Table 2. Monthly variations in Primary productivity ($g^c m^{-2} day^{-1}$) of River Rushikulya at Aska (Down Stream, S_2)

Month & Year	GPP $g^c m^{-2} day^{-1}$	NPP $g^c m^{-2} day^{-1}$	CR $g^c m^{-2} day^{-1}$	NPP/GPP	Respiration as % of GPP	Water temperature	Weather Condition
2013					Calculation		
Jan	1.89 ±0.147	1.14±0.211	0.75	0.60	39.68	19.0±0.828	Bright
Feb	1.65±0.136	1.20±0.179	0.45	0.72	27.27	21.6±0.606	Bright
Mar	1.85±0.303	1.49±0.151	0.36	0.80	19.45	28.0±0.644	Bright
Apr	2.28±0.280	1.79±0.215	0.49	0.78	21.39	29.6±0.834	Bright & Sunny
May	1.63±0.251	1.19±0.126	0.44	0.73	26.99	30.4±0.918	Bright & Sunny
June	1.35±0.155	0.96±0.060	0.39	0.71	28.88	31.0±1.286	Bright & Sunny
July	1.05±0.067	0.68±0.84	0.37	0.64	35.23	27.8±0.910	Cloudy /Rainy
Aug	0.85±0.088	0.90±0.067	0.05	1.05	5.88	29.6±0.865	Cloudy /Rainy
Sept	1.06+0.109	0.57+0.071	0.49	0.53	46.22	29.0±0.746	Cloudy /Rainy
Oct	1.29±0.169	0.59+0.111	0.70	0.45	54.26	27.0±0.544	Cloudy
Nov	1.59±0.328	0.77±0.213	0.82	0.48	51.57	22.0±0.182	Bright
Dec	1.77±0.201	1.31±0.169	0.46	0.74	25.98	17.0±0.476	Bright
2014							
Jan	1.80±0.101	1.02±0.033	0.78	0.56	43.33	19.0±0.834	Bright
Feb	1.65±0.157	1.41±0.114	0.24	0.85	14.54	20.0±0.708	Bright
Mar	1.73±0.321	1.47±0.113	0.26	0.84	15.02	25.4±0.485	Bright
Apr	2.16±0.146	1.76±0.174	0.40	0.81	18.43	28.6±1.050	Bright & Sunny
May	1.69±0.085	1.26±0.164	0.43	0.74	25.44	30.0±0.782	Bright & Sunny
June	1.37±0.155	1.00±0.101	0.37	0.72	27.00	32.6±0.992	Cloudy
July	1.14±0.087	0.71±0.037	0.43	0.62	37.71	29.6±0.692	Cloudy /Rainy
Aug	1.02±0.088	0.56±0.070	0.46	0.55	44.66	28.6±0.854	Cloudy /Rainy
Sept	1.27±0.115	0.61±0.113	0.66	0.48	51.96	27.4±0.524	Cloudy /Rainy
Oct	1.39±0.181	0.63±0.399	0.76	0.45	54.67	27.0±0.493	Cloudy
Nov	1.49±0.155	0.76±0.346	0.73	0.51	48.99	25.0±0.228	Bright
Dec	1.61±0.073	1.12±0.058	0.49	0.69	30.43	16.5±0.440	Bright

RESULTS AND DISCUSSION

Gross and net primary productivity, temperature and general weather observations were presented in table 1 to 5 and Fig 1. This means gross and net primary productivity of 2013 and 2014 varied from 0.76 $g^c m^{-2} day^{-1}$ to 1.856 $g^c m^{-2} day^{-1}$ and 0.73 to 1.84 $g^c cm^{-2} day^{-1}$ respectively While the highest gross primary productivity value 2.29 $g^c m^{-2} day^{-1}$was observed in the month of April from S_2, and the lowest value 0.66 $g^c m^{-2} day^{-1}$ in August from S3. The highest NPP 1.79 $g^c cm^{-2} day^{-1}$value was observed in the month of April from S2 an the lowest NPP 0.19 $g^c cm^{-2} day^{-1}$ value in August from S3. The water temperature varied from 17.5 ^{0}C (December) to 32.5^{0}C (June) with gradual increasing trend from December to June 2013 and 17.1 (Dec) to 32.3^{0}C (June) 2014. The reduced production from June to September coincides with low illumination. Thomas *et al*. (1980), Agarwas (1980) and Henry *et al.* (1980) state that the weather conditions markedly affect productivity in aquatic system.

Table 3. Monthly variations in Primary productivity ($g^c m^{-2} day^{-1}$) of River Rushikulya at Ganja (Down Stream, S_3)

Month & Year	GPP $g^c m^{-2} day^{-1}$	NPP $g^c m^{-2} day^{-1}$	CR $g^c m^{-2} day^{-1}$	NPP/GPP	Respiration as % of GPP	Water temperature	Weather Condition
2013					Calculation		
Jan	1.57±0.227	0.88±0.144	0.69	0.56	43.94	19.4±0.398	Bright
Feb	1.29±0.221	0.94±0.098	0.35	0.72	27.13	20.8±0.608	Bright
Mar	1.70±0.186	1.32±0.254	0.38	0.77	22.35	26.8±0.562	Bright & Sunny
Apr	1.52±0.90	1.17±0.097	0.35	0.77	28.87	29.4±1.085	Bright & Sunny
May	1.47±0.247	0.98±0.162	0.49	0.66	33.33	30.0±0.826	Bright & Sunny
June	0.95±0.123	0.62±0.062	0.33	0.65	34.73	29.8±0.820	Bright & Sunny
July	0.84±0.132	0.42±0.036	0.42	0.50	50.00	28.8±0.766	Cloudy /Rainy
Aug	0.66±0.063	0.19±0.017	0.47	0.29	70.14	27.8±0.894	Cloudy /Rainy
Sept	0.79±0.076	0.30±0.116	0.49	0.37	62.02	28.0±0.840	Cloudy /Rainy
Oct	0.98±0.088	0.42±0.204	0.56	0.42	57.14	26.8±0.740	Cloudy
Nov	1.15±0.150	0.44±0.160	0.71	0.38	61.73	21.8±0.246	Bright
Dec	1.38±0.092	0.78±0.098	0.60	0.56	43.47	17.4±0.306	Bright
2014					Calculation		
Jan	1.63±0.106	0.96±0.054	0.73	0.58	44.78	18.6±0.606	Bright
Feb	1.38±0.065	0.98±0.066	0.40	0.71	28.98	18.0±0.504	Bright
Mar	1.45±0.138	1.25±0.094	0.20	0.86	13.79	24.0±0.780	Bright & Sunny
Apr	1.69±0.075	1.42±0.127	0.27	0.94	15.88	28.2±0.898	Bright & Sunny
May	1.30±0.086	1.01±0.118	0.29	0.77	22.30	30.5±0.674	Bright & Sunny
June	1.22±0.035	0.66±0.106	0.56	0.54	45.90	31.8±0.860	Cloudy
July	0.96±0.038	0.52±0.012	0.44	0.54	45.83	28.6±0.898	Cloudy /Rainy
Aug	0.69±0.033	0.29±0.031	0.40	0.42	57.14	28.4±1.019	Cloudy /Rainy
Sept	0.92±0.38	0.36±0.032	0.56	0.39	60.86	27.0±0.576	Cloudy /Rainy
Oct	1.16±0.112	0.46±0.280	0.70	0.39	60.34	26.6±0.658	Cloudy
Nov	1.30±0.124	0.64±0.126	0.66	0.49	50.76	24.0±0.835	Bright
Dec	1.32±0.220	0.83±0.038	0.49	0.63	37.12	17.6±0.410	Bright

Table 4. Mean seasonal variation in primary productivity ($g^c m^{-2} day^{-1}$)and weather Temperature at S_1, S_2 & S_3 during 2013 and 2014

	S_1	S_2	S_3
Winter			
GPP	1.54	1.68	1.38
NPP	0.95	1.10	0.81
Summer			
GPP	1.52	1.76	1.38
NPP	1.15	1.37	1.06
Rainy			
GPP	1.02	1.14	0.88
NPP	0.46	0.66	0.37

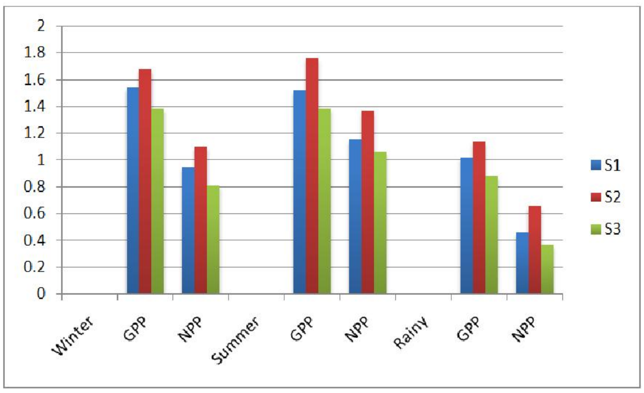

Fig. 1. Mean seasonal variation in primary productivity ($g^c m^{-2} day^{-1}$) and weather Temperature at S_1, S_2 & S_3 during 2013 and 2014

This is also noted in the present studies as the highest GPP and NPP values were obtained in bright days except in November.This may be due to high current velocity during this month which raised turbulence in the river.

There appears to be a direct correlation between temperature and production which is in agreement with Agarwal (1980) and Thomas *et al.* (1980). Thomas *et al.* (1980) state that seasonal variations in temperature (20^0C to 30.5^0C) in the riverine system in tropics are comparatively low.

Table 5. Gross production in different fresh water Habitats in the tropics

Location	Production $g^c m^{-2} day^{-1}$	Reference
Kodaikanal Lake	0.88	Sreenivasan (Thomas et. al, 1980)
Vellore Fort Moat	15.90	Sreenivasan (Thomas et. al, 1980)
Ayyankulam Tank	11.00	Sreenivasan (Thomas et. al, 1980)
Amaravathy Reservoir	6.80	Sreenivasan (Thomas et. al, 1980)
Vihar lake	0.50	Hussainy (Thomas et. al, 1980)
Yanamali Pond	2.56	Sumitra (Thomas et. al, 1980)
Yanamali Pond	2.21	Karnuakaran et.al, Thomas et. al, (1980)
Sasthamkotta Lake	2.21	(Thomas et. al, 1980)
Rybik Reservoir (warmed water)	5.54	Pasternak et.al, (1979)
River Rushikulya	0.86	Present author

In the present study, the temperature raised from 17.5 ^{0}C to 32.5^{0}C around the year. This values are regarded as very low rate of production in comparison to the result obtained by Sreenivasan. Thomas *et al.* (1980) in Vellore Forte Moat and Ayyankulum tank, and somewhat greater than the low production rate in kodiaikanal lake. The rate of primary production in the river Rushikulya is comparable to or slightly less than other reported values for tropical system (Table 5). The maximum daily primary production 5.456 gm in the warmer water was observed in Rybrik reservoir (Pasternak and Hensyk, 1979). This reservoir has several factors stimulating a high rate of production; increased water temperature, high current of nutrient minerals such as phosphorus and nitrogen in water and an increased (non-toxic) concentration of some of micro-elements (Mn, Zn, Ni, Cu).

The increased nutrient concentration and warmer temperature of the tanks and reservoirs result in higher algal production. But in the river Rushikulya these fundamental minerals and microelements needed to stimulate primary production are present in low concentration.

In fact, these substances associated with the affluent from different industries (i.e. factories and mills etc) are diluted by the river and do not provide high nutrient to the producer level. Further high current velocity constantly washed away the producer organisms. Thus the plankton community is disturbed and production is lower than in the lentic ecosystems. Anderson (1979) while studying in a tropical mangrove bay on the South-West coast of Thailand, observed annual production of 468 gm where as the present investigation the dial production ranged from 0.30 gm day to 1.43 gm day with annual productivity 371.89 gm yr. This production rate exists in the river Rushikulya in spite of potential toxic conditions resulting from human and animal abuse of the river and discharge of sewage directly into the river.

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