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Research Paper

COMPREHENSIVE ASSESSMENT OF THE TROPHIC STATE INDEX OF OKACHETTY VAGU RESERVOIR, WANAPARTHY DISTRICT TELANGANA

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Abstract:

Water bodies globally are struggling with serious problems of degradation, that might have significant effect on economy, society, and ecosystem. From January 2024 to December 2024, Okachetty Vagu reservoir's eutrophication level has been evaluated with Carlson's Trophic State Index (TSI). Most significant markers that are essential to eutrophication process Total phosphorous (TP), chlorophyll a (Chl (a)), and water transparency have been employed to calculate eutrophication indexes. During the study period, TP concentrations peaked in May and were lowest in February. Similarly, Chl-a levels have been highest in May and declined to their lowest in January. In contrast, Secchi disc transparency peaked in May and reached its minimum in February. Carlson TSI values, ranging from 46.82-58.55, suggest that the study area predominantly exhibits mesotrophic to eutrophic conditions.

Keywords: Deterioration, Eutrophication, Trophic State Index, Water transparency.

INTRODUCTION

The most valuable sources of drinking water for people globally remain lakes, reservoirs, and streams; however, they are susceptible to contamination and deterioration of water quality, especially eutrophication. Consequently, evaluating eutrophication status of lake water bodies constitutes a critical aspect of comprehensive water quality assessment and serves as a foundational element in formulating effective conservation and management strategies

(Sharma et al., 2010). Aquatic ecosystems are commonly categorized according to their trophic status, which reflects their nutrient enrichment and biological productivity (Chapra et al., 1997). These classifications include oligotrophic (nutrient-deficient, exhibiting low primary productivity), mesotrophic (moderately enriched, supporting balanced productivity), eutrophic (nutrient-rich, characterized by elevated biological activity and potential algal proliferation), and hypereutrophic (excessively nutrient-loaded, often leading to harmful algal blooms, hypoxia, and ecological degradation). A frequently employed metric for quantitatively assessing degree of eutrophication in lake ecosystems is TSI, that had been established by Carlson in 1977. TSI, specific ranking system created for this purpose, allows lakes, ponds, and reservoirs to be systematically categorized according to their biological productivity. Significant ecological markers that provide separate although related assessment of algal productivity in lentic habitats are Chl-a levels, Secchi disc transparency, and TP concentrations (Carlson, 1977). The average of the TSI values derived from these three indicators provides a robust composite index for classifying the trophic state of aquatic systems. An essential indicator of health of aquatic ecosystems is secchi depth, which is frequently employed for measuring water transparency. However, several parameters, including total suspended solids, resident sediment, and dissolved and colloidal inorganic and organic compounds, may contribute variability unrelated to eutrophication and affect its accuracy. Seasons, grazing, mixing depth, and other factors may affect impact of nutrients, however Trophic state is considered to reflect biological reaction to forcing factors including nutrient inputs (Nauuman, 1977). Freshwater ecosystems globally are experiencing escalating anthropogenic pressures, leading to recurrent ecological disturbances including harmful algal blooms (Lee et al., 2016). Although lake eutrophication is a natural process, recent research has demonstrated that it can be significantly accelerated by anthropogenic activities and climate change (Li et al., 2011). Maintaining phytoplankton and algal concentrations within optimal thresholds is essential for sustaining biological productivity and ecological health in lake ecosystems (Patra et al., 2017). This study is undertaken to quantitatively evaluate TSI of Okachetty vagu Reservoir, with objective of characterizing its ecological productivity and nutrient enrichment status through standardized limnological metrics. Knoll et al. (2015), states that these indices have been demonstrated to be extremely beneficial in influencing policy and developing lake management plans. Overpopulation significantly exacerbates water pollution through multiple pathways: the discharge of untreated sewage and solid waste contaminates water bodies; intensive agricultural expansion introduces harmful agrochemicals such as pesticides and synthetic fertilizers into aquatic ecosystems via runoff;

and unregulated industrial growth contributes to the release of toxic effluents and hazardous substances, collectively degrading water quality and threatening both environmental and public health. (Sheela et.al).

II. MATERIALS AND METHODS:

Monthly data collection was systematically carried out at the sampling station between January 2024 to December 2024. Numerous techniques have been employed to classify reservoirs and indicate their trophic status.

Carlson Trophic State Index:

The most popular and widely utilized approach is productivity-based, however Carlson's (1977) biomass-related tropic state indicator is often employed. This index is appropriate for volunteer programs since it takes minimal data and is generally easy to understand, numerically and in regards to standard trophic state categories connected to nutrients. Secchi disk transparency measurements were obtained using a 12-inch Secchi disk. Given the strong inverse relationship between total phosphorus concentrations and Secchi depth, a twofold increase in total phosphorus typically results in a proportional reduction in Secchi depth by half. As reported by Carlson (1980), chlorophyll-a concentrations increase exponentially along the trophic state index, with a doubling observed approximately every seven units, differing from the ten-unit scaling associated with Secchi depth and total phosphorus. Entire range of oligotrophic to hypereutrophic conditions is covered by TSI scale, that roughly extends from 0-100. According to Carlson's (1977) definition of trophic state, TSI classifies trophic states based on algal biomass, that is independently estimated by three variables: TP, Secchi depth, and chl-a pigment.

Formulae for calculation of Carlsons Trophic State Index (TSI) (Carlson 1977)

1. TSI based on Chlorophyll-a

"$TSI(Chl\text{-}a) = 9.81 \times \ln(Chl\text{-}a) + 30.6$"

Where Chl-a is chlorophyll-a concentration in µg/L.

2. TSI based on Secchi Disk Depth

"$TSI(SD) = 60 - 14.41 \times \ln(SD)$"

Where SD is Secchi disk depth in meters.

3. TSI based on Total Phosphorus

“TSI(TP)=14.42×ln(TP)+4.15”

Where TP is total phosphorus concentration in μg/L.

where TSI is Carlson Trophic State Index and ln is Natural logarithm.

Carlson’s trophic state index “(CTSI)=[TSI(TP) + TSI(Chl) + TSI(SD)]/3"

SD transparency in meters, TP and Chl-a in μg/L. Lakes are categorized as “oligotrophic (low productive), mesotrophic (moderately productive), and eutrophic (very productive)” based on CTSI values. Table 2 displays classification of lakes and range of Carlson's TSI values.

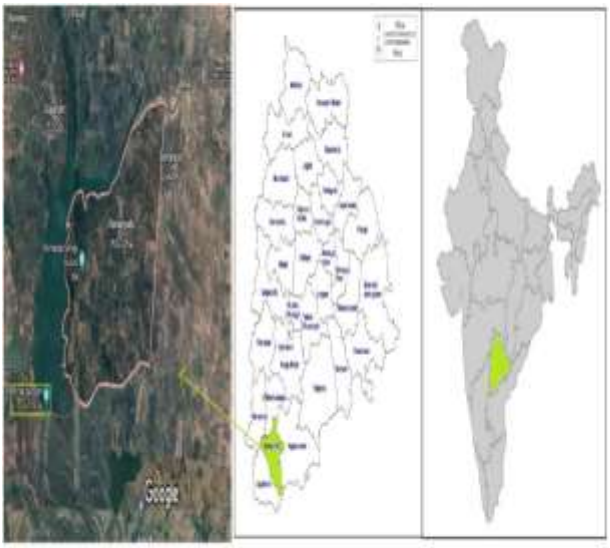
Water sample analysis:

To maintain sample integrity, water samples were brought to lab in an ice box containing ice packs. The amounts of chl-a and total phosphorus have been then examined using conventional techniques described in APHA (2017).

Study area:

Okachetty vagu reservoir

Map of the Okachetty vagu reservoir



The Okachetty Vagu Reservoir serves as a major drinking water source for Wanaparthy district while also supporting irrigation and pisciculture. In Telangana, it is classified as a medium-sized irrigation project and is also known as Pedha Vagu. The reservoir is located in Ramanpad village, Madanapuram mandal, Wanaparthy district. Due to its location, it is popularly referred to as the Ramanpad Reservoir. It has constructed across the Pedha Vagu in

1972, the reservoir lies at "latitude of 16°21′12″N and longitude of 77°50′51″E". It has a free catchment area of 341.37square kilometres, with a water spread of 305 hectares. While pisciculture has been extensively studied, the reservoir still lacks expertise in algal diversity and physico-chemical parameter analysis.

III. Results:

Table.1: Values for the Carlson Trophic State Index

S.NO	MONTH	SDD	Chlorophyll a	TP	TSI SDD	TSI Chlorophyll a	TSI TP	TSI Average
1	January-2024	1.9	6.3	20	50.75	48.65	47.34	48.91
2	February	1.8	8.5	10	51.52	51.59	37.35	46.82
3	March	1.2	16.4	40	57.37	58.04	57.34	57.58
4	April	1.1	17.1	42	58.62	58.45	58.04	58.37
5	May	1.2	19.3	44	57.37	59.63	58.71	58.57
6	June	1.3	18.5	41	56.21	59.22	57.69	57.70
7	July	1.3	16.1	40	56.21	57.86	57.34	57.13
8	August	1.4	15.6	37	55.15	57.55	56.21	56.30
9	September	1.5	14.3	32	54.15	56.69	54.12	54.98
10	October	1.6	13.5	30	53.22	56.13	53.19	54.18
11	November	1.7	10.1	28	52.35	53.28	52.20	52.61
12	December-2024	1.8	8.2	24	51.52	51.24	49.97	50.91

Table.2 Carlson's Trophic State Index (TSI):

Lake Classification Employing Trophic Status and TSI Values

TSI values	**Trophic Status**	**Attributes**
< 30	Oligotrophic	Persistent water clarity and maintenance of oxic conditions within the hypolimnion across seasonal cycles are hallmark features of oligotrophic freshwater

		ecosystems, reflecting low nutrient availability and limited primary productivity.
30-40	Oligotrophic	Oligotrophic lakes may maintain low productivity, yet shallow systems can undergo summer hypolimnetic anoxia due to limited depth and reduced mixing.
40- 50	Mesotrophic	Even though summer stratification increases risk of hypolimnetic anoxia, the water remains reasonably clear.
50-60	Eutrophic	Water transparency significantly decreases near lower threshold of classical eutrophy, and because deeper strata have less oxygen available, circumstances usually only support warm-water fish assemblages.
60-70	Eutrophic	Characterized by widespread macrophyte overgrowth, frequent algal scums, and cyanobacterial dominance.
70-80	Eutrophic	Algal blooms that occur frequently in summer are an indication of hypereutrophic conditions.
>80	Eutrophic	Marked by algal scums, occasional summer fish kills, limited macrophyte presence, and dominance of tolerant rough fish species.

IV. DISCUSSIONS:

Phosphorus serves as a key limiting nutrient in freshwater ecosystems and plays a pivotal role in regulating their trophic status. Alterations in phosphorus loading can drive significant shifts in ecological productivity. As highlighted by Carvalho and Kirika (2003), reductions in external nutrient inputs result in lower in-lake phosphorus concentrations, thereby constraining phytoplankton growth and leading to a corresponding decline in trophic status. In freshwater ecosystems, TP has been repeatedly demonstrated to be a major limiting nutrient and a major driver of biological production (Scholten et al., 2005). As presented in Table 1, total phosphorus concentrations varied between 10 and 44 µg/L

Previous research states that chl-a concentration is good substitute to measure phytoplankton biomass (Harper, 2010). Chl-a concentrations peaked during the summer months, likely driven by elevated phytoplankton activity and reduced water levels within the lake system. Previous research additionally demonstrated that chl-a and water levels are inversely related

(Wang et al., 2012). Chl-a concentrations were lowest during winter, primarily due to reduced primary productivity during this period. Key environmental factors influencing phytoplankton growth—such as temperature, photosynthetically active radiation (PAR), nutrient availability, and hydraulic retention time. tend to reach suboptimal levels in winter conditions (Hoffman, 1988). Chl-a concentrations throughout research period varied from 6.3-19.3μg/L, as illustrated in Table 1.

Transparency levels reached their minimum during the summer months, likely due to intensified phytoplanktonic activity, as evidenced by elevated chlorophyll-a concentrations, indicating heightened primary productivity (Kumar et al., 2012). Transparency levels during the study period fluctuated within the range of 1.1 to 1.9 meters, as summarized in Table 1. indicating moderate water clarity consistent with eutrophic conditions."

The observed spatial and temporal variability in Secchi Depth (SD) suggests dynamic changes in water transparency influenced by seasonal factors. The minimum SD values during summer may be attributed to increased algal growth and suspended particulate matter, while the maximum values in winter likely reflect reduced biological activity and clearer water conditions. This seasonal trend aligns with findings reported by Sheela et al. (2011b) for the Akkulam-Veli Lake, and Ridhi Saluja (2016) for the Bhindawas Lake, Haryana for reinforcing the broader applicability of these limnological patterns across similar aquatic systems.

Carlson TSI values, ranging from 46.82-58.5 as shown in Table 1, suggest that the study area predominantly exhibits mesotrophic to eutrophic conditions, indicating moderate productivity and nutrient levels. The present situation of the Okchetty vagu reservoir is at the lower threshold of classical eutrophy, water transparency declines noticeably, and conditions typically support only warm-water fish assemblages due to reduced oxygen availability in deeper layers as per Table 2.

V. CONCLUSION:

Current research revealed that trophic status of Okachetty vagu Reservoir is dynamic and exhibits temporal fluctuations, likely driven by seasonal variations in nutrient loading, hydrological conditions, and biological productivity. These alterations illustrate that human activity and natural processes have affected ecological dynamics of reservoirs. Carlson's TSI values, derived from TP, SD, and Chl-a measurements, classify the Okachetty vagu reservoir as a eutrophic system, underscoring the urgent need for targeted conservation interventions to enhance water quality. The Okachetty Vagu Reservoir remained in a eutrophic state throughout the entire duration of the investigation, indicating consistently high nutrient levels and sustained phytoplankton productivity. This persistent eutrophic condition suggests ongoing nutrient enrichment, potentially from agricultural runoff, domestic wastewater discharge, or other anthropogenic inputs, which may have long-term implications for water quality, aquatic biodiversity, and reservoir management. Assessing the trophic status of freshwater ecosystems is critical for informing evidence-based mitigation and management strategies aimed at curbing nutrient enrichment and preventing the proliferation of harmful algal blooms.

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