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Estimation of Primary Productivity of Aquaculture Ponds with Special Reference to Duration of Desilting

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ABSTRACT

The present study was taken to assess the impact of pond age and water quality on the primary productivity of an ecosystem. Three stocking ponds A, B and C were selected for a period of three months from September to November, 2016 from the Instructional Fish Farm of College of Fisheries, Pantnagar on the basis of their age and last renovation. The different physico-chemical parameters like temperature, pH, Dissolved Oxygen (DO) and Total Dissolved Solids (TDS) were analyzed and found in optimum range during the study period. Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community Respiration (CR) were analyzed for the estimation of primary productivity. The value of GPP (mg C/m^3/h), NPP (mg C/m^3/h) and CR (mg C/m^3/h) of pond A ranged between 67.12 to 81.17, 45.30 to 57.81 and 21.82 to 23.36 respectively. The value of GPP, NPP and CR of pond B ranged between 94.43 to 109.74, 69.98 to 80.88 and 24.45 to 28.86, respectively. The value of GPP, NPP and CR of pond C ranged between 64.89 to 67.60, 40.86 to 41.45 and 24.03 to 26.15 respectively. The results suggested that pond B had better primary productivity followed by pond A and pond C.

Keywords: Gross Primary Productivity, Nutrients, Primary productivity and Renovation etc.

INTRODUCTION

The productivity of the aquatic ecosystem depends on various parameters like physicochemical characteristics of the water, the presence of the primary producers and its consumers. The primary producers of the aquatic ecosystems are phytoplankton, periphyton and macrophytes (Deka, 2017). 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). The study of the primary productivity helps to understand the water quality, food chain, food web and the productivity of the ecosystem. The productivity depends on several factors like the density of the primary producers, nutrient availability, water temperature, sunlight, *etc*. The abiotic and biotic components of the aquatic ecosystems are directly related to each other and the biological productivity helps to determine the trophic status as well as production potential of the ecosystem. Sometimes the study of the primary productivity also helps to understand the pollution status of the aquatic ecosystem. In any aquatic ecosystem either natural or manmade, the production directly depends on the physicochemical factors and if they are favorable, it leads to higher production (Sultan *et al*, 2003). Lots 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). The important relationship for estimating the productivity in an ecosystem is carbon fixation and oxygen evolution (Dash *et al*, 2011). The radiant energy stored in the producer is transferred to higher trophic level as

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Table 1. Physico-chemical parameters of ponds during the study period (Mean±SD).

Month	Temperature (°C)	pH	Dissolve Oxygen (mgl^{-1})	Alkalinity (mgl^{-1})	Total Dissolve Solids (mgl^{-1})
			Pond A		
September	30.56±0.44	7.8±0.46	6.1±0.21	79.83±0.89	161.41±0.87
October	26.5±.90	7.8±0.28	6.2±0.85	75.30±0.78	185.30±1.13
November	23.1±0.43	7.9±0.08	5.8±0.15	72.50±0.76	195.60±.95
			Pond B		
September	30.08±0.58	8.0±0.32	6.4±0.25	81.30±0.79	150.58±0.89
October	26.5±0.89	8.1±0.20	6.5±0.85	79.80±0.53	164.30±0.67
November	23.1±0.33	7.9±0.18	5.6±0.15	76.56±.67	168.60±0.76
			Pond C		
September	30.6±0.75	7.9±0.42	6.3±0.48	75.89±0.68	98.89±0.78
October	26.01±0.94	8.1±0.16	6.5±0.69	74.68±0.76	103.69±0.93
November	23.1±0.43	7.9±0.20	5.6±0.45	72.89±.45	125.89±0.81

a food material at the time of primary production (Alom and Zaman, 2005).

The productivity of the aquatic ecosystem also depends on the age of the water body. Newly formed or oligotrophic water body has less productivity as compared to the older ones (mesotrophic and eutrophic). The estimation of primary productivity of an aquatic ecosystem is of great importance for fisheries management as it helps to understand the food chain and food web relationship that prevails in the ecosystem. By considering the importance of the primary productivity in an aquatic ecosystem, the present study was done in the water which is geographically located at 29° N latitude, 79.3° E longitude and an altitude of 243.3 m above Mean Sea Level (MSL), in Tarai belt of Shivalik range of Himalaya at the College of Fisheries, Pantnagar to understand the production and the relation of productivity with the physico-chemical parameters.

MATERIALS AND METHODS

The present study was carried out for the duration of three months from September to November, 2016. The sampling was done weekly from the selected sampling sites for the analysis of physico-chemical characteristics and primary productivity. Three ponds were selected on the basis of their age and last renovation. Pond A was desilted four years ago (2012), pond B was desilted two years ago (2014) and Pond C in the same year (2016). The physico-chemical parameters to be studied were water temperature, pH, dissolved oxygen, alkalinity and Total Dissolved Solids (TDS). Water temperature and TDS was measured using TDS and temperature meter (HM Digitals) and others were measured following APHA (2012). The primary productivity *i.e.* Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community respiration (CR) were calculated with the help of light and dark bottle method. Initial oxygen was taken at the time of sampling and the values of light bottle oxygen and dark bottle oxygen were taken after the incubation time of four hours. The value of GPP, NPP and CR was estimated by using the formula and the dissolved oxygen values are converted into carbon values by multiplying with a factor of 0.375 (Sharma, 2000).

GPP (mg $C/m^3/h$) = LO-DO x 0.375 x 1000/T x PQ

NPP (mg $C/m^3/h$) = LO-IO x 0.375 x 1000/T x PQ

CR (mg $C/m^3/h$) = GPP-NPP

Table 2. GPP, NPP and CR values expressed as mgC/m^3/h of ponds (Mean±SD)

Month	Pond A			Pond B			Pond C		
	GPP	NPP	CR	GPP	NPP	CR	GPP	NPP	CR
September	67.12± 2.23	45.30± 2.15	21.82± 2.12	94.43± 3.67	69.98± 3.25	24.45± 3.18	64.89± 1.68	40.86± 1.43	24.03±1.45
October	81.17± 3.15	57.81± 2.98	23.36± 2.76	109.74± 2.89	80.88± 2.78	28.86± 2.65	67.60± 1.78	41.45± 1.45	26.15±1.34
November	70.96± 2.67	49.12± 2.54	21.85± 2.54	95.05± 3.56	70.45± 3.12	24.60± 3.21	66.65± 1.65	41.35± 1.38	24.30± 1.23

Where

IO= Initial concentration of dissolved oxygen (mgl^{-1})

LO and DO= Dissolved Oxygen concentration in light and dark bottle after exposure (mgl^{-1})

T = Time (hours)

P.Q. = Photosynthetic Quotient (1.2)

RESULTS AND DISCUSSION

The water quality parameters of selected ponds are given in Table 1. It was observed that water temperature was highest in the month of September in all the three selected ponds and lowest in the month of November. The value of pH showed alkaline condition in all the three ponds with range of 7.8 to 8.1. For the better growth of plankton, the pH value is very important (Chisty, 2002). Umavathi *et al.* (2007) observed that pH ranges from 5 to 8.5 is good for plankton growth and if the value is higher than 8.8, is harmful to the growth of the plankton. The value of dissolved oxygen (DO) was in range of 5.3-6.8 mgl^{-1} in all the selected ponds. The dissolved oxygen value showed that DO of all the three ponds was good for the growth of the fishes as well as the other aquatic organisms. Ramachandra and Solanki (2007) observed that DO below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to fish mortality. The alkalinity decreased from September to November in all the three ponds and may be due to the dilution of water in the monsoon season. Rajashekhar *et al*, (2007) reported that the total alkalinity value was maximum during the pre-monsoon and minimum during the post-monsoon months. The Total Dissolve Solids (mgl^{-1}) was highest during the month of November while lowest in the month of September in all the three ponds A, B and C respectively. The maximum value of Total Dissolved Solids (TDS) was 195.60±.95 mg/l, 168.60±0.76 mg/l and 125.89±0.81 mg/l whereas minimum value was 161.41±0.87 mg/l, 150.58±0.89 mg/l and 98.89±0.78 mg/l in pond A, B and C respectively. It was observed that the TDS value was higher in pond A as compared to others, which may be due to the accumulation of the organic materials into the water body. The value of TDS was in optimum range for the production of the pond ecosystem.

The monthly variation in Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community Respiration (CR), are given in Table 2. The GPP, NPP and CR were highest in October in all the ponds. The maximum value of GPP was found in pond B (109.74 mgC/m3/h) followed by A and C. The maximum value of NPP also showed the same trend. The value of CR (mgC/m^3/h) was 23.36, 28.86 and 26.15 in pond A, B and C respectively. The GPP, NPP, and CR values were found maximum in pond B followed by pond C and pond A throughout the study. The maximum productivity was observed in October followed by November and September in all three ponds. Optimum temperature during September and October enhanced the primary production. 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. The lower productivity in the monsoon season is due to limitation of sunlight intensity, turbidity and the silt received from the catchment areas which affect the productivity of the aquatic ecosystem. The increase in the productivity during the post-monsoon season is due to increases in the allochthonous nutrient content received from the catchment area during the monsoon season which helps in the growth of the primary producer. Earlier worker also observed that productivity increases after the monsoon season due to increase in the phytoplankton concentration (Kumar *et al*, 2001; Pandit *et al*, 2008 and Singh *et al*, 2010). Prabhakae *et al* (2009) reported from Khadakwasla reservoir of Pune that primary productivity was higher in winter season as compared to monsoon season due to addition of nutrient with runoff water during monsoon season and later increased the growth and development of algae. 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. During the study, it was observed that the primary productivity also depends on the age of the pond. The pond which was desilted and renovated two years ago *i.e.* pond B (2014) showed higher productivity followed by pond A which was desilted and renovated four years ago (2012). The lowest productivity was observed in pond C that was desilted and renovated in the same year (2016). As a pond ages increases, the nutrient level and amount of organic material increases. With the pond aging, algae begin to grow and thereby releasing oxygen during the day and carbon dioxide at night. Thus algae provide food source to different organism in the ecosystem. Later the death of these algae releases nutrient for higher orders of floral and faunal life. But as the age of a rather small ecosystem like pond is increased the nutrient level starts declining in general due to accumulation of inorganic and organic sediment resulting in reduction of productivity of the ecosystem leading to lesser productivity.

CONCLUSION

The primary productivity of a pond can be affected by both the physico-chemical parameters and aging of the pond. The water quality plays a vital role in interpreting the primary production and health of the ecosystem. The seasonal variation also influenced the productivity as it was observed that post-monsoon season showed better productivity, as during monsoon season all allocthonous nutrients came along with the rain and played a major role to increase the population of the algae in post-monsoon season. Different vital parameters like solar radiation, temperature, dissolved oxygen and nutrient level are crucial for primary productivity and contributed to seasonal variation in various aquatic ecosystems. From the results, it may be concluded that the renovation and desiltation helps in increasing the productivity of the aquatic ecosystems. The study suggested that for better production, the pond should be renovated time to time and in the culture based fishery, post-monsoon season can serve as good time for fish stocking and lately increase the overall fishery yield of the ecosystem.

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