ISSN 2250-3153

Primary Productivity of Bay of Bengal at Chandipur in Odisha,India

Swati Sucharita Mohanty[*], D.S.Pramanik[**], B.P.Dash.[***]

[*] Department of Bioscience,F.M.University,Balasore
[**]Department of Zoology,DR Nayapalli College,Bhubaneswar
[***]Department of Bioscience,F.M.University,Balasore,Odisha,India

Abstract- Productivity refers to the rate of production on a unit area basis. The total amount of solar energy converted to chemical energy by green plant is gross primary production. For the estimation of primary productivity of Bay of Bengal at Chandipur coastal area of Odisha, the light dark oxygen method was followed. Seasonally, the minimum GPP was recorded in monsoon and maximum GPP during summer. On monthly basis minimum value was observed in July and maximum in May. The higher value of GPP and NPP respectively during summer may be due to penetration of more light into water body.

Index Terms- Seasonal Variation, gross Primary Production, Net primary production, Community Respiration, Bay of Bengal, Chandipur.

I. Introduction

Primary production is centrally important to ecological process and biochemical cycling in marine ecosystems. It is thus surprising, if not disconcerting as discussed by Williams in 1993, that there is no consensus on a definition of Planktonic Primary Productivity, or its major components, net and gross primary production (Cullen, 2001, Yeragi and Shaikh, 2003). The primary productivity of a water body is the manipulation of its biological production. It forms the basis of the ecosystem functioning (Odum, 1971). It plays an important role in energy and organic matters available to the entire biological community (Ahmed et al, 2005). The estimation of primary productivity is predicted on the relationship between oxygen evolution and carbon fixation (Dash et al, 2011). Primary productivity varies from freshwater to estuarine and from estuarine to marine water body (Dash et al, 2011).

The area under study is Bay of Bengal at Chandipur in Odisha, India. Chandipur is situated between 86^0.20' to 87^0.29' East (Longitude) and 21^0.3' to 21^0.59' North (Latitude). The uniqueness of the beach lies in the fact that during a low tide the water recedes upto 5 km. into the sea exposing the golden sands. Further it is an important fish landing Centre of varieties of edible and commercially as well as economically important fish species. This water body is very much conducive for migratory fish Hilsa Ilisha. The drastic reduction in finfish and shellfish fauna and diversity along the Chandipur sea beach calls for immediate analysis and interaction.

II. MATERIAL AND METHODS

For the analysis of primary productivity, the water samples in triplicates were collected from 50 cm. depth of pelagic layer in sea-shore and observations were made in the middle of every month for a period of one year 2010-2011.

For the estimation of Primary productivity different techniques have been used by different workers viz. Radioactive Carbon (c^{14}) (Slumann-Nielson, 1952), Chlorophyll method (Ryther and Yentsch, 1957) and oxygen method by light and dark bottle (Gaarder and Gran, 1927, Vollenweiden, 1969). The light dark oxygen method is a standard approach for measuring photosynthesis in aquatic systems and does not require extensive instrumentation and therefore it was used during the present investigation.

The sample in the first bottle was used immediately to determine the initial level of dissolved oxygen following Wrinklers Volumetric method (APHA, 2008). Dissolved oxygen values obtained were converted to carbon values by multiplying with the factor 0.375 (Odum, 1956, Mohapatra and Patra, 2012).

The second bottle was painted with black color to prevent light penetration and hence served as a control to measure respiration. The third light bottle was treated as a test to measure the net production. The last two bottles were incubated under water in the euphotic zone for a period of twenty four hours at 50 cm. depth and then oxygen content was measured and then the DO. values were converted to gCm^{-2} day^{-1} multiplied by average water depth. Oxygen values mgl^{-1} were converted to carbon values by applying the equation suggested by Thomas et al, 1980 and Ahmed et al, 2005.

Primary Production gC = mg l^{-1} x 0.375/PQ
Where PQ = 1.25

PQ represents respiratory quotient = respiration/photosynthesis and a compromised value of 1.25 was used which represent metabolism of sugars, some fats and proteins.

III. RESULTS AND DISCUSSION

The observed data of seasonal variations of gross primary productivity (GPP), net primary productivity (NPP) and community respiration (CR) along with mean standard deviation for four different seasons was shown in Table-2.

Seasonally, the minimum GPP (151.25± 2.16 gC m^{-2} day^{-1}) was recorded in monsoon season and maximum GPP value

(220.65 ± 5.76 gC m^{-2} day^{-1}) was recorded during summer. Whereas, on monthly basis minimum value (150.0 ± 5.19 gC m^{-2} day^{-1}) during july and maximum (227.0 ± 2.29 gC m^{-2} day^{-1}) during May (Table-1).

However, the minimum NPP value (100.25 ± 3.25 gC m^{-2} day^{-1}) was recorded in monsoon whereas maximum (144.2 ± 4.27 gC m^{-2} day^{-1}) in summer. No particular trend was observed in seasonal variations of NPP. On comparison of the monthly variations, an increasing trend was observed from September to February, which is in agreement with Dash, Patra and Adhikary, 2011. Kumar et al, 2001, also obtained the same observations with the present study of decreasing values of GPP and NPP during monsoon. Although this has been variedly attributed to the light inhibition due to turbidity and cloud cover as well as high water current (Madhupratap et al, 2001). Besides, the poor nutrient, concentration of Phosphates and Nitrogen in monsoon period may bring about the low productivity values (Pasternak and Kasza, 1979) and this confirmed the present study. At the same time the organic matter entering the marine system, through flooded riverine system caused increased demand of dissolved oxygen for the oxidation of allochthorous organic matter that possibly of decreasing trend may not be ruled out.

The higher values (221.41 ± 4.97 , 144.2 ± 4.27 gC m^{-2} day^{-1}) of GPP and NPP respectively during the summer (clean weather and higher temperature) may be due to penetration of more light into water body which facilitates the higher rate of planktonic photosynthesis and thus ultimately the productivity of the marine system (madhupratap, 2001).

The community respiration (CR) exhibited a systematic seasonal pattern with maximum (77.31 ± 2.78 gC m^{-2} day^{-1}) during summer and minimum (42.69 ± 5.52 gC m^{-2} day^{-1}) during winter. The decreased value during winter was linked with low water temperature and reduced light (Ahmed and Singh, 1987 and Dash et al, 2011).

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). The ratio between NPP : GPP as well as NPP : CR was highest (0.775, 3.57) during winter and lowest (0.644, 1.82) during summer while community respiration may account for 20 – 40% of GPP (Table-3), which shows good index (Muraleedharan, 2001).

The NPP : CR value > 1 (3.57) in winter which accounts for more penetration of light into water body as well as suitable temperature which favors abundance of planktons and more photosynthetic activities (Das, Patra and Adhikary, 2011).

Higher production is not governed by a single factor as stated by Singh and Singh, (1999), Moharana and Patra (2013). There are certain physicochemical and biological factors which in fact control the rate of production in marine ecosystem (Mohanty, 2000). It appears that there is a direct correlation between temperature and production which is in agreement with Srinivasan (1964), Hall & Moll (1975), Goldman and Wetzel (1963), Mohanty (2000), Pauly & Christensen (1995) and Thomas et al, (1980). In the present study too the productivity is high at high temperature, while in winter as the temperature is low the productivity is also low.

A positive correlation between GPP and NPP (r = 0.996, P.Er=0.075) during summer demonstrated that high NPP is followed by higher GPP. During winter a positive relationship between GPP and NPP (r = 0.827, P.Er=0.14) was noted in the current study. The above findings are in agreement with that of the work Ahmed et al, (2005), Dash et al, (2011) and Moharana and Patra, (2013).

A positive relationship between GPP and CR (r = 0.813, P.Er=0.13) states that the growth of Phytoplankton resulting the high primary productivity may be due to high organic wastes, containing high nutrient values in the sea water.

Table1: Mean Monthly Variations of GPP, NPP and RES Values in gC m^{-2} day^{-1} (mean ± SD) at Chandipur during 2010-2011.

Months	**Temperature of Water in ^{0}C**	**GPP gC m^{-2} day^{-1}**	**NPP gC m^{-2} day^{-1}**	**RES (CR) gC m^{-2} day^{-1}**
January	20.6	191.5 ± 2.86	146.41 ± 3.95	45.11 ± 3.37
February	23.4	193.25 ± 2.76	147.0 ± 7.79	46.25 ± 5.10
March	25.6	217.75 ± 1.56	141.16 ± 2.30	76.58 ± 2.87
April	29.6	219.2 ± 10.73	141.7 ± 5.25	79.7 ± 4.3
May	30.8	227.3 ± 2.29	149.3 ± 5.26	78.0 ± 3.00
June	30.4	153.75 ± 2.75	102.25 ± 2.75	51.5 ± 3.03
July	28.4	150.0 ± 5.19	102.0 ± 6.00	51.0 ± 3.0
August	28.3	150.0 ± 5.25	96.5 ± 4.82	53.5 ± 2.43
Septemeber	26.3	165.5 ± 2.29	113.5 ± 2.29	52.5 ± 1.5
October	26.2	166.75 ± 2.41	121.5 ± 5.41	45.25 ± 4.99
November	22.4	171.25 ± 1.56	130.8 ± 2.51	40.41 ± 3.12
December	20.9	175.33 ± 1.25	139.33 ± 2.88	35.83 ± 3.77

Table2: Mean Seasonal Variations of GPP, NPP and RES Values in (mean ± SD) in gC m^{-2} day^{-1} at Chandipur during 2010-2011.

Season	**GPP gC m^{-2} day^{-1}**	**NPP gC m^{-2} day^{-1}**	**RES (CR) gC m^{-2} day^{-1}**
Summer	221.41 ± 4.97	144.2 ± 4.27	77.31 ± 2.78
Winter	186.69 ± 9.87	144.0 ± 4.26	42.69 ± 5.52
Monsoon	151.25 ± 2.16	100.25 ± 3.25	52.0 ± 1.32
Post Monsoon	167.87 ± 3.02	121.9 ± 8.65	46.05 ± 6.08

Table 3: Total and Seasonal Ratio between Different Productivity Parameters of Bay of Bengal at Chandipur during 2010-2011.

Total			**Seasonal**											
NPP: GPP	**NPP: CR**	**CR% of GPP**	**NPP : GPP**				**NPP : CR**				**CR % of GPP**			
			S	**W**	**M**	**PM**	**S**	**W**	**M**	**PM**	**S**	**W**	**M**	**PM**
0.701	2.45	29.95	0.649	0.772	0.661	0.725	1.76	3.45	1.92	2.7	22.64	35.29	34.41	27.48

S=summer, **W**=winter, **M**=monsoon, **PM**= post monsoon

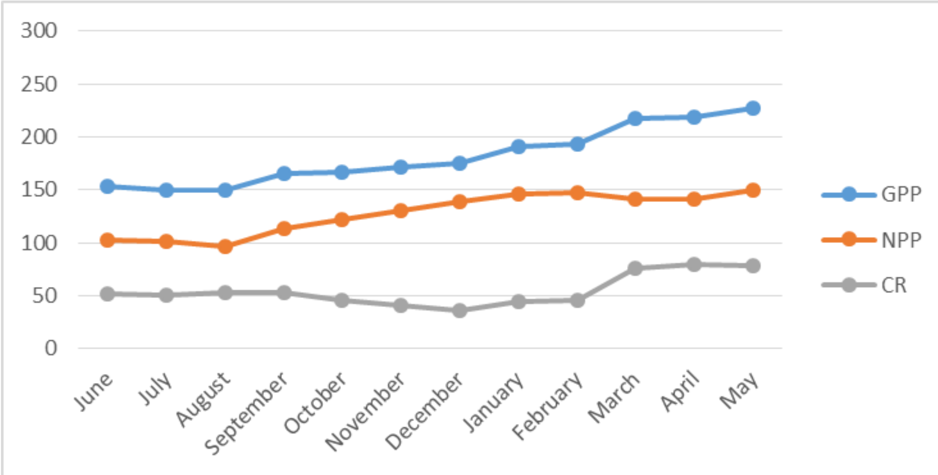

Figure 4: Monthly variations in Primary Productivity (GPP, NPP & CR) of Chandipur – on – Sea during 2010-2011 in (gc m^{-2} day^{-1}).

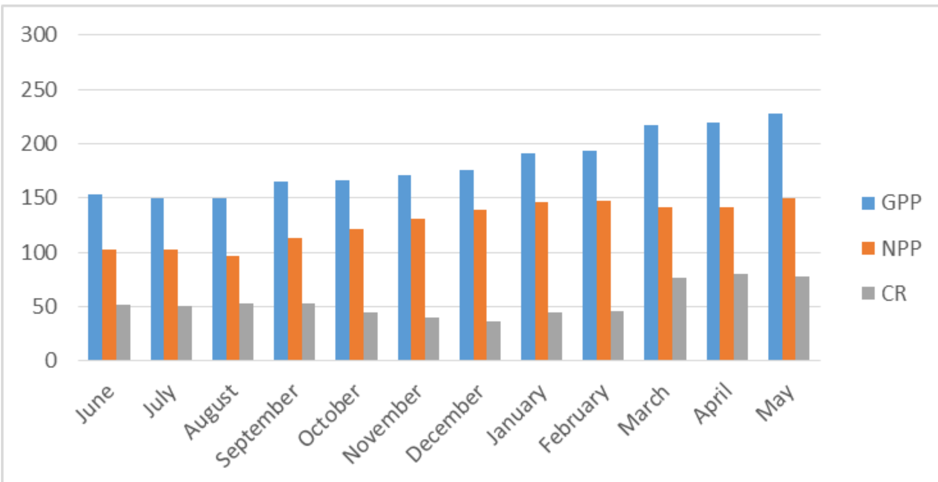

Figure 5 : Monthly variations in Primary Productivity GPP, NPP & CR of Chandipur – on - sea during 2010-2011 in (gc m^{-2} day^{-1}).

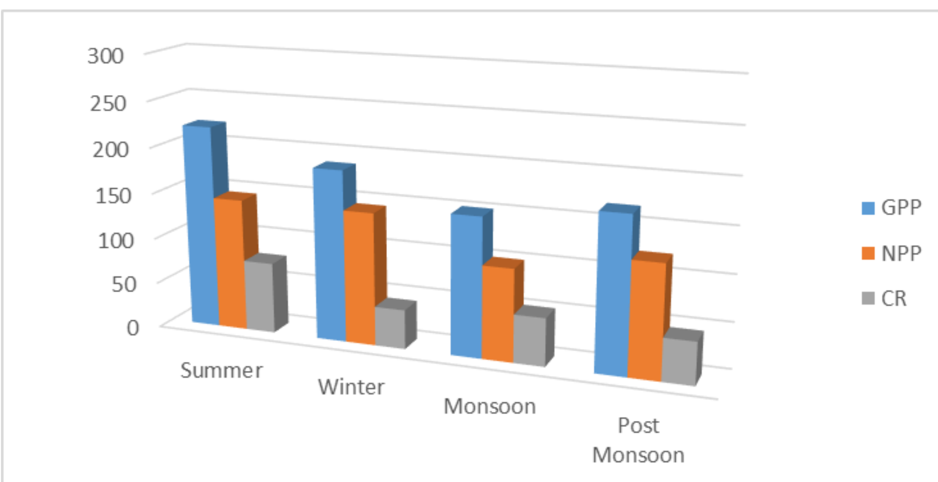

Figure 6: Seasonal variations in Primary Productivity (GPP, NPP & CR) of Chandipur – on – Sea during 2010-2011 in (gc m^{-2} day^{-1}).

IV. ACKNOWLEDGEMENT

Authors are thankful to the Head of the Department of Biosciences, F.M. University, Balasore,Odisha,India for providing necessary laboratory facilities.

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AUTHORS

First Author – Swati Sucharita Mohanty, M.Sc(Zoology) Department of Bioscience, F.M. University, Balasore, Odisha.
Second Author – D.S. Pramanik,(Ph.D.) Department of Zoology, DR Nayapalli College, Bhubaneswar, Odisha. E-mail-debansu2003@rediffmail.com,Contact No.09437173121
Third Author – B.P. Dash,(Ph.D) Department of Bioscience, F.M. University, Balasore, Odisha.