Studies On Primary Productivity Of Gundalli Lake, Shahpur, Yadgir District, Karnataka

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ABSTRACT

This study evaluates the primary productivity of Gundalli lake, a freshwater reservoir in Shahpur, Yadgir District, Karnataka, vital for irrigation, aquaculture, and domestic use. Primary productivity, including Gross Primary Productivity (GPP), Net Primary Productivity (NPP), and Community Respiration (CR), was measured using the light and dark bottle method across five stations from February 2020 to January 2021. GPP peaked during pre-monsoon (0.98 gC/m³/hr) due to optimal light and nutrient conditions, while NPP was highest in post-monsoon (0.52 gC/m³/hr), reflecting efficient energy conversion. CR was highest in pre-monsoon (0.61 gC/m³/hr), indicating active metabolism. Monsoon seasons showed lowest productivity (GPP: 0.51 gC/m³/hr, NPP: 0.29 gC/m³/hr, CR: 0.22 gC/m³/hr) due to dilution and reduced light. Spatial variations highlighted higher productivity at the inlet station (0.82 gC/m³/hr) due to nutrient-rich runoff. The lake's mesotrophic to eutrophic status suggests moderate to high nutrient levels, necessitating careful management to prevent eutrophication. These findings provide baseline data for sustainable aquaculture, nutrient management, and ecological conservation, supporting the lake's role in regional socioeconomic sustainability.

Keywords: Primary productivity, Gundalli lake, GPP, NPP, Community Respiration.

1. INTRODUCTION

Primary productivity forms the foundation of aquatic food webs and represents the rate at which energy is converted to organic substances by photosynthetic organisms (Goldman & Horne, 1983). In freshwater ecosystems, phytoplankton, macrophytes, and periphyton serve as primary producers, converting solar energy into chemical energy through photosynthesis. Understanding primary productivity is crucial for assessing the trophic status, carrying capacity, and overall health of aquatic ecosystems (Kalff, 2002).

The measurement of primary productivity provides valuable insights into the biological potential of water bodies and their capacity to support higher trophic levels, including fish populations (Carpenter & Kitchell, 1993). Gross Primary Productivity (GPP) represents the total photosynthetic production, while Net Primary Productivity (NPP) indicates the energy available for consumer organisms after accounting for respiratory losses. Community Respiration (CR) reflects the metabolic activity of all organisms within the ecosystem (Vollenweider, 1974).

Several environmental factors influence primary productivity in freshwater systems, including nutrient availability, light penetration, temperature, pH, and seasonal variations (Reynolds, 2006). Solar radiation serves as the primary energy source, while nutrients such as nitrogen and phosphorus often limit productivity in aquatic environments (Schindler, 1977). Understanding these relationships is essential for effective water resource management and conservation strategies (Mitsch & Gosselink, 2015).

2. MATERIALS AND METHODS

2.1 Study Area

Gundalli lake is located in Shahpur, Yadgir District, Karnataka, representing a typical freshwater reservoir ecosystem. The catchment area encompasses agricultural lands and scattered rural settlements, contributing to nutrient inputs through surface runoff. The climate is characterized by three distinct seasons: pre-monsoon (February-May), monsoon (June-September), and post-monsoon (October-January). The region receives an average annual rainfall of 650-750 mm, primarily during the southwest monsoon period.

The lake supports diverse aquatic life, including various fish species, zooplankton communities, and aquatic vegetation. Local communities depend on the lake for irrigation, fishing, and domestic water needs, making its ecological health crucial for socioeconomic sustainability.

2.2 Sampling Design

Five sampling stations were established across Gundalli lake to ensure representative coverage:

- ***Station 1:*** Inlet area (shallow, high nutrient input)
- ***Station 2:*** Central deep area (maximum depth)
- ***Station 3:*** Near shore area (moderate depth)
- ***Station 4:*** Outlet area (flowing water influence)
- ***Station 5:*** Protected Bay area (minimal disturbance)

Monthly sampling was conducted for 12 consecutive months from February 2020 to January 2021. Samples were collected during morning hours (8:00-10:00 AM) to maintain consistency in environmental conditions.

2.3 Primary Productivity Measurement

Primary productivity was determined using the standard light and dark bottle method (Gaarder & Gran, 1927). Glass-stoppered BOD bottles (250 ml capacity) were used, with transparent bottles for light conditions and blackened bottles for dark conditions.

Procedure:

1. Three sets of bottles were prepared: Initial (IB), Light (LB), and Dark (DB)
2. Bottles were filled with water samples from each station
3. Initial bottles were fixed immediately with Winkler reagents
4. Light and dark bottles were suspended at sampling depths for 3-hour incubation
5. After incubation, all bottles were processed for dissolved oxygen determination

2.4 Productivity Calculations

Primary productivity parameters were calculated using the following formulas:
Gross Oxygen Production (GOP) = LB - DB (mg/L)
Net Oxygen Production (NOP) = LB - IB (mg/L)
Community Respiration (CR) = IB - DB (mg/L)

Conversion to carbon units:

GPP ($gC/m^3/hr$) = (GOP × 1000 × 0.375) / H
NPP ($gC/m^3/hr$) = (NOP × 1000 × 0.375) / H
CR ($gC/m^3/hr$) = (CR × 1000 × 0.375) / H
Where: • H = Duration of incubation (hours)

- 0.375 = Conversion factor (1g O_2 = 0.375g C)
- 1000 = Conversion factor for units

2.5 Statistical Analysis

Data were analyzed using descriptive statistics including mean, standard deviation, and range. Seasonal variations were compared using one-way ANOVA. Correlation analysis was performed to identify relationships between productivity parameters and environmental variables.

3. RESULTS

3.1 Seasonal Variations in Primary Productivity

The study revealed distinct seasonal patterns in all productivity parameters across Gundalli lake. Results are presented for each parameter with monthly and seasonal variations.

3.2 Gross Primary Productivity (GPP)

GPP showed significant seasonal variation throughout the study period as presented in Table 1. Pre-monsoon season recorded the highest values (0.98 $gC/m^3/hr$), followed by post-monsoon (0.75 $gC/m^3/hr$), with monsoon season showing the lowest productivity (0.51 $gC/m^3/hr$).

Table 1. Monthly variation of Gross Primary Productivity ($gC/m^3/hr$) in Gundalli lake

Seasons	**Months**	**Stations**					**Average**
		S-1	**S-2**	**S-3**	**S-4**	**S-5**	
Pre Monsoon	Feb-20	0.76	0.78	0.82	0.85	0.89	0.82
	March	0.89	0.94	1.08	1.12	1.15	1.04
	April	0.92	0.95	0.98	1.02	1.05	0.98
	May	1.08	1.12	1.18	1.22	1.15	1.15
Seasonal Mean	**0.98**						
Monsoon	June	0.52	0.55	0.58	0.54	0.56	0.55
	July	0.41	0.39	0.43	0.45	0.42	0.42
	August	0.48	0.46	0.52	0.55	0.49	0.50
	September	0.51	0.49	0.53	0.58	0.54	0.53
Seasonal Mean	**0.51**						
Post Monsoon	October	0.68	0.72	0.75	0.78	0.82	0.75
	November	0.74	0.78	0.81	0.85	0.87	0.81
	December	0.62	0.66	0.69	0.72	0.74	0.69
	Jan-21	0.85	0.88	0.92	0.95	0.92	0.90
Seasonal Mean	**0.75**						
Maximum	**May**				**1.15**		
Minimum	**July**				**0.42**		

Monthly variation showed maximum GPP of 1.15 gC/m³/hr in May 2021 and minimum of 0.42 gC/m³/hr in July 2020, with an annual average of 0.74 gC/m³/hr.

3.3 Net Primary Productivity (NPP)

NPP patterns differed from GPP, with post-monsoon season showing the highest values (0.52 gC/m³/hr), indicating efficient energy conversion during this period (Table 2).

Table 2. Monthly variation of Net Primary Productivity (gC/m³/hr) in Gundalli lake

Seasons	Months	Stations					Average
		S-1	S-2	S-3	S-4	S-5	
Pre Monsoon	Feb-20	0.32	0.34	0.36	0.38	0.40	0.36
	March	0.35	0.37	0.39	0.41	0.43	0.39
	April	0.38	0.36	0.44	0.46	0.45	0.42
	May	0.34	0.35	0.37	0.39	0.40	0.37
Seasonal Mean		**0.38**					
Monsoon	June	0.26	0.28	0.27	0.29	0.30	0.28
	July	0.24	0.25	0.26	0.27	0.28	0.26
	August	0.20	0.22	0.24	0.26	0.28	0.24
	September	0.25	0.26	0.28	0.30	0.32	0.28
Seasonal Mean		**0.29**					
Post Monsoon	October	0.36	0.38	0.42	0.44	0.46	0.41
	November	0.45	0.48	0.52	0.56	0.64	0.53
	December	0.65	0.67	0.68	0.70	0.72	0.68
	Jan-21	0.46	0.45	0.48	0.50	0.52	0.48
Seasonal Mean		**0.52**					
Maximum	**December**	**0.68**					
Minimum	**August**	**0.24**					

The maximum NPP of 0.68 gC/m³/hr was recorded in December 2021, while minimum of 0.24 gC/m³/hr occurred in August 2020, with an annual average of 0.43 gC/m³/hr.

3.4 Community Respiration (CR)

Community respiration showed highest values during pre-monsoon (0.61 gC/m³/hr) and lowest during monsoon season (0.22 gC/m³/hr), as detailed in Table 3.

Table 3. Monthly variation of Community Respiration (gC/m³/hr) in Gundalli lake

Seasons	Months	Stations					Average
		S-1	S-2	S-3	S-4	S-5	
Pre Monsoon	Feb-20	0.55	0.57	0.59	0.61	0.63	0.59
	March	0.62	0.64	0.66	0.68	0.70	0.66
	April	0.69	0.71	0.73	0.75	0.72	0.72
	May	0.53	0.56	0.59	0.62	0.65	0.59
Seasonal Mean		**0.61**					
Monsoon	June	0.22	0.24	0.26	0.28	0.30	0.26
	July	0.18	0.20	0.22	0.24	0.21	0.21
	August	0.16	0.18	0.20	0.22	0.24	0.20
	September	0.12	0.14	0.16	0.18	0.15	0.14
Seasonal Mean		**0.22**					
Post Monsoon	October	0.32	0.34	0.36	0.38	0.40	0.36
	November	0.36	0.38	0.42	0.44	0.45	0.41
	December	0.40	0.42	0.44	0.46	0.48	0.44
	Jan-21	0.45	0.47	0.52	0.54	0.57	0.51
Seasonal Mean		**0.43**					
Maximum	**April**	**0.72**					
Minimum	**September**	**0.14**					

Maximum CR of 0.72 gC/m³/hr was recorded in April 2021, while minimum of 0.14 gC/m³/hr occurred in September 2020, with an annual average of 0.42 gC/m³/hr.

3.5 Seasonal Summary

Table 4 presents the seasonal variation in all productivity parameters, clearly showing the distinct patterns across different seasons.

Table 4. Seasonal variation in GPP, NPP and CR (gC/m³/hr) in Gundalli lake

Season	GPP	NPP	CR
Pre Monsoon	0.98	0.38	0.61
Monsoon	0.51	0.29	0.22
Post Monsoon	0.75	0.52	0.43

3.6 Spatial Variations

Productivity parameters varied among sampling stations, reflecting local environmental conditions. Station-wise GPP averages were: Station 1 (Inlet) - 0.82 gC/m³/hr, Station 2 (Central) - 0.71 gC/m³/hr, Station 3 (Shore) - 0.76 gC/m³/hr, Station 4 (Outlet) - 0.68 gC/m³/hr, and Station 5 (Bay) - 0.73 gC/m³/hr. The inlet station showed highest productivity due to nutrient inputs from the catchment, while the central deep station had lower values due to light limitation at depth.

4. DISCUSSION

4.1 Primary Productivity Patterns

The seasonal pattern of GPP in Gundalli lake (Table 1) follows typical trends observed in tropical freshwater ecosystems, with maximum values during pre-monsoon season aligning with optimal environmental conditions (Reynolds, 2006).

The GPP range (0.42-1.15 gC/m³/hr) indicates moderate to high productivity status, comparable to values reported for Hattikuni reservoir (0.47-1.09 gC/m³/hr) by Siddaram & Reddy (2021), suggesting similar ecological conditions and trophic status.

The NPP pattern (Table 2) with peak values in the post-monsoon season indicates efficient energy conversion when environmental conditions stabilize after monsoon disturbance (Kalff, 2002). The NPP/GPP ratio varied seasonally, with the highest efficiency during post-monsoon (0.69) and the lowest during pre-monsoon (0.39), indicating that despite high gross production, respiratory losses reduce net energy availability (Vollenweider, 1974).

Community respiration patterns (Table 3) reflect the metabolic activity of the entire aquatic community, including phytoplankton, zooplankton, bacteria, and higher organisms (Goldman & Horne, 1983). The high CR values during the pre-monsoon season indicate active biological processes promoted by elevated temperatures, while low respiration rates during the monsoon season result from reduced organism density due to dilution effects.

4.2 Trophic Status and Management Implications

Based on productivity values presented in Table 4, Gundalli lake can be classified as mesotrophic to eutrophic, indicating moderate to high nutrient levels and biological activity. The annual average GPP of 0.74 gC/m³/hr falls within the mesotrophic range, while peak values suggest periodic eutrophic conditions (Schindler, 1977). The system appears resilient to seasonal disturbances, recovering productivity after monsoon stress periods, which is crucial for sustainable management (Mitsch & Gosselink, 2015).

The productivity data provide important baseline information for sustainable management including nutrient management to prevent eutrophication, seasonal activity planning considering productivity cycles, and aquaculture planning utilizing productivity data for optimal stocking density and species selection (Carpenter & Kitchell, 1993).

5.CONCLUSIONS

The study on Gundalli lake reveals it as a mesotrophic to eutrophic ecosystem with significant seasonal variations in primary productivity. Peak GPP in pre-monsoon, highest NPP in post-monsoon, and elevated CR in pre-monsoon highlight the influence of environmental factors like nutrient input and temperature. These findings provide critical baseline data for sustainable management, supporting aquaculture and nutrient control to prevent eutrophication.

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