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An assessment on the primary productivity of two fresh water aquaculture ponds at Guwahati with reference to physicochemical parameters

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Abstract
The variation of primary productivity in terms of NPP, GPP and CRV of water was studied at two fresh water aquaculture ponds named as Pond A, a manually managed pond (surface area 1.4 hac) with the application of lime and fertilizers and Pond B (surface area 0.5 hac), a natural pen culture pond recovered from a part of swamp located at Gauhati University Campus, Guwahati, Assam, India (latitude $26^0 09^/ 26^{//}$ N and longitude $91^0 40^/ 21^{//}$ E). In both the ponds comparatively high density of plankton were recorded in monsoon season of the study period with a luxuriant growth of *Microcystis aeruginosa* during late monsoon to early autumn in Pond A. The differences of water temperature between the two studied aquaculture ponds are not well marked, however, the water temperature of Pond B is always observed lower than that of the Pond A. The water of Pond A is found to be more alkaline than the Pond B. A normal range of fluctuation in DO, FCO_2, TA and TH of water in both the ponds is maintained throughout the study period. During the investigations period, the experimental values of GPP, NPP, CRV show more or less a normal trend where GPP and NPP of the studied ponds indicates bimodal pattern of increase showing lower value in rainy monsoon season and higher during pre-monsoon summer months. The CRV of Pond A shows two prominent winter and autumn peaks followed by a lean period in summer and monsoon whereas in Pond B does not show prominent peak but exhibits the lowest profile in June of investigation period.

Keywords: primary productivity, GPP, NPP, CRV manually managed pond, pen culture pond

1 Introduction

Primary productivity is defined as the rate at which organic matter is created by producer in an ecosystem whereby low energy inorganic carbon is converted to high energy organic carbon form. The chlorophyll bearing microscopic organisms such as phytoplankton, periphyton and macrophytes serve as primary producers in an aquatic food chain system and thus act as a keystone species in the ecosystem. Primary producers produce a wide range of organic compounds during photosynthesis and release oxygen as a byproduct to the surrounding waters. Primary producer also fixes the energy of the sunlight while driving the flow of energy to the higher trophic level. In other word the rate at which this energy accumulates as a result of photosynthesis is called primary productivity. In any water system the rate of organic carbon fixed through the chlorophyll bearing phytoplankton provided the basic information for assessing the productive function of the system (Odum, 1971 [11])

A number of environmental factor controls the rate of photosynthesis which determines the productivity of an ecosystem. For Thornton *et al.*, 1990 [17], two primary factors controlling productivity are light and nutrient availability. Apart from the nutrient factors and light, seasonality and climatological parameters like air temperature, rainfall, relative humidity, sunshine hours, clouds of the sky etc. also influence the quality of water, thus influencing the primary productivity through phytoplankton growth. Romaire and Boyd, 1979 [13] showed that cloudy days cause a decrease in photosynthetic rates.

In view of the importance of primary productivity in freshwater ecosystem in relation with physicochemical parameters, the present work has been carried out in two aquaculture pond at Gauhati University Campus, Guwahati, Assam.

2. Materials and Methods

2.1 Study site: The present work deals with the monthly fluctuation of Net Primary Productivity (NPP), Gross Primary Productivity (GPP) and Community Respiration Value

(CRV) of water in two fresh water aquaculture ponds named as Pond A (manually managed pond with the application of lime and inorganic and organic fertilizers) and Pond B (natural pen culture pond, recovered from a part of swamp without addition of any fertilizer) located at Gauhati University Campus, Guwahati, Assam, India (latitude of $26^0 09^{/} 26^{//}$ N and longitude of $91^0 40^{/} 21^{//}$ E). The natural pond is reclaimed from the part of perennial swamp by bamboo screen. Pond A is with a surface area of 1.4 hac which is triangular in shape and pond B is rectangular sized pond with a surface area of 0.5 hac (Deka and Goswami, 2011 [2]). Three sides of the Pond B are completely surrounded by swamp. In both the ponds comparatively high density of plankton were recorded in monsoon season of the year (Deka and Goswami, 2015 [3]) along with high rainfall which is common in Assam.

2.2. Sampling: For the study of physicochemical parameters of water, the samples were collected weekly from November 2007 to October 2008 from both surface and bottom layers of the randomly selected spots following the sampling procedure of Jhingran *et al*., 1969 [6]. The surface and bottom samples were mixed to estimate the physicochemical parameters of water. The water samples were collected in the morning between 8.00 A.M. and 8.30 A.M. The parameters were analysed at the laboratory of Zoology Department, Pandu College following "Standard Methods for Examination of Water and waste Water", A.P.H.A., 1988 [1] and "Manuals on Water and Waste Water Analysis", N.E.E.R.I., 1989 [10]. To study the Physico-chemical properties of water, the most significant parameters like water temperature p^H, Dissolved oxygen, free carbon dioxide, total alkalinity as $CaCO_3$, total hardness as $CaCO_3$. The Pond A is encountered with a luxuriant growth of *Microcystis aeruginosa*, a phytoplankton during late monsoon to early autumn of the present study.

The Net Primary Productivity (NPP), Gross Primary Productivity (GPP) and Community Respiration Value (CRV) were estimated following light and dark bottle method of Gaarder and Gran, 1927 [5]. In the experiment, two sets of bottles were prepared, having a light bottle (LB) and a dark bottle (DB) in each set. The darkened bottles were prepared by black painting followed by wrapping with aluminium foil to make the bottles 100% light proof. The light and dark bottles sets were fixed at two different depths of the euphotic zones measured by Sacchi disc. Of the two sets, one set was placed just beneath the surface of water while other at the point of just disappearance of Sacchi disc. All the experimental sets were set off in the morning hours at 8.30 A.M. and allowed to incubate up to 12.30 P.M. i.e. for 4 hours. The dissolved oxygen values of both sets of bottles were recorded at the beginning of the experiment and after four hours of solar incubation.

3. Results: The observed variation in some of the important physicochemical parameters of the water of two pond ecosystems is depicted in the Table-1 citing their respective range, yearly average value and Standard Deviation (SD).

The seasonal variations of water temperature in the studied ponds are depicted in Table-1. The differences of water temperature between the two studied aquaculture ponds are not well marked as the lowest value remains between 18.8 ºC in Pond B against 19.5 ºC in Pond A while the highest remains between 33.5 ºC in Pond B and 31.8 ºC in Pond A. However, the water temperature of Pond B is always observed lower than that of the Pond A. The water temperature shoots up to the highest in June and the lowest in January during the study period has been observed in both the ponds.

The value of p^H shows a fluctuating range between mild acidic (6.75) and alkaline (8.74) in Pond A showing its average of 8.05±0.42 whereas in Pond B the range of variation lies between acidic (6.15) and mild alkaline (7.55) with an average of 6.77±0.53. The water of Pond A is found to be more alkaline than the Pond B.

The trends of Dissolved oxygen concentration (DO) in the two studied ponds exhibits a wide range of fluctuation in both the ponds; but the range of Pond A is higher (6.15 to 12.65 $mg.l^{-1}$ with an average of 8.94±2.04) than Pond B (4.5 to 7.05 $mg.l^{-1}$ with an average of 5.58±0.94).

The Free CO_2 (FCO_2) concentration in the two ponds has been found in the ranges from 0 to 5.5 $mg.l^{-1}$ ($\bar{x}$=2.99±0.98) in Pond A and from 5.0 to 10.5 $mg.l^{-1}$ ($\bar{x}$=7.73±1.75) in Pond B. However, Pond B always contains FCO_2 throughout all seasons of the year but in winter and monsoon season, FCO_2 is found absent in Pond A.

The total alkalinity (TA) trend of water in the studied ponds during the study period exhibit higher range in Pond B (57.5 to 91.0 $mg.l^{-1}$ with an average of 75.87±10.49) than the Pond A (61.5 to 82 $mg.l^{-1}$ with an average of 66.93±7.26). However, phenolphthalein alkalinity is observed to be absent in Pond B throughout the study period. Indeed, the Pond A experiences the P-alkalinity in certain months of winter and monsoon seasons is interesting.

The total hardness as $CaCO_3$ (TH) fluctuates from 58.5 to 79 $mg.l^{-1}$ ($\bar{x}$=68.68±5.91) in Pond A and 53.5 to 79.5 $mg.l^{-1}$ ($\bar{x}$=65.98±8.46) in Pond B.

Table 1: Physicochemical parameters of water in Pond A and Pond B showing the ranges, averages and Standard Deviation (SD).

Parameters	Pond	Range	Average	SD
Water temperature (^{0}C)	Pond A	18.8 to 31.8	25.21	3.55
	Pond B	19.5 to 33.5	27.4	4.24
p^H	Pond A	6.75 to 8.74	8.05	0.42
	Pond B	6.15 to 7.55	6.77	0.53
Dissolved oxygen ($mg.l^{-1}$)	Pond A	6.15 to 12.65	8.94	2.04
	Pond B	4.5 to 7.05	5.58	0.94
Free Carbon dioxide ($mg.l^{-1}$)	Pond A	Nil to 5.5	2.99	0.98
	Pond B	5.0 to 10.5	7.73	1.75
Total alklinity as $CaCO_3$ ($mg.l^{-1}$)	Pond A	61.5 to 82.0	66.93	7.26
	Pond B	57.5 to 91.0	75.87	10.49
Total hardness as $CaCO_3$ ($mg.l^{-1}$)	Pond A	58.5 to 79	68.68	5.91
	Pond B	53.5 to 79.5	65.98	8.46

During the investigations period, the average Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community Respiration Value (CRV) of Pond A are recorded as 53.30±14.09, 38.69±12.08 and 14.61±5.07 respectively. In Pond B it is, however, recorded as 51.05±17.37, 36.79±17.82 and 14.28±3.36. The experimental values of GPP, NPP and CRV show more or less a normal trend as shown in Figure-1 to 3. The detailed data of primary production is depicted in Table-2.

On the basis of investigations, the GPP (Figure-1) of the studied ponds indicates bimodal pattern of increase showing lower value in rainy monsoon season and higher during pre-monsoon summer months. GPP of Pond A shows the highest value during late monsoon to early autumn, which results in higher productivity of the pond. It is interesting to note that the GPP of Pond A exhibits more or less stable conditions throughout the year excepting somewhat lower value in the months of June and October.

Concomitantly, the highest value of NPP is observed in the month of October, 2008 in Pond A and September, 2008 in Pond B. During the investigation period, NPP of Pond A exhibits no prominent peak period, rather it shows an interesting minima in the month of June, while the Pond B shows bimodal pattern of fluctuation exhibiting its first peak in autumn followed by a lean period in winter and second prominent peak in summer followed by the second lean period in monsoon. During last part of the investigation period i.e in autumn a very prominent peak is observed contributing to the highest NPP value in Pond A.

The community respiration value (CRV) of Pond A shows two prominent winter and autumn peaks followed by a lean period in summer and monsoon during observation period The CRV of Pond B does not show prominent peak but exhibits the lowest profile in June of investigation period.

Table 2: Gross Primary Production (GPP), Net Primary Production (NPP) and Community Respiration values (CRV) expressed as $g.C.m^{-3}.month^{-1}$ in pond A and pond B (Nov 2007-Oct 2008)

Month	Pond A			Pond B		
	GPP	**NPP**	**CRV**	**GPP**	**NPP**	**CRV**
Nov	42.82	31.21	11.61	55.39	45.89	9.5
Dec	53.45	39.45	14.0	38.44	19.86	18.58
Jan	54.81	30.47	24.34	32.47	17.37	15.1
Feb	59.84	38.56	21.28	27.54	13.98	13.56
Mar	49.21	33.94	15.27	39.54	23.79	15.75
Apr	60.16	50.89	9.27	58.49	41.56	16.93
May	54.77	40.97	13.8	66.43	48.0	18.43
Jun	24.4	15.02	9.4	41.29	33.79	7.75
Jul	60.12	46.54	13.58	44.6	31.03	13.58
Aug	64.97	52.36	12.61	48.48	32.0	16.48
Sep	78.83	57.71	21.11	79.8	65.69	14.1
Oct	36.2	27.15	9.1	80.16	68.52	11.64
Average	53.30	38.69	14.61	51.05	36.79	14.28
SD	14.09	12.08	5.07	17.37	17.82	3.36

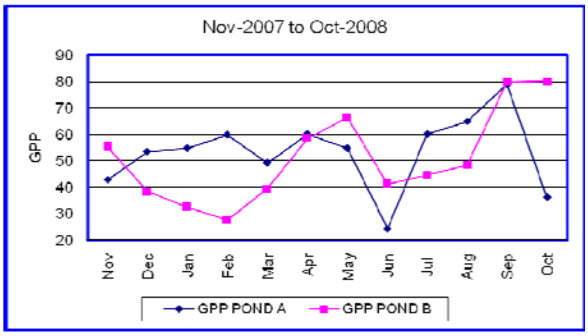

Fig 1: Monthly variation of GPP ($g.C.m^{-3}.month^{-1}$) in Pond A and Pond B

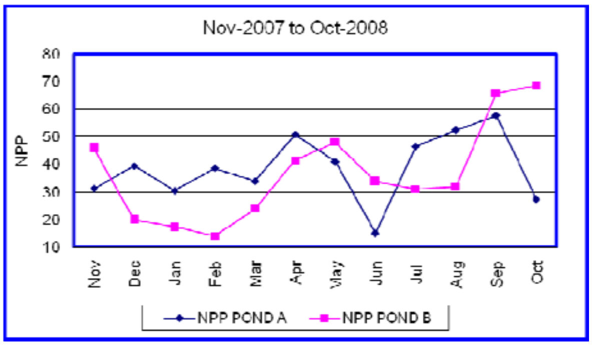

Fig 2: Monthly variation of NPP ($g.C.m^{-3}.month^{-1}$) in Pond A and Pond B

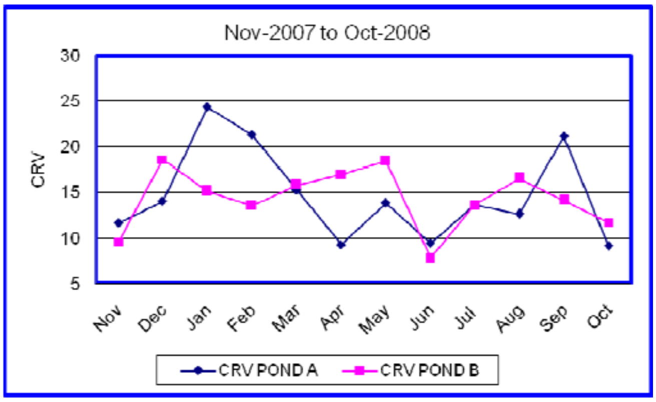

Fig 3: Monthly variation of CRV ($g.C.m^{-3}.month^{-1}$) in Pond A and Pond B

4. Discussion

The primary productivity of a water body is a function of autotrophs associated with utilization of radiant energy. The solar energy that required for biological activities is first converted to chemical energy by the process of photosynthesis primarily executed by phytoplankton and macrophytes.

The gross primary productivity (GPP) of the studied ponds is found to be higher than those of other lentic waters in India (Sreenivasan, 1964 [15]; Mathew, 1975 [9]; Singh and Desai, 1980 [14]; Lahon, 1983 [8]; Rajbongshi *et al.*, 2016 [12]). The

GPP in both Pond A and Pond B of the present study indicates bimodal pattern due to interruption of the heavy monsoon rainfall in Assam. The Pond A is encountered by a luxuriant growth of *Microcystis aeruginosa* during late monsoon to early autumn, which results in higher GPP in the studied pond at that time. Higher growth of algal biomass results in higher primary productivity (Ganpati and Kulkarni, 1973 [4]; Talling *et al.*, 1973 [16]; Wassink, 1975 [19]). During the present study, the maximum value of GPP and NPP is observed during summer and subsequently the lower values during rainy season which corresponds to the intensity of light energy. Lower rate of primary production during rainy season is the result of limitation of sunshine period and low light energy due to interruption of clouds. Subsequently, the dilution effect of rain on phytoplankton density and as well as the increased in allochthonous turbidity from nearby area are prime causes of lowering primary productivity during rainy season.

However, primary productivity of Pond A is more static throughout the year, whereas Pond B shows higher fluctuation. This may be due to fluctuation of physico-chemical parameters (Table-1) results from the shallowness and smaller surface area in Pond B.

5. Acknowledgement

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