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Primary Productivity of Phytoplankton in Kotwal Reservoir and their Potential Ecological Significance

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Abstract

The primary productivity of a particular water body gives quantitative information about the amount of energy available to support bioactivity of the system. At Kotwal reservoir the mean of gross primary productivity was minimum 68.94 mg Cm^3 per hour and maximum 153.51 mg Cm^3 per hour with an average of 111.9+4.19 mg Cm^3 per hour, The net primary productivity was 41.7 mg Cm^3 per hour to 100.30 mg Cm^3 per hour with an average of 66.98+2.75 mg Cm^3 per hour, The respiration rate was found 27.24 mg Cm^3 per hour to 65.25 mg Cm^3 per hour with an average of 44.92+2.02 mg Cm^3 per hour during study period from June, 2008 to May, 2010. The ratio of NP: GP, NP: RR and RR% were estimated 0.60, 1.53, 2.53 and 40.11% respectively.

Keywords: Primary productivity, gross primary productivity, net primary productivity, respiratory rate, kotwal reservoir.

Introduction

The primary productivity of a water body is a manifestation of its, biological production in which the chlorophyll bearing organisms utilize solar energy and convert it into carbohydrate molecule by taking carbon dioxide and water from the environment. Primary productivity helps in measuring the ability of an area to support a biological population and sustain a level of growth and respiration. Primary productivity is measured in terms of gross primary productivity and net primary productivity. The gross primary productivity is the total rate of photosynthesis including the organic matter used up in respiration during the measurement period. Net primary productivity is the rate of storage of organic matter in tissue of plants in excess of the respiratory utilization by plants during the measurement period. The ecologists interested in energetic are concerned with efficiency with which solar energy is converted into chemical bond energy by producers and the efficiency with which this energy is utilized by the consumers. The energy flow approach leads one to view a biological system as being driven by solar energy that is trapped during photosynthetic activity and passed on to consumer levels.

Material and Methods

Study area: Kotwal reservoir has been constructed on Asan river, a tributary of Chambal river near Kotwal village in Morena district in Madhya Pradesh, India. The reservoir has been named on the name of village as Kotwal reservoir. Geographically, it lies between 26°29'15" N latitude and 78°7'30"E longitude. Reservoir is used for different purposes like drinking, irrigation and fisheries etc. Four sampling stations namely station-A, station-B, station-C and station-D were established in the reservoir for detailed sampling.

Estimation of primary productivity: Primary production was estimated by the oxygen measurement method and the classical "Light and Dark bottle" technique was used for the purpose to find out the primary productivity water samples subsurface zone were collected after sunrise at 10.00 am and light and dark bottles were hung immediately in triplicate in the water at the same depth and incubation was done for 6 hours. After incubation, dissolved oxygen of both the bottles measured by Winkler's method.

Gross Primary Productivity

$$G.P.P\ (mg.C.m^3\ hr^{-1}) = \frac{L_b - D_b}{T} \times \frac{0.375}{PQ} \times 1000$$

Net Primary Productivity

$$N.P.P\ (mg.C.m^3 hr^{-1}) = \frac{L_b - I_b}{PQ} \times \frac{0.375}{T} \times 1000$$

Respiratory rate

$$\text{Respiratory rate}\ (mg.C.m^3 hr^{-1}) = \frac{I_b - D_b}{T} \times \frac{0.375}{RQ} \times 1000$$

GPP = gross primary productivity, NPP = Net Primary Productivity, IB = Initial D.O. in $mg.l^{-1}$, Lb = D.O. in light bottle in $mg.l^{-1}$, Db =DO. In dark bottle in $mg.l^{-1}$, RQ =Respiratory quotient (1.0), PQ =Photosynthetic quotient (1.2), T =Incubation time in hours.

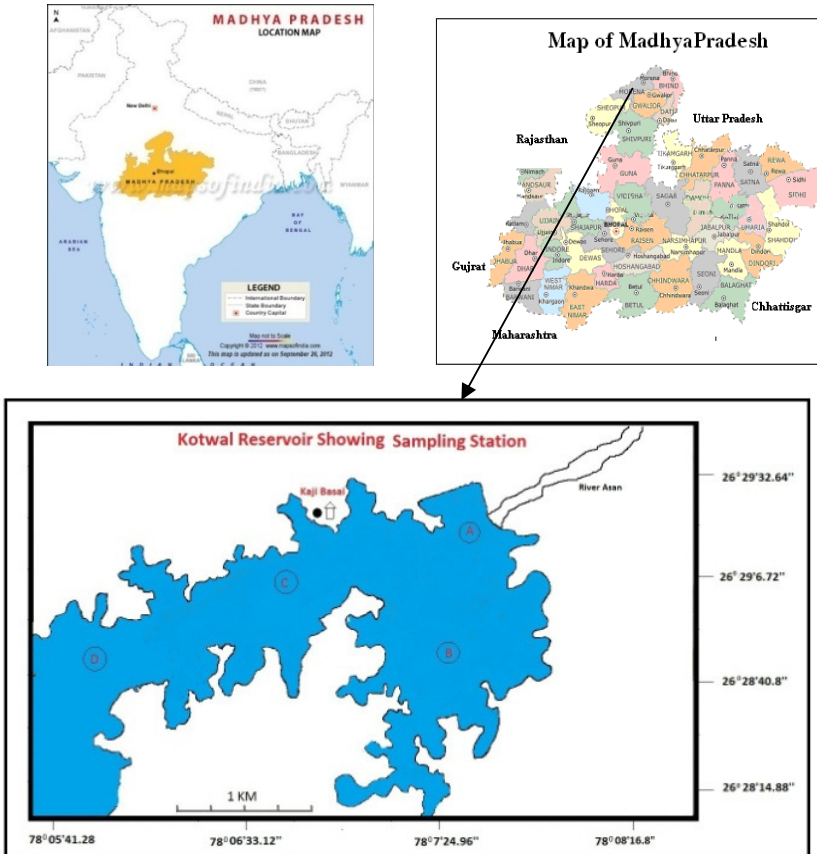

Figure-1
Showing location of Kotwal reservoir with sampling station

Results and Discussion

In the present study, the primary productivity experiment were conducted for a period of two year i.e., from June, 2008 to May, 2010 and the GPP (gross primary productivity), NPP (Net primary productivity) and RR (respiration rate) were determined at all the four stations.

At Station-A: The gross primary productivity during 2008-09 at station A was found minimum (41.39 mg Cm3 per hour) in the month of September, 2008 and maximum (160.48 mg Cm^3 per hour) in the month of November, 2008 with an average of 97.31 ± 11.45 mg Cm^3 per hour. The net primary productivity was minimum (21.12 mg Cm^3 per hour) in the month of September, 2008 and January 2009 and maximum (105.58 mg Cm^3 per hour) in the month of May, 2009 with an average value was 60.36±7.71 mg Cm^3 per hour. The respiration rate was minimum i.e., 20.27 mg Cm^3 per hour in the month of September, 2008 and maximum i.e., 76.02 mg Cm^3 per hour in the month of November, 2008 with an average of 36.95±5.09 mg Cm^3 per hour (table-1). During the period of second year (2009-10) of study, the gross primary productivity at was minimum (88.69 mg Cm^3 per hour) in the month of July, 2009 and maximum (171.04 mg Cm^3 per hour) in the month of October, 2009 with an average of 124.83± 7.36 mg Cm^3 per hour. The net primary productivity was minimum i.e., 52.79 mg Cm^3 per hour in the month of December, 2009 and February 2010 and maximum i.e., 95.02 mg Cm^3 per hour in the month of October, 2009. The average value during this period was 74.79±4.0 mg Cm^3 per hour with a minimum respiration rate of 25.34 mg Cm^3 per hour in the month of July and September, 2009 and maximum of 76.02 mg Cm^3 per hour in the month of October, November 2009 and February, 2010 with an average of 50.05±5.58 mg Cm^3 per hour (table-2). mg Cm3 per hour.

At Station-B: During the year 2008-2009 at station B the gross primary productivity was minimum (77.71 mg Cm^3 per hour) in the month of August, 2008 and maximum (202.72 mg Cm^3 per hour) in the month of October, 2008 with an average of 118.64±11.40 mg Cm^3 per hour. The net primary productivity was minimum (42.23 mg Cm^3 per hour) in the month of June and August, 2008 and August, 2008 and maximum (126.70 mg Cm^3 per hour) in the month of October, 2008 and the average value was 67.75±6.69 mg Cm^3 per hour. The respiration rate was minimum (25.34 mg Cm^3 per hour) in the month of July, 2008 and maximum (88.69 mg Cm^3 per hour) in the month of September, 2008 with an average of 50.89±5.56 mg Cm^3 per hour(Table-3).and the gross primary productivity during 2009-2010 was minimum as 93.76 mg Cm^3 per hour in the month of March, 2010 and maximum as 152.04 mg Cm^3 per hour in the

month of September, 2009 with an average of 116.07 ± 5.20 mg Cm^3 per hour. The net primary productivity was minimum (52.79 mg Cm^3 per hour) in the month of November, 2009 and January, 2010 and maximum (126.70 mg Cm^3 per hour) in the month of September, 2009 and the average value was 74.26±6.07 mg Cm^3 per hour and the respiration rate was minimum (25.34 mg Cm^3 per hour) in the month of September and October,2009 and maximum (58.28 mg Cm^3 per hour) in the month of April, 2010 with an average of 41.81±3.37 mg Cm^3 per hour (table-4).

At Station-C: During 2008-09 at station C the gross primary productivity was minimum (56.17 mg Cm^3 per hour) in the month of August, 2008 and maximum (135.14 mg Cm^3 per hour) in the month of November, 2008, with an average of 89.07±5.34 mg Cm^3 per hour. The net primary productivity was minimum (35.90 mg Cm^3 per hour) in the month of August, 2008 and maximum (71.79 mg Cm^3 per hour) in the month of November, 2008 and the average value was 55.08±2.57 mg Cm^3 per hour. The respiration rate was minimum i.e., 10.14 mg Cm^3 per hour in the month of December, 2008 and maximum i.e., 63.35 mg Cm^3 per hour in the month of November, 2008 with an average of 34.00±3.88 mg Cm^3 per hour (table-5). The gross primary productivity, during 2009-10 of study, was minimum (72.64 mg Cm^3 per hour) in the month of August, 2009 and maximum (204.83 mg Cm^3 per hour) in the month of Ma, 2009 with an average of 125.08±9.34 mg Cm^3 per hour. The net primary productivity was minimum (42.23 mg Cm^3 per hour) in the month of August, 2009 and maximum (128.81 mg Cm^3 per hour) in the month of May, 2010. The average value of net primary productivity was 70.39±6.30 mg Cm^3 per hour. The respiration rate was minimum i.e., 30.41 mg Cm^3 per hour in the month of August, 2009 and maximum i.e., 76.02 mg Cm^3 per hour in the month of May, 2010 with an average of 54.69±4.0 mg Cm^3 per hour (table-6).

At Station-D: During the year 2008-2009 at station D the gross primary productivity was minimum (52.37 mg Cm^3 per hour) in the month of August, 2008 and maximum (129.65 mg Cm^3 per hour) in the month of December, 2008 with an average of 99.21±7.17 mg Cm^3 per hour. Similarly, the net primary productivity was minimum (29.56 mg Cm^3 per hour)in the month of June and August, 2008 and maximum (84.46 mg Cm^3 per hour) in the month of February, 2009 and the average value was 57.19±4.8 mg Cm^3 per hour. The respiration rate was minimum (20.27 mg Cm^3 per hour) in the month of September, 2008 and maximum (63.35 mg Cm^3 per hour) in the month of November, 2008 with an average of 42.02±4.34 mg Cm^3 per hour (table-7). During the second year of study, the gross primary productivity was also minimum (81.09 mg Cm^3 per hour) in the month of August, 2009 but maximum (156.26 mg Cm^3 per hour) was in the month of May, 2009 with an average of 125.01±6.06 mg Cm^3 per hour. The net primary productivity was minimum (50.68 mg Cm^3 per hour) in the month of August, 2009 and maximum (105.58 mg Cm^3 per hour) in the month of November, 2009 and May 2010 and the average value was 76.02±5.51 mg Cm^3 per hour. The respiration rate was minimum (25.34 mg Cm^3 per hour) in the month of November, 2009 and maximum (65.88 mg Cm^3 per hour) in the month of February, 2010 with an average of 48.99±3.66 mg Cm^3 per hour (table-8).

Range of variation of primary productivity at all stations together during study Period: The average and mean values of gross primary productivity, at various stations taken together during study period found minimum 68.94 mg Cm^3 per hour in the month of August, 2008 and maximum153.51 mg Cm^3 per hour in the month of May, 2010 with an average of 111.9+4.19 mg Cm^3 per hour (table 9).

The net primary productivity was found lowest 41.7mg Cm^3 per hour in the month of August, 2008 and highest 100.30 mg Cm^3 per hour in the month of May, 2010 with an average of 66.98+2.75 mg Cm^3 per hour during 2008-2010 (table 9).

The respiration rate was lesser 27.24 mg Cm^3 per hour in the month of August, 2008 and higher 65.25 mg Cm^3 per hour in the month of November, 2008 with an average of 44.92+2.02 mg Cm^3 h^1 during study period of both years (table 9).

In the present investigation, the ratio of NP: GP, NP: RR, GP: RR and Res. % in Kotwal reservoir were estimated minimum was 0.49, 0.98, 1.98 and 29.54% respectively and it is found maximum was 0.70, 2.39, 3.39 and 50.63% respectively. The average value along with std. error of the ratio of NP: GP, NP: RR, GP: RR and Res. % at kotwal reservoir found 0.60+0.01, 1.53+0.06, 2.53+0.06 and 40.11+0.93 respectively. It may be mentioned that in Kotwal reservoir is quite productive and greater organic production is available for its transfer to next trophic level indicated a potential for fish yield from the reservoir (table 10).

Various workers studied on primary productivity and reported the range of gross primary productivity from 04-200 mg Cm3 per hour in freshwater ponds of Calcutta[1]. In Khandong and Umrang reservoir[2]. Verma and Sharma observed the gross primary productivity high values in the summer followed by winter and monsoon seasons respectively in Rana Pratap Sagar lake, Udaipur[3]. In the present investigation at Kotwal reservoir, the average and mean values of gross primary productivity, at various stations taken together during study period from June, 2008 to May, 2010 found minimum 68.94 mg Cm^3 per hour in the month of August, 2008 and maximum153.51 mg Cm^3 per hour in the month of May, 2010 with an average mean value 111.9+4.19 mg Cm^3 per hour. The net primary productivity was found lowest 41.7 mg Cm^3 per hour in the month of August, 2008 and highest 100.30 mg Cm^3 per hour in the month of May, 2010 with an average mean value 66.98+2.75 mg Cm^3 per hour during 2008-2010. The respiration rate was lesser 27.24 mg Cm^3 per hour in the month of August, 2008 and higher 65.25 mg Cm^3 per hour in the month of November, 2008 with an average mean value 44.92+2.02 mg C m^3 h^1 during study period

of both years. The ratio of NP: GP, NP: RR and % R in Kulgarhi reservoir of Madhya Pradesh was observed to be 0.56, 1.31 and 43.19% respectively[4]. The ratio of NP: GP, NP: RR and % R was observed to be 1.19, 0.51 and 45.67 respectively in Jaderua bandha of Morar River in Gwalior[5]. In Khandong reservoir of north east, the ratio of GP: NP, NP: RR and %R was reported to be 0.61, 1.60 and 38.40% respectively[6]. Sultan *et al*. have estimated ratio of NP: GP, NP: RR and %R as 0.73, 5.75 and 26.27% respectively in Pahung reservoir of Uttar Pradesh[7]. Shrotriy *et al*. observed the ratio of NP: GP, NP: RR and % R in Harsi reservoir were 0.623, 1.87 and 37.70%[8]. In the present investigation, the ratio of NP: GP, NP: RR and % R in Kotwal reservoir were estimated 0.60, 1.53 and 40.11% respectively. It may be concluded that Kotwal reservoir is a good productive water body in this area.

Conclusion

Gross Primary Productivity, net primary productivity, respiration rate and NPP: GPP ratio should approach unity in a healthy population, if the respiration is 5% to 10% of gross primary production. If this ratio is zero, it may indicate towards stressed physiological state of phytoplankton arising either due to nutrient deficiency or some environmental factor such as light and turbidity and respiration percentage in freshwaters have been quite variable. While in the present investigation, the ratio of NP: GP, NP: RR and % RR were estimated 0.60, 1.53, 2.53 and 40.11% respectively. It may be mentioned that, in Kotwal reservoir, the NP: GP is exceeding 0.5, NP: RR in more than 1 and % respiration is less than 41%, which is indicative of the fact of that Kotwal reservoir is good productive water body and maximum organic production is available for its transfer to next trophic level which indicate that this reservoir has great potential for fish yield.

Table-1
Primary productivity in Kotwal reservoir at station A during the year 2008-2009

Para	June	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Apr.	May	Min.	Max.	Mean + SE
GPP	135.14	67.57	89.53	41.39	78.13	160.48	67.57	46. 46	90.80	137.25	109.80	143.59	41.39	160.48	97.31 +11.45
NPP	84.46	42.23	59.13	21.12	52.79	84.46	42.23	21.12	52.79	73.91	84.46	105.58	21.12	105.58	60.36 +7.71
RR	50.68	25.34	30.41	20.27	25.34	76.02	25.34	25. 34	38.01	63.35	25.34	38.01	20.27	76.02	36.95 +5.09

Table-2
Primary productivity in Kotwal reservoir at station A during the year 2009-2010

Para.	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan.**	**Feb.**	**Mar**	**Apr**	**May**	**Min**	**Max.**	**Mean + SE**
GPP	114.03	88.69	135.14	109.80	171.04	160.48	90.80	147.81	128.81	124.59	111.92	114.87	88.69	171.04	124.83 +7.36
NPP	63.35	63.35	84.46	84.46	95.02	84.46	52.79	84.46	52.79	73.91	73.91	84.46	52.79	95.02	74.79+ 4.00
RR	50.68	25.34	50.68	25.34	76.02	76.02	38.01	63.35	76.02	50.68	38.01	30.41	25.34	76.02	50.05+ 5.58

Table-3
Primary productivity in Kotwal reservoir at station B during the year 2008-2009

Para.	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Min**	**Max.**	**Mean+ SE**
GPP	80.24	78.13	77.71	162.59	202.72	132.19	93.33	90.80	96.29	124.59	137.25	147.81	77.71	202.72	118.64+11. 40
NPP	42.23	52.79	42.23	73.91	126.70	73.91	52.79	52.79	63.35	73.91	73.91	84.46	42.23	126.70	67.75+6.69
RR	38.01	25.34	35.48	88.69	76.02	58.28	40.54	38.01	32.94	50.68	63.35	63.35	25.34	88.69	50.89+5.56

Table-4
Primary productivity in Kotwal reservoir at station B during the year 2009-2010

Para	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Min	Max.	Mean+ SE
GPP	133.03	124.59	96.29	152.04	109.80	98.40	111.92	103.47	114.03	93.76	117.41	138.10	93.76	152.04	116.07+5.20
NPP	95.02	73.91	63.35	126.70	84.46	52.79	73.91	52.79	63.35	63.35	59.13	82.35	52.79	126.70	74.26+6.07
RR	38.01	50.68	32.94	25.34	25.34	45.61	38.01	50.68	50.68	30.41	58.28	55.75	25.34	58.28	41.81+3.37

Table-5
Primary productivity in Kotwal reservoir at station C during the year 2008-2009

Para	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Min.	Max.	Mean+ SE
GPP	88.69	80.66	56.17	90.80	81.09	135.14	73.48	94.60	86.15	87.84	97.98	96.29	56.17	135.14	89.07+5.34
NPP	63.35	52.79	35.90	52.79	50.68	71.79	63.35	59.13	50.68	54.90	54.90	50.68	35.90	71.79	55.08+2.57
RR	25.34	27.87	20.27	38.01	30.41	63.35	10.14	35.48	35.48	32.94	43.08	45.61	10.14	63.35	34.00+3.88

Table-6
Primary productivity in Kotwal reservoir at station C during the year 2009-2010

Para	June	July	Aug.	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Min.	Max.	Mean+ SE
GPP	134.72	129.23	72.64	103.47	129.65	146.12	114.03	127.54	94.18	111.07	133.45	204.83	72.64	204.83	125.08+9.34
NPP	73.91	63.35	42.23	65.46	73.91	80.24	76.02	71.79	48.57	52.79	67.57	128.81	42.23	128.81	70.39+6.30
RR	60.81	65.88	30.41	38.01	55.75	65.88	38.01	55.75	45.61	58.28	65.88	76.02	30.41	76.02	54.69+4.00

Table-7
Primary productivity in Kotwal reservoir at station D during the year 2008-2009

SN	Para.	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Min.	Max.	Mean+ SE
1	GPP	54.90	103.89	52.37	87.84	110.65	120.36	129.65	103.05	109.80	94.18	96.29	127.54	52.37	129.65	99.21+7.17
2	NPP	29.56	63.35	29.56	67.57	54.90	57.01	73.91	54.90	84.46	48.57	50.68	71.79	29.56	84.46	57.19+4.80
3	RR	25.34	40.54	22.81	20.27	55.75	63.35	55.75	48.14	25.34	45.61	45.61	55.75	20.27	63.35	42.02+4.34

Table-8
Primary productivity in Kotwal reservoir at station D during the year 2009-2010

Para.	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Min.	Max.	Mean+ SE
GPP	119.10	98.40	81.09	132.19	130.92	130.92	121.63	108.96	133.45	139.37	147.81	156.26	81.09	156.26	125.01+6.06
NPP	63.35	52.79	50.68	73.91	92.91	105.58	63.35	63.35	67.57	88.69	84.46	105.58	50.68	105.58	76.02+5.51
RR	55.75	45.61	30.41	58.28	38.01	25.34	58.28	45.61	65.88	50.68	63.35	50.68	25.34	65.88	48.99+3.66

Table-9
Range of variation of Primary productivity in Kotwal reservoir during 2008-2010

S.N.	PARAMETERS	MINIMUM	MAXIMUM	Mean+SE
1	GPP (mg Cm3 per hour)	68.94	153.51	111.9+4.19
2	NPP (mg Cm3 per hour)	41.70	100.30	66.98+2.75
3	RR (mg Cm3 per hour)	27.24	65.25	44.92+2.02

Table-10
Mean value of The Ratio of NP; GP; RR; and RR% of Kotwal reservoir during 2008-10

S.N.	Parameters	Minimum	MAXIMUM	Mean+SE
1	NP:GP (mg Cm3 per hour)	0.49	0.70	0.60+0.01
2	NP:RR (mg Cm3 per hour)	0.98	2.39	1.53+0.06
3	GP: RR (mg Cm3 per hour)	1.98	3.39	2.53+0.06
4	RES% (mg Cm3 per hour)	29.54	50.63	40.11+0.93

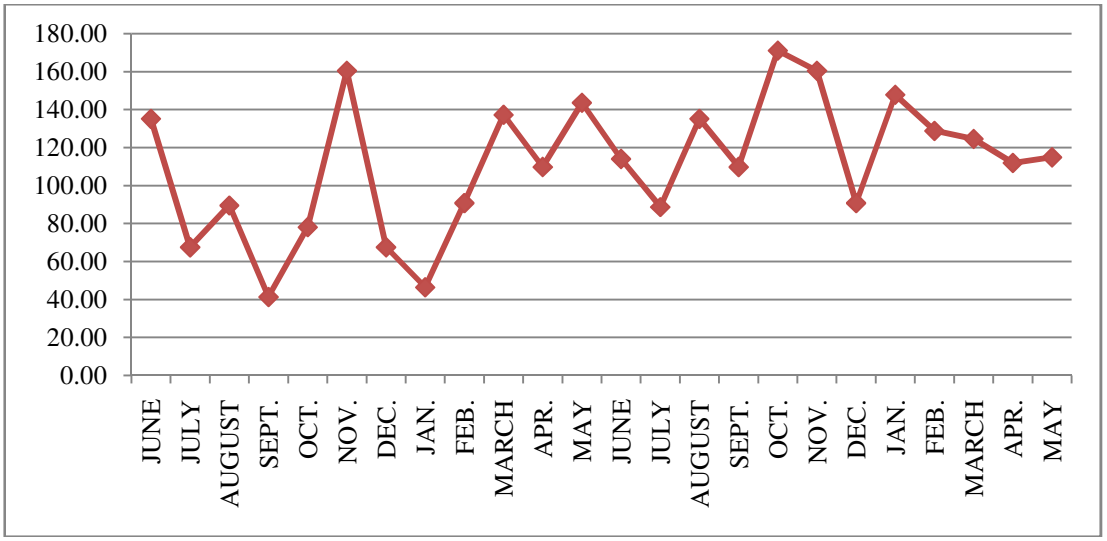

Figure-2
Showing the monthly variation of GPP of Kotwal reservoirat station A

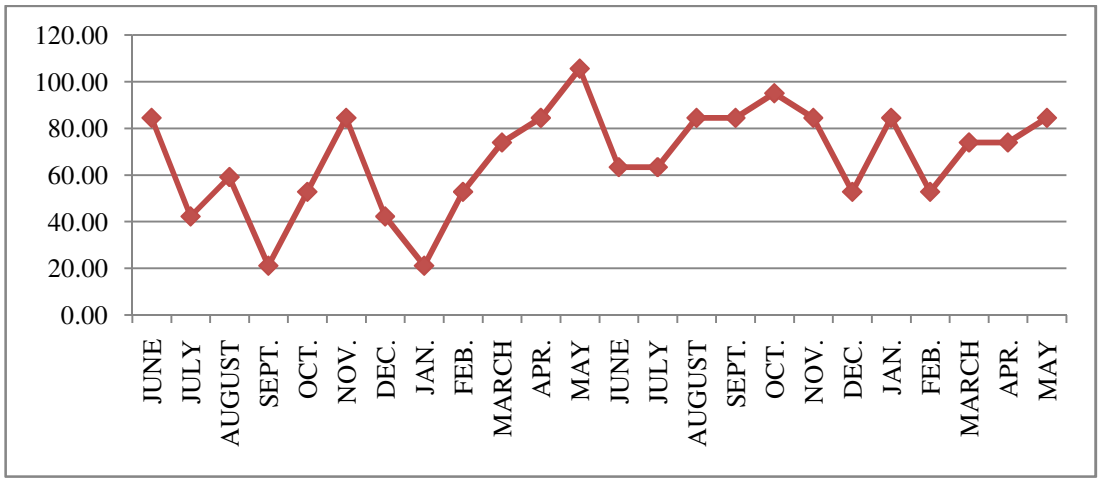

Figure-3
Showing the monthly variation of NPP of Kotwal reservoirat station A

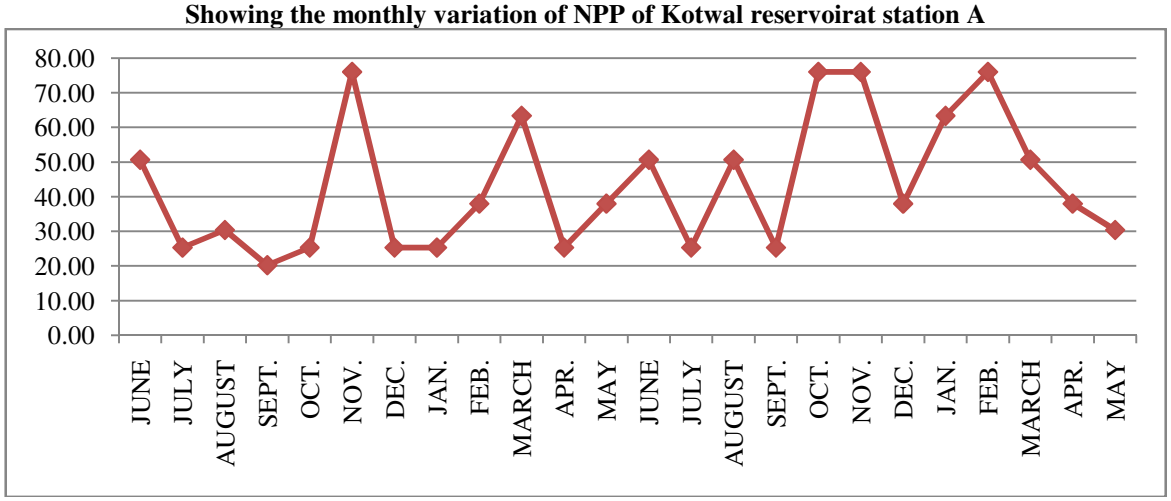

Figure-4
Showing the monthly variation of RR of Kotwal reservoirat station A

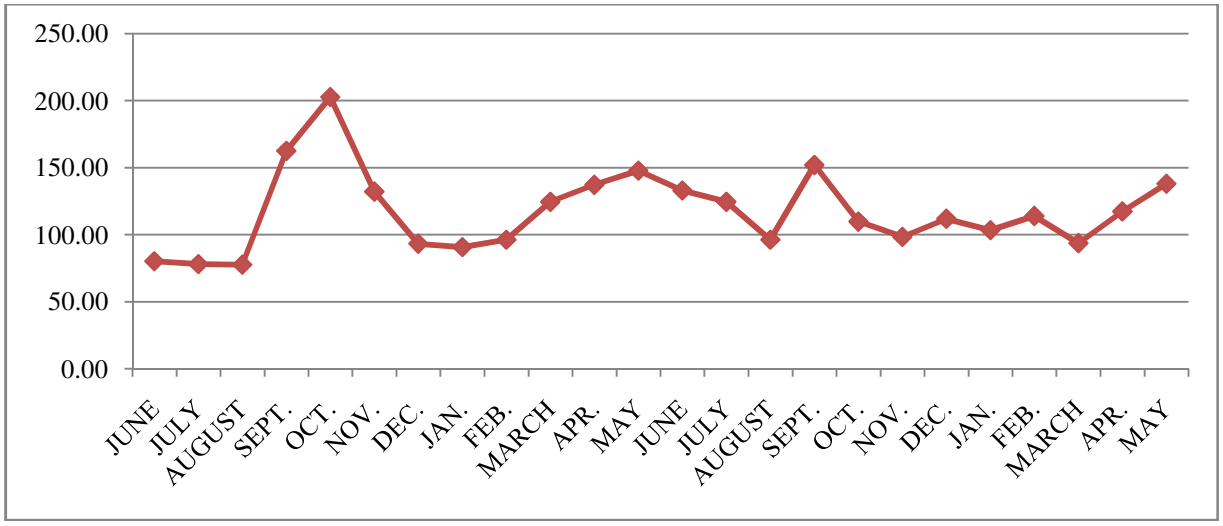

Figure-5
Showing the monthly variation of GPP of Kotwal reservoirat station B

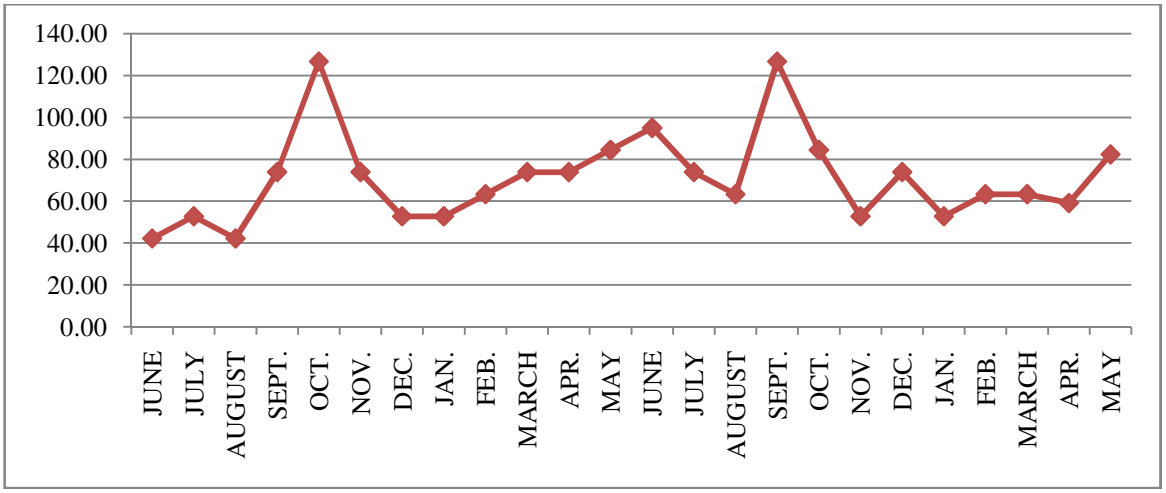

Figure-6
Showing the monthly variation of NPP of Kotwal reservoirat station B

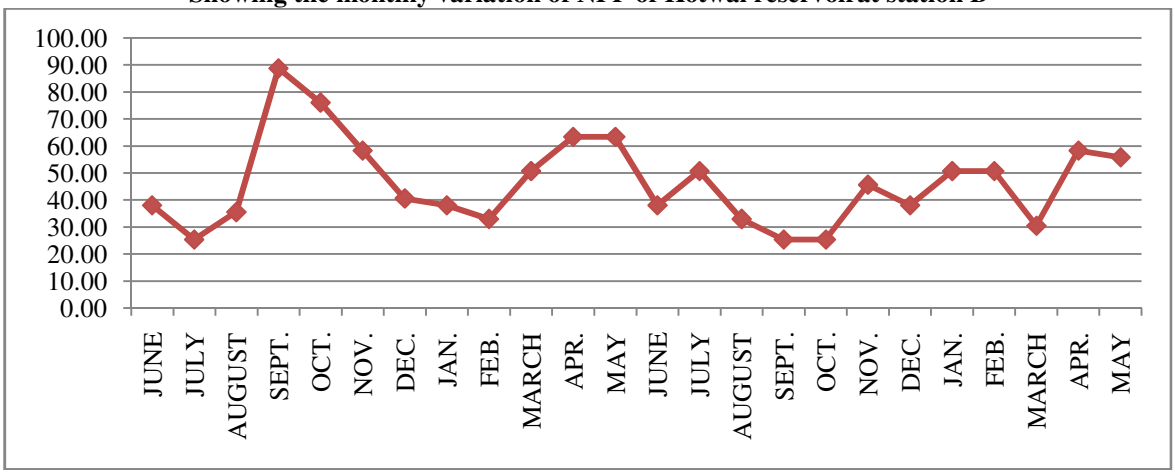

Figure-7
Showing the monthly variation of RR of Kotwal reservoirat station B

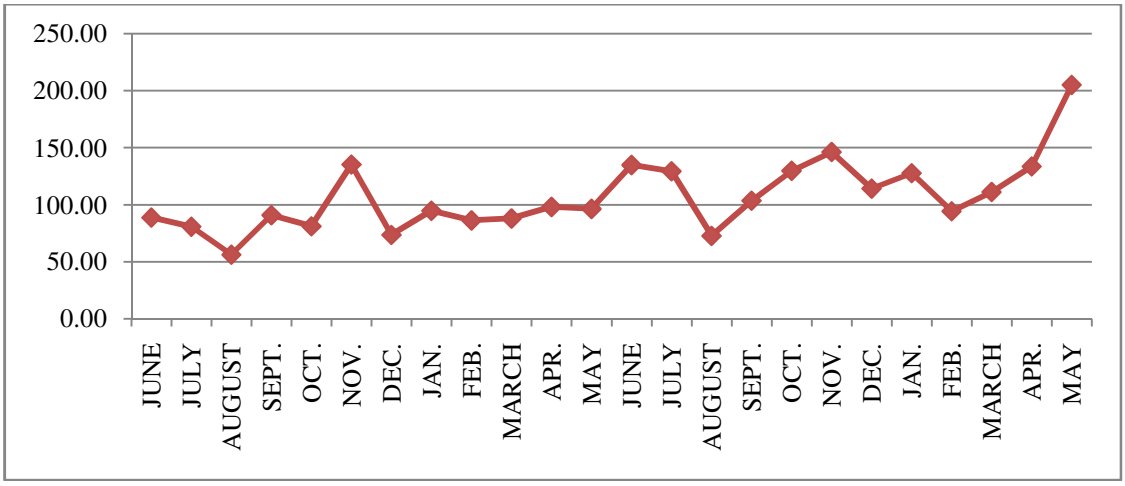

Figure-8
Showing the monthly variation of GPP of Kotwal reservoirat station C

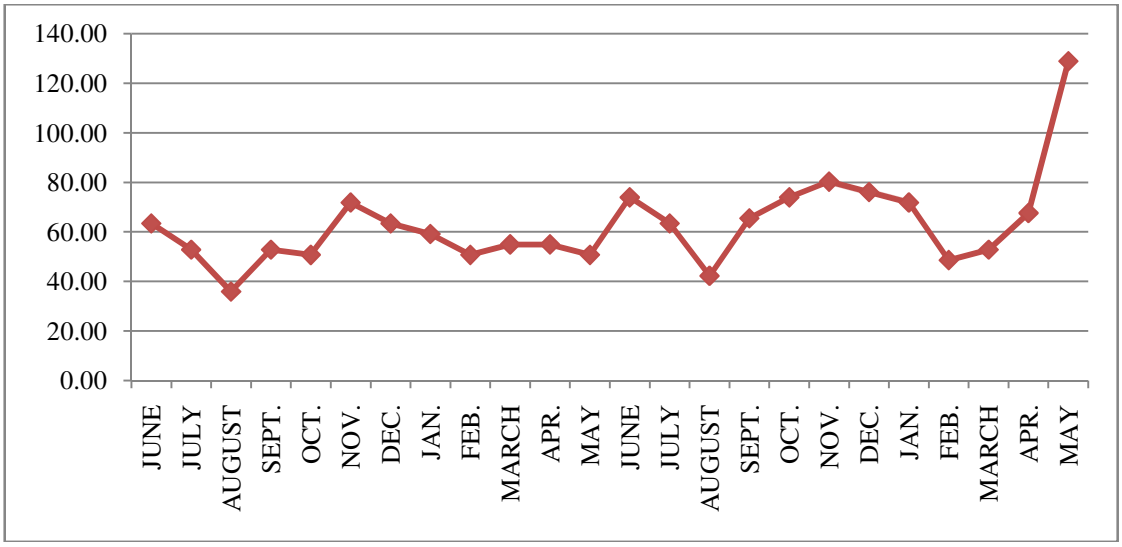

Figure-9
Showing the monthly variation of NPP of Kotwal reservoirat station C.

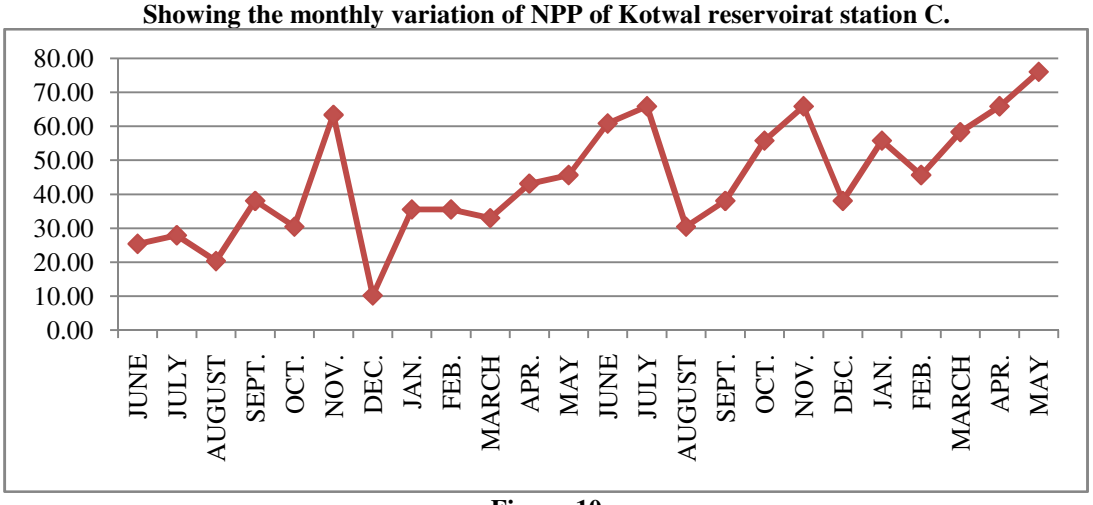

Figure-10
Showing the monthly variation of RR of Kotwal reservoirat station C

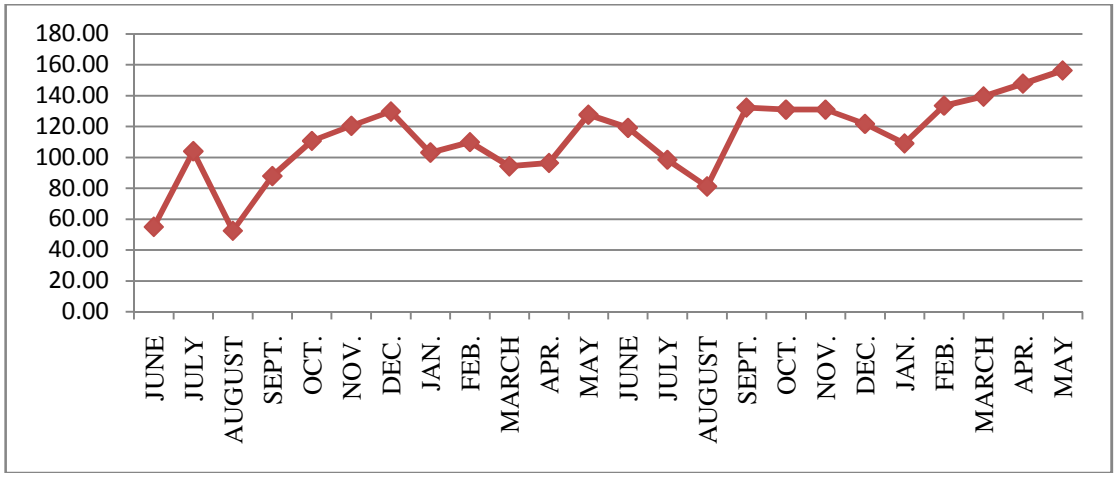

Figure-11
Showing the monthly variation of GPP of Kotwal reservoirat station D.

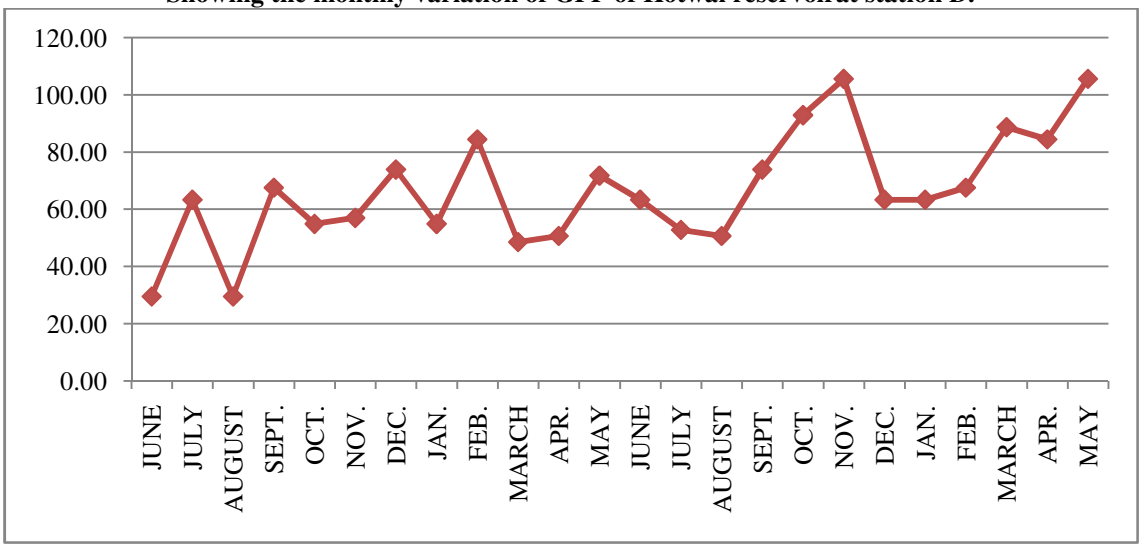

Figure-12
Showing the monthly variation of NPP of Kotwal reservoirat station D.

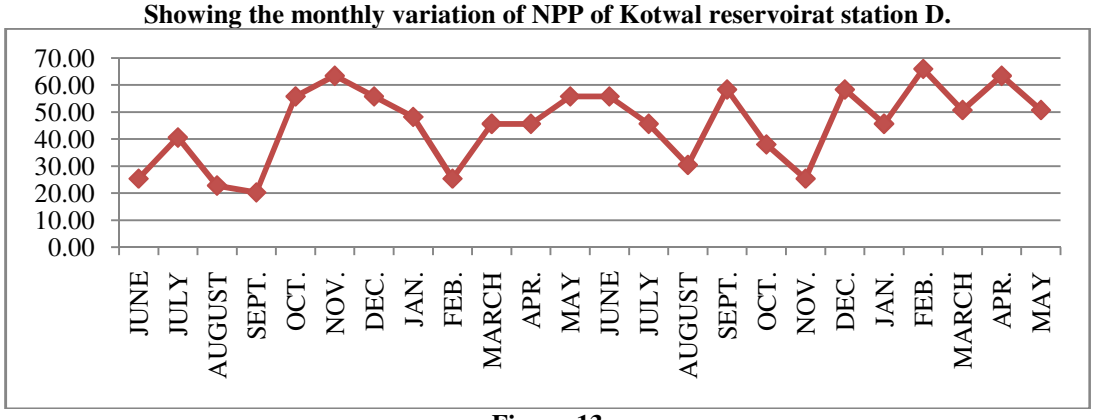

Figure-13
Showing the monthly variation of RR of Kotwal reservoirat station D

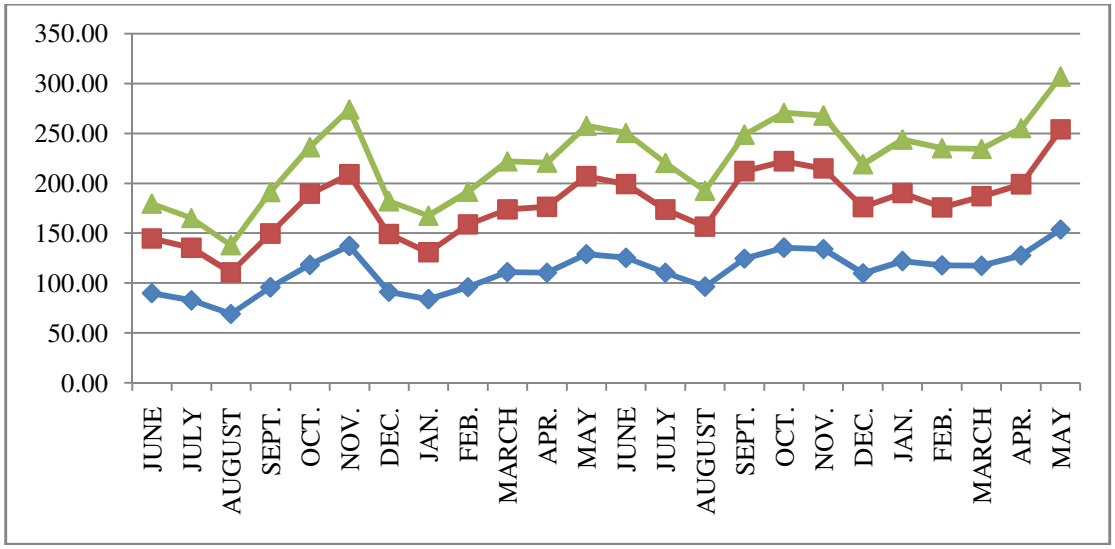

Figure-14
Showing the average variation of GPP, NPP and RR of Kotwal reservoir

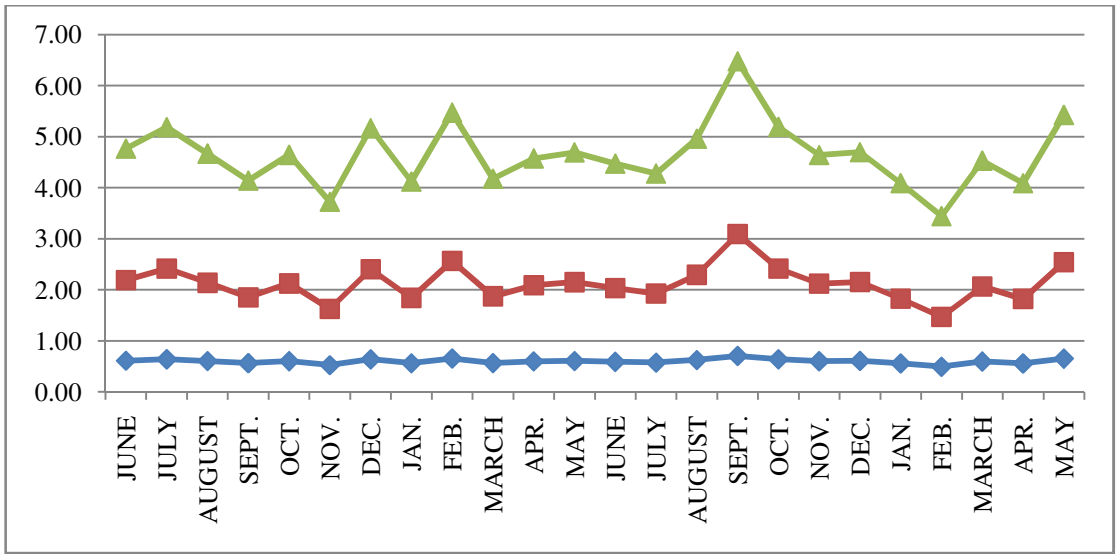

Figure-15
Showing the ratio of NP:GPP,NPP:RR and GPP:RR of Primary Productivity at Kotwal reservoir

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