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A Comprehensive Review Of Physico-Chemical Water Quality Assessment In Freshwater Ecosystems Of Central India

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Abstract:

Freshwater ecosystems of Central India play a vital role in supporting drinking water supply, irrigation, fisheries, and biodiversity. However, increasing anthropogenic pressure has resulted in noticeable deterioration of water quality across rivers, lakes, and reservoirs of the region. Physico-chemical water quality assessment is a fundamental approach for evaluating ecosystem health and water usability. This review synthesizes published studies from Central India, focusing on key parameters such as temperature, turbidity, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), hardness, alkalinity, and nutrients. Seasonal trends, ecosystem-wise differences, and the influence of domestic, agricultural, and industrial activities are critically examined using evidence from published literature. The review highlights major findings, ecological implications, research gaps, and future perspectives for sustainable freshwater management in Central India.

Keywords: Physico-chemical parameters; Freshwater ecosystems; Water quality assessment; Central India; Rivers; Lakes; Reservoirs

1. INTRODUCTION

Freshwater resources are indispensable for human survival and economic development. Central India, particularly Madhya Pradesh, possesses an extensive network of rivers, lakes, and reservoirs that form the backbone of regional water security. Rapid urbanization, industrial expansion, agricultural intensification, and population growth have imposed severe stress on these freshwater ecosystems. Numerous studies conducted in Central India indicate growing concern regarding deterioration of water quality. Physico-chemical water quality assessment provides a scientific basis for evaluating pollution levels, ecological health, and suitability of water for various purposes. Despite the availability of several localized studies, a consolidated review focusing on Central India is limited, which necessitates the present synthesis.

2. Physico-Chemical Characteristics of Freshwater Ecosystems of Central India

Numerous studies have been conducted on physico-chemical water quality assessment of freshwater ecosystems across Central India, particularly in Madhya Pradesh. These studies primarily focused on rivers, reservoirs, ponds, and dams using following parameters:

Water Temperature

most studies in Central India reveal higher temperature in the water during the summer season, which greatly affects the level of dissolved oxygen in the freshwater bodies (Sharma et al., 2015; Nagpure et al., 2020).

Turbidity

Higher turbidity has also been reported to occur during monsoon season due to runoff, soil erosion, or discharge from urban areas, specifically in reservoirs or urban ponds (Pathak, 2022; Gour et al., 2021).

pH

pH values of water resources in Central India tend to be slightly alkaline due to the influence of Carbonate rocks (Saxena, 1990; Somgare & Saket, 2024), except in areas around sewage and agricultural water intake points.

Dissolved Oxygen (DO)

A few studies have also found a reduction in dissolved oxygen during summer, primarily because of an increase in organic load, temperature, and low volume of water (Khichi, 2020; Daheriya, 2022).

Biochemical Oxygen Demand (BOD)

High BOD levels have been reported in water bodies where domestic sewage and agricultural runoff enter the water bodies. This indicates higher levels of organic pollution in water bodies (Tiwari et al. 2019; Daheriya 2022).

Chemical Oxygen Demand (COD)

Increased COD values in the reservoirs and river water bodies of Central India indicate the presence of oxidizable organic and inorganic pollutants, which are associated with human activities (Solanki & Upadhyay, 2021; Daheriya, 2022).

Total Dissolved Solids

Seasonal rises in TDS, especially in the summer season, have also been linked to evaporation and the inflow of wastewater in reservoirs and dams (Mishra, 2016; Pathak, 2022).

Total Hardness

The moderate to high values in the Central Indian freshwater bodies are generally dependent on the geological weathering and domestic wastewater discharge (Johri, 1990; Daheriya, 2022).

Alkalinity

Research has shown that a certain level of alkalinity in fresh water bodies stabilizes pH; higher alkalinity levels might resemble nutrients in excess in contributing to algal growth (Wetzel, 2001; Venkatesh et al., 2020).

Nutrients (Nitrate/Phosphate)

Agricultural runoff and release of sewage has been indexed as a major contributing factor for eutrophication in the reservoirs and ponds of Central India (Parte et al., 2021; Gour et al., 2021).

Heavy Metals

The occurrence of heavy metals like lead, cadmium, and chromium in various reservoirs has been noted, emphasizing their persistence in the environment, bioaccumulative capacity, and toxic effects on ecosystems (Patil & Ahmad, 2022; Tabrez et al., 2021)

Water Quality Index (WQI)

WQI-based studies have appeared frequently in the literature for determining the status of freshwater resources in Central India and have also served for a simplified assessment by management agencies (Sankat et al., 2018; Nagpure et al., 2020).

Overall, studies from the past decade clearly indicate that freshwater ecosystems of Central India are under increasing stress due to urbanization, agriculture, aquaculture, and industrial activities. Seasonal variation remains a dominant factor influencing water quality, and WQI-based assessments have emerged as a reliable tool for integrated evaluation.

3. DISCUSSION

The data summarized in Table 1 and illustrated in Fig. 1 clearly demonstrate that seasonal variation is a dominant factor influencing physico-chemical characteristics of freshwater ecosystems in Central India. During the summer season, elevated water temperature and reduced water volume result in lower dissolved oxygen (DO) concentrations, accompanied by higher biochemical oxygen demand (BOD) and total dissolved solids (TDS). These trends indicate intensified organic pollution and reduced dilution capacity of water bodies during summer months. Similar seasonal deterioration in water quality during summer has been widely reported from rivers and reservoirs of Madhya Pradesh, where increased evaporation and anthropogenic discharge exacerbate water quality stress.

In contrast, the monsoon season is characterized by high turbidity and nutrient enrichment, as shown in Table 1. Increased surface runoff during monsoon transports suspended solids, nutrients, and contaminants from agricultural fields, urban areas, and catchment zones into freshwater systems. Although monsoon inflow temporarily improves dissolved oxygen levels due to increased water volume and turbulence, it simultaneously elevates the risk of eutrophication, particularly in lakes and reservoirs. Winter conditions generally represent the most favorable water quality status, with lower temperature, reduced microbial activity, higher DO levels, and comparatively stable physico-chemical conditions.

The comparative assessment presented in Table 2 and visualized in Fig. 2 highlights distinct differences in water quality behavior among rivers, lakes, and reservoirs. Rivers, being lotic systems, exhibit higher self-purification capacity and lower pollutant retention, owing to continuous flow and dilution processes.

Consequently, rivers show moderate eutrophication risk and relatively stable dissolved oxygen levels compared to stagnant systems. However, river stretches near urban settlements and discharge points may still experience localized degradation.

Lakes and reservoirs, categorized as lentic and semi-lentic systems respectively, demonstrate higher pollutant retention and greater susceptibility to eutrophication, as indicated in Table 2. Limited water exchange, longer retention time, and continuous nutrient input promote algal blooms, oxygen depletion, and seasonal hypoxic conditions. The high eutrophication risk depicted in Fig. 2 for lakes and reservoirs underscores the vulnerability of these ecosystems to anthropogenic pressures, particularly agricultural runoff, domestic sewage discharge, and aquaculture activities.

Fluctuations in dissolved oxygen are more pronounced in lakes and reservoirs due to thermal stratification, organic matter accumulation, and reduced mixing, especially during summer. In contrast, rivers maintain comparatively moderate DO fluctuations due to continuous flow and aeration. The observed patterns emphasize that ecosystem type strongly regulates the response of freshwater bodies to seasonal and anthropogenic influences.

Overall, the integrated interpretation of tables and figures suggests that summer-induced concentration effects and monsoon-driven runoff collectively govern water quality dynamics in Central Indian freshwater ecosystems. Lakes and reservoirs emerge as critical hotspots of degradation, requiring focused management interventions. These findings reinforce the need for ecosystem-specific and season-specific water quality management strategies, combining pollution control, catchment regulation, and continuous monitoring to prevent further ecological deterioration

4. Seasonal and Ecosystem-wise Variation in Water Quality

Table 1. Season-wise variation in physico-chemical parameters (general trends)

Parameter	**Summer**	**Monsoon**	**Winter**
Water Temperature	High	Moderate	Low
Turbidity	Low–Moderate	High	Low
Dissolved Oxygen (DO)	Low	Moderate	High
Biochemical Oxygen Demand (BOD)	High	Moderate	Low
Total Dissolved Solids (TDS)	High	Low	Moderate
Nutrients (Nitrate, Phosphate)	Moderate	High	Low

Table 2. Comparative Water Quality Characteristics of Freshwater Ecosystems

Parameter	**Rivers**	**Lakes**	**Reservoirs**
Flow condition	Flowing (lotic)	Stagnant (lentic)	Semi-lentic
Pollutant retention	Low	High	Moderate–High
Eutrophication risk	Moderate	High	High
DO fluctuation	Moderate	High	High
Self-purification capacity	High	Low	Moderate

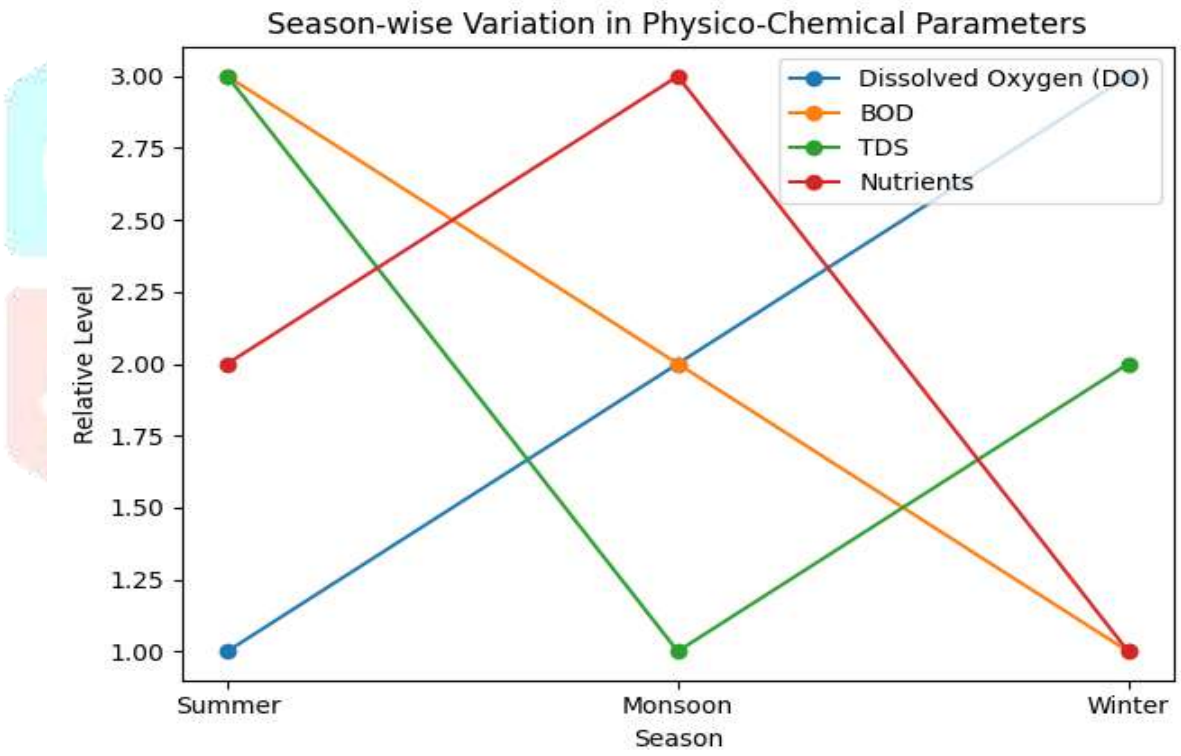

Fig.1 Season-wise variation in selected physico-chemical parameters of freshwater ecosystems of Central India.

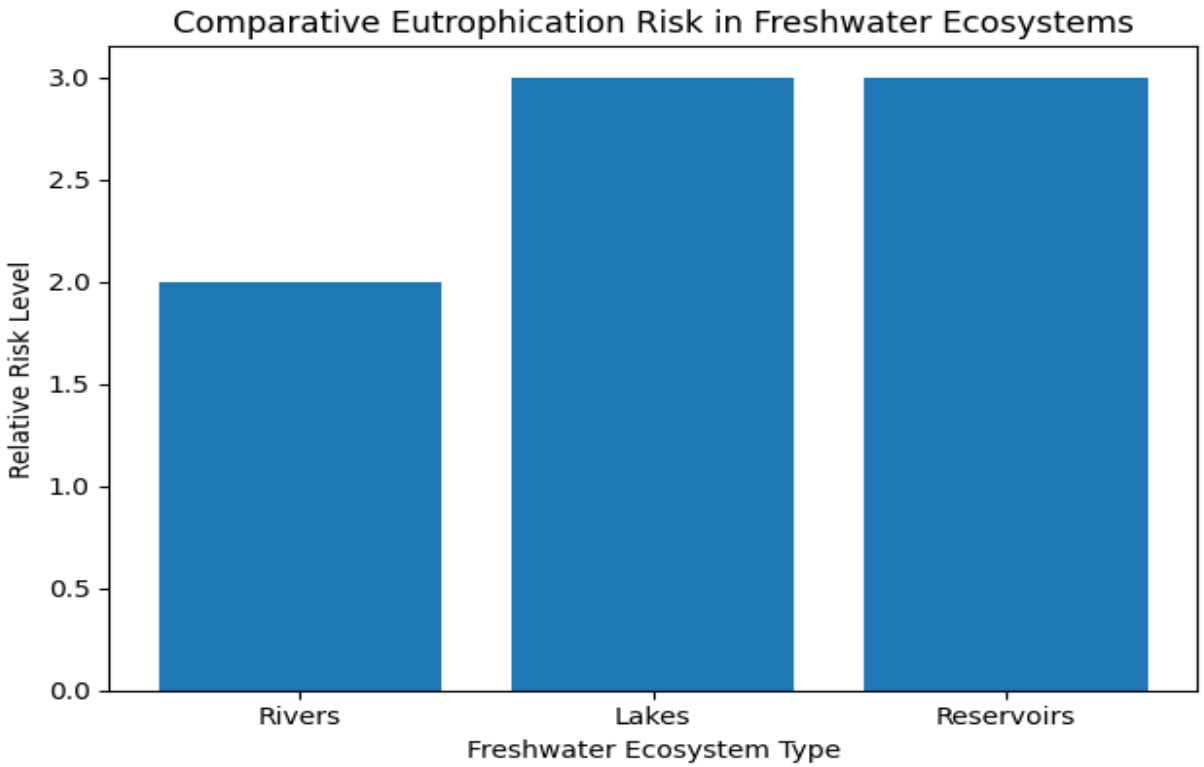

Fig. 2 Comparative eutrophication risk in rivers, lakes, and reservoirs of Central India.

5. CONCLUSION

The present review demonstrates that freshwater ecosystems of Central India are experiencing progressive degradation due to anthropogenic activities and seasonal variability. Physico-chemical water quality assessment remains an effective and widely adopted tool for monitoring ecosystem health. Strengthening long-term monitoring, reducing pollutant inputs, and integrating biological indicators with physico-chemical analysis are essential steps for sustainable freshwater resource management in Central India.

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