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Effect on Primary Productivity in Swine Dung Treated Fish Ponds

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Abstract

Primary productivity, i.e. Gross primary productivity (GPP), Net primary productivity (NPP) and Community respiration (CR) were estimated in three pig dung treated fish ponds. The present investigation envisage on the estimation of primary productivity in carp polyculture system in three pig dung manured ponds. The monthly estimations were done for three years. Pig density were 30, 40 and 50 pigs ha^{-1} in the 1st, 2nd and 3rd year respectively, while fish density was kept constant at 8500 nos. ha^{-1}. The control received no pig dung. As the density of pigs ha^{-1} increased, primary productivity of the treated ponds were also found to increase. The highest values were observed in the 3rd year when pig density ha^{-1} water area was the maximum (50 pigs ha^{-1}). The effect of available nutrients and water temperature was significantly observed in augmentation of primary productivity. The GPP, NPP and CR were found to be much lower in the Control being 0.940 ± 0.246 gCm^{-2}d^{-1}, 0.600 ± 0.264 gCm^{-2}d^{-1} and 0.502 ± 0.345 gCm^{-2}d^{-1} respectively. However, NPP:GPP was the highest in the Control where organic load was minimum.

Keywords: Productivity, Integrated fish farming.

Introduction

Primary productivity of an ecological system, community or any part thereof, is defined as the rate at which radiant energy is stored by photosynthetic or chemosynthetic activity of producer organisms (chiefly green plants) in the form of organic substances which can be used as food materials, Odum (1971). Of this gross primary productivity is the total value of photosynthesis including the organic matter used up in respiration during the measurement period, while net primary productivity indicates the amount of organic matter that is stored in the plant tissues after meeting the demand of respiration. In a managed aquatic environment, the green plants are chiefly the phytoplankton biomass, which is one of the most important sources of energy input in freshwater ecosystems, Moss *et al*. (1980). This productivity is greatly dependent on the nutrient status of the aquatic body in relation to other physio-chemical parameters, Verma and Paul (1998). The present study was undertaken to estimate primary productivity of three pig dung manured ponds where carp polyculture system was adopted.

Materials and Methods

Integrated pig-fish farming system was adopted in three ponds with water area of 0.25 ha (TP$_1$), 0.3 ha (TP$_2$) and 0.24 ha (TP$_3$) respectively. The fish density per hectare water area was @ 8500 no. One pond (0.2 ha) was used as the Control. Pig density was 30, 40 and 50 pigs ha^{-1} in the 1st, 2nd and 3rd year respectively.

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Estimation of primary productivity:

Primary productivity of the fish ponds were determined as per Goldman and Wetzel (1963) from the difference in DO values of water samples incubated in bottles under light and dark conditions. The decrease in DO content in the dark bottle, as compared to initial value represented the amount of DO consumed by respiration by all the biomass in the bottle. The increase in DO in the light bottle indicated that amount of DO in water, which exceeded oxygen consumption by respiration. Gross primary productivity (GPP), Net primary productivity (NPP) and Community respiration (CR) were calculated from the differences in these DO values. Sampling was performed at regular monthly intervals.

Calculation:

$$GPP = \frac{LB - DB}{T} \times \frac{0.375}{1.2} \text{ g Cm}^{-2}\text{h}^{-1}$$

$$NPP = \frac{LB - IB}{T} \times \frac{0.375}{1.2} \text{ g Cm}^{-2}\text{h}^{-1}$$

$$CR = \frac{(IB - DB) \times RQ \times 0.375}{T}$$

Where, LB = DO (mgl^{-1}) in light bottle

DB = DO (mgl^{-1}) in dark bottle

IB = DO (mgl^{-1}) in initial bottle

T = Time of incubation

$$RQ = \frac{+\Delta CO_2}{-\Delta O_2} = \frac{\text{molecules of } CO_2 \text{ liberated during respiration}}{\text{molecules of } O_2 \text{ consumed}} = 1.0$$

0.375 = ratio of the weight of C and O_2, i.e. 12 mgC/32 mg O_2 = 0.375

1.2 = Photosynthetic co-efficient

The calculated average hourly values were pooled in an average monthly data. The statistical analysis was done following the methods given in Biostatistical analysis (Zar, 2004) with level of significance P<0.05.

Results

The monthly fluctuations of gross primary productivity (GPP), net primary productivity (NPP), community respiration (CR) and the ratio between NPP and GPP of the three pig dung treated ponds @ 30 pigs ha^{-1} in the year 2004 – 05 have been presented in the Table 1. The GPP in the year ranged from 1.972 (March'04) to 5.396 $gCm^{-2}d^{-1}$ (Feb'05). Monthly estimation revealed that GPP increased slowly from the initial values and reached the first peak (4.321 $gCm^{-2}d^{-1}$) in the month of June'04. Thereafter it started to decrease slightly during the rainy months, gaining momentum from September'04 reaching the next peak (4.201 $gCm^{-2}d^{-1}$) in the month of October'04. During winter, productivity was not found to decrease drastically, attaining the last but one peak (4.921 $gCm^{-2}d^{-1}$) in the month of January'05. The average value of GPP in the year was found to be 3.818 ± 0.9 $gCm^{-2}d^{-1}$. NPP revealed a parallel trend of monthly fluctuations, the average being 2.232 ± 0.6 $gCm^{-2}d^{-1}$ in the year. CR also revealed the same trend. The average CR in the year was observed to be 1.939 ± 0.603 $gCm^{-2}d^{-1}$. The NPP:GPP in 30 pigs ha^{-1} was found to fluctuate between 0.469 (March'04) and 0.668 (December'05), the average being 0.58 ± 0.06.

Due to increment of pig dung by 37.44% in the second year (40 pigs ha^{-1}), primary productivity was found to be elevated substantially (Table 2). GPP was found to range from 1.982 (April'05) to 6.629 $gCm^{-2}d^{-1}$ (March'06). The average GPP in the year was found to be 4.551 ± 1.2 $gCm^{-2}d^{-1}$. As observed in the case of the first year monthly fluctuations of NPP was similar to that of GPP in the initial year. The average NPP in the year was computed to be 2.73 ± 0.8 $gCm^{-2}d^{-1}$. CR was also observed to be augmented in the year. It fluctuated between 0.933 $gCm^{-2}d^{-1}$ (April'05) and 2.998 $gCm^{-2}d^{-1}$ (July'05). The highest NPP:GPP was noted in the month of May'05 (0.695), the average value being 0.56 ± 0.11.

Beneficial effect of addition of increased quantity of swine manure in fish pond to augment productivity was observed to be more distinct in the third year (2006-07) when number of pigs was 50 ha^{-1} as depicted in Table 3. As the nutrients level in water increased due to introduction of enhanced quantity of pig dung GPP was also observed to be increased attaining the maximum value of 8.3 $gCm^{-2}d^{-1}$ of the last month of the experimental period in the third year. The average GPP in the year was 5.663 ± 1.6 $gCm^{-2}d^{-1}$, the range being 1.89 to 8.3 $gCm^{-2}d^{-1}$. NPP and CR was also found to increase in the year. The average NPP:GPP was 0.546 ± 0.049.

Unlike the high productivity profiles of the pig dung treated ponds, the control pond, though situated in the same vicinity, revealed a completely different picture. The details of GPP, NPP, CR and NPP:GPP values of the control have been presented in Table 4. Primary productivity was in the increasing trend in the treated ponds, while in the control, it was found to be in the decreasing trend. Higher values of GPP, NPP were observed in the summer months which decreased drastically in the following rainy months. With a weak peak in the post monsoon period the values were found to decrease again in the winter months. Similar trend was also observed in the case of CR. The average GPP, NPP and CR were 0.94 ± 0.25 $gCm^{-2}d^{-1}$, 0.6 ± 0.264 $gCm^{-2}d^{-1}$ and 0.502 ± 0.345 $gCm^{-2}d^{-1}$ respectively in one year experimental period (2004-05). The average NPP:GPP was worked out to be 0.61 ± 0.17 in the Control.

Table I. Variations of primary productivity ($gCm^{-2}d^{-1}$) in the treated ponds (TP): 30 pigs ha^{-1} (2004-05)

Months	Gross primary productivity (GPP)	Net primary productivity (NPP)	Community respiration (CR)	NPP:GPP
March'04	1.972	0.924	0.978	0.469
April	2.727	1.381	1.241	0.506
May	3.662	2.411	2.599	0.658
June	4.321	2.811	2.433	0.651
July	3.472	2.207	1.978	0.636
August	3.696	2.041	2.126	0.552
September	3.920	2.137	1.678	0.545
October	4.201	2.421	1.872	0.576
November	3.628	2.072	1.831	0.571
December	3.896	2.601	1.146	0.668
January'05	4.921	2.873	2.619	0.584
February	5.396	2.901	2.771	0.538
Average	3.818	2.232	1.939	0.580
S.D. (±)	0.9	0.596	0.603	0.063

The figures are averages of three replications (TP_1, TP_2 & TP_3). Data was figured as monthly averages standard deviation.

Table II. Variations of primary productivity ($gCm^{-2}d^{-1}$) in the treated ponds (TP): 40 pigs ha^{-1} (2005-06)

Months	Gross primary productivity (GPP)	Net primary productivity (NPP)	Community respiration (CR)	NPP:GPP
March'05	1.982	0.980	0.933	0.494
April	3.861	2.682	1.612	0.695
May	5.062	2.987	2.768	0.590
June	4.906	2.860	2.998	0.583
July	4.167	2.447	2.314	0.530
August	4.021	2.124	1.860	0.528
September	4.326	2.719	2.407	0.629
October	3.942	2.737	1.404	0.694
November	3.962	1.216	2.033	0.307
December	5.142	2.867	2.018	0.558
January'06	6.161	2.912	2.649	0.473
February	6.629	3.824	2.807	0.577
Average	4.551	2.530	2.150	0.555
S.D. (±)	1.198	0.778	0.626	0.105

The figures are averages of three replications (TP_1, TP_2 & TP_3). Data was figured as monthly averages standard deviation.

Table III. Variations of primary productivity ($gCm^{-2}d^{-1}$) in the treated ponds (TP): 50 pigs ha^{-1} (2006-07)

Months	Gross primary productivity (GPP)	Net primary productivity (NPP)	Community respiration (CR)	NPP:GPP
March'06	2.969	1.887	1.696	0.636
April	5.021	2.982	2.241	0.594
May	6.261	3.230	3.106	0.516
June	4.801	2.200	2.225	0.458
July	5.629	3.196	2.622	0.568
August	5.672	3.102	2.826	0.547
September	4.806	2.872	2.213	0.598
October	3.606	2.017	1.899	0.559
November	5.942	2.917	2.775	0.491
December	7.361	4.101	3.180	0.557
January'07	7.623	3.984	3.307	0.523
February	8.269	4.607	3.958	0.545

Average	5.663	3.091	2.671	0.546
S.D. (±)	1.58	0.833	0.653	0.049

The figures are averages of three replications (TP_1, TP_2 & TP_3). Data was figured as monthly averages standard deviation.

Table IV. Variations of primary productivity ($gCm^{-2}d^{-1}$) in the control pond

Months	Gross primary productivity (GPP)	Net primary productivity (NPP)	Community respiration (CR)	NPP:GPP
March’04	1.201	0.753	0.803	0.63
April	1.225	0.780	0.898	0.64
May	1.263	0.926	0.981	0.73
June	1.203	0.904	1.107	0.75
July	0.600	0.300	0.481	0.50
August	0.563	0.225	0.240	0.40
September	0.837	0.243	0.360	0.29
October	0.670	0.273	0.233	0.41
November	0.937	0.754	0.281	0.80
December	0.930	0.727	0.150	0.78
January’05	0.901	0.623	0.240	0.69
February	0.948	0.694	0.247	0.73
Average	0.940	0.600	0.502	0.61
S.D. (±)	0.246	0.264	0.345	0.17

Data was figured as monthly averages standard deviation. This shows that the control was mentioned for one year and was considered as standard for the other two years of study.

Discussion

Primary productivity of an impounded water body is directly dependent on duration and intensity of solar radiation, physico-chemical properties and nutrient status of the water body. Goldman and Wetzel (1963) suggested that temperature has the most effective impact on aquatic productivity. This is in conformity with the present study. In the treated and control ponds, GPP and NPP values were found to be higher in summer months followed by the monsoon (based on ambient temperature). In winter, GPP and NPP values were lowest in the control while the treated ponds received maximum quantity of pig dung to the tune of 54, 735.77 $kgha^{-1}yr^{-1}$. As the treated ponds received pig excreta and urine continuously, replenishment of the required nutrients occurred everyday. Therefore, though temperature was low in the winter months, productivity was not found to decrease significantly. From Table 4 it was observed that without pig dung productivity is lowest in July, August, Sept & Oct. The results are in concurrence with Bilgrami and Dutta Munshi (1985), who reported the lowest GPP in winter. Prasad (1990) observed increased productivity during winter and post monsoon season indicating significant role of nutrients in augmenting productivity. Adoni and Joshi (1989) found high primary productivity in Sagar lake which was rich in nutrients due to regular sewage input. In presence of adequate nutrients, primary productivity reaches a maximum value set by the amount of solar energy penetrating the pondwater. In tropical and subtropical climates, this is about 10 $gCm^{-2}d^{-1}$ and is observed in algal production ponds by Tamiya (1957) and Anon (1977). However, in the present study, maximum GPP observed was 8.3 $gCm^{-2}d^{-1}$ in the treated ponds of 50 pigs ha^{-1}, the average being 5.7 ± 1.58 $gCm^{-2}d^{-1}$. Had there been no filter feeding fishes in the ponds, probably the GPP level would have been more than what was estimated in the algal ponds.

Continuous grazing over the primary producers by the macro and micro herbivores in the treated ponds kept the GPP levels in check. The average of primary production level, observed in Israeli fish ponds by Hapher (1962) and Schroeder (1978) was 1 to 5 $gCm^{-2}d^{-1}$ in the spring and fall and 4 to 8 $gCm^{-2}d^{-1}$ in summer.

Community respiration is also a good indicator to assess the productivity of a water body, Singh and Sinha (1994). The findings of the present study corroborate the statement. The highest CR was observed in the third year, when productivity was the best followed by the second and the first year.

NPP and GPP ratio is deeply related with the physiological state of primary producers and nutrients present in the waterbody, Ketchem *et al*. (1958). Quasim *et al*. (1969) suggested that the decomposing organic matter demands more oxygen resulting in enhanced respiratory values which in turn give rise to low NPP:GPP.

Conclusion

This confirms the findings of the present study, as the most productive ponds with high organic load revealed low values of NPP:GPP, while the unproductive pond (the Control) showed higher ratio of NPP and GPP.

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