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In situ measurement of primary production and production respiration ratio of Thol Wetland, Mehsana, Gujarat, India

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Abstract

The value of primary productivity reflects the ecological health of an aquatic ecosystem. Considering this, the in situ measurement of primary production and production respiration were made using light and dark bottle in the Thol Wetland Bird Sanctuary during the year 2015 - 2016 covering winter, summer and monsoon seasons. The total productivity ranged from 12.45 g C/m^3/d to 0.3 g C/m^3/d having maximum value in summer and minimum value in monsoon. The production respiration ratio ranged from 2.06 to 0.032 having maximum value in summer and minimum value in monsoon. Factors affecting the Primary Productivity and Photosynthesis Respiration ratio in an aquatic ecosystem are mainly light, nutrients, hydrographic conditions, temperature, turbidity, solar radiation and plankton density.

Keywords: Primary productivity, Photosynthesis respiration ratio, Thol Wetland.

Introduction

In an aquatic ecosystem, majority of primary production is accomplished by phytoplankton. The total amount of organic material produced by photosynthesis represents Gross Primary Production. As a portion of the organic material produced by photosynthesis is utilized in cellular Respiration, any excess production is referred to as Net Primary Production. It represents amount of organic material available to support consumers and decomposers[1]. In other words it is an estimation of glucose ($C_6H_{12}O_6$) produced by photosynthetic autotrophs in a known volume of water over a specific time. The ratio of total primary production to total community respiration is used to classify communities quantitatively according to their predominantly heterotrophic or autotrophic characteristics[2-4].

Study area: Thol Bird Sanctuary (TBS) is located at about 22 km away from Kadi town of Mehsana district of Gujarat State, India. Originally, it was a shallow manmade water reservoir (tank) and subsequently declared as a sanctuary in November 1988 owing to its high conservation value. It has a total area of 699 ha and the periphery is 5.62 km[5]. There is a continuous earthen bund on its western, southern and eastern periphery, which helps in collection of water that flows into it during the monsoon from the catchment area. Thol water body also supports a canal based irrigation system. It is always important to carry out studies related to environmental aspects on regular basis so as to monitor the changes in a dynamic ecosystem, as here in this case, the changing water regime of the Thol Wetland. It remains covered with water in the rainy season. During winter it begins to dry and by summer the wetland is separated into water bodies of varying in size, the biggest being towards the western side. An in situ measurement of primary production and production respiration ratio of the Thol wetland using light dark bottle methodology[6-10] was carried out at sampling location near culvert no.1 (Lat. 23° 07’ 53.9’’ N, Long. 72° 24’ 46.7’’E) where minimal human intervention was observed. The study was carried out for three seasons during the year 2015-2016.

Materials and methods

A set comprising three (one dark and two light bottles) 300 ml capacity bottles were taken. In each set, one of the bottles was double coated with black paint and labeled. Each of the bottles were carefully filled with wetland water sample by keeping the bottles at 45° angle with the water surface avoiding shaking or splashing so that no oxygen is added to the water sample from outside. The bottles suspended vertically from an indigenously made floating platform (Figure-1 A and B). The whole setup was placed in the water column in the area having continuous exposure to sunlight. The dissolved oxygen of one of the light bottles representing the initial dissolved oxygen value was fixed with Wrinkler’s reagents.

The in situ incubation was carried out for 3 hrs. After the incubation period the bottles were retrieved and the dissolved oxygen was immediately fixed in dark and light bottle with Wrinkler’s reagents (Manganous Sulphate and Alkaline Potassium Azide Solution). Dissolved Oxygen levels were estimated using Wrinkler’s titrimetric method[11]. Various field and experimental observations are reflected in Table-1. The seasonal pattern of estimated dissolved oxygen is represented in Figure-2.

After the incubation period, dissolved oxygen is measured in all bottles and total oxygen produced is calculated by adding the oxygen consumed in the dark bottles to the oxygen produced in the corresponding light bottles.

Total oxygen production was used to calculate gross primary production by multiplying its value with the conversion factor 0.375[1,12]. Accordingly, the summary of calculations[1,12,13] is placed in Table-2.

Results and discussion

It is found that the total daily productivity (Gross Primary Productivity - GPP) was maximum (12.45 g $C/m^3/d$) in summer season and minimum 0.3 g $C/m^3/d$ in monsoon against the annual average value of 5.910 g $C/m^3/d$ (Figure-3). Thus, it is revealed that to the yearly primary production, summer season contributes about 70%, winter 28% and monsoon 2% (Figure-4). The Photosynthesis – Respiration ratio (P/R) is found to be maximum (2.06) in summer and minimum (0.032) against the annual average P/R ratio of 1.234 (Figure-5).

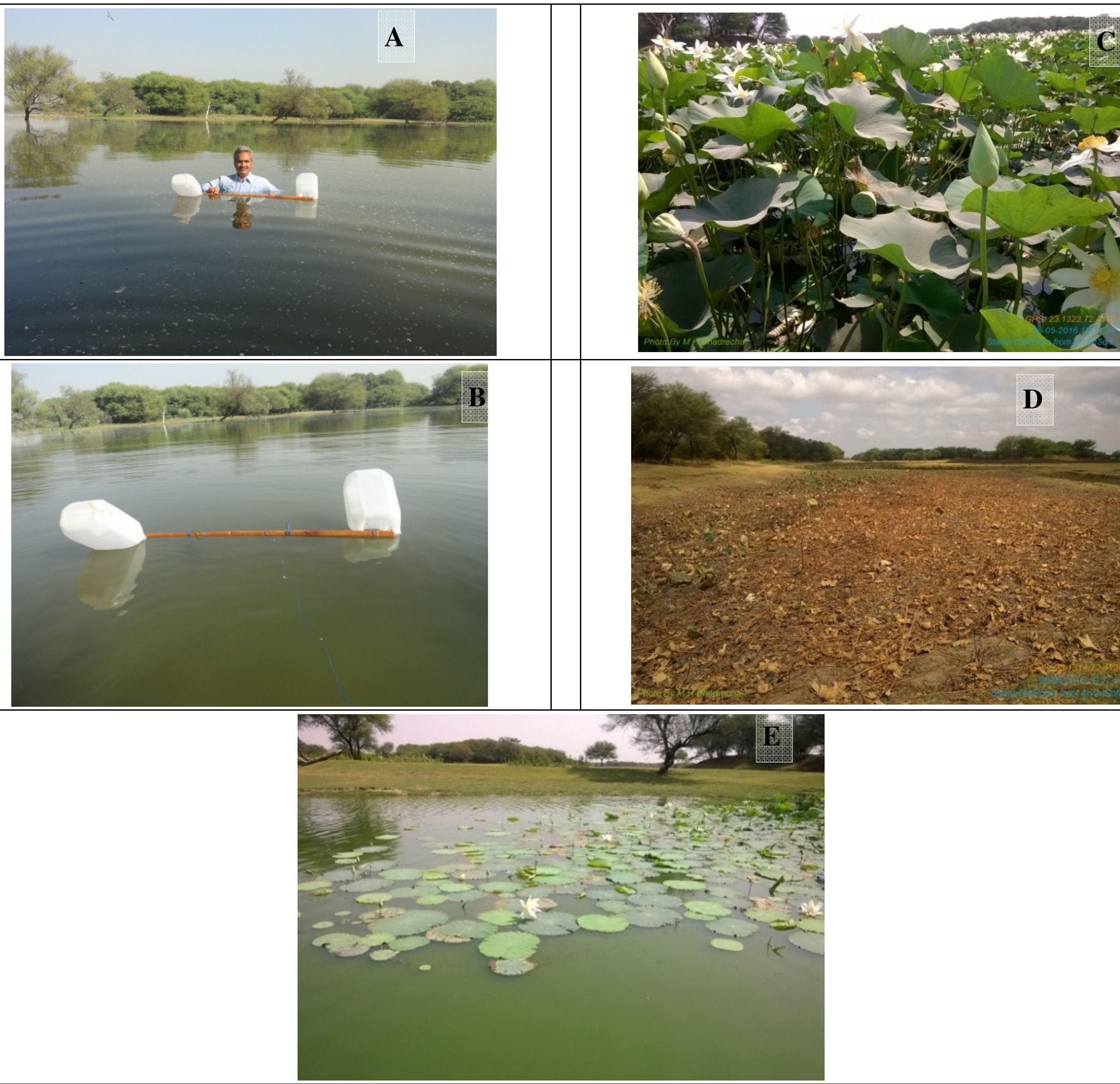

Figure-1 A to E: A. Arranging the Dark and Light Bottle Experimental Setup in Water Column, B. Floating Platform for Suspending Dark and Light Bottle in Water Column, C. Profulus Growth of *Nelumbo lucifera* (kamal kakadi), D. Dried and Dead *Nelumbo lucifera* during Extreme Summer, E. *Nelumbo lucifera* in Sourrounding Waters.

Table-1: Various Field and Experimental Observations.

Parameter	Season		
	Winter	Summer	Monsoon
Start Date and Time.	07.12.2015 10:30 hrs	08.05.2016 11:15 hrs	28.08.2016 08:40 hrs
End Date and Time	07.12.2015 13:30 hrs	08.05.2016 14:15 hrs	28.08.2016 11:40 hrs
Incubation Period (hrs)	3	3	3
Temperature ^{o}C (Ambient/Water)	25.6/ 19.0	35.5 / 28.0	29.0 / 26.5
Average Depth (ft)	4.5	2.3	5.0
Light Penetration i.e. Sacchi Disc Depth (ft)	1.5	1.0	2.0
Colour of Water Body -Visual Appearance	Light green. (due to phyto-plankton growth)	Greenish. (due to rich phyto-plankton growth and algal bloom)	Colourless and clean.
Weather	Clear with moderate sun intensity.	Clear with high sun intensity	Cloudy with occasional rain showers of several minutes with intermittent low sun intensity.
Initial Dissolved Oxygen i.e. before incubation period (mg/l)	4.575	13.640	7.300
Final Dissolved Oxygen			
In Light Bottle (mg/l)	5.850	17.035	6.225
In Dark Bottle (mg/l)	4.190	12.890	6.125

Table-2: Summary of Calculations.

Parameter	Season			Yearly Average
	Winter	Summer	Monsoon	
Net Oxygen Production mg/l. Subtracting ‘Initial Dissolved Oxygen’ from ‘Final Dissolved Oxygen (Light Bottle).’	1.275	3.395	-1.075	1.198
Oxygen Consumed by Community **Respiration** mg/l. Subtracting ‘Final Dissolved Oxygen (Dark Bottle)’ from ‘Initial Dissolved Oxygen.’	0.385	0.755	1.175	0.772
Total Dissolved Oxygen Production mg/l. Adding ‘Oxygen Consumed by Community Respiration’ to ‘Net Oxygen Production.’	1.660	4.150	0.100	1.970
Total Carbon **Production** mg C/mg O_2/l. Multiplying ‘Total Dissolved Oxygen Production’ by 0.375 mg C/mg O_2	0.6225	1.55625	0.0375	0.739
Carbon Production Rate mg C/mg O_2/l/hr Dividing ‘Total Carbon Production’ by ‘Incubation Time’	0.2075	0.51875	0.0125	0.246
Total Daily Productivity g C/m^3/d Multiplying ‘Carbon Production Rate’ by 1,000 to convert liters to cubic meters, then dividing by 1,000 to convert mg to grams, then is multiplying by 24 to convert hours to days.	4.980	12.450	0.300	5.910
Photosynthesis Respiration Ratio. Dividing gross primary production by respiration	1.610	2.060	0.032	1.234

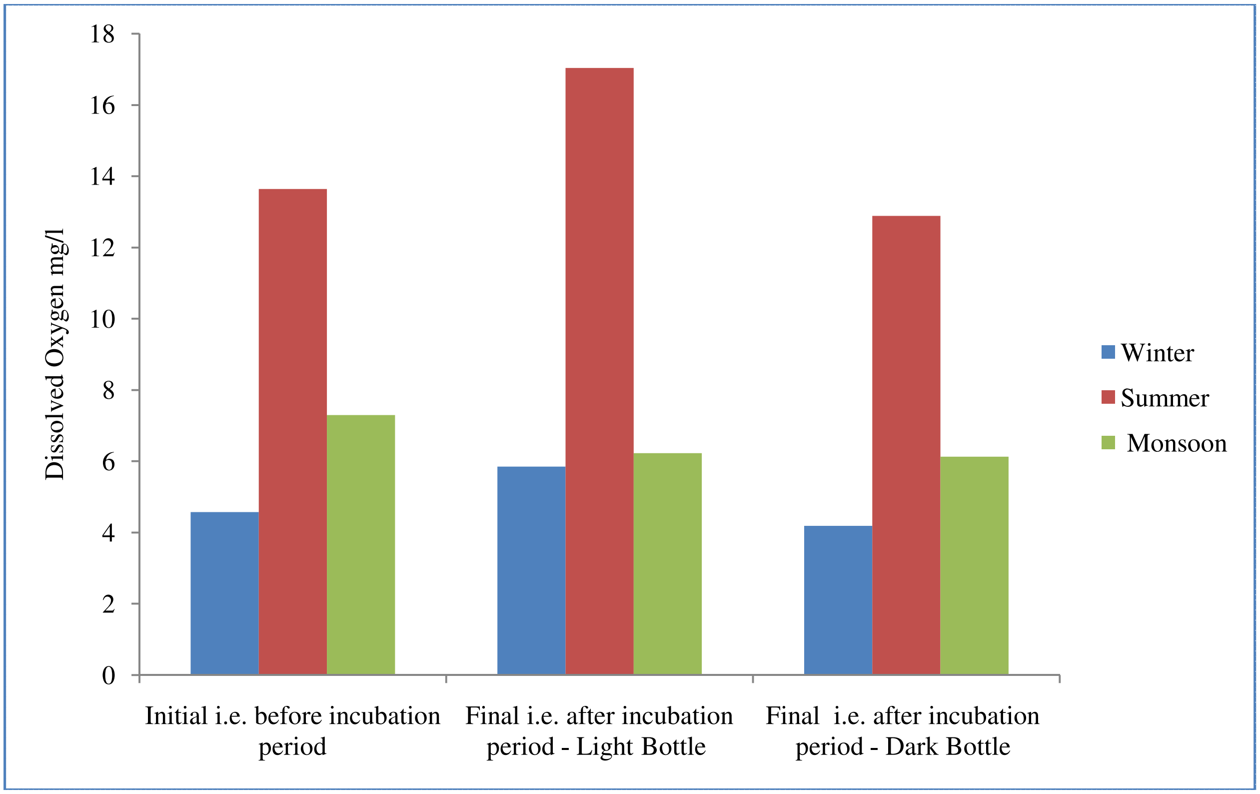

Figure-2: Seasonal Pattern of Dissolved Oxygen.

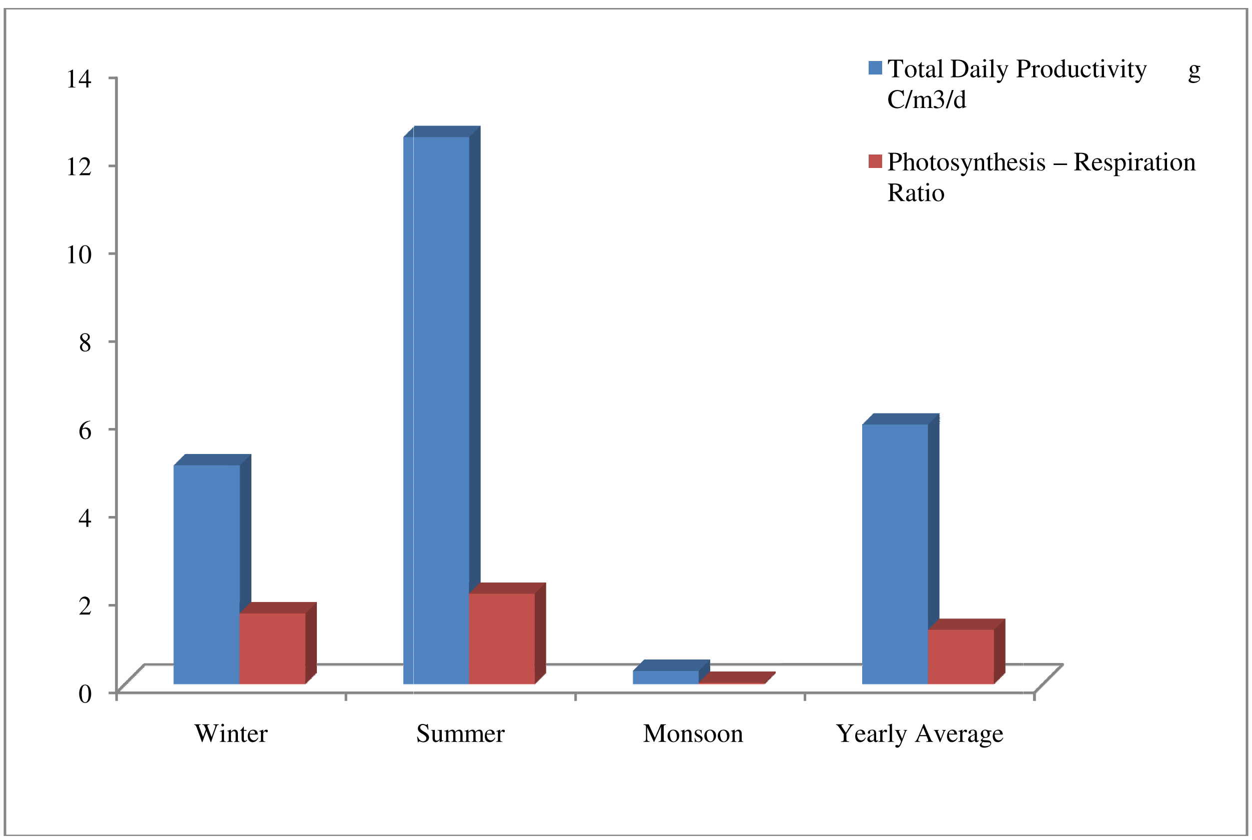

Figure-3: Representation of GPP and P/R ratio

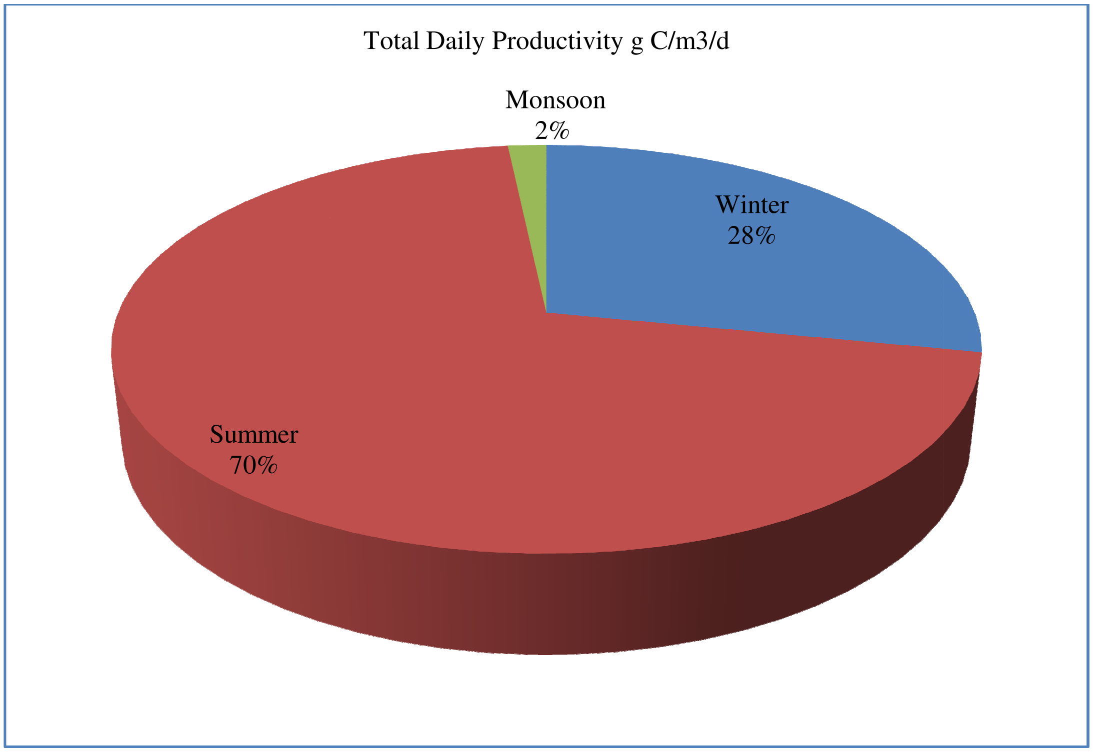

Figure-4: Percentage Contribution of Seasons to GPP

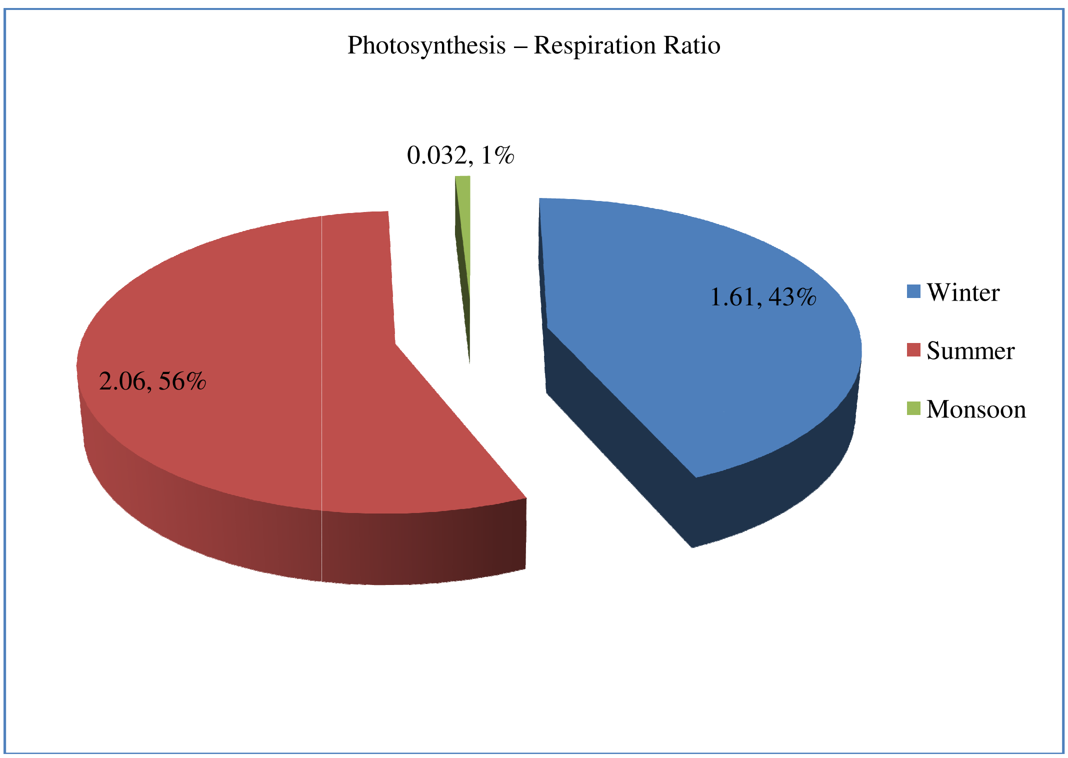

Figure-5: Percentage Contribution of Seasons to P/R Ratio.

The linear trend line is plotted for Photosynthesis Respiration ratio and for Gross Primary Production to understand the seasonal trend. Linear regression model was generated for these two parameters where seasons were taken on the X axis and quantitative value of parameters on Y axis. The regression equation is depicted as component on each graph (Figure-6 and 7).

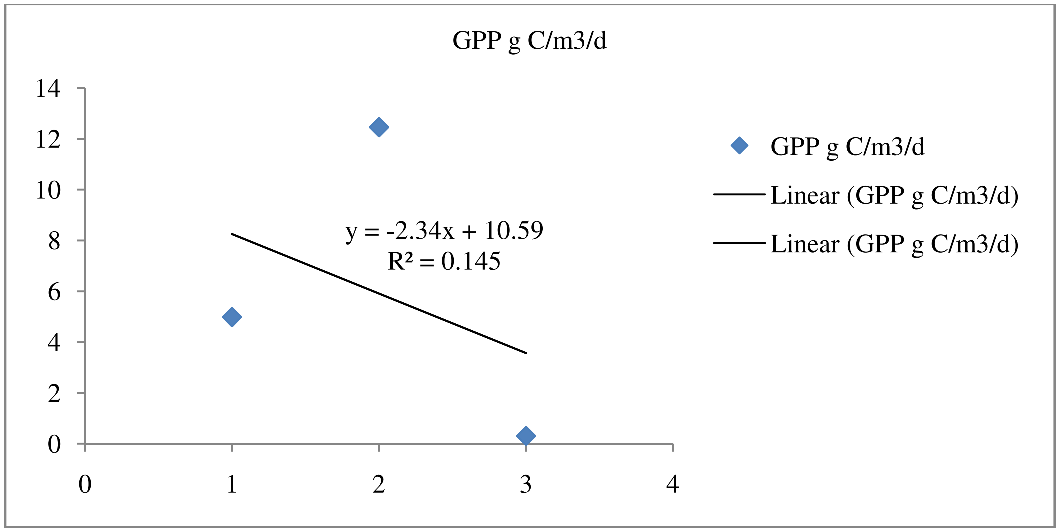

Figure-6: Linear Regression for Photosynthesis Respiration ratio.

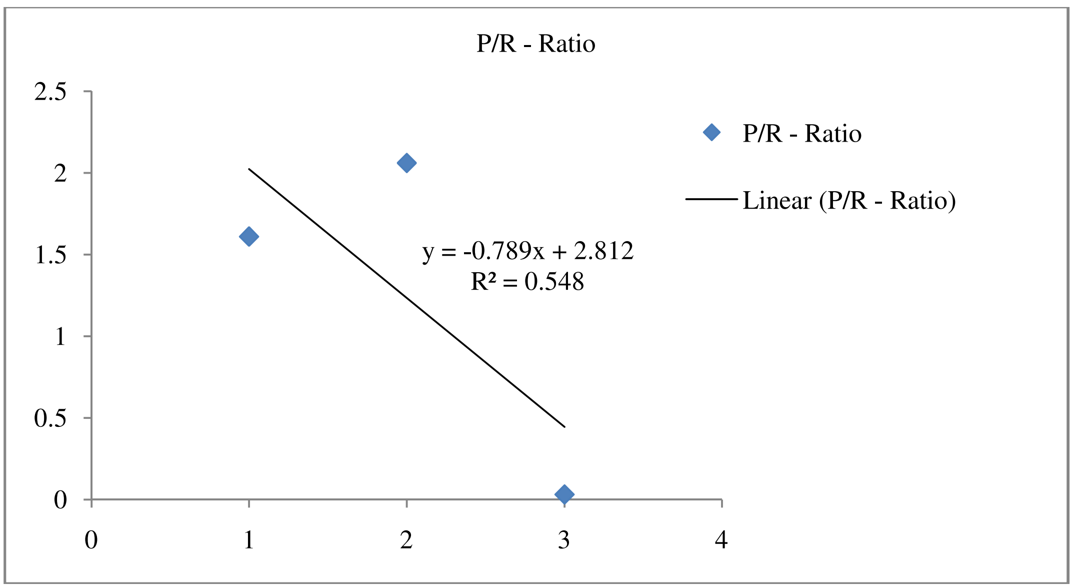

Figure-7: Linear Regression for Gross Primary Production.

The statistical correlation of both parameters within them was calculated to understand the interrelationship between these two parameters. The specific correlation is represented in Table-3. A strong correlation of 0.9 is found to exist between Gross Primary Productivity and Photosynthesis Respiration ratio.

Table-3: Statistical Correlation between GPP and P/R ratio.

	GPP g C/m^3/d	*P/R - Ratio*
GPP g C/m3/d	1	
P/R - Ratio	0.903668798	1

Field observations during the study period revealed that the Wetland water is enriched by organic detritus[14,15]. Aquatic birds were also found grazing and swimming in water and taking rest near the water edges. With monsoon season set, the surrounding flora starts getting revived and flourish. There was also a populous growth of emergent aquatic weed lotus – *Nelumbo lucifera* at this location (Figure-1 C, D and E). The big leaves of *Nelumbo* shades the water keeping it cool and thus allowing for more dissolved oxygen. The plant also provides shelter for small aquatic creatures, which in turn attract predator birds. The seasonal pattern of dissolved oxygen during the in situ experiment shows that during the summer the values remains comparatively higher which is probably due to rich phytoplankton growth[14,16]. Moreover, there exists a relationship[2-4,15] between Gross Production (P) and Total Community Respiration (R), where P/R = 1 indicates a steady-state community and if the P/R is greater or less than 1 then organic matter either accumulates or is depleted respectively.

During the in situ measurements, the Photosynthesis Respiration Ratio is found to be greater than 1 during winter and summer seasons. This indicates that there is an accumulation of organic matter in Thol Wetland during these months. This finding was also substantiated by the fact that (i) organic detritus in the form of dried leaves, twigs, flowers etc. falling from the surrounding trees and shrubs and (ii) the water column visually appeared greenish due to lush phytoplankton growth indicating high organic content.

Conclusion

It is concluded that during monsoon season, the Photosynthesis Respiration ratio is found to be less than 1 indicating that Respiration activity is more than the Photosynthesis the reasons being organic content gets diluted during the monsoon season as well as the rapid depletion of organic content by the primary consumers.

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References

1. Odum H.T. (1956). Primary Production in Flowing Waters. *Limnol. Oceanogr*., 1(2), 102-117.

2. Cornell Linda P. and Klarer David M. (2008). Patterns of Dissolved Oxygen, Productivity and Respiration in Old Woman Creek Estuary, Erie County, Ohio during Low and High Water Conditions. *Ohio Journal of Science*, 108(3), 31-43.

3. Zwart D. de., Kruijf HAM de and Trivedi Dr. R.C. (1995). Manual on Integrated Water Quality Evaluation. RIVM, Report 802023003.

4. Pringault O., Tassas V. and Rochelle-Newall E. (2007). Consequences of respiration in the light on the determination of production in pelagic system. *Biogeoscience*, 4(1), 105-114.

5. Principal Chief Conservator of Forest and Head of the Forest Force Govn. of Gujarat (2016) https://forests.gujarat.gov.in, accessed on 21.12.2016

6. Ajayan K.V. and Parameswara Naik T. (2014). Phytoplankton Primary Productivity in Lentic Water Bodies of Bhadravathi Taluk, Shimoga District, Karnataka, India. *International Research Journal of Environment Sciences*, 3(4), 34-41.

7. Kumar Ashok (2015). Studies on Monthly and Seasonal Variations in Primary Productivity of Glacial fed Mountainous Goriganga River in Kumaun Himalaya, Uttarakhand. *International Research Journal of Environment Sciences, India*, 4(3), 53-65.

8. Selvaraj G.S.D. (2005). Estimation of Primary Productivity (Modified Light and Dark bottle Oxygen method). *Mangrove Ecosystems: A manual for the Assessment of Biodiversity*, 83, 199-200.

9. Kohler Jan (1998). Measurement of photosynthetic oxygen production. *Rostock, Meerersbiol, Beitr*., 6, 17-21.

10. Koenings J.P., Edmundson Jim A., Kyle G.B., Edmundson J.M. and Burkett R.B. (1987). Limnology Field and Laboratory Manual : Methods for Assessing Aquatic Production. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, 71, 221.

11. Water Environmental Federation, APH Association (2005). Standard methods for the examination of water and wastewater. 21st edition, APHA, AWWA, WEF.

12. Sarma Jayashree (2016). A comparative study of Primary Productivity Estimation in the Selected Wetlands of Dimoria Tribel –belt in Kamrup Metro District, Assam, India. *Imperial Journal of interdisciplinary Research* (IJIR), 2(5), 460-462.

13. Ocean (2016). Message in the Bottles. http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_message.pdf, accessed on 24.12.2016

14. Leonard Nancy J., Wang Lili and Mitsch William J., (2000). Gross primary productivity and aquatic plant Biomass: Indicators of divergence in two constructed wetlands. The Olentangy River Wetland Research Park, GPP, 69-76.

15. Rajyalakshmi T. and Premswarup T.V. (1975). Primary productivity in river Godavari India. *Indian Journal of Fisheries*, 22(1), 205-214.

16. Williams P.J.le B and del Giorgio P.A. (2005). Respiration in aquatic ecosystems. Oxford University Press, New York, 1-17, 103-121.