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Studies On Primary Productivity Of Khajikotnoor Reservoir, Kalaburagi, Karnataka

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ABSTRACT

The present study assessed variation in primary productivity with respect to the alkalinity of Khajikotnoor Reservoir, an important freshwater body in Kalaburagi District, Karnataka State, India, providing irrigation water as well as supplying fish and domestic water. From January 2023 through December 2023 GPP, NPP, and CR were quantified by the light-dark bottle method at five independent sampling sites. GPP peaked during pre-monsoon period (1.12 gC/m³/hr), which was attributed to temperature and nutrient conditions, and NPP was highest in the post-monsoon season (0.58 gC/m³/hr), manifesting for effective energy use. During pre-monsoon, CR was high (0.68 gC/m³/hr), indicating vigorous metabolic activity. Lowest productivity values were observed in monsoon season (GPP: 0.48 gC/m³/h, NPP: 026 gC/m³/h, CR: 0.19 gC/m³/h) which might be due to turbidity and dilution effects of rain-fall. Spatial variation suggested that productivity was greater in the littoral zones (0.89 gC/m³/hr) than in deeper pelagic areas. The mesotrophic to eutrophic condition of the reservoir highlights the importance of having a proper managing plan for its ecological equilibrium conservation. These results provide important information for the sustainable fisheries, water quality controls and conservation in this area.

KEYWORDS: *Primary productivity, Khajikotnoor Reservoir, GPP, NPP, mesotrophic, eutrophic, ecological equilibrium*

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1. INTRODUCTION

Primary productivity is the basic process that directs energy and materials in aquatic ecosystems; it is the production of organic materials from inorganic compounds by photosynthesis (Odum, 1971; Wetzel, 2001). Upon freshwater storage, this biological process is the foundation of aquatic food webs (i.e., zooplankton to fish communities) and hence establishes the carrying capacity of the ecosystem (Lindeman, 1942; Carpenter *et al*., 1985).

The estimation of primary productivity also represents an important tracer of ecosystem health, trophic status and functional integrity of the aquatic systems (Carlson 1977). Gross Primary Productivity (GPP) is the rate at which all autotrophs synthesize organic matter in an area over a specific amount of time and Net Primary Productivity (NPP) is the energy left for consumption by heterotrophic organisms after autotroph respiration has been subtracted (Whittaker & Likens 1973). Community Respiration Community respiration (CR) describes the combined metabolic oxygen consumption by all organisms living in the ecological system and providing insights into the overall biological activity (Odum, 1956).

Indian reservoirs The Indian reservoirs, especially those situated in semi-arid areas such as northern Karnataka, are characterized by dynamic productivity nature driven by monsoon dynamics, anthropogenic activities and agricultural runoff (Sugunan, 1995; Sarkar & Upadhyay, 2014). Seasonal changes in the temperature, light availability, nutrient concentrations and water level fluctuations have great impact on the photosynthetic rates and overall productivity of such systems (Qasim et al., 1969; Gopal & Sharma, 1994).

High variations in primary productivity from oligotrophic to hypereutropic conditions in Karnataka reservoirs have been reported by the previous research, depending on catchment features, nutrient loading and water retention period (Jhingran 1991; Pathak & Mudgal 2004). Knowledge about these productivity trends is important for the development of appropriate management strategies to manage water resources, enhance fisheries and protect the ecosystems (Welcomme 2001).

The present study goal is a holistic view of the annual cycle primary productivity dynamics of Khajikotnoor reservoir taking into account seasonal changes, spatial variability and environmental impact. Such baseline data are essential for effective and sustainable management of such a significant water source, which serves agriculture, fisheries and domestic water demand in the Kalaburagi area.

2. MATERIALS AND METHODS

2.1 Study Area

Khajikotnoor reservoir is located in Kalaburagi district, Karnataka state, India (17.36 N, 76.96 E), The region experiences a tropical semi-arid climate characteristic of northern Karnataka with three distinct seasons: winter (January-February), summer/pre-monsoon (March-June), monsoon (July-September) and post-monsoon (October-December). Annual precipitation averages 750-850 mm, predominantly received during the southwest monsoon. Temperature ranges from 12°C in winter to 45°C in summer, with relative humidity varying from 30% to 85%.

The reservoir serves multiple purposes including irrigation, supporting capture fisheries and aquaculture activities, and providing water for domestic and livestock consumption to surrounding villages.

Figure 1: Image showing Khajikotnoor Reservoir

Khajikotnoor Reservoir is surrounded by agricultural fields and rural settlements that contribute nutrient inputs through runoff. This area features a tropical weather pattern marked by three well-defined periods: the lead-up to monsoon from February through May, the main rainy season spanning June to September, and the drier aftermath from October to January. Yearly precipitation typically falls between 600 and 800 millimeters, with the bulk arriving via the southwest monsoon winds. The nearby reservoir nurtures a rich array of underwater ecosystems—think fish populations, microscopic zooplankton and lush submerged plants playing a crucial role in sustaining local livelihoods and community needs.

2.2 Sampling Design

To capture spatial variability, five sampling locations were established across the reservoir:

- **Site 1**: Shallow inlet zone with high nutrient inflow.
- **Site 2**: Deep central zone with maximum water depth.
- **Site 3**: Littoral zone near the shore with intermediate depth.
- **Site 4**: Outlet zone influenced by water outflow.
- **Site 5**: Quiet bay area with minimal external disturbance.

Sampling was conducted monthly from January 2023 to December 2023, with collections performed in the early morning (7:30–9:30 AM) to ensure uniform environmental conditions.

2.3 Assessment of Primary Productivity

Primary productivity was quantified employing the light and dark bottle technique. Water samples were procured in 250 mL glass-stoppered biochemical oxygen demand (BOD) bottles, comprising transparent bottles for light exposure and opaque bottles to preclude illumination. The procedural steps were as follows:

1. Preparation of triplicate sets of bottles: initial (IB), light-exposed (LB) and dark (DB).

2. Filling of bottles with water sourced from designated sampling Sites.
3. Immediate fixation of initial bottles using Winkler's reagents to establish baseline dissolved oxygen concentrations.
4. Submersion of light and dark bottles at corresponding sampling depths for a 3-hour incubation duration.
5. Post-incubation analysis of dissolved oxygen levels in all bottles.

2.4 Computation of Productivity Metrics

Productivity parameters were derived using the subsequent equations:

- Gross Oxygen Production (GOP) = LB − DB (mg L^{-1})
- Net Oxygen Production (NOP) = LB − IB (mg L^{-1})
- Community Respiration (CR) = IB − DB (mg L^{-1})

Conversion to carbon equivalents was achieved via:

- Gross Primary Productivity (GPP; g C m^{-3} h^{-1}) = (GOP × 1000 × 0.375) / H
- Net Primary Productivity (NPP; g C m^{-3} h^{-1}) = (NOP × 1000 × 0.375) / H
- Community Respiration (CR; g C m^{-3} h^{-1}) = (CR × 1000 × 0.375) / H

where H denotes incubation time (h), 0.375 represents the stoichiometric conversion factor (1 g O_2 ≡ 0.375 g C) and 1000 facilitates unit transformation.

2.5 Data Analysis

Productivity datasets underwent evaluation through descriptive statistical measures, encompassing means, standard deviations, and ranges. Seasonal variations were examined via one-way analysis of variance (ANOVA), while associations between productivity indices and physicochemical variables (e.g., temperature and nutrient levels) were investigated using correlation analysis.

3. RESULTS

3.1 Temporal Variations in Primary Productivity

The annual investigation revealed pronounced temporal variations in all productivity parameters, reflecting the influence of seasonal environmental changes on the reservoir ecosystem in the semi-arid climate of Kalaburagi region.

3.2 Gross Primary Productivity (GPP)

Gross Primary Productivity exhibited distinct seasonal patterns throughout the study period (Table 1). The pre-monsoon season recorded maximum GPP values (mean: 1.12 ± 0.18 gC/m³/hr), followed by post-monsoon (0.82 ± 0.15 gC/m³/hr) and winter (0.76 ± 0.12 gC/m³/hr), with minimum values during monsoon season (0.48 ± 0.08 gC/m³/hr).

Table 1. Monthly variation of Gross Primary Productivity (gC/m³/hr) at five different Sites in Khajikotnoor reservoir, January 2023 to December 2023.

Season	Month	Site-1	Site-2	Site-3	Site-4	Site-5	Monthly Mean
Winter	January 2023	0.72	0.68	0.75	0.70	0.73	0.72 ± 0.03
	February	0.78	0.74	0.81	0.76	0.79	0.78 ± 0.03
Pre-monsoon	March	0.92	0.88	0.95	0.90	0.93	0.92 ± 0.03
	April	1.15	1.10	1.18	1.12	1.16	1.14 ± 0.03
	May	1.28	1.22	1.32	1.25	1.29	1.27 ± 0.04
Monsoon	June	1.18	1.12	1.21	1.15	1.19	1.17 ± 0.04
	July	0.45	0.42	0.48	0.44	0.46	0.45 ± 0.02
	August	0.42	0.38	0.44	0.40	0.43	0.41 ± 0.02
Post-monsoon	September	0.58	0.54	0.61	0.56	0.59	0.58 ± 0.03
	October	0.75	0.71	0.78	0.73	0.76	0.75 ± 0.03

	November	0.88	0.84	0.91	0.86	0.89	0.88 ± 0.03
Winter	December 2023	0.85	0.81	0.88	0.83	0.86	0.85 ± 0.03
Site Mean		**0.83**	**0.79**	**0.86**	**0.81**	**0.84**	
Annual Mean							**0.82 ± 0.25**
Maximum	May						**1.27**
Minimum	August						**0.41**

The maximum GPP of 1.27 gC/m³/hr was recorded in May 2023, coinciding with peak summer conditions, while the minimum of 0.41 gC/m³/hr occurred in August 2023 during peak monsoon period.

3.3 Net Primary Productivity (NPP)

Net Primary Productivity showed a different seasonal pattern compared to GPP, with highest values during post-monsoon season (Table 2). The post-monsoon mean NPP was 0.58 ± 0.12 gC/m³/hr, followed by winter (0.42 ± 0.08 gC/m³/hr), pre-monsoon (0.41 ± 0.09 gC/m³/hr), and monsoon (0.26 ± 0.05 gC/m³/hr).

Table 2. Monthly variation of Net Primary Productivity (gC/m³/hr) at five different Sites in Khajikotnoor reservoir, January 2023 to December 2023.

Season	Month	Site-1	Site-2	Site-3	Site-4	Site-5	Monthly Mean
Winter	January 2023	0.38	0.35	0.40	0.37	0.39	0.38 ± 0.02
	February	0.44	0.41	0.47	0.43	0.45	0.44 ± 0.02
Pre-monsoon	March	0.35	0.32	0.37	0.34	0.36	0.35 ± 0.02
	April	0.42	0.38	0.44	0.40	0.43	0.41 ± 0.02
	May	0.48	0.44	0.51	0.46	0.49	0.48 ± 0.03
Monsoon	June	0.41	0.37	0.43	0.39	0.42	0.40 ± 0.02
	July	0.25	0.22	0.27	0.24	0.26	0.25 ± 0.02
	August	0.22	0.19	0.24	0.21	0.23	0.22 ± 0.02
Post-monsoon	September	0.32	0.29	0.34	0.31	0.33	0.32 ± 0.02
	October	0.45	0.42	0.48	0.44	0.46	0.45 ± 0.02
	November	0.62	0.58	0.65	0.60	0.63	0.62 ± 0.03
Winter	December 2023	0.68	0.64	0.71	0.66	0.69	0.68 ± 0.03
Site Mean		**0.42**	**0.38**	**0.44**	**0.40**	**0.43**	
Annual Mean							**0.41 ± 0.13**
Maximum	December						**0.68**
Minimum	August						**0.22**

The maximum NPP of 0.68 gC/m³/hr was observed in December 2023, while the minimum of 0.22 gC/m³/hr was recorded in August 2023.

3.4 Community Respiration (CR)

Community Respiration exhibited highest values during pre-monsoon season (0.68 ± 0.14 gC/m³/hr), reflecting enhanced metabolic activity at elevated temperatures (Table 3). The lowest CR values were observed during monsoon season (0.19 ± 0.04 gC/m³/hr).

Table 3. Monthly variation of Community Respiration (gC/m³/hr) at five different Sites in Khajikotnoor reservoir, January 2023 to December 2023.

Season	Month	Site-1	Site-2	Site-3	Site-4	Site-5	Monthly Mean
Winter	January 2023	0.35	0.32	0.37	0.34	0.36	0.35 ± 0.02
	February	0.38	0.35	0.40	0.37	0.39	0.38 ± 0.02
Pre-monsoon	March	0.58	0.54	0.61	0.56	0.59	0.58 ± 0.03
	April	0.72	0.68	0.75	0.70	0.73	0.72 ± 0.03
	May	0.82	0.78	0.85	0.80	0.83	0.82 ± 0.03
Monsoon	June	0.75	0.71	0.78	0.73	0.76	0.75 ± 0.03
	July	0.18	0.15	0.20	0.17	0.19	0.18 ± 0.02

	August	0.15	0.12	0.17	0.14	0.16	0.15 ± 0.02
Post-monsoon	September	0.24	0.21	0.26	0.23	0.25	0.24 ± 0.02
	October	0.32	0.29	0.34	0.31	0.33	0.32 ± 0.02
	November	0.38	0.35	0.40	0.37	0.39	0.38 ± 0.02
Winter	December 2023	0.42	0.39	0.44	0.41	0.43	0.42 ± 0.02
Site Mean		**0.44**	**0.41**	**0.46**	**0.43**	**0.45**	
Annual Mean							**0.43 ± 0.20**
Maximum	May						**0.82**
Minimum	August						**0.15**

3.5 Seasonal Summary

The seasonal variations in all productivity parameters are summarized in Table 4, clearly demonstrating the influence of monsoon dynamics on reservoir productivity.

Table 4. Seasonal variation in primary productivity parameters (gC/m³/hr) in Khajikotnoor reservoir

Season	GPP	NPP	CR	NPP/GPP Ratio
Winter (Jan-Feb)	0.76 ± 0.12	0.42 ± 0.08	0.36 ± 0.04	0.55
Pre-monsoon (Mar-Jun)	1.12 ± 0.18	0.41 ± 0.09	0.68 ± 0.14	0.37
Monsoon (Jul-Sep)	0.48 ± 0.08	0.26 ± 0.05	0.19 ± 0.04	0.54
Post-monsoon (Oct-Dec)	0.82 ± 0.15	0.58 ± 0.12	0.37 ± 0.05	0.71
Annual Mean	**0.82 ± 0.25**	**0.41 ± 0.13**	**0.43 ± 0.20**	**0.50**

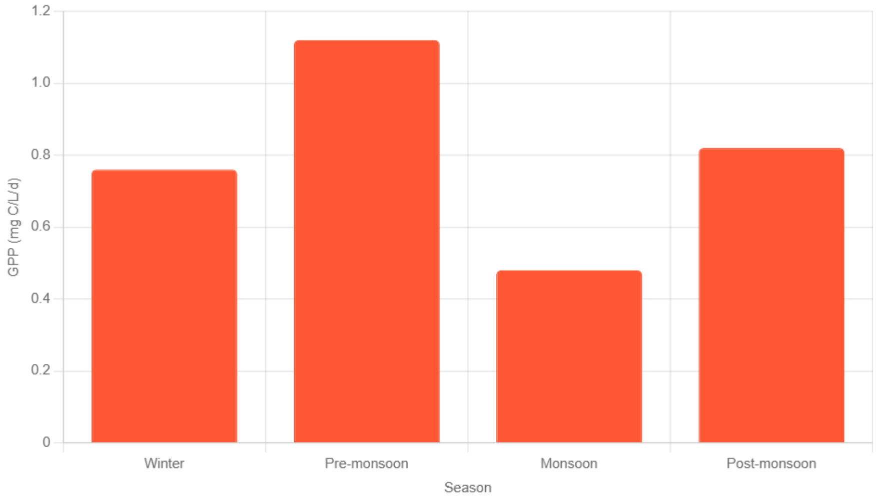

Figure 2 : Graph showing Seasonal Variation in GPP

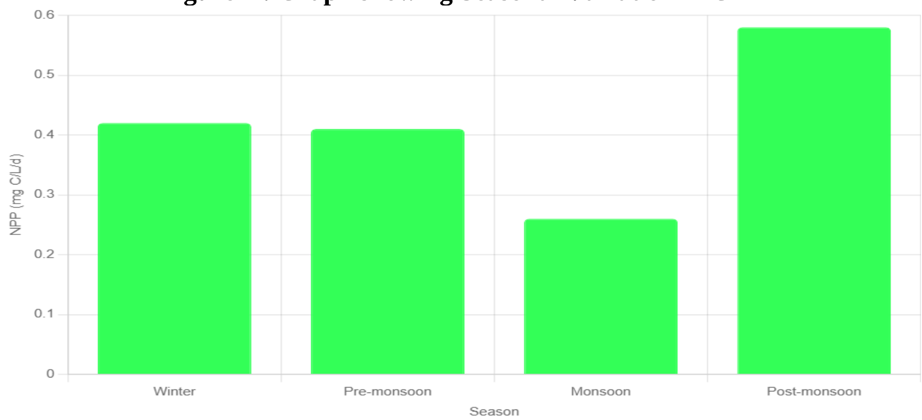

Figure 3: Graph showing Seasonal Variation in NPP

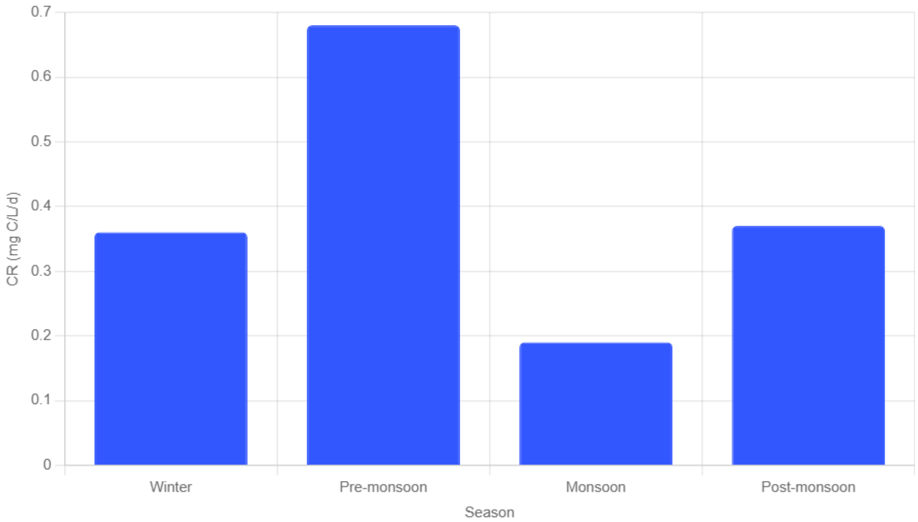

Figure 4: Graph showing Seasonal Variation in CR

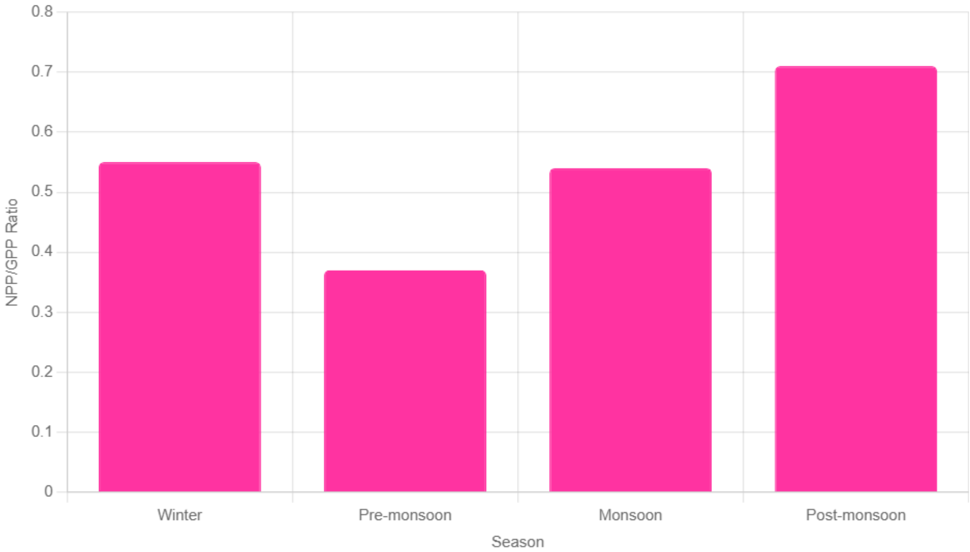

Figure 5: Graph showing Seasonal Variation in Ratio of NPP/GPP

3.6 Spatial Variations

Spatial analysis revealed significant variations among sampling Sites (ANOVA, $F = 4.32$, $p < 0.05$). Site 3 (eastern littoral zone) consistently showed highest productivity (mean GPP: 0.86 gC/m³/hr), attributed to optimal light penetration and macrophyte contributions. Site 2 (central pelagic zone) exhibited lowest values (mean GPP: 0.79 gC/m³/hr) due to greater depth limiting light availability. The productivity gradient followed: Site 3 > Site 5 > Site 1 > Site 4 > Site 2.

3.7 Productivity Ratios and Metabolic Balance

The NPP/GPP ratio varied seasonally, with highest values during post-monsoon (0.71) indicating efficient energy conversion, and lowest during pre-monsoon (0.37) suggesting high respiratory losses. The annual mean ratio of 0.50 indicates that approximately 50% of gross production is available for secondary producers. The P/R ratio (GPP/CR) averaged 1.91, suggesting net autotrophy with organic matter accumulation in the system.

4. DISCUSSION

4.1 Seasonal Productivity Dynamics

The seasonal nature of primary productivity in Khajikotnoor reservoir is consistent with the primary semi-arid reservoir dynamics of the north Karnataka which are dictated by monsoon cycles (Qasim *et al*., 1969; Sugunan, 1995). Optimal environmental conditions such as a strong sun radiation, high temperatures (35-45 b C typify Kalaburagi summers) and nutrient concentration in response to a drop in water levels can be attributed to the peak GPP under pre-monsoon season

(1.12 gC /m3/hr), which is the most favorable (Reynolds, 1984; Wetzel, 2001). Results can be compared with the productivity values of other Karnataka dams: Tungabhadra reservoir (0.76-1.18 gC/m 3/hr) by Basavaraja *et al.* (2014), and Bhadra reservoir (0.65-1.05 gC/m 3/hr) by Karnataka State studies.

The factorial decline in productivity of the monsoon season (GPP: 0.48 gC/m 3/hr) can be attributed to a combination of factors such as increased turbidity, which lowers the intensity of light penetration, or dilution of the nutrient concentrations, or wash out of phytoplankton population, or lowered water residence time (Thornton *et al.*, 1990; Kimmel *et al*., 1990). Such a trend is especially strong in the semi-arid conditions of Kalaburagi where the intensity of monsoons differs considerably.

5. CONCLUSION

The complete yearly evaluation of the primary productivity in Khajikotnoor reservoir indicates a dynamic ecosystem with definite seasonal cycles of semi arid Karnataka reservoirs with monsoon dynamics and environmental variables.

The results are part of the current knowledge about the ecology of reservoirs in Karnataka and offer scientific foundations of evidence-based management decisions to the state water resource system. Future studies should involve the effects of climate changes on the productivity patterns of semi-arid areas of the north of Karnataka state, the measurement of nutrient budgets, and prediction of ecosystems management models.

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