VOLUME 02 ISSUE 01 (2023)

e-palli

AMERICAN JOURNAL OF AQUACULTURE AND ANIMAL SCIENCE (AJAAS)

ISSN: 2835-8945 (ONLINE)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Aquaculture and Animal Science (AJAAS)

Volume 2 Issue 1, Year 2023
ISSN: 2835-8945 (Online)
DOI: https://doi.org/10.54536/ajaas.v2i1.1165
https://journals.e-palli.com/home/index.php/ajaas

Spatial and Seasonal Variation of the Primary Productivity in the Major Nursery Grounds of Hilsa (*Tenualosa ilisha*)

Flura[1], Md. Moniruzzaman[1], Mohammad Ashraful Alam[1], Md. Hashibur Rahman[2*], Khondaker Rashidul Hasan[1], Rabina Akther Lima[3], Yahia Mahmud[2]

Article Information

Received: January 05, 2023

Accepted: February 21, 2023

Published: February 23, 2023

Keywords

Seasonal Variation, Primary Productivity, Nursery Grounds, Tenualosa ilisha

ABSTRACT

The present study was conducted to estimate the primary productivity of major nursery grounds of hilsa both spatially and seasonally. The net primary productivity (NPP), community respiration (CR) and gross primary productivity (GPP) were estimated in summer, rainy, and winter, respectively. The maximum NPP (0.27 $gCm^{-3}h^{-1}$) and GPP (0.68 $gCm^{-3}h^{-1}$) were noted during summer season and minimum (0.19 $gCm^{-3}h^{-1}$ and 0.31 $gCm^{-3}h^{-1}$) in rainy season at all the six stations. The annual average GPP varied from 0.36±0.008 $gCm^{-3}h^{-1}$to 0.70±0.1 $gCm^{-3}h^{-1}$. From the month of March to June, the NPP value ranged from 0.23±0.001 $gCm^{-3}h^{-1}$ to 0.51±0.09 $gCm^{-3}h^{-1}$ and usually showed an increasing trend. The CR ranged from 0.12±0.003 $gCm^{-3}h^{-1}$ to 0.20±0.05 $gCm^{-3}h^{-1}$ and exposed an rising trend from the month of January to May whereas the study revealed that, during summer and winter the CR value has also seasonal pattern with maximum and minimum value in all experimental sites. The data of primary productivity at all stations showed that except S6, all stations has a good nutrient profile and suitable for hilsa production.

INTRODUCTION

Primary production is the total amount of organic matter made from inorganic matter by the photosynthesis process. Primary producers need to enliven some crucial inorganic components such as nitrogen, magnesium, zinc, iron, phosphorous, etc. In aquatic ecosystems, autotrophs (algae, planktons, etc.) act as primary producers on which all the life forms depend (Ogbaugu *et al.*, 2011). The primary producers of the aquatic ecosystems are phytoplankton, periphyton and macrophytes (Deka, 2017). It makes organic matters available to the entire biological community and facilitate to produce the chemical energy by playing an important role in any ecosystem (Ahmed *et al.*, 2005). The organic material which is produced with the help of sunlight by the producer from an inorganic material through the process of photosynthesis is called primary production (Babar and Raje, 2015). Primary productivity is to be estimated to sustain a level of growth and respiration and support a biological population (Bishnoi *et al.*, 2013). The basis of ecosystem functioning is the biological production of autotrophs which is manipulated by primary productivity of a water body (Mohanty *et al.*, 2014; Odum *et al.*, 1971). To supplement the energy and organic matters to the whole biological community is a crucial responsibility of primary productivity (Ahmed *et al.*, 2005). Light (solar energy) and nutrients are the main limiting factors to primary production in an aquatic ecosystem (Guildford and Hecky 2000; Simmons *et al.*, 2004), though distribution of phytoplankton (algae) are also affected by temperature and seasonal variations in light intensity (Vaillancourt *et al.*, 2003). The production can be distinguished further into gross production at each level, i.e., the net production and total amount of organic matters produced at a particular level. In auspicious state, the net primary productivity has a positive value and the organic matters produced. But in unpleasant conditions, the rate of net primary productivity may dwindle up to zero or negative when respiratory diminution overpassed the photosynthetic accumulation (Yeragi and Shaikh, 2003). The primary production of an aquatic ecosystem could be measured through the measurement of net primary productivity (NPP) or gross primary productivity (GPP). NPP accounts for losses such as respiration and excretion while GPP includes the total amount of fixed carbon. Factor influences primary productivity such as solar radiation, water transparency, and fluctuations in the water level and nutrient contents (Tailing, 1957). In Bangladesh a little research work has been done so far on the primary productivity of the lentic waters of Bangladesh (Hussain *et al.*, 1978, ARG 1986, Haldar and Ahmed 1991, Haldar*et al.*, 1992, Ahmed 1994) and very little work has been done from lotic water (Ahmed *et al.*, 2005). Alsolots of studies have already been done in the lentic ecosystem in India in relation to physicochemical status and primary productivity (Shukla and Pawar, 2001, Fatima *et al.*, 2011, Koli and Ranga, 2011) but no work has been done from lotic water. Therefore, present studies have been undertaken to estimate the primary productivity in the six hilsa sanctuary areas.

MATERIALS AND METHODS

Study areas and duration

The study was carried out for one year between June 2021 to July 2022 at six different stations in the major nursery grounds of hilsa. Data was collected from three locations

[1] Bangladesh Fisheries Research Institute, Riverine Station, Chandpur, Bangladesh
[2] Bangladesh Fisheries Research Institute, Headquarters, Mymensingh, Bangladesh
[3] Bangladesh Fisheries Research Institute, Riverine Sub-station, Rangamati, Bangladesh
[*] Corresponding author's e-mail: hasibkhan94bfri@gmail.com

of each nursery ground (Table 1). These nursery grounds were located Shatnol, Chandpur-Alexander, Laxmipur 100 km considered as station 1, Tarabunia, Shariotpur 20 km, Lower Padma considered as station 2, Hizla, Mehindigonj, Barishal (82 km) considered as station 3, Bheduria, Bhola, Char Rustom, Potuakhali (100 km, Tetulia River considered as station 4, Char Ilisha-Char Pial, Bhola (90 km), Shahbazpur Channel considered as station 5, and Kalapara Upazilla, Potuakhali (40km) considered as station 6 were collected and analyzed. (Figure1).

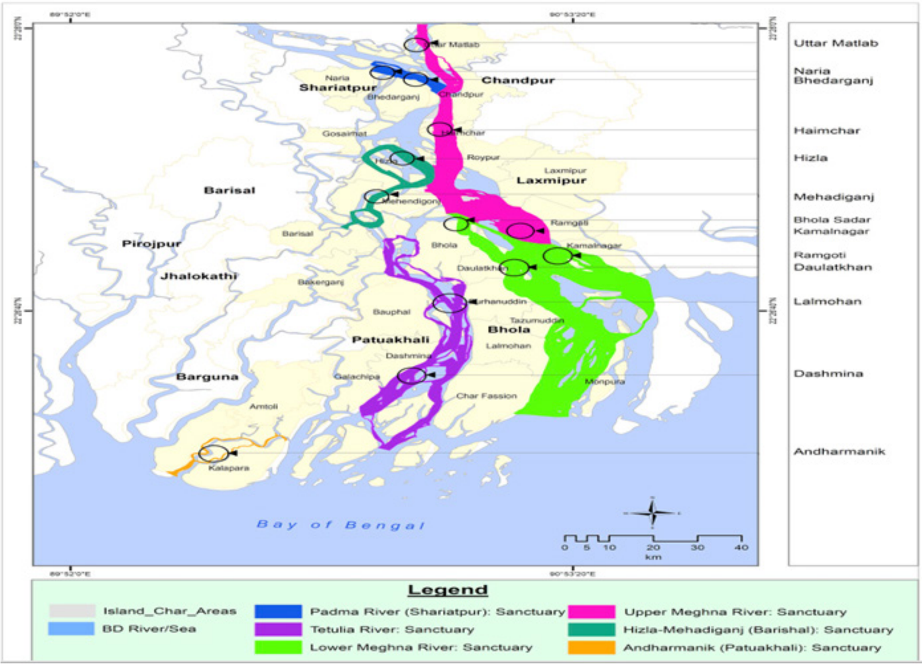

Figure 1: Map of the study area and the location of different sampling station.

Table 1: Six Nursery Grounds With Eighteen Treatment Areas

Sl no.	Sanctuary Area	Area Length (Km)	Treatments
1.	Shatnol, Chandpur-Alexander, Laxmipur (S1)	100	Shatnol, Confluence (Padma & Meghna) and Chor Alexandar
2.	Tarabunia, Shariotpur (S2)	20	Tarabunia, Sureswar and Bashgari
3.	Hizla, Mehendigonj, Barisal (S3)	82	Bhasanchor, Hizla and Mollikpur
4.	Bheduria, Bhola- Char Rustom, Patuakhali (S4)	100	Bheduria, Kalaiya and Chor Rustam
5.	Char Ilisha-Char Pial, Bhola (S5)	90	Elisha, Daulatkhan and Monpura
6.	Kalapara Upazila, Patuakhali (S6)	40	Bailatoli, Khepupara and Mohipur

Design of the Experiment

In order to determine the seasonality of the primary productivity, sampling was done in the Twelve consecutive months. Sampling occurred among the six research stations and each sample contained three replications. Based on the sampling month, seasonality of the primary productivity was determined.

Table 2: Represents The Sampling Design of the Experiment.

Month	Seasons
November to February	Winter
March to Jun	Summer
July to October	Rainy

Determination of the Primary Productivity

The "Light and Dark bottle" method of Gaarder and Gran method was followed to obtained primary productivity analysis (1927), as recommended by Vollenweider, (1969), was followed. The technique of exercise of light and dark bottles and Winkler's titration to assess the production and consumption of oxygen was first proposed by Gaarder and Gran in 1927. The primary productivity i.e., Net Primary Productivity (NPP), Community respiration (CR) and Gross Primary Productivity (GPP) were calculated with the assistance of light and dark bottle method. The values of light bottle oxygen and dark bottle oxygen were taken after the incubation time of eight hours while initial oxygen was taken at the time of sampling. The value of NPP, CR and GPP were estimated by using the formula.

Net Primary Productivity (NPP) O2 mg/L/h = (D1-Di)/h

Community Respiration O2 mg/L/h =(Di-Dd)/h

Gross Primary Productivity (GPP) O2 mg/L/h = (D1-Dd)/h

Where:

D1 = DO (mg/L/h in the light bottle).

Di = DO (mg/L/h in the initial bottle).
Dd = DO (mg/L/h in the dark bottle).
h = Duration of exposure in hours.
Through the multiplication with the duration of sunshine, the hourly rate can be converted to daily rates. By applying the equation suggested by Thomas *et al.*, (1980), oxygen values (mg/L) were converted to carbon value.
Production (gC) = (O2 (mg/L) x 0.375)/PQ
Where PQ = 1.25
PQ indicates respiratory quotient = Respiration and a comprised value of (1.25) represents metabolism of sugar, fat, and proteins. To convert oxygen value to carbon value (Thomas *et al.*, 1980), the value 0.375 represents a constant.

Statistical Analysis

Experimental data were collected, summarized and analyzed by using Microsoft Excel (version-16). Mean value of the primary productivity of each sampling stations was obtained and thus statistical comparison of the seasonality of the primary productivity was determined.

RESULTS

The standard and average deviation of NPP, CR and GPP of twelve (12) different months have been depicted in Table-3, 4 and 5 respectively. The seasonal variation of net primary productivity (NPP), community respiration (CR) and gross primary productivity (GPP) showed in Table-6.

Gross Primary Productivity

Gross primary productivity (GPP) ranged from 0.51 gCm^{-3} h^{-1} to 0.89gCm^{-3} h^{-1}, 0.40 gCm^{-3} h^{-1} to 0.89 gCm^{-3} h^{-1}, 0.32 gCm^{-3} h^{-1} to 0.77 gCm^{-3} h^{-1}, 0.32 gCm^{-3} h^{-1} to 0.77 gCm^{-3} h^{-1}, 0.32 gCm^{-3} h^{-1} to 0.77 gCm^{-3} $h^{-1}$and 0.32 gCm^{-3} $h^{-1}$to 0.77 gCm^{-3} $h^{-1}$from S1, S2, S3, S4, S5 and S6, respectively (Table 3 and Figure 2). Highest gross primary productivity (GPP) was recorded in S1 and S2 in March. Lowest gross primary productivity was recorded from all six stations in November. From the month of February to August, an increasing trend was found in the experimental sites.

Net primary productivity

Net primary productivity (NPP) ranged from 0.37 gCm^{-3} h^{-1} to 0.68 gCm^{-3} h^{-1}, 0.29 gCm^{-3} h^{-1} to 0.62 gCm^{-3} h^{-1}, 0.21 gCm^{-3} h^{-1} to 0.59 gCm^{-3} h^{-1}, 0.29 gCm^{-3} h^{-1} to 0.51 gCm^{-3} h^{-1}, 0.31 gCm^{-3} $h^{-1}$to 0.62 gCm^{-3} h^{-1} and 0.19 gCm^{-3} $h^{-1}$to 0.29 gCm^{-3} h^{-1} from S1, S2, S3, S4, S5 and S6, respectively (Table 4 and Fig. 3). Highest NPP was recorded in S1 in March. Lowest NPP was recorded from S6 in September. From the month of March to May, an increasing trend was found during the study.

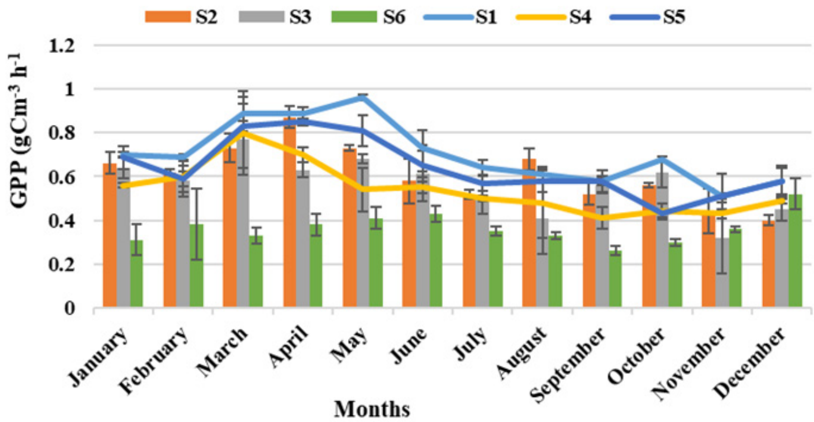

Figure 2: Comparative estimation of GPP

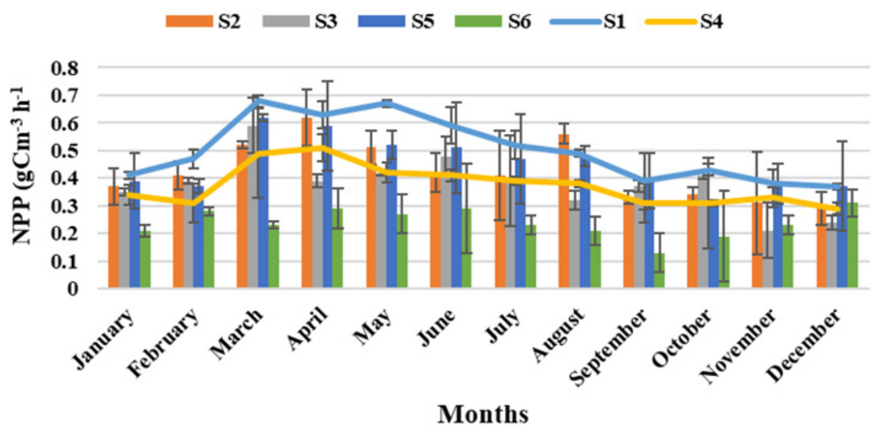

Figure 3: Monthly variation of NPP

Table 3: Monthly Average GPP values in gCm-3 h-1 (mean±SD)

Month	S1	S2	S3	S4	S5	S6
January	0.71±0.013	0.67±0.051	0.65±0.051	0.57±0.013	0.70±0.051	0.32±0.072
February	0.70±0.013	0.63±0.013	0.59±0.072	0.61±0.072	0.60±0.036	0.39±0.164
March	0.90±0.101	0.74±0.068	0.78±0.164	0.81±0.164	0.84±0.022	0.34±0.036
April	0.90±0.026	0.88±0.051	0.64±0.036	0.71±0.036	0.86±0.016	0.39±0.051
May	0.97±0.013	0.74±0.013	0.69±0.022	0.55±0.101	0.82±0.072	0.42±0.051
Jun	0.74±0.013	0.59±0.103	0.62±0.016	0.56±0.026	0.66±0.164	0.44±0.036
July	0.65±0.036	0.53±0.022	0.51±0.072	0.51±0.013	0.58±0.036	0.36±0.022
August	0.62±0.022	0.69±0.051	0.42±0.164	0.49±0.164	0.59±0.051	0.34±0.016
September	0.59±0.051	0.53±0.051	0.57±0.036	0.42±0.051	0.59±0.022	0.27±0.022
October	0.69±0.013	0.57±0.013	0.63±0.072	0.45±0.036	0.44±0.016	0.31±0.016
November	0.52±0.103	0.45±0.103	0.33±0.164	0.44±0.022	0.52±0.013	0.37±0.013
December	0.59±0.061	0.41±0.026	0.46±0.051	0.50±0.016	0.59±0.072	0.53±0.072

Table 4: Monthly Average NPP values in gCm-3 h-1 (mean±SD)

Month	S1	S2	S3	S4	S5	S6
January	0.42±0.068	0.38±0.013	0.36±0.013	0.35±0.036	0.40±0.101	0.22±0.022
February	0.48±0.051	0.42±0.036	0.40±0.013	0.32±0.072	0.38±0.026	0.29±0.016
March	0.69±0.013	0.53±0.022	0.60±0.101	0.50±0.164	0.63±0.013	0.24±0.013
April	0.64±0.103	0.63±0.051	0.40±0.026	0.52±0.051	0.60±0.164	0.30±0.072
May	0.68±0.061	0.52±0.013	0.43±0.013	0.43±0.036	0.53±0.051	0.28±0.072
Jun	0.51±0.072	0.43±0.068	0.49±0.072	0.42±0.022	0.52±0.164	0.30±0.164
July	0.53±0.164	0.42±0.051	0.40±0.164	0.40±0.016	0.48±0.164	0.24±0.036
August	0.50±0.036	0.57±0.013	0.33±0.036	0.39±0.013	0.49±0.036	0.22±0.051
September	0.40±0.024	0.34±0.103	0.38±0.022	0.32±0.072	0.40±0.101	0.14±0.072
October	0.44±0.027	0.35±0.022	0.42±0.016	0.32±0.164	0.32±0.013	0.20±0.164
November	0.39±0.185	0.32±0.051	0.22±0.101	0.34±0.036	0.39±0.072	0.24±0.036
December	0.38±0.059	0.30±0.013	0.25±0.026	0.30±0.022	0.38±0.164	0.32±0.051

Community respiration

Community respiration (CR) ranged from 0.13 gCm^{-3} h^{-1} to 0.29 gCm^{-3} h^{-1}, 0.11 gCm^{-3} h^{-1} to 0.29 gCm^{-3} h^{-1}, 0.11 gCm^{-3} h^{-1} to 0.29 gCm^{-3} h^{-1}, 0.1 gCm^{-3} h^{-1} to 0.31 gCm^{-3} h^{-1}, 0.1 gCm^{-3} $h^{-1}$to 0.30 gCm^{-3} h^{-1} and 0.09 gCm^{-3} $h^{-1}$to 0.21 gCm^{-3} h^{-1} from S1, S2, S3, S4, S5 and S6, respectively (Table 5 and Fig.4). Highest CR was recorded in S4 in March. Lowest CR was recorded from S6 in April. Among six stations, lowest GPP, NPP and CR were found at S6.

Table 5: Monthly Average CR values in gCm^{-3} h^{-1} (mean±SD)

Month	S1	S2	S3	S4	S5	S6
January	0.30±0.013	0.30±0.101	0.30±0.103	0.23±0.022	0.31±0.164	0.11±0.022
February	0.23±0.026	0.22±0.026	0.20±0.022	0.30±0.016	0.23±0.036	0.11±0.016
March	0.22±0.013	0.22±0.013	0.19±0.051	0.32±0.013	0.22±0.101	0.11±0.013
April	0.27±0.013	0.26±0.013	0.25±0.051	0.20±0.072	0.27±0.013	0.10±0.072
May	0.30±0.153	0.23±0.036	0.27±0.013	0.13±0.164	0.30±0.072	0.15±0.072
Jun	0.15±0.072	0.17±0.022	0.14±0.101	0.15±0.164	0.15±0.013	0.15±0.164
July	0.13±.164	0.12±0.051	0.12±0.026	0.12±0.036	0.11±0.072	0.13±0.036
August	0.13±0.036	0.13±0.072	0.10±0.013	0.11±0.101	0.11±0.164	0.13±0.051
September	0.20±0.022	0.20±0.164	0.20±0.072	0.11±0.026	0.20±0.036	0.14±0.022
October	0.26±0.027	0.23±0.036	0.22±0.164	0.14±0.013	0.13±0.051	0.12±0.016
November	0.14±0.014	0.14±0.022	0.12±0.051	0.11±0.072	0.14±0.036	0.14±0.013
December	0.22±0.056	0.12±0.016	0.22±0.051	0.21±0.126	0.22±0.022	0.22±0.026

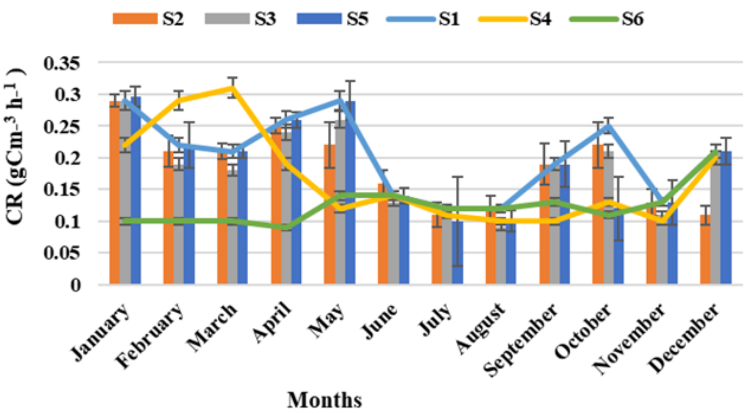

Figure 4: Comparative estimation of community respiration

Seasonal variation of gross primary productivity

Average value of GPP was estimated 0.68 gCm^{-3} h^{-1}, 0.50 gCm^{-3} h^{-1} and 0.52 gCm^{-3} h^{-1} in summer, season rainy and winter, respectively. Seasonally, the maximum was recorded during summer season and minimum GPP was recorded in rainy season (Table 6 and Fig. 5).

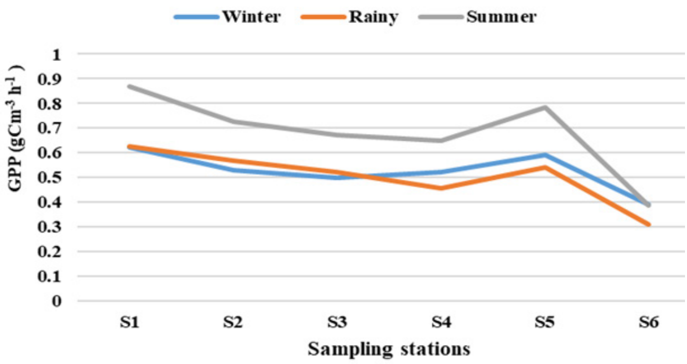

Figure 5: Seasonal variation of gross primary productivity

Seasonal variation of community respiration

Average value of CR was estimated 0.33 gCm^{-3} h^{-1}, 0.36 gCm^{-3} $h^{-1}$and 0.48 gCm^{-3} h^{-1}in winter, rainy and summer season, respectively (Figure 6). The highest net primary productivity was estimated in summer and the lowest net productivity was estimated in winter season.

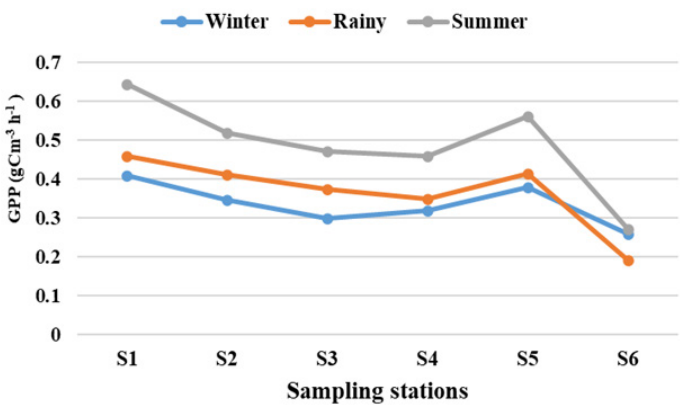

Figure 6: Seasonal variation of gross primary productivity

Seasonal variation of community respiration

Average value of CR was estimated 0.19 gCm-3 h-1, 0.13 gCm-3 h-1and 0.19 gCm-3 h-1 in winter, rainy and summer season, respectively (Figure 7). The highest net primary productivity was estimated in winter and summer and the lowest net productivity was estimated in rainy season.

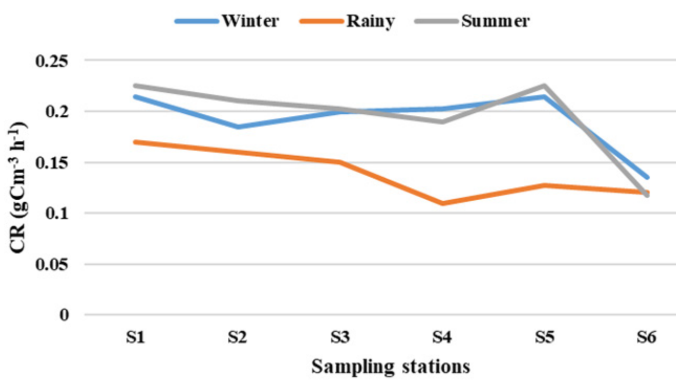

Figure 7: Seasonal variation of gross primary productivity

Table 6: Seasonal variation of GPP, NPP and CR (mean±SD)

Stations	GPP			CR			NPP		
	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter
S1	0.87±0.09	0.63±0.04	0.63±0.09	0.23±0.07	0.18±0.55	0.22±0.07	0.65±0.36	0.46±0.06	0.42±0.04
S2	0.74±0.11	0.58±0.06	0.54±.012	0.22±0.04	0.17±0.05	0.20±0.08	0.519±0.08	0.42±0.02	0.346±0.05
S3	0.67±0.06	0.52±0.07	0.50±0.12	0.20±0.05	0.15±0.05	0.20±0.06	0.47±0.07	0.37±0.03	0.29±0.07
S4	0.64±0.10	0.45±0.03	0.52±0.06	0.19±0.07	0.11±0.01	0.20±0.06	0.45±0.04	0.34±0.03	0.31±0.01
S5	0.78±0.07	0.54±0.06	0.59±0.06	0.22±0.05	0.12±0.03	0.21±0.05	0.56±0.04	0.41±0.06	0.37±0.008
S6	0.38±0.03	0.31±0.03	0.39±0.07	0.11±0.02	0.12±0.007	0.13±0.04	0.27±0.03	0.19±0.03	0.25±0.03

DISCUSSION

In Bangladesh, scarcity of information about open water because very few work has been reported from any lotic water. The present study of GPP was found that the recorded highest GPP being 0.89gCm^{-3} h^{-1}in Marchat S1 and April while lowest (0.26gCm^{-3} h^{-1}) in September at S6, respectively. The study found the highest NPP (0.68gCm^{-3} h^{-1}) in March at S1 and the lowest (0.13gCm^{-3} h^{-1}) in September at S6. On the other hand, highest CR (0.30 gCm^{-3} h^{-1}) in January at S5 and the lowest (0.09 gCm^{-3} h^{-1}) in April at S6,respectively. Lohani *et al.* (2020) found that the GPP, NPP and CR were highest in October in research ponds. Rathod *et al.*, (2016) also observed highest productivity, GPP and NPP in the month of October and November. Koli and Ranga (2011) observed three peaks for GPP during their study, which is in the month of October 2007, April and June 2008 which was similar to this study.Radwan (2005) assessed the Nainital and Bhimtal lakes of Kumaon Himalaya of Uttarakhand, and reported that higher productive water bodies have a dense population of plankton than lower productive water bodies.Bhouyain and Sen (1983) found the highest net primary productivity (66.93 mgCm^{-3} h^{-1}) in April and the lowest (1.87 mgCm^{-3} h $^{-1}$) in July. The highest gross primary productivity (105.72 mgCm^{-3} h $^{-1}$) was recorded in April and the lowest (18.14 mgCm^{-3} h $^{-1}$) being in July which is coincided with the present study. Saha *et al.* (2001) found mean values of net primary productivity (NPP), and community respiration (CR) and gross productivity (GPP), ranged from 0.27 to 0. 92 gCm^{-3} h^{-1}, 0.09 to 0.37 gCm^{-3} h^{-1} and 0.51 to 1.16 gCm^{-3} h^{-1}, respectively, which is almost nearly close to the findings of the present study. In the present findings, GPP and NPP were minimum in Rainy season and maximum in Summer season.Sontakke and Mokashe, (2014) reported that, the lowest amount of productivity during rainy season might be due to inadequate sunlight, higher water depth, cloudy weather, and turbidity by suspended solid resulting from soil erosion from adjacent hills. The high suspended solids in the flood water occurs due to the decreasing production in rainy season which restricts the light penetration into the water and thereby results in less photosynthetic activities and productivity. The highest productivity in summer could be due to sufficient sunlight, temperature, and photoperiod. Subtracting net productivity from gross productivity and converted into carbon dioxide is the community respiration or breathing. Mitsch *et al.* (2015) reported that gross and net primary productivity values show an increasing trend both in winter and summer and decreasing during monsoon, which is similar to this present study. Prabhakar *et al.*, (2009) observed high primary productivity in winter and low in monsoon from the Khadakwasla reservoir of Pune.

The present study also showed that community respiration was higher in summer, which is coincided to the study of Stuart and Ueland, (2017) found that the reason for this is likely due to higher amount of decomposition and water temperature, because it can be assumed that the decomposition rate becomes higher with the increase of temperature. Also, the highest productivity in summer could be due to sufficient sunlight, temperature, and photoperiod. Similarly, the organic matter entering the riverine system cannot be ruled out which resulted because of increasing demand of oxygen for the oxidation of organic matter. The temperature affects seasonal variations of the primary productivity of a lake stated by the previous investigators (Sontakke and Mokashe, 2014) agreed with the present study. Sontakke and Mokashe (2014) found minimum gross and net primary productivity in monsoon, and maximum in summer at Mombatta and in winter at Kagzipura Lake, Maharashtra, India which is very close to the values obtained in the present study.

CONCLUSION

Primary productivity is an ultimate outcome of photosynthesis that forms the basis of ecosystem functioning. An overview of the result obtained in this study revealed that the maximum primary productivity observed in Summer season and the lowest in Rainy season. The studyalso concluded that,highest primary productivity was found at Meghna river and lowest primary productivity was found at Andermanik River.

Acknowledgment

It is also a great pleasure for the investigators to express their sincere and deep sense of gratitude and indebtedness to Bangladesh Fisheries Research Institute (BFRI) for providing financial support. The investigators also express their profound indebtedness and sincere gratitude to the Director General of Bangladesh Fisheries Research Institute (BFRI), Mymensingh for his continuous support, encouragement and kind cooperation to carry out this research works.

REFERENCE

Ahmed, K.K.U., Ahmed, S.V., Halder G.C., Hossain, M.R.A., & Ahmed, T.S. (2005). Primary production and fish yield estimation in the Meghana River system, Bangladesh. *Asian Fisheries Science, 18,* 95–105.

Babar, H.T., & Raje G.B. (2015). Primary productivity study of Morawane dam in Ratnagiri district of Maharashtra, India. *J Global BioSci, 4*(2), 1430-1438.

Bhouyain, M. A., & Sen H. (1983). Primary production of Foy's Lake, Chittagong, Bangladesh. I*n 8. Bangladesh Science Conference, Dhaka (Bangladesh).*

Bishnoi, R.K., Sharma, B.K., Durve, V.S., & Sharma, L.L. (2013). Primary Productivity in relation to Planktonic Biodiversity in a Stretch of Gang Canal (Rajasthan). *Universal Journal of Environmental Research and Technology, 3*(2), 266-272.

Deka P. (2017). An assessment on the primary productivity of two fresh water aquaculture ponds at Guwahati with reference to physicochemical parameters. *Int J of Fauna and Biological Stu, 4*(2), 101-10.

Gaarder, T., & Gran, H.H. (1927) Investigation on the production of plankton in the Oslo Fjord, P-V Reun. Commn. *Inter. Explor. Sci, Mer. Medieterr., 42,* 1-48.

Guildford, S.J., & Hecky, R. E. (2000). Total nitrogen. Total phosphorus, and nutrient limitation in lakes and oceans: Is there a common relationship? *Limnology and Oceanography 45,* 1213-1223.

Koli, V.K., & Mohan, R.M. (2011). Physicochemical Status and Primary Productivity of Ana Sagar Lake, Ajmer (Rajasthan), India. *Universal J Environ Res and Tech 1*(3), 286-292.

Mitsch, W. J., & Gosselink, J. G. (2015). Wetlands. John Wiley & Sons. A study of primary productivity of Clear Lake, California. *Ecology, 44,* 283–294

Mohanty, S.S., Pramanik, D.S., & Dash, B.P. (2014). Primary Productivity of Bay of Bengal at Chandipur in Odisha, India. *International Journal of Scientific and Research Publications, 4*(10), 1-6.

Odum, E.P. (1971). Fundamentals of Ecology, 3rd Ed. W.B. Saunders Company, Philadelphia, 574.

Ogbuagua, D.H. & Ayoade, A.A. (2011). Estimation of primary production along gradients of the middle course of Imo River in Etche, Nigeria. *International Journal of Biosciences, 1*(4), 68-73.

Prabhakar, V.M., Vaidya, S.P., Garud, V.S., & Swain, K.K. (2009). Trend in Primary Production in Khdakwasla Reservoir. 13th World Lake Conference, Wuhan, China.

Radwan, A.M. (2005). Some Factors Affecting the Primary Production of Phytoplankton in Lake, Burulus. *Egyptian J Aquatic Res, 31*(2),72-88.

Pralhad, R.R., Chavan, B.B.R., & Pai, R.K. (2016). Variation in Primary Production in Relation to Physicochemical parameters of Kadwai Reservoir, Ratnagiri, Maharashtra, India. *Current World Environ, 11*(1), 228-232.

Saha, T., Manna, N. K., Majumder, S. S., & Bhattacharya, I. N. (2001). Primary Productivity of the Subhas Sarobar Lake in East Calcutta in Relation to Some Selected Physico-Chemical Parameters. *Pollution Research, 20*(1), 47-52.

Simmons, J.A., Long, J.M., & Ray, J.M. (2004). What limits the productivity of acid mine drainage treatment ponds? *Mine Water and the Environment, 23,* 44-53.

Sontakke, G.K., & Mokashe, S.S. (2014). Seasonal variation in primary productivity of two freshwater lakes of Aurangabad district, Maharashtra, India, *International Journal of Fauna and Biological Studies, 1*(6), 07–10.

Stuart, B. H., & Ueland, M. (2017). Decomposition in aquatic environments. Taphonomy of Human Remains: Forensic Analysis of the Dead and the Depositional Environment: Forensic Analysis of the Dead and the Depositional Environment, 235-250.

Talling, J. F. (1957). Diurnal changes of stratification and photosynthesis in some tropical African waters. Proceedings of the Royal Society of London. *Series B-Biological Sciences, 147*(926), 57–83.

Thomas, P.A., Abraham, T. & Abraham, K.G. (1980) Observation on the primary productivity of Sasthamkotta lake: 1-7. In: Alexender, K.M. *et al.* (eds.) Proc. Symp. Environ. Biol. Trivandram.

Vaillancourt, R.D., Marra, J. and Barber R. T. (2003). Primary productivity and in situ quantum yields in the Ross Sea and Pacific Sector of the Antarctic Circumpolar Current. *Deep-Sea Res., 11*(50), 559-578.

Vollenweider, R.A. (1969) A Manual on Methods for Measuring Production in the Aquatic Environments. IBP, Hand Book 12, Blackwell Scientific Publications, Oxford, *England., 138,* 465- 482.

Yeragi, S.G., & Shaikh, N. (2003) Studies on primary productivity of Tansa river. *J. Natcon 15,* 125-130.