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Study on Seasonal Productivity of two Rivers Receiving Petrochemical Effluent from NRL, Assam, India

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Abstract

The seasonal productivity of two rivers in Assam receiving petrochemical effluent were conducted from March 2012 to February 2014 on a seasonal basis – pre-monsoon, monsoon, post monsoon and winter. The fluctuation trends of GPP were pre monsoon (0.87mgC/L/hour) > post monsoon (0.82mgC/L/hour) > winter (0.58) > monsoon (0.51mgC/L/hour). The fluctuation trends of NPP were post monsoon (0.28mgC/L/hour)> pre monsoon (0.24mgC/L/hour)>winter (0.23mgC/L/hour) > monsoon (0.13mgC/L/hour). The fluctuation trends of CR were found as pre monsoon (0.64mgC/L/hour) > post monsoon (0.55mgC/L/hour) > monsoon (0.37mgC/L/hour) > winter (0.35mgC/L/hour). The mean annual NPP% of GPP were found highest at S5(33.8%) and lowest at the point of effluent discharge(14.8%). The CR% of GPP were highest at S6 (85.1%) and lowest at S1 (61.4%).

Keywords: Seasonal, productivity, GPP, NPP, CR, Point effluent, discharge.

Introduction

The primary productivity is the rate of formation of organic matter from inorganic carbon by photosynthesizing organisms[1]or autotrophs, including algae and larger aquatic vascular plants. Assessment of primary productivity gives a clear indication of the rate of organic matter produced from inorganic carbon through photosynthesis. It is also an indicator of pollution status of the water body in question[2-3]. The primary productivity is the root of all food chains and food-webs of any ecosystem generating 70% atmospheric oxygen of the world[4].The aim of the study was to determine seasonal productivity of the two rivers Kaliani and Dhansiri receiving petrochemical effluent form Numaligarh Refinery Limited of Assam. The Kaliani is a tributary of river Dhansiri and the Dhansiri is a perennial source of water located within 5-kms radial distances from the NRL. They receive effluent from the refinery and reported to be contaminated since its operation from the year, 2001.

Material and Methods

The study was conducted from March 2012 to February 2014 on a seasonal basis – pre monsoon (March-May), monsoon (June-August), post monsoon (September-November) and winter (December-February). River segments were divided into two parts - up and down stream (with reference to discharge point of effluent) with a length of 15 km. and each segment was divided into five sampling stations for this purpose. Some selected physicochemical parameters were analyzed as per standard procedures of APHA[5]. The Light and Dark bottle method of Garderand Gran[6] was used for determination of seasonal productivity. Oxygen were measured using modified Winkler's method and data obtained were converted in terms of carbon using conversion factor of 0.375 and according to Trived yet al.[7], values were expressed as mg C/L/hour.

Gross Primary Productivity (GPP): O_2mg/L/hr= $D_l - D_d$/hr
Net Primary Productivity (NPP): O_2mg/L/hr= $D_l - D_i$/hr
Community Respiration (CR): O_2mg/L/hr = $D_i - D_d$/hr

Where, D_l= light bottle, D_i= initial bottle, D_d= dark bottle

Results and Discussion

Physicochemical parameters: The annual mean fluctuations of the physicochemical parameters in ten sampling stations of the two rivers from March 2012 to February 2014 have been showed in the table-1.

The DO were found highest in winter season (8.2mg/l) at S1 (10mg/l) and lowest at S6(3.7mg/l) in monsoon season. The cause of maximum DO in the winter months may be due to the reduced rate of decomposition by decreased microbial activity at low temperature[8]. Among the chemical parameters all the parameters were found highest at the point of effluent discharge (S6), except DO and pH. The minimum DO (4.24±.23mg/l) at point of effluent disharge may be the result of the oilly effluent disharged from NRL which affect on gaining of DO from atmosphere in addition to the reduction of the primary producer– phytoplankton population. Some of the parameters were showed higher valuesin monsoon season such as, turbidity(46.98 NTU) with an annual mean of 62.30±23.45NTU at S6, conductivity (150.6µS/cm) with an annual mean of 446.21±35.86µS/cm at S6, FCO2 (5.07mg/l)

with an annual mean of 5.21±.38mg/l atS6, TDS(59.71mg/l) with an annual mean of 108.97±25.53mg/l at S6, water temperature (31.05°C) with an annual mean of 22.44±8.82°C at S10, water current (0.82m/s) with an annual mean of 0.51±0.21m/s at S1; in winter season on the other hand some parameters were showed highest values – alkalinity (54.98mg/l) with an annual mean of 69.03±36.77mg/l at S6; total hardness (49mg/l) with a 68.26±36.05mg/l atS6, calcium hardness (26.72mg/l) with an annual mean of 43.41±17.90mg/l at S6, pH(7.17) with annual mean of 6.95±.26 at S5, Chloride (7.32mg/l) with an annual mean of 24.19±18.17mg/l at S6. The lowest values of alkalinity found during the monsoon season might be due to dilution effect of river water as was found in Malayan rivers and the Halali Reservoir by Bishop[9] and Jainet al.[10] respectively. The increased conductivity in monsoon season confirmed the finding of Taheruzzaman and Kushari[11]who observed similar phenomenon in water bodies of Burdwan (West Bengal) during monsoon when heavy runoff carrying diverse type of electrolytes from the catchment area increased conductivity.

Seasonal productivity: A distinct seasonal fluctuations of productivity were observed in the study period of 2012-2014. The seasonal trends of fluctuation of productivity have been showed in the figure-1.

Table-1
Mean values of physicochemical parameters at different sampling stations of Kaliani and Dhansiri rivers

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
DO(mg/l)	8.73±1.09	8.55±1.10	8.39±1.10	8.18±1.01	7.84±.99	4.24±.23	5.88±.55	6.69±.73	7.14±.78	7.51±.89
Turbidity (NTU)	18.39±13.4	19.09±13.54	19.93±13.59	20.90±14.25	26.84±22.33	62.30±23.45	47.20±16.96	36.48±14.75	34.53±13.82	34.08±14.06
TH. (mg/l)	19.67±2.44	19.6±2.36	20.45±3.09	19.55±2.67	21.26±9.57	68.26±36.05	46.89±24.83	38.63±18.91	27.99±11.57	26.05±9.88
Alkal. (mg/l)	23.55±2.93	23.62±3.06	23.8±2.93	24.01±3.011	25.30±9.27	69.03±36.77	49.53±25.64	42.89±20.26	30.54±12.16	29.80±11.20
Conduct. (µS/cm)	61.21±8.97	62.42±7.83	62.04±8.019	63.25±7.76	61.38±8.	446.21±35.8	215.29±42.97	153.04±38.46	115.67±31.46	88.04±9.05
Ca H.(mg/l)	13.68±3.65	13.33±3.28	13.63±2.94	14.03±5.64	14.68±6.28	43.41±17.90	31.35±15.51	24.74±9.79	20.89±6.72	20.34±6.57
Velocity (m/s)	0.51±0.21	0.50±0.21	0.50±0.21	0.49±0.21	0.49±0.20	0.48±.20	0.47±.20	0.47±.20	0.47±.20	0.47±.20
Chloride (mg/l)	0.98±.49	0.96±.44	0.91±.43	1.23±.49	1.19.60	24.19±18.17	12.37±6.73	3±2.59	1.95±1.27	1.37±.63
pH	6.89±.25	6.92±.27	6.94±.27	6.94±.26	6.95±.26	6.62±.14	6.76±.18	6.90±.32	6.89±.32	6.91±.32
TDS (mg/l)	31.06±3.90	31.47±3.81	31.31±3.81	31.45±3.77	31.12±3.89	108.97±25.53	77.25±12.02	61.39±16.49	46.6±12.61	42.39±6.16
FCo_2 (mg/l)	4.16±.39	4.34±.32	4.41±.36	4.44±.32	4.51±.34	5.21±.38	5±.34	4.83±.37	4.79±.37	4.79±.39
Wat. Temp. (^{0}C)	20.86±8.54	21.08±8.53	21.21±8.58	21.36±8.58	21.60±8.64	22.03±8.55	22.13±8.54	22.18±8.68	22.24±8.78	22.44±8.82
Depth(m)	2.2±88	2.19±87	2.22±97	2.30±92	2.41±93	2.72±1.16	3.81±1.38	3.87±1.37	3.91±1.26	4.05±1.37

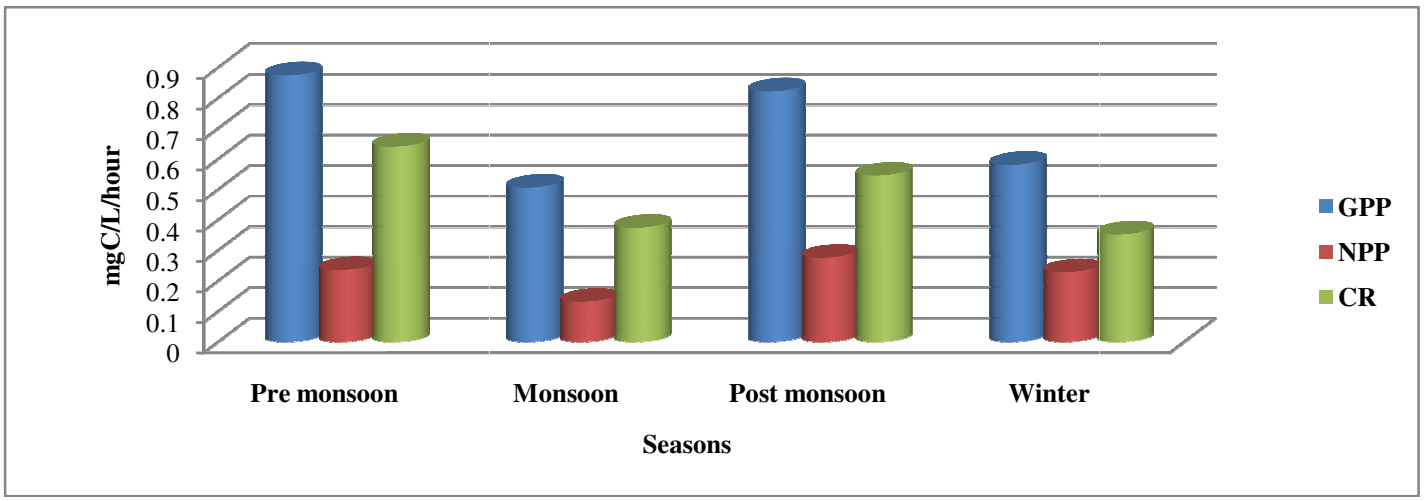

Figure-1
Mean seasonal productivity of Kaliani and Dhansiri rivers

The fluctuation trends of GPP werepre monsoon (0.87mgC/L/hour) > post monsoon (0.82mgC/L/hour) > winter (0.58mgC/L/hour) > monsoon (0.51mgC/L/hour). These confirmed the finding of Sarma and Dutta[12], according to which higher range of primary productivity in pre monsoon and retreating monsoon might have resulted due to less amount of rainfall and high density of phytoplankton population. In the pre monsoon season the highest productivity was found in March 2012 at S1 (1.09mgC/L/hour) and lowest in monsoon (0.34mgC/L/hour)were found in Jun 2012 at S6 (point of effluent discharge). The mean seasonal highest GPP were found at S1 (0.97mgC/L/hour) and lowest in S6 (0.39mgC/L/hour). The fluctuation trends of NPP were post monsoon(0.28mgC/L/hour) > pre monsoon (0.24mgC/L/hour) > winter (0.23mgC/L/hour) > monsoon (0.13mgC/L/hour). The NPP fluctuation trends were in conformity with Adoni and Vaishya[13]. The NPP were varied from 0.33mgC/L/hour atS1 and S2 in post monsoon, to the lowest of 0.04mgC/L/hour in monsoon at S6. The fluctuation trends of CR were found as pre monsoon (0.64mgC/L/hour)> post monsoon (0.55mgC/L/hour) > monsoon (0.37mgC/L/hour) > winter (0.35mgC/L/hour). The highest CR were found in pre monsoon at S6 and S9 (0.67mgC/L/hour) and lowest at S1 (0.28mgC/L/hour). Grimm and Fisher[14], Bottet al.[15] classified river segment as autotrophic (containing enough organic matter for sustaining organism respiration within its reach *i.e.* NPP is positive) and heterotrophic (with a need of importing organic matter from an upstream reach for sustaining organism respiration within its reach *i.e.*NPP is negative). The NPP were found positive at all the sampling stations throughout the study periods. The mean annual productivity fluctuations in the ten sampling stations are shown in thefigure-2.

The GPP were found highest at S3 (0.74mgC/L/hour) and lowest at S6(0.59mgC/L/hour). The NPP were found highest at S1 and S2(both with a 0.28mgC/L/hour) and lowest value were found at S6(0.09mgC/L/hour). The highest value of CR were found atS6 and S10 (0.50mgC/L/hour); lowest value were found atS1 and S2 (0.45mgC/L/hour). The fluctuations of NPP/CR and NPP/GPPratios at the ten sampling stations of Kaliani and Dhansiri are shown in the figure-3.

The NPP/CR ratios were found highest at S1 (0.63mgC/L/hour) and lowest at S6 (0.17mgC/L/hour). The NPP/GPP ratios were found highest at S1(0.39mgC/L/hour) and lowest at S6(0.15mgC/L/hour).The mean annual NPP% of GPP were found highest at S5(33.8%) and lowest at S6(14.8%). The CR% of GPP were highest at S6 (85.1%) and lowest at S1 (61.4%). According to Ketchenet al.[16] for a healthy aquatic ecosystem, respiration needs 5-10% of the gross primary production. At the point of effluent discharge (S6), there were found the lowest NPP/GPP(0.15mgC/L/hour), NPP/CR (0.17) and NPP% of GPP (14.8%). The highest CR% of GPP (85.1%) was found at S6 which indicated unhealthy ecosystem. The correlation between productivity and physicochemical parameters are shown in the figure-4.

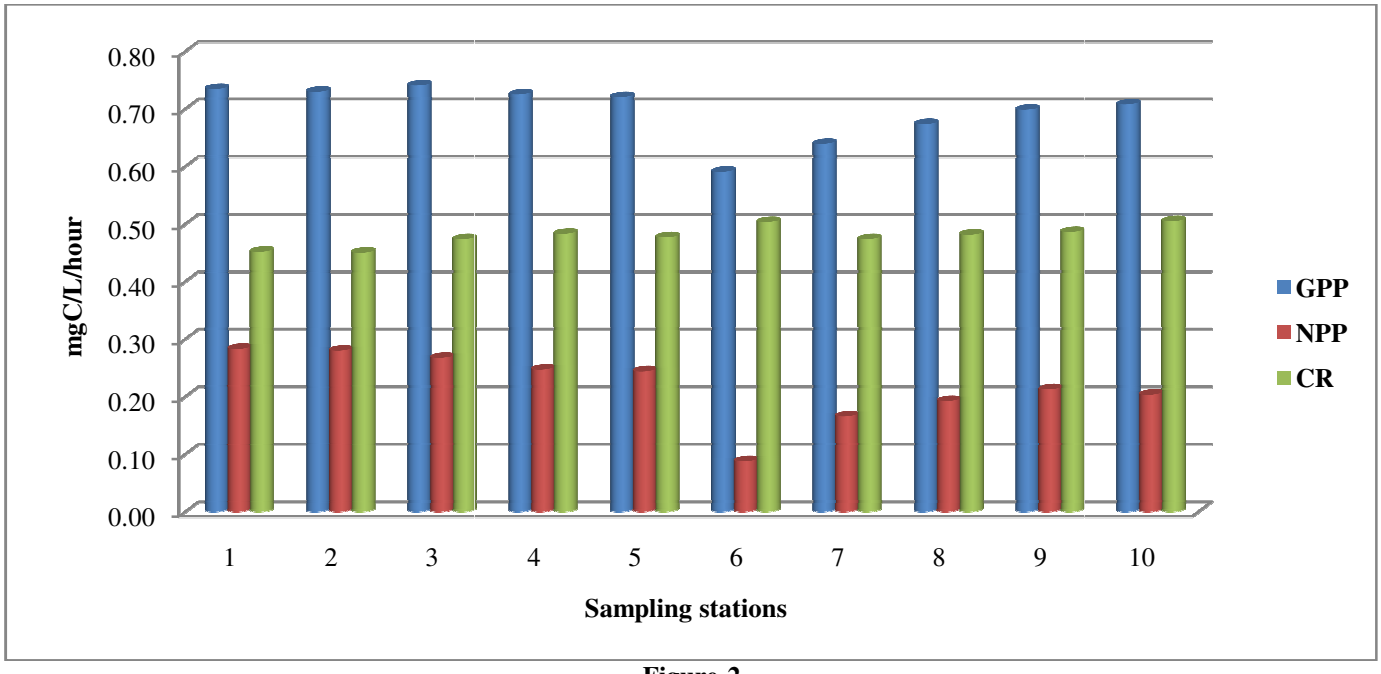

Figure-2
Mean annual productivity at different sampling stations of Kaliani and Dhansiri rivers

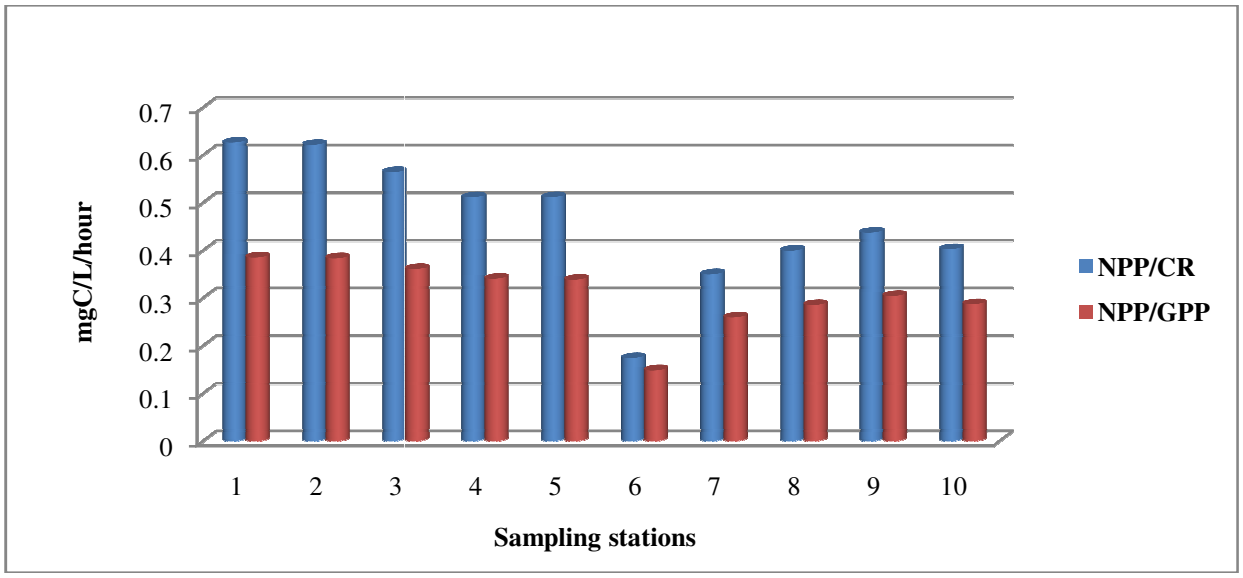

Figure-3
Mean annual NPP/CR and NPP/GPP at different sampling stations of Kaliani and Dhansiri rivers

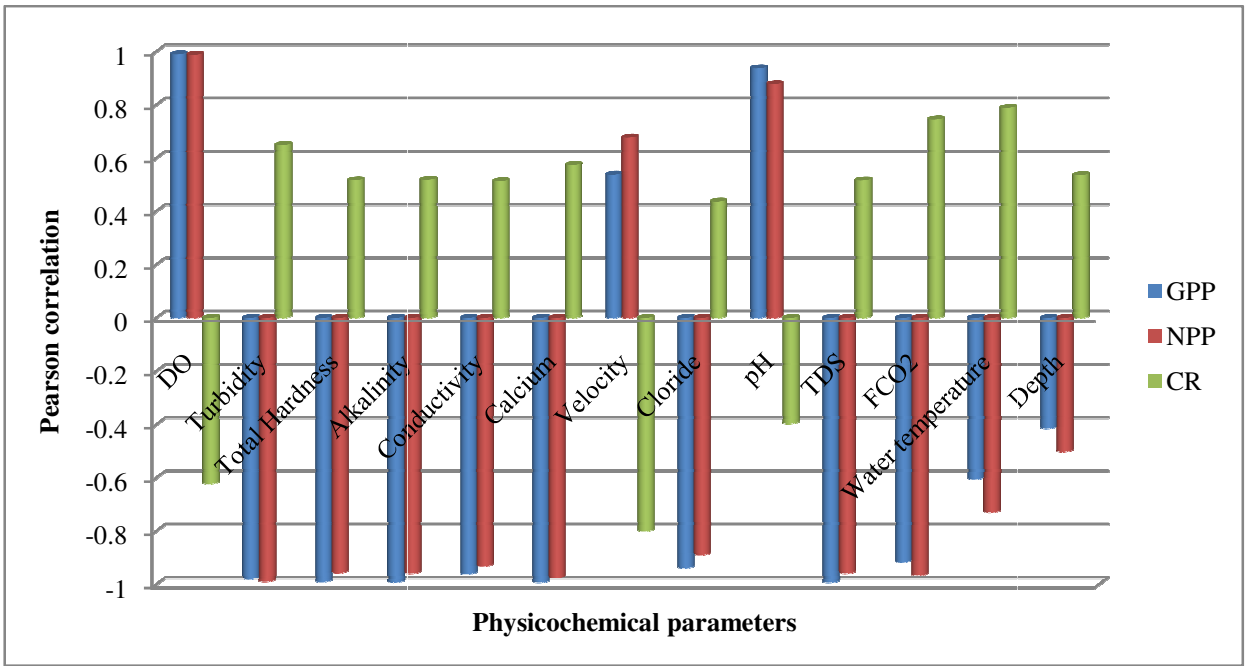

Figure-4
Showing the Pearson correlation between productivity and physicochemical parameters

The positive correlations of GPP have been observed with the DO(0.99), pH(0.94) and velocity (0.54). Negative correlations have been found with other parameters.Cloern[17] viewed that turbidity of water affect the primary productivity as it prevents photosynthetic activity.

Conclusion

Thus the GPP were recorded highest in pre monsoon and lowest in monsoon season; the NPP were found maximum in post monsoon and minimum in monsoon, while the CR were found highest in pre monsoon and lowest in winter season. At the point of effluent discharge (S6)the observed values of GPP, NPP and CR indicated the severe effect of petroleum effluent discharged from NRL. The lower values of CR, higher values of GPP and NPP at the upstream of Kaliani indicated relatively healthier ecosystem. At the downstream of the point of effluent discharge there were observed recovery from pollution impacts with increasing values of NPP/GPP, NPP/CR and decreasing values of CR. The proper effluent treatment plant is of immense

importance to conserve the health of the two rivers –Kaliani and Dhansiri.

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