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COMPARATIVE STUDIES ON PRIMARY PRODUCTIVITY OF SEWAGE FED FRESHWATER FISHPOND IN RELATION TO PRODUCTION EFFICIENCY OF PHYTOPLANKTON

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ABSTRACT
The present study emphasizes to measure the gross and net primary productivity of productive freshwater fish culture pond and a non- productive one and also studied the qualitative and quantitative analysis of the primary producers of the sewage fed fishpond in relation to the production efficiency of phytoplankton. The fertility of any natural water body depends on the productivity of the green plants within it. Thus, primary productivity is the rate at which sunlight is used by plants to produce carbon containing compounds, typically polysaccharides. This study includes the analysis of physicochemical properties of water quality, GPP, NPP and Community respiration and planktonic analysis of sewage fed freshwater fish pond and a non productive pond. Results of Gross Primary Production (GPP) and Net Primary Production (NPP) in sewage fed fishpond are comparatively higher than the non productive one. Community respiration also indicates the positive correlation among the two ponds. Therefore, phytoplankton abundance in sewage fed fish pond shows considerable diversities and densities as compared to nonproductive one. Statistical analysis of outcome result also revealed the significant correlation at 0.01% and 0.05% level.

KEYWORDS: Primary productivity, community respiration, sewage fed fish pond .

INTRODUCTION
The primary productivity of an ecological system, community or any part thereof, is defined at the rate at which radiant energy is stored by photosynthetic and chemosynthetic activities of the producer organisms (chiefly green plants) in the form of organic substances which can be used as food materials. Primary productivity thus denotes the rate of primary production, i.e. the primary production per unit of time and area. Primary production which refers to the quantity of new organic matter produced by photosynthesis. Photosynthetic fixation of carbon in the inland aquatic system occurs in various plant communities such as phytoplankton, periphytic algae, benthic algae, and macrophytes. Production by the phytoplankton, the primary synthesis, is the most important phenomenon and reflects the nature and the degree of productivity in the aquatic ecosystem. This has received much attention in limnological studies during the past few decades and it has been measured by several workers in various aquatic ecosystem of the world. Steeman- Nielson (1952) discovered the C^{14} method for regular analysis of photosynthetic rates of planktonic algae and this has been elucidated by Steeman- Nielson & Hensen (1959). Some modifications of this technique were done by Arthur & Rigler (1967). The impact of solar radiation on the aquatic system and primary productivity has been discussed and worked out by many authors. In order to identify the causative agent for the increase or decrease in photosynthesis, works on isolated chloroplasts and the importance of pigments and algae were done by Fogg & Watt (1965). Experimental studies aimed at investigation of possible role of various major photosynthetic organisms in aquatic ecosystem to increase the productivity of fishpond.

MATERIALS AND METHODS
The present study was carried out at East Kolkata Fisherman Co-operative Society, Anandapur, Kolkata – 700105. The farm approximately has 62 ponds of varying area and volume. This farm is a sewage fed one. Every pond of this farm is connected to drains for the supply of the nutrients from the sewage. The rate of photosynthesis was measured by estimating oxygen (O_2) in light and dark bottle method of Gaarder and Gran (1927). The carbon values were obtained from the O_2 values by multiplying with 0.375 (Sreenivasan, 1964). The gross and net productions were calculated with the following equations:

G.P.P = (L.B – D.B)/T * 0.375/PQ * 1000 mgc m^{-2} h^{-1}

N.P.P. = (L.B – I.B)/T * 0.375/PQ * 1000 mgc m^{-2} h^{-1}

Respiration Rate = (I.B – D.B)/T * 0.375 * RQ * 1000 mg cm^{-2} h^{-1}

Water quality is usually defined as the suitability of water for survival and growth of fish and it is normally governed by few variables (Boyd, 1979). Most of these properties like, Water transparency pH, DO, alkalinity etc. were measured as the methods developed by APHA (2005) with appreciable degree of accuracy and the data can be used for productivity management of the pond as well as intensive culture system. The quantitative and qualitative analysis of plankton were done through collection of 100 litres of water and filtered through a net made up of battering silk No. 25 with 79 meshes per linear centimeters. The filtered was fixed in 4% formalin and brought to the laboratory for further analysis. Enumeration of planktonic taxa were made after Welch (1948) and expressed as plankton per litre. The identification of different planktonic organisms was done as per guideline of Edmonoson (1959). For convenience, the productive sewage fed fishpond has been designated as Pond I while the unproductive one as Pond II.

RESULTS AND DISCUSSION

The primary productivity is the first fundamental step of ecosystem function and it makes the chemical energy and organic matter available to consuming organisms. The rate of energy transformation of solar radiation to chemical energy by the photosynthetic pigments gives dependable parameter in assessments of the production potential. In order to evaluate these potentialities in the presently studied the rate of gross and net primary production and the rate of respiration have been estimated. Gross primary productivity is, perhaps, an intangible quantity and the net primary productivity is said to be actual production to the subsequent trophic level. The result of water quality analysis in both the ponds was tabulated in Table -1 and 2. The minimum and maximum range of air temperature found to be 33.0^0C and 35.5 ^{0}C respectively during the study period. The mean value was found to be 34.25 ^{0}C and the standard deviation was 0.92. The minimum and maximum water temperature of Pond I was found to be 30.4 ^{0}C and 32.5^0C and that of Pond II were 31^0C and 32^0C respectively. The mean values were found to be 31.36^0C in Pond I and 31.1^0C in Pond II and the S.D. was 0.3 of both ponds. The minimum and maximum range of pH was 8.0 and 8.3 respectively in Pond I and Pond II. The mean values were found to 8.18 in Pond I be 8.14 in Pond II and the S.D. was 0.31 of both ponds. The minimum and maximum range of Transparency was12.8 cm and 19.2 cm of Pond I 20.1 cm and 22.3cm respectively of Pond II and. The mean values were found to be 16.7 of Pond I 20.7 of Pond II and the S.D was 0.9 of both ponds. The minimum and maximum of DO was 3.12 and 4.89 (mgl^{-1}) of Pond I and 4.1and 2.3 (mgl^{-1}) of Pond II respectively. The mean values were found to be 3.66 in Pond I and 3.7 in Pond II and the S.D. was 0.52 of both ponds. The minimum and maximum range of Alkalinity was 122.7 and 167.2 85(mgl^{-1}) of Pond I and 88 (mgl^{-1}) of Pond II respectively. The mean values were found to be 139.54 of Pond I 77.4 of Pond II and the S.D was 25.82 of both ponds. The Gross primary productivity (GPP),Net primary productivity (NPP) and Community respiration was estimated in every 7 days interval and recoded in table-3 and 4. The average values and standard deviation of GPP, NPP and Community respiration is comparatively higher in sewage fed fishpond i.e., experimental pond -1 (Fig. –I and II). The densities and diversities of phytoplanktonic population was measured and tabulated in table -5 and 6. The Cholorophyceae or green algae as noticed in the pond was found to be predominant over all phytoplanktonic communities excepting two days. The range of variation was from 3288 to 9906 units/litre during the study period in the Pond I and 2600 to 6200 units/litre. The mean value of Cholorophyceae during the study period was 6885.4 units/litre in the Pond I and 4057.7 units/litre in the Pond II. Numerically, the second largest group among the phytoplanktonic communities was the blue green algae or the Cyanophyceae. The maximum population of this group was 8209 units/litre and the minimum was 3628 units/litre in the Pond I and 5905 units/litre and 2835 units/litre in the Pond II. The mean value of Cyanophyceae during the study period was 5760.4 units/litre in the Pond I and 4318.5 units/litre in the Pond II. The diatoms in the pond though found in least numbers but occurred in all the occasions during the study period. The minimum numerical abundance was encountered 2632 units/litre in the Pond I and 1550 units/litre in the Pond II and the maximum was 8809 units/litre in the Pond I and 4535 units/litre in the in the Pond II. Mandal *et. al.* (2006, 2008, 2009a and 2010) have opined that the plankton density and diversity was highly encourageable for culture of Indian major carps in china clay mines.

The rate and extent of organic matter in aquatic ecosystem is largely controlled by a variety of physical and chemical parameters. Obviously, primary productivity is greatly influenced by the collective action of all of these factors. The higher rate of primary productivity during summer has also been reported by Williams & Murdoch (1966). Datta & Bandhopadhay (1982) who also accounted that the production in freshwater ponds of West Bengal is generally higher during summer. Steeman- Nielson (1959) reported light penetration as a reliable indicator. In general, transparency of water in aquatic ecosystem especially in ponds; tanks and lakes are largely influenced by the biotic communities present therein. Devis (1955) is of the opinion that pH may be used as an indicator of aquatic production. pH values largely controlled by photosynthetic activities (Ganapati, 1940; Lauff,1953; George, 1961b) specially CO_2 equilibrium state in water ($CO_2 + CO_3 + H_2O = 2HCO_3$). CO_2 is being utilized during photosynthesis. The resulting CO_2 decreases pH values. The degree of super saturation by the CO_3 and OH^- ions is a function of higher pH. Such variations are extreme in small stagnant water bodies like ponds and tanks with high quantity of living organisms.

However, respiration is a continuous process and its rate is almost same during 24 hours and in the present study community respiration refers to only those organisms which are depressed in water together with phytoplankton. The values as obtained in the present study are comparatively high as reported from others eutrophic tropical waters. Respiration as percent of gross production may be as a measure of eutrophic nature (Ganff & Horne, 1975). They contended that in a productive aquatic ecosystem respiration accounts for large proportion of gross primary productivity. The data obtained in the present study also indicate the eutrophic nature of the aquatic ecosystem.

Therefore, from this investigation we found that, incase of sewage fed fishpond (Experimental pond- 1) GPP, NPP , Community respiration and planktonic densities and diversities values were comparatively higher than nonproductive pond (Experimental pond -II). The value of gross primary productivity confirms the values of the highest and lowest phytoplanktonic communities. It is revealed from the above study that the Pond I is highly productive in comparison to Pond II with respect to the values of gross primary production. It is also revealed from the owner of the ponds that the fish production of the Pond I is much higher (approximately 3500 Kg/ha water area) as compared to Pond II (roughly 1200 Kg / ha water area) which was unproductive.

Table -1. Physico – Chemical Parameters of water in experimental Pond - I.

Sl No	Date	Air Temperature (0^0C)	Water Temperature (0^0C)	Transparency (cm)	pH	DO (mgl^{-1})	Alkalinity (mgl^{-1})
1	1.4.2009	34.0	32.5	12.8	8.2	4.67	135.5
2	7.4.2009	35.0	31.7	13.4	8.2	3.36	142.8
3	14.4.2009	35.5	31.2	15.6	8.4	3.12	167.2
4	21.4.2009	35.5	31.5	17.8	7.1	3.91	154.7
5	28.4.2009	34.5	31.6	15.4	8.0	3.48	148.8
6	5.5.2009	33.5	30.9	18.4	8.1	3.081	143.6
7	12.5.2009	35.0	30.8	19.2	8.1	4.21	130.8
8	19.5.2009	33.0	30.4	16.7	8.2	3.67	122.7
9	26.5.2009	33.5	31.8	18.2	8.3	3.306	126.5
10	5.6.2009	33.0	31.2	17.5	8.2	4.89	122.8

Table -2: Physico – Chemical Parameters of water in experimental Pond - II.

SL. No	Date	Air Temperature (0^0C)	Water Temperature (0^0C)	Transparency (cm)	pH	DO (mgl^{-1})	Alkalinity (mgl^{-1}
1	1.4.2009	34.8	32.5	20.1	8.1	3.2	86.2
2	7.4.2009	35.0	31.2	20.9	8.0	3.8	85.8
3	14.4.2009	35.5	31.5	22.3	8.2	2.9	85.9
4	21.4.2009	35.5	31.7	20.2	8.3	3.1	86.1
5	28.4.2009	34.5	31.5	20.5	8.1	2.7	85.8
6	5.5.2009	33.5	31.2	21.1	8.2	2.5	85.9
7	12.5.2009	35.0	31.5	22.1	8.2	3.7	88.1
8	19.5.2009	33.0	32.2	22.2	8.0	3.2	86.4
9	26.5.2009	33.5	32.0	20.8	8.1	2.3	85.5
10	5.6.2009	33.0	33.0	20.5	8.2	4.1	88.9

Table -3: Gross and Net Primary Productivity, GPP and NPP ratio and Community Respiration of Pond - I.

Sl No	Date	GPP (mg cm^{-3} h^{-1})	NPP (mg cm^{-3} h^{-1})	GPP : NPP (%)	Community Respiration (mg cm^{-3} h^{-1})
1	1.4.2009	347.91	167.71	207.44	216.25
2	7.4.2009	280.52	228.12	122.97	62.87
3	14.4.2009	255.10	227.70	112.03	32.87
4	21.4.2009	378.48	244.58	154.74	160.62
5	28.4.2009	217.71	133.33	163.28	101.25
6	5.5.2009	212.5	117.60	180.69	113.87
7	12.5.2009	212.18	156.25	135.79	67.125
8	19.5.2009	127.5	42.81	297.82	101.62
9	26.5.2009	227.39	109.06	208.49	142.00
10	5.6.2009	70.93	43.33	163.69	33.12

Table -4 : Gross and Net Primary Productivity, GPP and NPP ratio and Community Respiration of Pond - II.

SL. No.	Date	GPP (mg cm^{-3} h^{-1})	NPP (mg cm^{-3} h^{-1})	GPP : NPP (%)	Community Respiration (mg cm^{-3} h^{-1})
1	1.4.2009	197.91	156.25	126.66	50.0
2	7.4.2009	302.08	145.83	207.14	187.5
3	14.4.2009	239.85	187.5	127.77	62.5
4	21.4.2009	218.75	125.0	175.0	112.5
5	28.4.2009	197.91	114.85	172.72	100.0
6	5.5.2009	208.33	145.83	142.85	75.0
7	12.5.2009	239.85	177.08	135.29	75.0
8	19.5.2009	229.16	93.75	244.43	37.5
9	26.5.2009	229.16	187.5	122.21	50.0
10	5.6.2009	177.08	135.4	130.78	50.0

Table -5: Numerical abundance of different phytoplanktonic communities in Pond - I.

Sl No.	Date	Cholorophyceae		Cyanophyceae		Bacillariophyceae		Total Units/litre
		Units/litre	%	Units/litre	%	Units/litre	%	
1	1.4.2009	7296	34.44	6277	27.27	8809	38.26	23014
2	7.4.2009	9723	43.71	7552	33.95	4967	22.83	22242
3	14.4.2009	9178	45.05	6818	33.46	4375	21.47	20371
4	21.4.2009	9906	39.71	8209	32.91	6826	27.36	24941
5	28.4.2009	8018	45.03	4598	25.82	5189	29.14	17805
6	5.5.2009	5805	34.12	5981	35.12	5294	30.9	17080
7	12.5.2009	6479	50.85	3628	28.44	2632	28.51	12739
8	19.5.2009	4285	33.72	5007	39.40	3415	26.87	12707
9	26.5.2009	4246	23.72	5718	31.34	8281	45.03	18245
10	5.6.2009	3288	33.21	3816	38.54	2796	28.24	9900

Table – 6: Numerical abundance of different Phytoplanktonic Communities in Pond - II.

Sl No.	Date	Cholorophyceae		Cyanophyceae		Bacillariophyceae		Total Units/litre
		Units/litre	%	Units/litre	%	Units/litre	%	
1	1.4.2009	5400	39.53	4300	33.33	3500	27.13	12900
2	7.4.2009	6200	43.9	5905	41.81	2017	14.28	14122
3	14.4.2009	4112	43.43	3805	40.19	1550	16.37	9467
4	21.4.2009	4935	43.04	4200	36.63	2330	20.32	11465
5	28.4.2009	2885	29.83	4935	51.03	1850	19.13	9670
6	5.5.2009	2600	20.42	5300	49.39	2830	26.37	10730
7	12.5.2009	3935	38.12	2835	27.47	3550	34.39	10320
8	19.5.2009	3110	29.31	3700	34.87	3800	35.81	10610
9	26.5.2009	2800	24.04	4300	36.95	4535	38.97	11635
10	5.6.2009	4600	51.08	3905	31.47	3900	31.41	12405

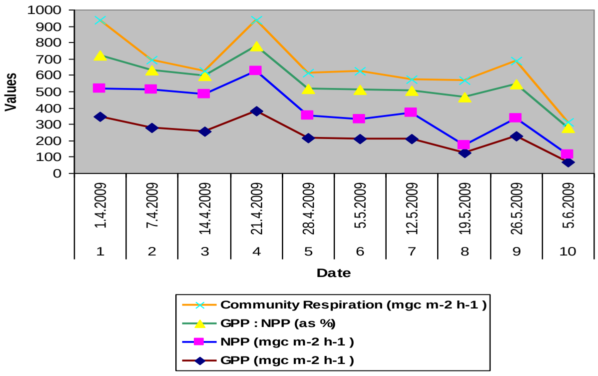

Fig-1: Comparison of GPP, NPP and CR values of experimental pond -I

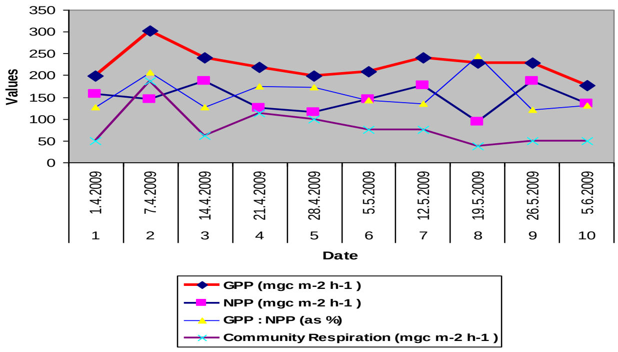

Fig-2: Comparison of GPP, NPP and CR values of experimental pond -II

Table 7: Results of Bivariate Correlations in experimental pond –I and Pond -II

		VAR00003	VAR00002	VAR00004	VAR00005
VAR00003	Pearson Correlation	1.000	.851	-.679	.114
	Sig. (2-tailed)	.	.002	.031	.753
	N	10	10	10	10
VAR00002	Pearson Correlation	.851	1.000	-.304	.619
	Sig. (2-tailed)	.002	.	.393	.056
	N	10	10	10	10
VAR00004	Pearson Correlation	-.679	-.304	1.000	.440
	Sig. (2-tailed)	.031	.393	.	.203
	N	10	10	10	10
VAR00005	Pearson Correlation	.114	.619	.440	1.000
	Sig. (2-tailed)	.753	.056	.203	.
	N	10	10	10	10

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

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