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`Seasonal Variation in Primary Productivity in Relation to Physico-Chemical Parameters of Lower Tiger Hills Reservoirs, Nilgiris District, Tamil Nadu, India

M. Abareethan, K. Kavitha

Department of Zoology,Government Arts College (Autonomous) Salem, Tamil Nadu

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ABSTRACT

The present study investigated the variation in primary productivity in the Lower Tiger Hills Reservoirs located in Udhagamandalam. The relationship between primary productivity and selected physico-chemical parameters, including air temperature, water temperature, conductivity, and dissolved oxygen, was also evaluated. Water samples were collected from November 2025 to April 2026. Primary productivity was estimated using the dark bottle method. The results revealed a significant relationship between primary productivity and the measured physico-chemical parameters. lower reservoirs exhibited comparatively high productivity, supporting the development and sustenance of plankton communities. The findings indicate that physico-chemical characteristics play an important role in regulating primary productivity and maintaining ecological balance in these freshwater ecosystems.

Keywords: Primary productivity, Lower Tiger Hills Reservoir, Dissolved oxygen, Conductivity, Temperature

INTRODUCTION

Primary productivity is a fundamental ecological process in aquatic ecosystems. It determines the amount of energy that flows through the ecosystem and the quantity of organic matter available to higher trophic levels. Primary productivity is defined as the rate at which autotrophic organisms convert inorganic substances into organic matter through photosynthesis.

Water quality significantly influences primary productivity in aquatic environments. The productivity of an ecosystem reflects its capacity to support biological communities and is closely associated with various physicochemical factors, including temperature, dissolved oxygen, conductivity, and nutrient availability. Among these factors, temperature plays a crucial role in regulating chemical reactions, metabolic activities, and other biological processes within aquatic systems.

Freshwater ecosystems are increasingly threatened by anthropogenic activities, resulting in habitat degradation and altered water quality. Therefore, monitoring physicochemical parameters and primary productivity is essential for understanding ecosystem health and developing effective management strategies. High phytoplankton productivity contributes to the maintenance of aquatic food webs and supports biodiversity by providing a primary source of energy for higher trophic levels.

The Nilgiris region of Tamil Nadu is characterized by a cool and humid climate and forms part of the Nilgiri Biosphere Reserve, a recognized biodiversity hotspot. Despite the ecological significance of this region, information on the productivity dynamics of many freshwater reservoirs remains limited. Therefore, the present study aims to evaluate the temporal variation in primary productivity and examine its relationship with selected physicochemical parameters in the Lower Tiger Hills Reservoirs of the Nilgiris, Tamil Nadu, India.

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MATERIALS AND METHODS

Study Area

The Lower Tiger Hills Reservoirs are located near Doddabetta Peak in Udhagamandalam, Tamil Nadu, India, and are surrounded by shola forests.

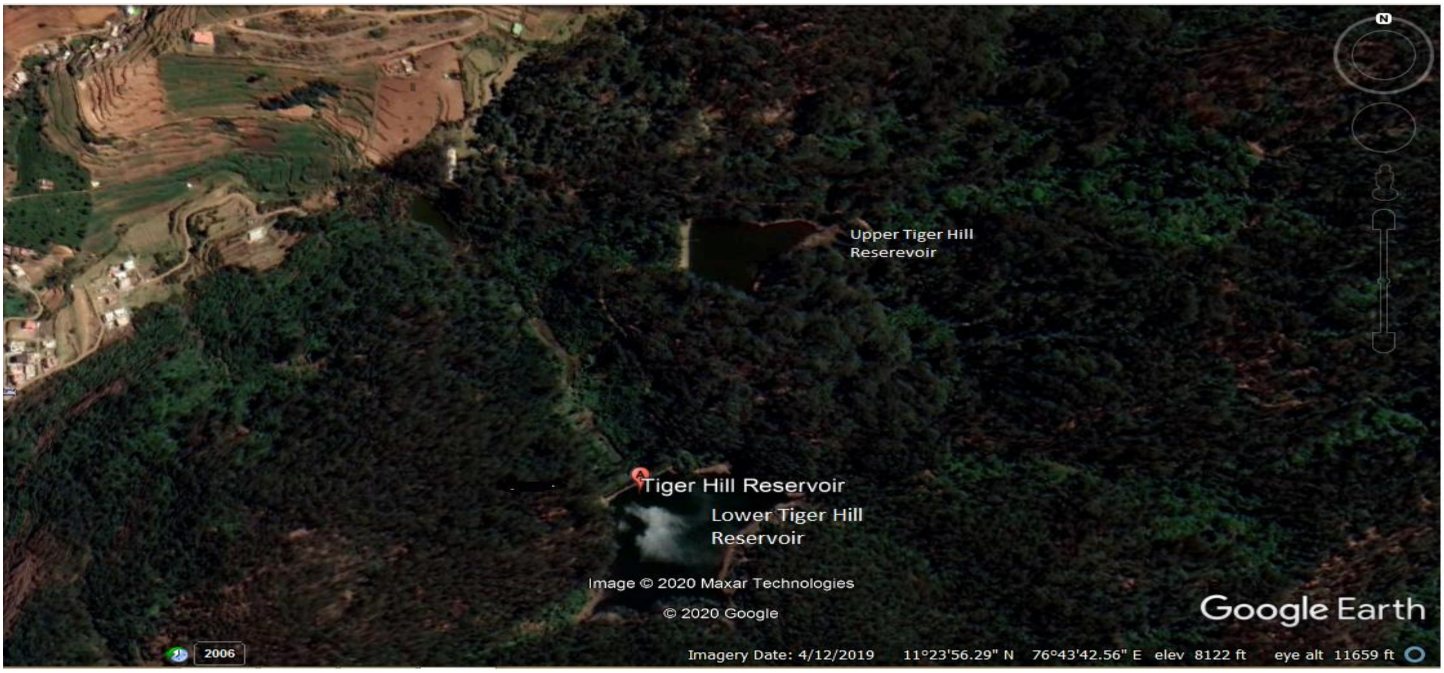
Lower Tiger Hills Reservoir: 11°23′49.09″ N, 76°43′41.13″ E

Lower Tiger hills reservoirs are lentic freshwater ecosystems situated at high altitudes in the Nilgiri Hills.

Sample Collection and Analysis

Water samples were collected over a six-month period from November 2025 to April 2026. Sampling was conducted twice monthly from four selected area in the reservoir. The collected samples were analyzed using standard methods for the assessment of physico-chemical parameters and primary productivity.

Figure 1. Satellite view of the Lower Tiger Hills Reservoirs.



The following parameters were analyzed:

- Air temperature
- Water temperature
- Electrical conductivity
- Dissolved oxygen (DO)
- Gross Primary Productivity (GPP)
- Net Primary Productivity (NPP)
- Community Respiration (CR)

RESULTS AND DISCUSSION

The air temperature varied between 16°C and 13°C during the study period. The minimum value 13°C was recorded in October and December 2025 in Lower Tiger Hills Reservoir. The maximum air temperature 16°C was recorded. This may be due to the changes in the weather factor and the difference in the time of observation.

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During summer solar radiation and clear sky enhanced the atmospheric temperature. The surface water temperature reflects to the dynamics of the living organisms such as metabolic and physiological behavior of aquatic ecosystem. (ArchanaGupte and NisarShaikh, 2013).

The water temperature varied between 21°C to 16°C during the study period of Lower Tiger Hills Reservoir. The maximum water temperature 21°C was recorded in the month of December'25 April'26 and and minimum

water temperature 16°C was observed in the month of Feb '26 and Lower Tiger Hills Reservoir was observed the maximum water temperature 21°C in the month of Dec 2025 and April 2026 and minimum water temperature observed 16°C in the month of Feb 2026. Similar results were reported by ArchanaGupte and NisarShaike (2013) in Shelar Lake, Thane and Karthick *et al*., 2016 in Kadamba Tank, Thoothukudi.

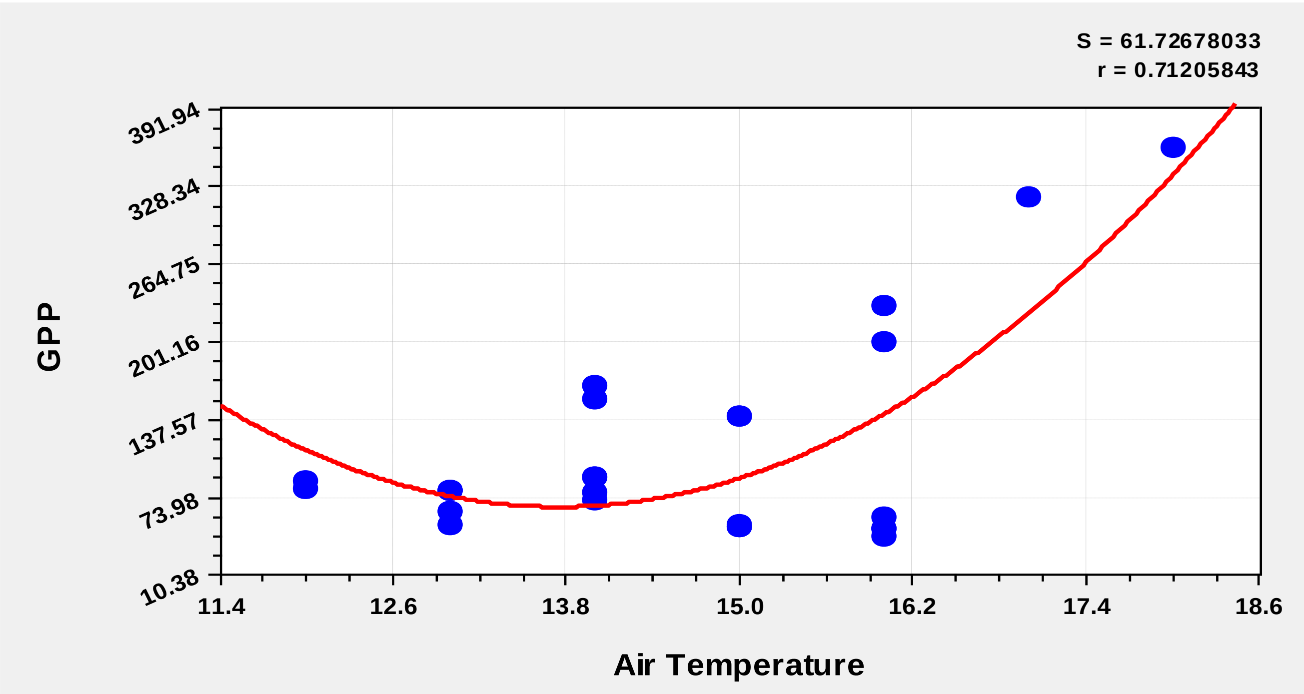
The GPP was found to have significant relationship with Air Temperature (r=0.71205843), Water Temperature(r=0.62830300), Conductivity (r=0.64011300) and dissolved oxygen ((r=0.67505606)

The Quadratic fit model (figure – 4) is the best fit to establish relationship of Air Temperature with GPP can be expressed as

GPP = 2.904529 A T + 4.129744 A T + 1.5022016 A T ^{2}

Where AT = Air Temperature

Figure: 2 Quadratic Fit showing the mathematical relationship between GPP and Air Temperature



The productivity of the any aquatic ecosystem depends on light energy. Transparency measures the light penetrating through the water body. The transparency appears to depend primarily of organic and inorganic materials particularly received during the rainy season. During the present study, the transparency was high in lower tiger hills reservoir. The minimum value of Conductivity (23.1 µS) was recorded during the month of March 2026 in both Stations. The maximum value (116` µS) was recorded during the month of November2025 in Lower Tiger Hills Reservoir. It is due to the influence of South West monsoon during the month of June. According to (Verma *et al*., 2010), a high level of conductivity reflects the pollution status as well as tropic level of the aquatic body. According to (Tamot *et al.*, 2008), dissolved oxygen concentration in water is primarily dependent upon temperature, dissolved salts, wind velocity, pollution load, photosynthetic activity, and respiration rate.

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The Polynomial fit model (figure – 6) in the best to establish relationship of conductivity with GPP. It can be expressed as

GPP= 3.633169 C + 2.596173 C + 5.8664492^2 C + 5.258020^3 C

Where C=Conductivity

(Pazhanisamy, 2005) also reported Polynomial fit relationship while studying the ecology of reservoir.

Figure: 3 Linear Fit model showing the mathematical relationship between GPP and Water Temperature

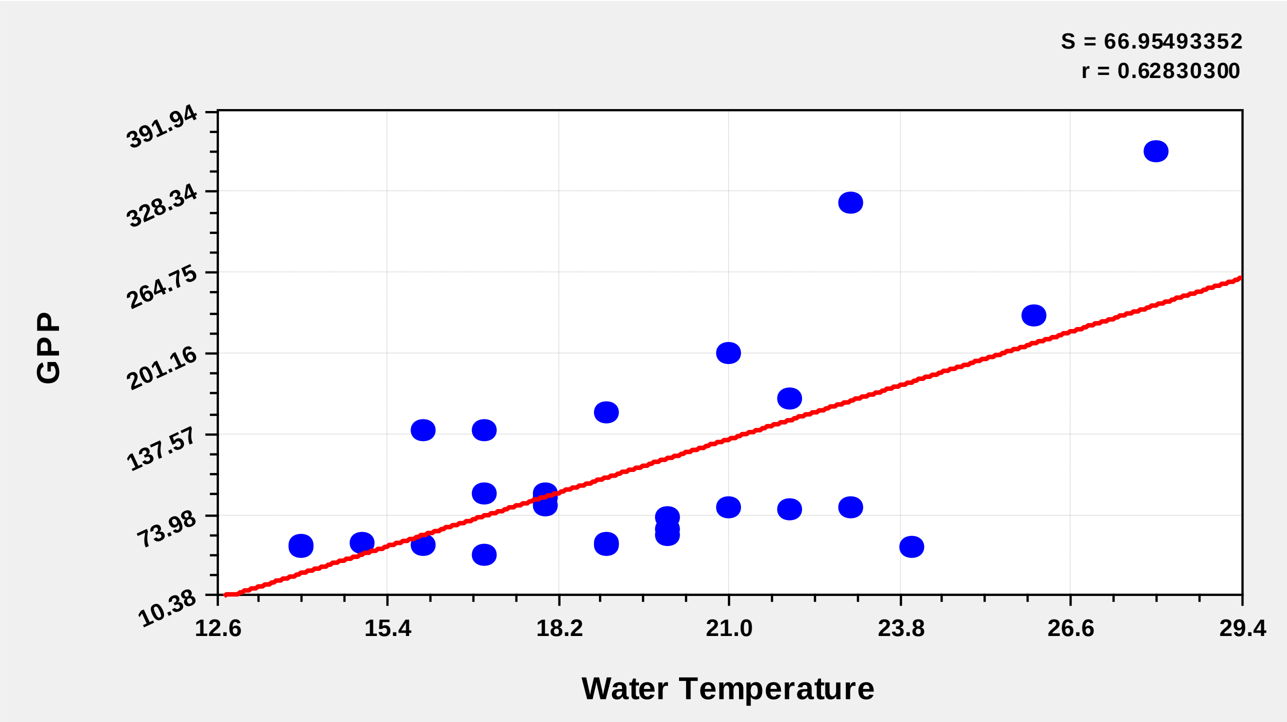

Figure: 4 Polynomial Fit showing the mathematical relationship between GPP and Conductivity

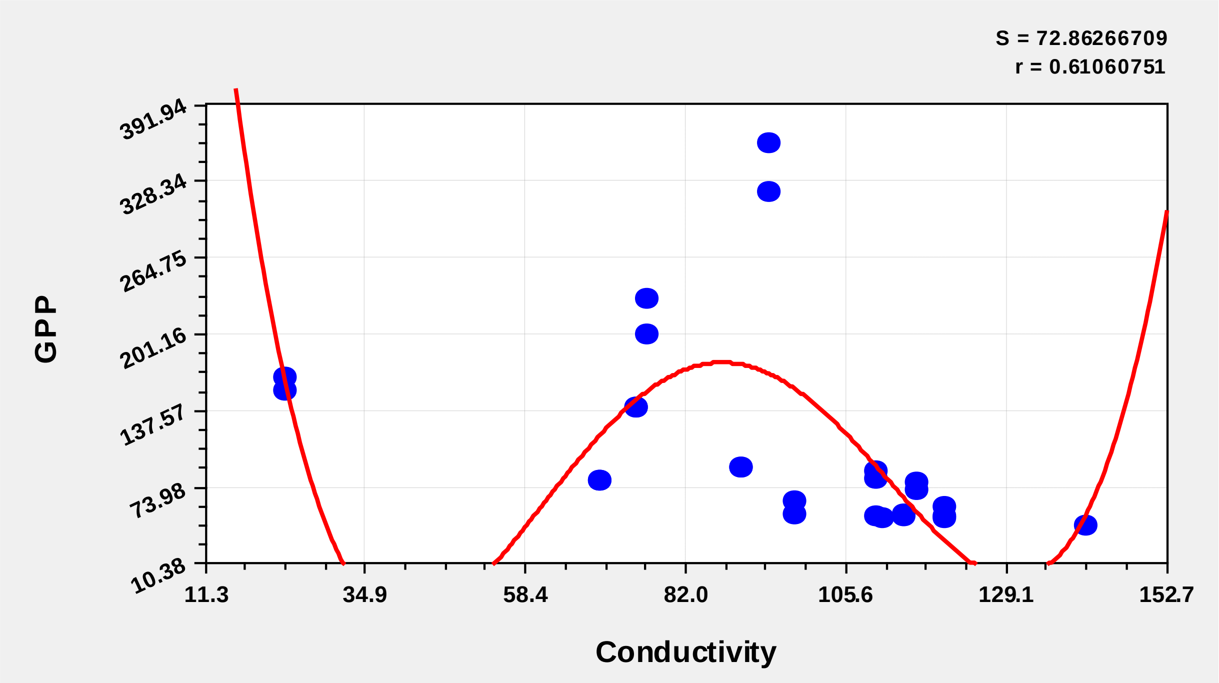

Figure: 5 Linear Fit model showing the mathematical relationship between GPP and dissolved oxygen

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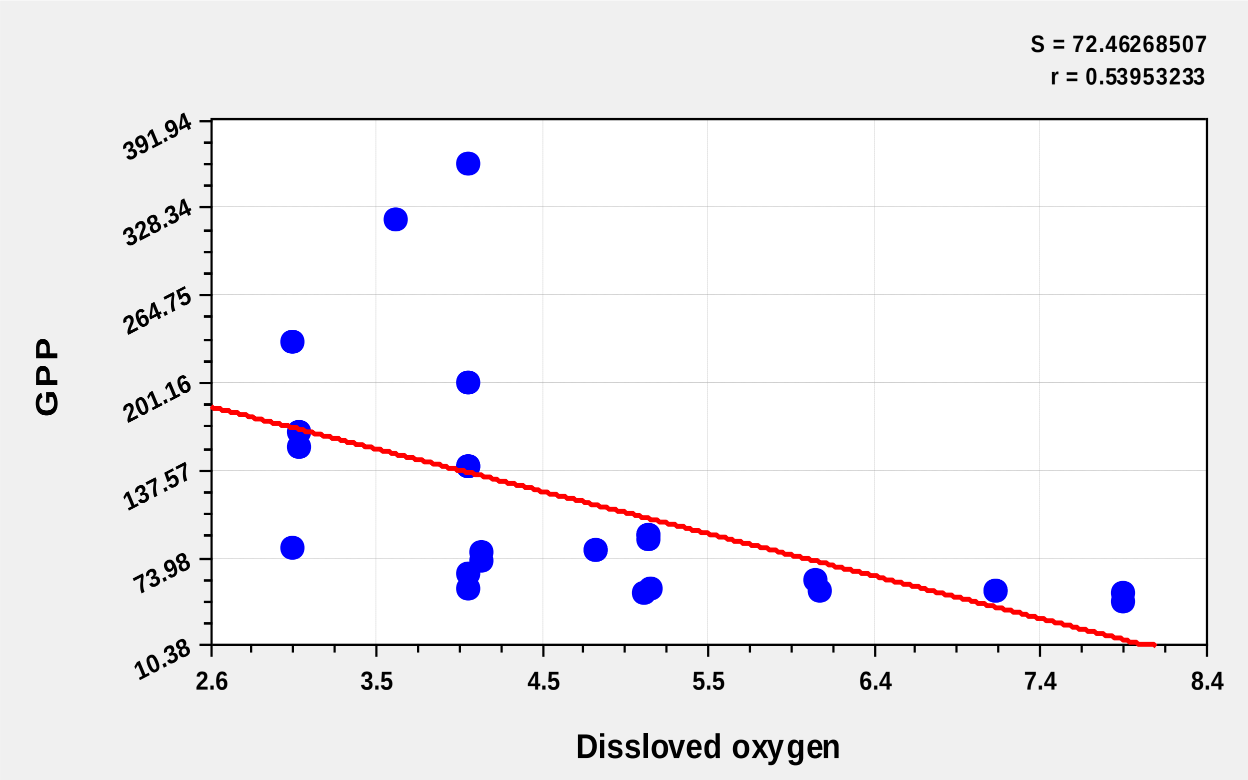

The Linear fit model (figure – 5) in the best to establish relationship of dissolved oxygen with GPP can be expressed as

GPP=1.740837 + 2.067642 DO

Where DO= Dissolved Oxygen

Observation on Primary Production in fresh water body was carried out GPP and Dissolved Oxygen has significantly relationship in Linear fit model. Meenakshi (2014) reported that dissolved oxygen does not influence of the productivity.

The NPP has the best fit and significant relationship with Air Temperature (r=0.51095020), Water Temperature(r=0.58452605), Conductivity(r =0.63446130) and Dissolved Oxygen (r =0.67505606)

The Polynomial fit model (figure – 6) is the best to establish relationship of Air Temperature with NPP and it can be expressed as

NPP = 1.877659 A T + 4.916947 AT + 4.733078^2 AT + 1.985734^3 AT

Where AT= Air Temperature

The Polynomial fit model (figure – 7) in the best to establish relationship of Water Temperature with NPP. It can be expressed as

NPP = 6.819317 WT+ 7.274521 WT

Where WT= Water Temperature

The study preliminarily conducted in peninsular India reveals the influence of Water Temperature on NPP (Sheeja,2004), also reported that the Water Temperature does not have influence on the productivity. In this present study also water Temperature shows significant influence by the Linear fit model. This may be due to the closed nature of Reservoir low level of Temperature, high altitude and the dynamics of water temperature.

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The Quadratic fit model (figure – 8) in the best to establish relationship of conductivity with NPP. It can be expressed as

NPP= 1.310838 C +2.231183 C +6.157123^2 C

Where C = Conductivity

According to (Pazanisamy, 2005), and (Meenakshi, 2014) also NPP and Conductivity does not agree significantly with Quadratic fit model. In this present study, NPP and Conductivity shows significant with Quadratic fit model.

The Quardratic fit model (figure – 9) in the best to establish relationship of dissolved oxygen with NPP and it can be expressed as

NPP=1.740837 DO+ 2.067642 DO

Where DO= Dissolved Oxygen

The Mathematical modeling studies preliminary conducted in peninsular India reveals the influence of Air temperature, Water Temperature and Community Respiration. (Meenakshi, 2014) showed that the Air Temperature and Water Temperature does not have influence the productivity. However, the result of the present study reveals that the Air Temperature and Water Temperature have a significant role in productivity and it can be expressed by linear fit model. Direct influence on CR may be due to the closed nature of Reservoir and the dynamics of water temperature.

The CR has the best fit and significant relationship with Air Temperature (r= 0.6222), Water Temperature (r=0.5817) and Conductivity (r=0.5024).

The Linear fit model (figure – 10) in the best to establish relationship of air temperature with CR. It can be expressed as

CR= 2.496822 AT+1.959645 AT

Where AT= Air Temperature

The Linear fit model (figure – 11) is the best to establish relationship of Water Temperature with CR. It can be expressed as

CR= 1.145818 W T+ 7.798103 W T

Where WT= Water Temperature

The Polynomical fit model (figure – 12) in the best to establish relationship of conductivity with CR can be expressed as

CR = 6.880187 C + 1.069766 C + 4.869653 C^2+9.079610 C^3

Where C = Conductivity

Our results on CR and Conductivity has significant Correlation with Polynomial fit model .It is also related to (Palanisamy, 2005), and (Meenakshi, 2014).

Altitude or terrain elevation plays an important role in water quality. As the altitude increases the temperature decreases and it impact changes in water quality. Water temperature, stream velocity, altitude, and level of organic matter content affect the amount of dissolved oxygen that the water can hold. Cold water contains more dissolved oxygen than warm water. The physico-chemical parameters of the water body are good in nature and

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are suitable for domestic uses and drinking. The results of the present study also reveal that polynomial fit can be an alternate model to linear model for expressing the relationship of productivity with other environmental parameters.

Figure: 6 Polynomial Fit showing the mathematical relationship between NPP and Air Temperature

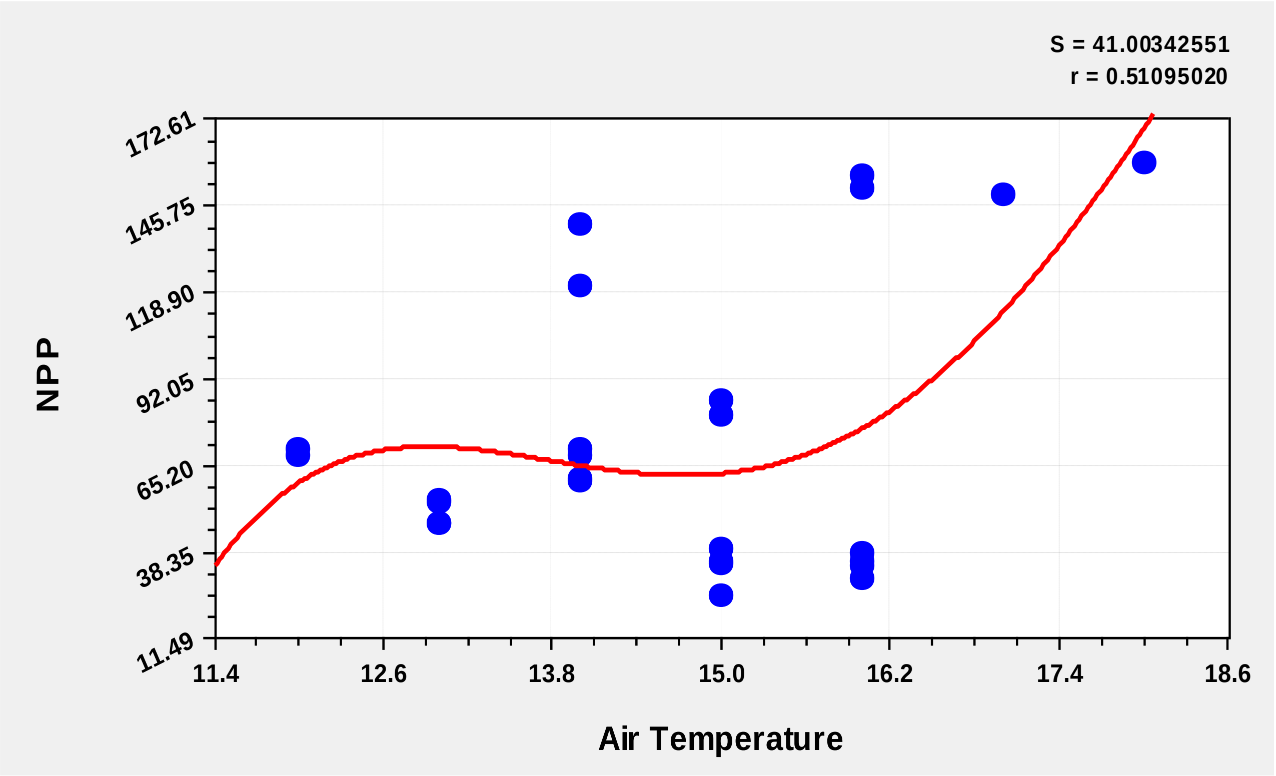

Figure: 7 Polynomial Fit model showing the mathematical relationship between NPP and Water Temperature

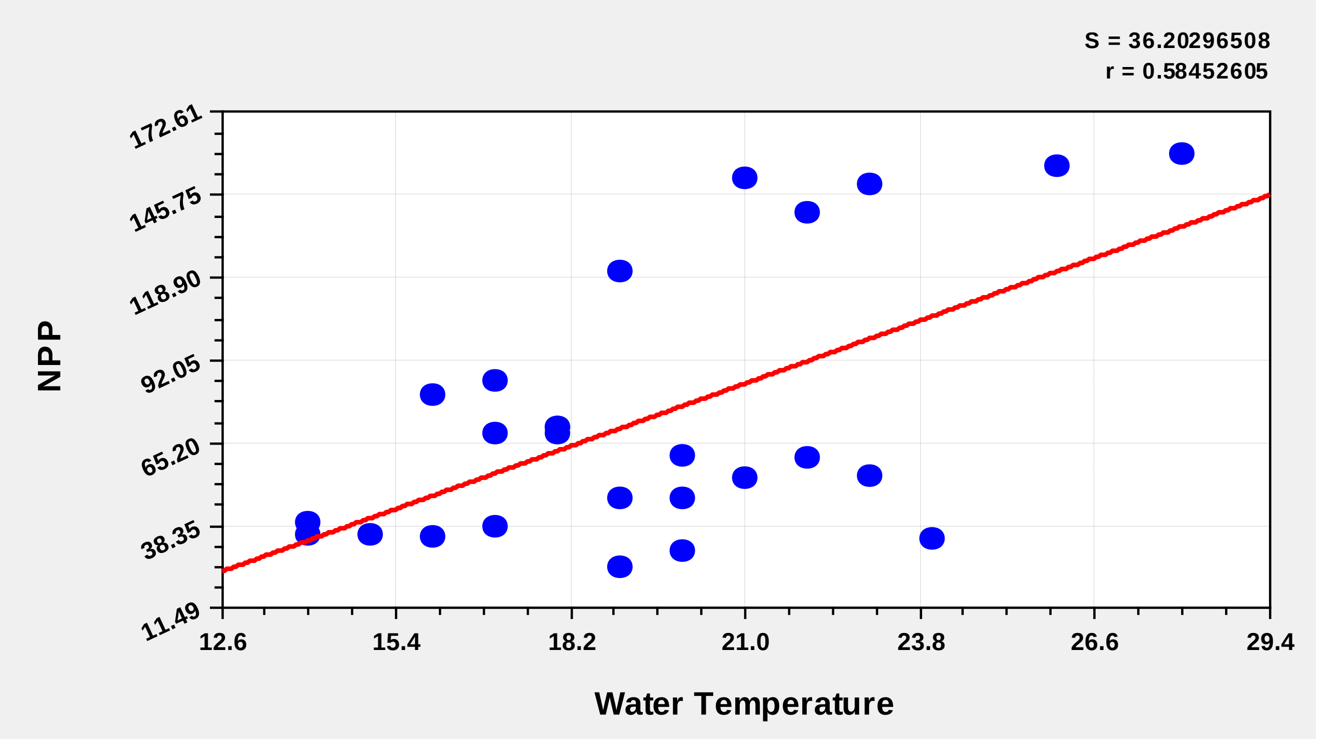

Figure: 8 Quadratic Fit modelshowing the mathematical relationship between NPP and Conductivity

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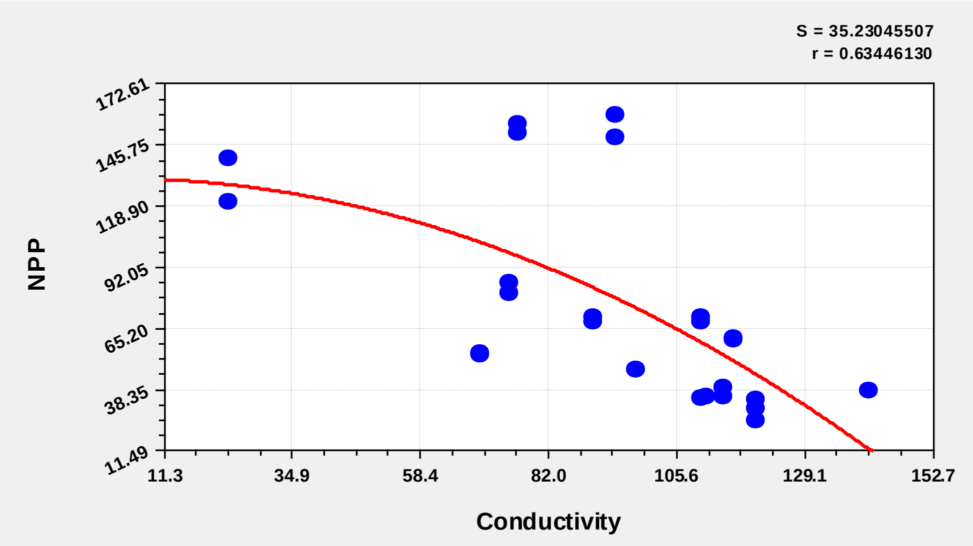

Figure: 9 Quadratic Fit model showing the mathematical relationship between NPP and Dissolved Oxygen

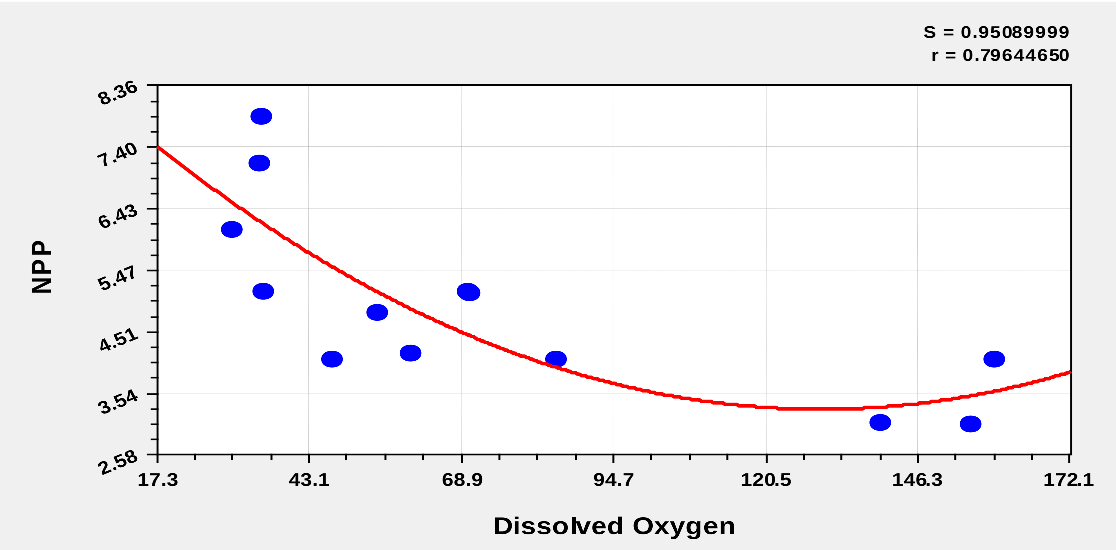

Figure: 10 Linear Fit model showing the mathematical relationship between CR and Air Temperature

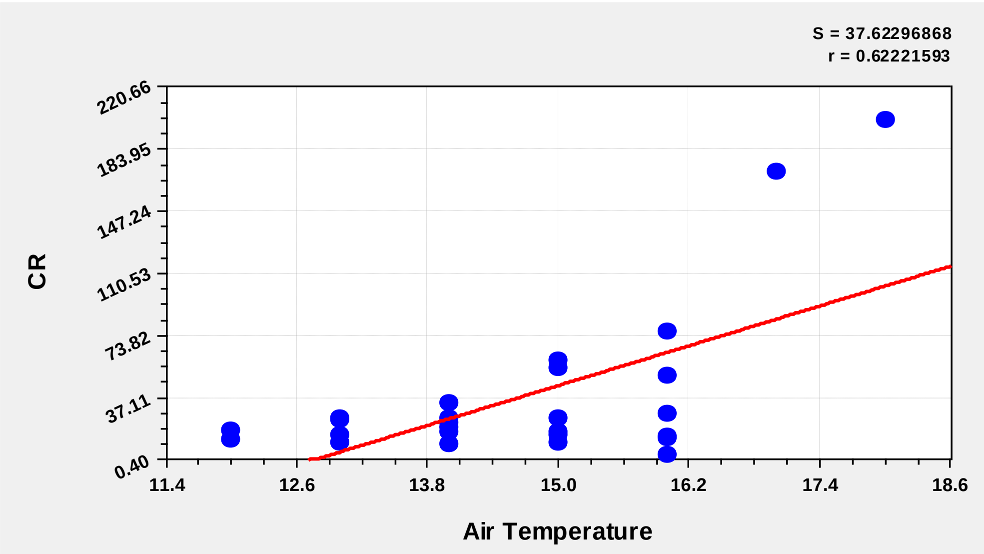

Figure: 11 Linear Fit model showing the mathematical relationship between CR and Water Temperature

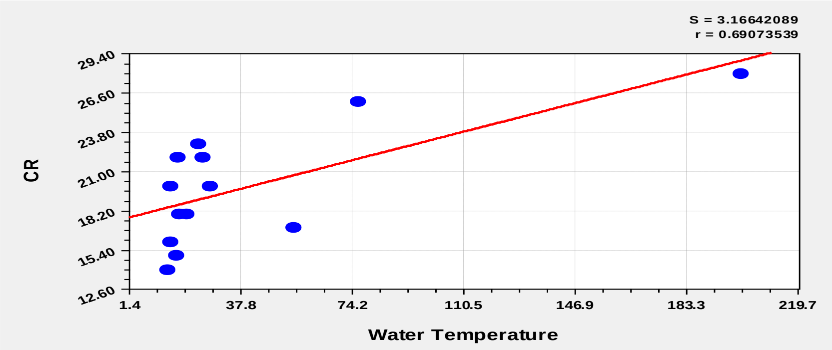

Figure: 12 Polynomial Fit model showing the mathematical relationship betwee CR and Conductivity

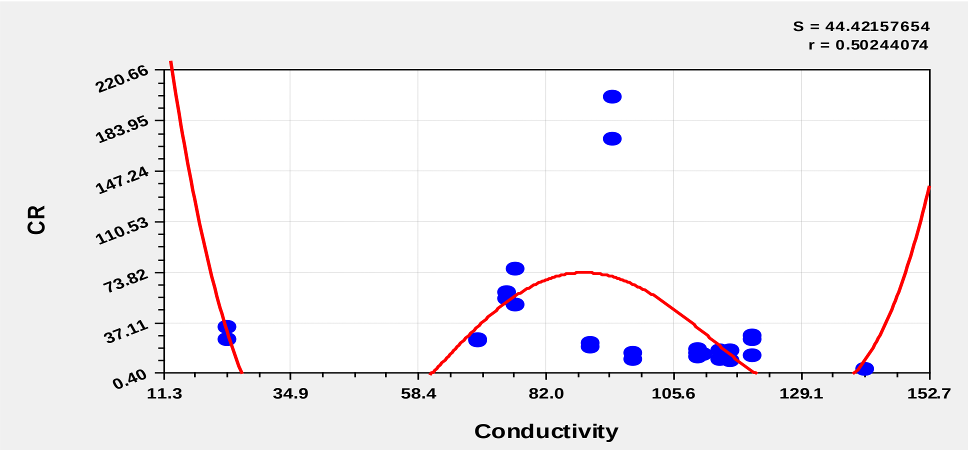

Table: 1

Physical and chemical factors in Lower Tiger Hills Reservoir

S.NO	PARAMETERS	METHOD
1	Air Temperature (°C)	Celsius Thermometer
2	Water Temperature (°C)	Celsius Thermometer
3	Conductivity (µS)	Conductivity meter (Elico CM 180)
4	Dissolved Oxygen(mg/l)	Winkler's Iodomeric method
5	Gross Primary Productivity (GPP)	Light and dark bottle method of Gaarder and Gran
6	Net Primary Productivity(NPP)	Light and dark bottle method of Gaarder and Gran
7	Community Respiration(CR)	Light and dark bottle method of Gaarder and Gran

Table: 2 Physico-chemical factors in Lower Tiger Hills Reservoir

Parameters /Months	Oct '25	Nov '25	Dec '25	Jan '26	Fe '26	Mar '26	Apr '26
Air Temperature(°C)	13	14	13	14	15	14	16
Water Temperature(°C)	19	20	21	17	16	19	21
Coductivity (µS)	98.1	116	69.4	90.3	74.7	23.1	76.2
Dissolved Oxygen(mg/l)	4.08	4.16	4.82	5.13	4.08	3.09	4.08
GPP	52.12	71.61	78.91	90.16	140.11	155.12	201.19

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mgC/m3/hr							
NPP mgC/m3/hr	41.12	61.37	53.69	68.12	81.16	120.82	151.26
CR mgC/m3/hr	11	10.24	25.22	22.04	58.95	34.3	49.93

CONCLUSION

The present study demonstrated that primary productivity in the Lower Tiger Hills Reservoirs is strongly influenced by physico-chemical parameters. Seasonal variations in temperature, conductivity, and dissolved oxygen significantly affected Gross Primary Productivity (GPP), Net Primary Productivity (NPP), and Community Respiration (CR).

The reservoirs exhibited favourable environmental conditions that support plankton growth and overall ecosystem productivity. Regression analysis indicated that polynomial and quadratic models effectively described the relationships between productivity parameters and environmental variables.

Overall, the water quality of both reservoirs remained within acceptable limits and appears suitable for domestic and drinking purposes following standard treatment procedures. Continuous monitoring is recommended to ensure the sustainable management and conservation of these freshwater resources.

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