

An Assessment of the Primary Productivity of Two Freshwater Aquaculture Ponds at Hajipur, Vaishali, 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 6 acre) with the application of lime and fertilizers and Pond B (surface area 4 acre), a natural pen culture pond recovered from a part of swamp located at Hajipur, Vaishali, Bihar. In both ponds, a comparatively high density of plankton was recorded in the monsoon season of the study period, with a luxuriant growth of *Microcystis aeruginosa* during late monsoon to early autumn in Pond A. The differences in water temperature between the two studied aquaculture ponds are not well marked; however, the water temperature of Pond B is always observed to be lower than that of Pond A. The water of Pond A is found to be more alkaline than that of Pond B. A normal range of fluctuation in DO, FCO₂, TA, and TH of water in both ponds is maintained throughout the study period. During the investigation period, the experimental values of GPP, NPP, and CRV show more or less a normal trend where GPP and NPP of the studied ponds indicate a bimodal pattern of increase, showing lower values in the rainy monsoon season and higher values 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 Pond B does not show a prominent peak but exhibits the lowest profile in June of the investigation period.

Key points: primary productivity, GPP, NPP, CRV, manually managed pond.

1. Introduction

Primary productivity is defined as the rate at which organic matter is created by producers 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 levels. In other words, the rate at which this energy accumulates as a result of photosynthesis is called primary productivity. In any water system, the rate .If organic carbon fixed through the chlorophyll-bearing phytoplankton provided the basic information for assessing the productive function of the system (Odum, 1971)

A number of environmental factor controls the rate of photosynthesis, which determines the productivity of an ecosystem. For Thornton et al. (1990), 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. Romaine and Boyd (1979 [13]) showed that cloudy days cause a decrease in photosynthetic rates.

In view of the importance of primary productivity in freshwater ecosystems in relation to physicochemical parameters, the present work has been carried out in two aquaculture ponds at Hajipur, Vaishali, Bihar.

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, recovered from a part of swamp without addition of any fertilizer) located at Hajipur, Vaishali, Bihar (latitude of 26°09'26" N and longitude of 91°40'21" E). The natural pond is reclaimed from a part of the perennial swamp by a bamboo screen. Pond A has a surface area of 6 acres, which is triangular in shape, and Pond B is a rectangular-sized pond with a surface area of 4 acres. Three sides of Pond B are completely surrounded by swamp. In both ponds, a comparatively high density of plankton was recorded in the monsoon season of the year (Deka and Goswami, 2015) along with high rainfall, which is common in Bihar.

2.2. Sampling: For the study of physicochemical parameters of water, the samples were collected weekly from November 2023 to October 2024 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 the 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 Chemistry Department, R.N College hajipur following "Standard Methods for Examination of Water and waste Water", A.P.H.A.. 1988 and "Manuals on Water and Waste Water Analysis", N.E.E.R.1., 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 the 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 the light and dark bottle method of Gaarder and Gran, 1927, 131. 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% lightproof. The light and dark bottle sets were fixed at two different depths of the euphotic zones, measured by the Sacchi disc. Of the two sets, one set was placed just beneath the surface of water, while the other was at the point of just disappearance of the 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

They 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

The physicochemical parameters of the water of two pond ecosystems are depicted in 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 in water temperature between the two studied aquaculture ponds are not well marked, as the lowest value remains between 18.8 °C in Pond B and 19.5 °C in Pond A, while the highest remains between 33.5 °C in Pond B and 31.8 °C in Pond A. However, the water temperature of Pond B is

always observed to be lower than that of Pond A. The water temperature shoots up to the highest in June and the lowest in January during the study period, as observed in both ponds.

The value of pH shows a fluctuating range between mildly 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 that of Pond B.

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

The Free CO (FCO₂) concentration in the two ponds has been found in the range from 0 to 5.5 mg/l (-2.99 ± 0.98)

in Pond A and from 5.0 to 10.5 mg/l (-7.73 ± 1.75) in Pond B. However, Pond B always contains FCO, throughout all seasons of the year, but in winter and monsoon season, FCO₂ is found absent in Pond A.

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

The total hardness as CaCO (TH) fluctuates from 58.5 to 79 mg/l (68.68 ± 5.91) in Pond A and 53.5 to 79.5 mg/l (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	Ranges	Average	SD
Water temperature (°C)	Pond A	18.8 to 31.8	25.21	3.55
	Pond B	19.5 to 33.5	27.4	4.24
p ⁿ	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)	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. ¹)	Pond A	Nil to 5.5	2.99	0.98
	Pond B	5.0 to 10.5	7.73	1.75
Total alkalinity as CaCO ₃ (mg. 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. ¹)	Pond A	58.5 to 79	68.68	5.91
	Pond B	53.5 to 79.5	65.98	8.46

During the investigation 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 Figures 1 to 3. The detailed data of primary production are depicted in Table 2.

On the basis of investigations, the GPP (Figure 1) of the studied ponds indicates a bimodal pattern of increase, showing a lower value in the rainy monsoon season and a higher value 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, except for somewhat lower values in the

Months of June and October.

Concomitantly, the highest value of NPP is observed in October, 2023 in Pond A and September, 2024 in Pond B. During the investigation period, NPP of Pond A exhibits no prominent peak period, rather it shows an interesting minima in 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 the last part of the investigation period, ie, 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 the observation period. The CRV of Pond B does not show a prominent peak but exhibits the lowest profile in June of the investigation period.

Table 2: Gross Primary Production (GPP), Net Primary Production (NPP), and Community Respiration values (CRV) expressed as g.C.m month in pond A and pond B (Nov 2023-Oct 2024)

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	33.96	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.month) in Pond A and

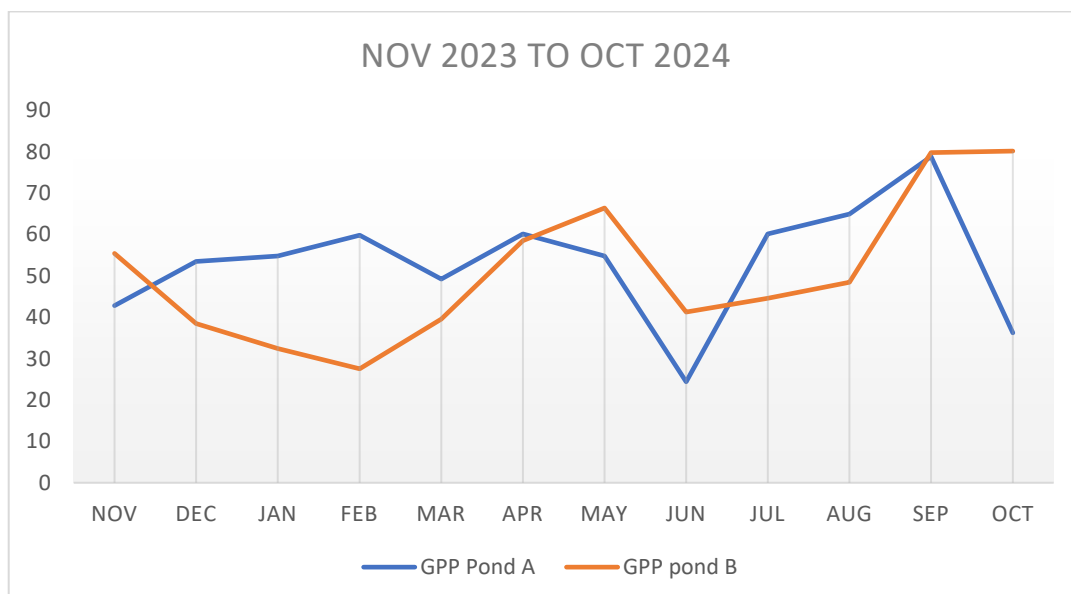
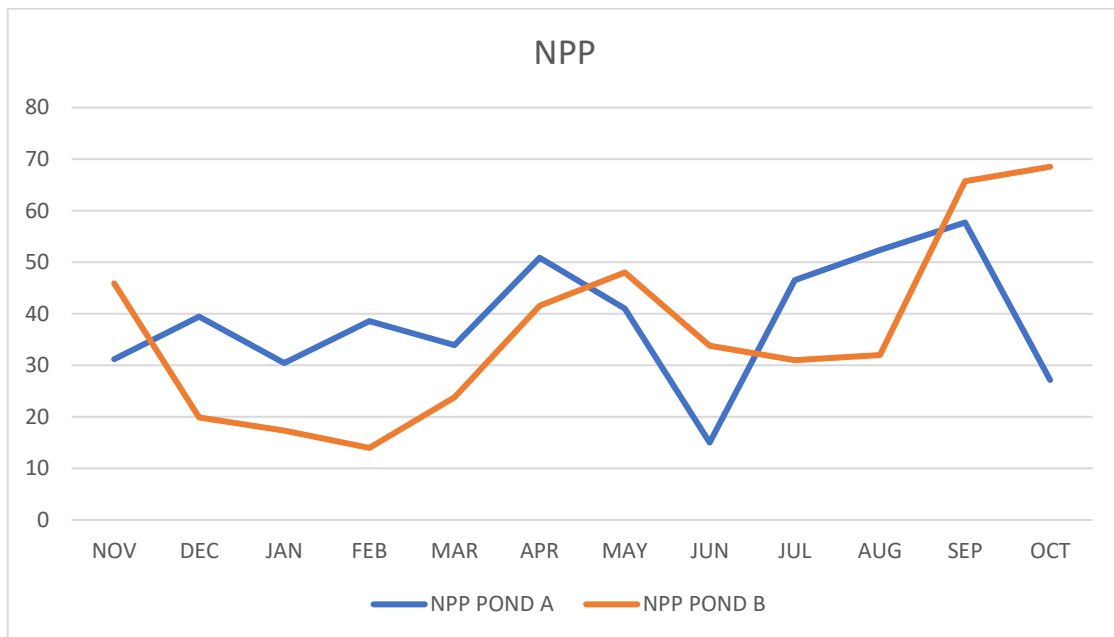
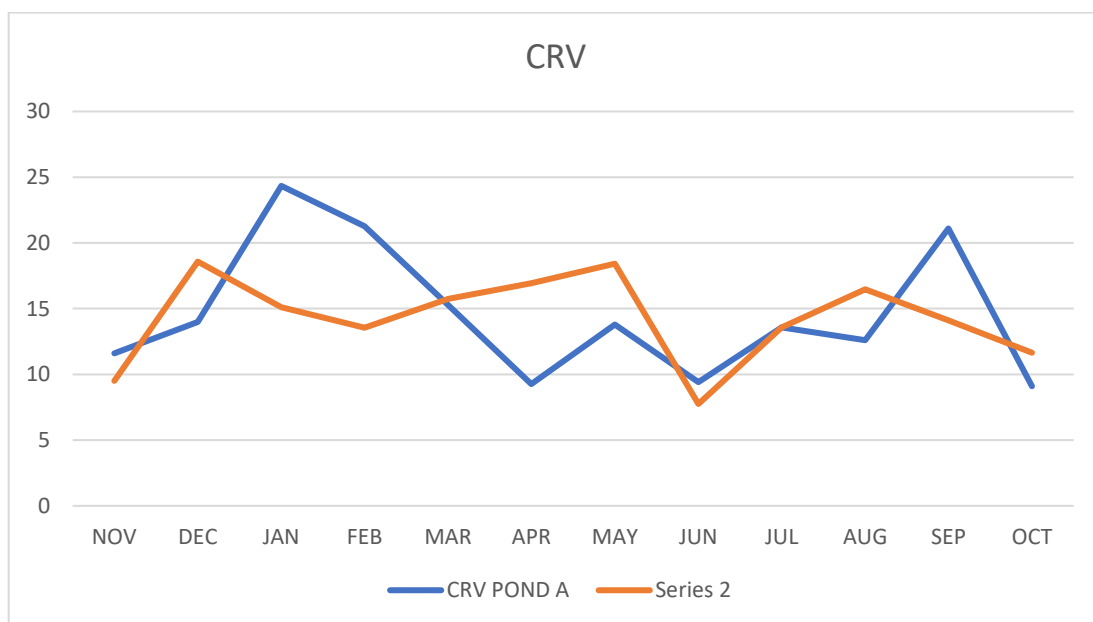


Fig 2: Monthly variation of NPP (g.C.m³ month) in Pond A and Pond BFig 3: Monthly variation of CRV (g C.m³.month) in Pond A and Pond B

4. Discussion

The primary productivity of a water body is a function of autotrophs associated with the utilization of radiant energy. The solar energy 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 that of other lentic waters in India (Sreenivasan, 1964, 1151; Mathew, 1975, 19; Singh and Desai, 1980, 1141; Lahon, 1983; Rajbongshi et al., 1121), тб

GPP in both Pond A and Pond B of the present study indicates a bimodal pattern due to the interruption of the heavy monsoon rainfall in Bihar. 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, 14; Talling et al., 1973, 1167; Wassink, 1975, 1191). During the present study. The maximum value of GPP and NPP is observed during summer, and

subsequently the lower values during the rainy season, which corresponds to the intensity of light energy. Lower rate of primary production during the rainy season is the result of the limitation of the sunshine period and low light energy due to the interruption of clouds. Subsequently, the dilution effect of rain on phytoplankton density, as well as the increase in allochthonous turbidity from the nearby area, are prime causes of lowering primary productivity during the rainy season.

However, the 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), which results from the shallowness and smaller surface area in Pond B.

6. References

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