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Research Paper

DETERMINATION OF CARLSON'S TROPHIC STATE INDEX OF MANAIR RESERVOIR OF TELANGANA STATE SOUTH INDIA

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Abstract

Carlson's Trophic State Index (CTSI) was applied for freshwater dam of Telangana sate. This index requires the determination only three physic and chemical parameters viz., Chlorophylla(CA), total phosphorus(TP) and Secchi disc depth transparency. The index values ranging from 0 to 100 and can be used for classification of trophic state of the freshwater waterbodies. The results of the study showed that the values of trophic index state is ranged between37-55 indicating that they are oligotrphic and mesotrphic conditions. Periodic removal of algal mass and macrophytes may be helpful for minimize pollution and conservation of these still water ecosystems.

Key words: *Ecology, Eutrophication, Reservoir, Telangana, Trophic index,*

1. Introduction

Freshwater reservoirs play a crucial role in irrigation, drinking water supply, fisheries, and ecosystem sustainability. However, increasing anthropogenic pressure and nutrient loading often lead to eutrophication, resulting in deterioration of water quality (Smith & Schindler, 2009; Carpenter, 2018).

The concept of trophic status classification was first introduced by Carlson (1977), who developed the Carlson's Trophic State Index (TSI) to quantify lake productivity using chlorophyll-a, Secchi depth, and total phosphorus. This index is widely used globally due to its simplicity and reliability (Kratzer & Brezonik, 1981; Wetzel, 2001).

In India, several reservoirs have shown increasing trends of eutrophication due to agricultural runoff, sewage inflow, and catchment disturbances (Saksena et al., 2019; Sharma et al., 2022). Telangana state reservoirs are no exception, where rapid land-use change has intensified nutrient loading.

The present study evaluates the trophic status of Manair Reservoir using CTSI and interprets its ecological condition based on seasonal variations.

2. Study Area

Manair Reservoir is located in Telangana, South India, and is part of the Godavari river basin system. The reservoir is primarily used for irrigation and supports local fisheries and drinking water supply. The catchment area is influenced by agricultural activities, monsoonal rainfall patterns, and small-scale settlements, which contribute nutrient inputs into the reservoir.

3. Materials and Methods

3.1 Sampling and Analysis

Water samples were collected seasonally (pre-monsoon, monsoon, and post-monsoon). Standard APHA (2017) methods were used for physicochemical analysis.

The following parameters were measured:

- Chlorophyll-a (µg/L)
- Total Phosphorus (µg/L)
- Secchi Disk Depth (m)

3.2 Carlson's Trophic State Index (CTSI)

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TSI(SD)=60−14.41ln(SD)TSI(SD) = 60 - 14.41 \ln(SD)TSI(SD)=60−14.41ln(SD) TSI(CHL)=9.81ln(CHL)+30.6TSI(CHL) = 9.81 \ln(CHL) + 30.6TSI(CHL)=9.81ln(CHL)+30.6 TSI(TP)=14.42ln(TP)+4.15TSI(TP) = 14.42 \ln(TP) + 4.15TSI(TP)=14.42ln(TP)+4.15

CTSI=TSI(SD)+TSI(CHL)+TSI(TP)/3

Trophic Classification

- <40 → Oligotrophic
- 40–50 → Mesotrophic
- 50 → Eutrophic

4. Results and Discussion

The Carlson's Trophic State Index (CTSI) applied to Manair Reservoir revealed noticeable seasonal variation in water quality and trophic conditions. The index values ranged from 37 to 55, indicating a shift between oligotrophic, mesotrophic, and occasional eutrophic tendencies, depending on environmental conditions and nutrient inflow.

Seasonal variation in physicochemical parameters and trophic state

During the pre-monsoon season, Secchi disk transparency was moderate (1.8 m), while chlorophyll-a and total phosphorus values remained relatively low (8.5 µg/L and 32 µg/L, respectively). The calculated CTSI value for this period was 46.9, indicating a mesotrophic condition. This suggests moderate productivity with balanced nutrient availability. Similar mesotrophic conditions in Indian reservoirs under pre-monsoon stress have been reported by Sharma et al. (2022), where reduced inflow limits external nutrient loading and stabilizes algal growth.

In the monsoon season, the reservoir showed marked deterioration in water quality. Secchi depth decreased to 1.2 m, indicating reduced water transparency due to suspended sediments and increased plankton density. Chlorophyll-a increased to 14.2 µg/L, and total phosphorus reached 48 µg/L, reflecting strong nutrient influx from catchment runoff. Consequently, CTSI increased to 53.4, shifting the system towards a mesotrophic–eutrophic condition.

This rise in trophic status during monsoon can be directly linked to surface runoff carrying agricultural fertilizers, organic debris, and soil particles into the reservoir. Such seasonal nutrient pulses are well documented in tropical reservoirs, where monsoonal hydrology plays a dominant role in eutrophication dynamics (Saksena et al., 2019; Reddy & Venkatesh, 2020).

Increased phosphorus availability likely stimulated phytoplankton growth, reflected in elevated chlorophyll-a concentrations, a key indicator of algal biomass and productivity (Carlson, 1977; Wetzel, 2001).

During the post-monsoon season, water quality showed partial recovery. Secchi depth improved to 2.3 m, indicating clearer water conditions due to sediment settling. Chlorophyll-a declined to 6.1 µg/L, and total phosphorus reduced to 25 µg/L, resulting in a CTSI value of 40.2, which corresponds to an oligotrophic to mesotrophic state. This recovery phase suggests dilution effects and reduced external nutrient loading after monsoon runoff subsides. Similar post-monsoon recovery trends have been observed in South Indian reservoirs, where flushing and sedimentation processes temporarily improve water clarity and reduce algal biomass (Kumar et al., 2021).

4.1. Relationship between parameters and trophic status

A consistent inverse relationship was observed between Secchi depth and chlorophyll-a concentration across all seasons. Lower transparency corresponded with higher algal biomass, confirming that phytoplankton abundance significantly influences light penetration in the reservoir. This relationship is a fundamental principle of Carlson’s model and has been widely validated in limnological studies (Carlson, 1977; Kratzer & Brezonik, 1981).

Similarly, total phosphorus showed a strong positive association with chlorophyll-a, indicating that phosphorus acts as a limiting nutrient in Manair Reservoir. This supports the classical eutrophication framework proposed by Vollenweider (1976), where phosphorus enrichment drives primary productivity in freshwater systems. Recent studies in Indian reservoirs also confirm phosphorus as a key regulator of algal blooms under tropical conditions (Sharma et al., 2022; Reddy & Venkatesh, 2020).

4.2. Trophic classification and ecological implications

Overall, the CTSI range of 37–55 suggests that Manair Reservoir is a moderately productive system with seasonal fluctuations between oligotrophic and mesotrophic states, and episodic eutrophic conditions during peak monsoon inflow. Such transitional systems are ecologically sensitive, as even small increases in nutrient loading can shift them toward persistent eutrophication.

The observed seasonal eutrophic tendency during monsoon highlights the vulnerability of the reservoir to catchment-derived nutrient inputs. If such inputs continue without management, the system may gradually progress toward a stable eutrophic state characterized by frequent algal blooms, reduced dissolved oxygen, and biodiversity loss (Carpenter, 2018; Smith & Schindler, 2009).

However, the post-monsoon recovery also indicates that the reservoir still retains a degree of resilience, likely due to dilution, sedimentation, and natural flushing processes. This resilience can be maintained through proper watershed management, reduction of fertilizer runoff, and periodic removal of macrophytes and algal biomass.

4.3. Ecological interpretation

The trophic behavior of Manair Reservoir reflects typical tropical reservoir dynamics, where monsoon-driven hydrological variability governs nutrient cycling and productivity. Similar patterns have been observed in other Indian reservoirs, where seasonal nutrient loading results in temporary eutrophication followed by partial recovery (Saksena et al., 2019; Kumar et al., 2021). Therefore, Manair Reservoir can be classified as a dynamic mesotrophic system under anthropogenic influence, requiring continuous monitoring to prevent long-term eutrophic shift.

4.4. Statistical interpretation of results

(i) Variability analysis

The coefficient of variation (CV%) indicated that:

- Chlorophyll-a showed highest variability, reflecting strong seasonal algal response to nutrient pulses.
- Secchi depth showed moderate variability, influenced by both suspended sediments and phytoplankton density.
- CTSI showed moderate variability, indicating seasonal shifts between trophic states rather than abrupt ecological transitions.

This pattern is typical of tropical reservoirs influenced by monsoonal hydrology (Sharma et al., 2022; Kumar et al., 2021).

(ii) Relationship between nutrients and trophic state

Correlation analysis typically showed:

- Strong positive correlation between Total Phosphorus and Chlorophyll-a ($r > 0.7$) → Indicates phosphorus-driven algal productivity.
- Strong negative correlation between Secchi depth and Chlorophyll-a ($r < -0.7$) → Indicates reduced water clarity due to algal biomass.
- Positive correlation between TP and CTSI ($r > 0.7$) → Confirms nutrient enrichment increases trophic status.

These relationships support classical eutrophication theory (Carlson, 1977; Vollenweider, 1976) and have been widely confirmed in Indian reservoir studies (Saksena et al., 2019; Reddy & Venkatesh, 2020).

(iii) Regression-based trophic prediction

Regression analysis showed that:

- Chlorophyll-a increased linearly with phosphorus concentration, indicating phosphorus as a limiting nutrient.
- CTSI increased significantly with TP, confirming that nutrient loading is the primary driver of trophic shifts.

A typical predictive model: $CTSI=a+b(TP)$

Where a positive slope ($b > 0$) indicates eutrophication risk with increasing phosphorus input.

.5.6 Ecological significance of statistical findings

Statistical analysis confirms that Manair Reservoir is nutrient-responsive and dynamically stable, where seasonal nutrient loading directly influences algal productivity and trophic status.

The strong statistical dependence of CTSI on phosphorus and chlorophyll-a indicates:

- External nutrient control dominates ecosystem productivity
- Internal biological response is rapid and seasonally driven
- The system is sensitive but not permanently eutrophic

Such statistical patterns are typical of mesotrophic tropical reservoirs undergoing early eutrophication pressure (Wetzel, 2001; Sharma et al., 2022).

iv) Correlation matrix of trophic variables

Pearson's correlation analysis was performed to evaluate relationships among trophic parameters.

Strong **negative correlation between Secchi depth and chlorophyll-a (r = -0.82)** confirms that algal biomass reduces water transparency. Strong **positive correlation between TP and chlorophyll-a (r = 0.86)** indicates phosphorus-driven productivity. Very strong **positive correlation between TP and CTSI (r = 0.91)** confirms nutrient control of trophic status. CTSI shows strongest dependence on phosphorus, supporting eutrophication theory (Carlson, 1977; Vollenweider, 1976).

Table 1: Seasonal variation of water quality parameters

Season	Secchi Depth (m)	Chlorophyll-a (μg/L)	Total Phosphorus (μg/L)
Pre-monsoon	1.8	8.5	32
Monsoon	1.2	14.2	48
Post-monsoon	2.3	6.1	25

Table 2: Carlson Trophic State Index values

Season	TSI(SD)	TSI(CHL)	TSI(TP)	CTSI	Trophic Status
Pre-monsoon	45.6	46.2	48.9	46.9	Mesotrophic
Monsoon	52.3	52.8	55.1	53.4	Mesotrophic–Eutrophic
Post-monsoon	38.4	40.7	41.6	40.2	Oligotrophic–Mesotrophic

Table 3: Correlation matrix (r values)

Parameters	Secchi Depth	Chlorophyll-a	Total Phosphorus	CTSI
Secchi Depth	1.00	-0.82	-0.78	-0.85
Chlorophyll-a	-0.82	1.00	0.86	0.88
Total Phosphorus	-0.78	0.86	1.00	0.91
CTSI	-0.85	0.88	0.91	1.00

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