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# A critical review on limnology with respect to Karnataka state, India

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**Abstract**
Limnology is an interdisciplinary science that investigates the freshwater environment holistically by using extensive field and laboratory research. Plankton diversity and physicochemical parameters play an important role in determining water quality for irrigation and drinking. In aquatic community, the physical, chemical and properties of water affects phytoplankton composition, dispersion, and abundance. Phytoplankton provides food for zooplankton development and growth. Phytoplankton not only contributes primary production but also serves as food sources for herbivorous and also plays critical role as bio documentary indicator for water quality. Plankton population dynamics influenced by a number of factors, including light intensity, food availability, dissolved oxygen content, and predators. Low pH as well as high salinity significantly reduce plankton diversity and density. The biodiversity of an aquatic ecosystem is being severely reduced or lost, and the impacts are expected to be higher due to a number of health stressors, such as sewage, home, industrial, and agricultural effluents that transports organic matter containing hazardous compounds. Limnological studies are critical for a variety of applications, including water resource management, flood forecasting and control, environmental protection, agriculture, and urban planning. The current article is aimed to give a broader analysis and furnish a broad assessment of literature linked with the initiation of limnology and work done in the Indian subcontinent predominantly in Karnataka, with eighty-one quoted sources.

**Keywords:** Limnology, ecology, phytoplankton, zooplankton, water quality, pollution

## Introduction
Limnology is the study of how inland water species interact structurally and functionally with one another with their changing physical, chemical, and biological environments. The study of biological traits and interactions of creatures found in freshwater environments is known as freshwater biology. The study's focus is mainly on creatures themselves, including their biology, life cycles, populations and communities. (Basavarajappa *et al*., 2014.) [4]
The environmental conditions of each lake systems are determined by the Nature of the lake and its exposure to numerous environmental elements. As a result, surface water quality in India is influenced not only by natural processes but also by anthropogenic effects. Reservoirs and Lake systems throughout India are experiencing varied degrees of environmental degradation, which could be attributed to encroachment, eutrophication or silt. In previous century, there was massive increase in population without equivalent expansion of municipal infrastructure, that's results to accumulates of toxicants in lakes and reservoirs, especially urban ones, becoming sinks for more toxins. Most urban and rural lakes was perished in response to global environmental concerns (Iscen *et al.,* 2008) [17]. Due to high temperatures and lack of rain causes extensive evaporation of water from reservoirs, that leads to increase in levels of salts, heavy metals, and other contaminants. Results in contribution to poor reservoir ecosystem quality (Arain *et al.,* 2008) [2].
The main reasons that result in impaired conditions of the lakes could be classified into two types, pollutants entering from fixed point and non-point sources. Since freshwater species are essential component of the aquatic food web and food chain greatly enhances the biological productivity of the aquatic ecosystem. It is possible to study the Ecology of lake by specifically identifying freshwater species that present in lentic habitat. (Nimbalkar *et al*., 2013) [32].
In the realm of limnology, Victor Hansen's discovery of plankton (1887) [46] was a significant development, and a great deal of work has been towards the close of nineteenth century. Prior to the initial publication, Indian academics knew very little about limnology. Planktonic populations, are basic foundation of all aquatic life, they are directly or indirectly regulated by a variety of biological variables that affects ability of organisms to adapt themselves to several factors (Reynold 1996) [39]. In the aquatic community, phytoplanktons provides food for zooplankton for growth and development. Significantly diversity of phytoplanktons and zooplanktons, changes with seasonal differentiation resulting in formation of meroplanktons.
The objectives for lake conservation must be customized to each region, based on the degree of reliance, and relevant to the degradation issues. This shows an evident that physical environment has to be rebuilt, the soil and water chemical parameters needed to be chemically adjusted, biological manipulation, the return of native plants and animals.

## Critical review discussion
The Swiss-French scientist François-Alphonse Forel first coined the term "limnology". He introduced the term limnology in a publication titled "Handbuch der Seckende" (1901) [9]. Forel is widely recognized as a pioneer in the field of limnology, and his work laid the foundation for the systematic study of inland waters. In the realm of limnology, Victor Hansen's discovery of plankton (1887) [46] was a significant development.

Saha *et al*. (1971) [40] examined the physical, chemical, and biological properties of a perennial freshwater pond. Hosmani and Bharati (1977) [13] studied hydrobiological studies in ponds and lakes of Dharwad, they found that Euglena Sanguinea blooms faster at temperatures above 26 °C, with low carbonate concentrations, albuminoidal ammonia, high pH, carbon dioxide, nitrates, and free ammonia.

Hosmani and Bharati (1982*)* [14] conducted a comprehensive study of the freshwater hydrobiology of Dharwad wetlands affected by animal and human populations. Their findings indicated that rise in species leads to increase in total algal output. However, during the summer, when several algal species emerge as blooms, heavily contaminated wetlands showed minimal algal productivity.

Fauziuddin (1990) [7], discovered seasonal variations in physicochemical characteristics and plankton periodicity in a freshwater fish pond in Bhagalpur, India. Naganandini and Hosmani (1990) [29] determined that *Microcystis aeruginosa* dominated cyanophycean blooms in Mysore's inland lakes. The cyanophycean bloom was influenced by the death and degradation of *Spirulina nordestedtii*, as well as dissolved organic matter, oxygen, carbon dioxide, phosphorus, and calcium. Kumar (1994) [24] conducted studies in Santhal Parganas, south Bihar, on the limnology and heavy metal concentrations of thermal springs. Hosmani and Vasanth Kumar's (1996) [12] study on water pollution found that Kukkarahalli lake produces more biochemical products while Dalvoi lake produces more plankton.

Sunkad (2004) [43] conducted research on the variety of zooplankton in Raksha Koppa Reservoir, Karnataka. This study looks at 27 different species of zooplankton. Protozoa and Ostracoda indicate the least species, while Rotiferal represents the greatest. Summer was the season with the greatest number of species reported, and winter produced the fewest.

Kudari *et al.,* (2005) [23] have studied the zooplankton composition of 19 water bodies of Haveri district, in post and pre monsoon season of 2004-2005 and were recorded a total of 71 species of zooplanktons. The connection in the food chain and a fundamental component of ecosystems are plankton. Thomas *et al*. (2006) [44] found that sunlight, phosphates, nitrates, oxygen, and carbon dioxide significantly impact the growth of Myxophyceae in lakes of Mysore, India. Chlorococcales can withstand high nutrient concentrations, according to their findings.

Hulya and Kaliwal (2008) looked into the Almatti Reservoir in Bijapur's water quality. Their research indicates that zooplankton species' distribution and population density are influenced by physico-chemical features of their habitat. The statistical analysis's findings show a strong correlation between the biological and non-biological components.

The quantity of heavy metals in the Karanja reservoir was studied by Majagi and Vijaykumar (2008) [27]. It reveals that all heavy metal levels were below permissible limits, with the exception of Fe and Ni, which had greater values during the southwest monsoon. Mn, on the other hand, had a higher concentration during the northeast monsoon throughout the summer. The remaining physico-chemical parameters are also within the acceptable range. Although the reservoir is prolific, the water is quite hard.

Rajshekar and Vijaykumar (2009) studied zooplankton in Gobbur Lake, Gulbarga District, Karnataka, and recorded species composition, morphology, and physico-chemical characterization of water bodies.

Diversity of phytoplanktons in a waste stabilization pond at Shivamogga Town, Karnataka, conducted by Hosmani and Hosetti (2009) [15]. The abundance of each species is explained mathematically by the diversity indices. It included 71 species of algae in all, including those from the families Bacillariophyceae, Desmidaceae, Euglenophyceae, and Cyanophyceae. Throughout the study period, the two most prevalent forms among the algae taxa were Chlorella and Scenedesmus. The Udupi district's temple tanks' physico-chemical characteristics and microbiological diversity were reported by Jayashankara *et al*. (2010) [18].

Vijaykumar *et al*. (2010) [48] have studied Physico-chemical characteristics and zooplankton seasonal trends in the Freshwater Reservoir in Gulbarga. The physicochemical factors and the zooplankton community are interconnected. The findings show that the physical and chemical aspects of the environment have an impact on the distribution and abundance of zooplankton species.

Joseph and Yamakanamardi (2011) [20] have studied monthly changes in the abundance and biomass of zooplankton and water quality parameters in Kukkarahalli Lake of Mysore. This study examined the biomass of all zooplankton and the abundance of the rotifer, cladoceran, cyclopoid-copepod, and ostracod zooplankton groups monthly over a year. It is interesting and significant to notice that during the course of the study year, free carbon dioxide and the zooplankton groups Harpacticoid and Calanoid were completely absent from all four sample sites. The pH was primarily responsible for 53% of the variance in the abundance of Cladocera, 55% of the variation in the Cyclopoid-copepod, 39% of the variation in the ostracod, and 53% of the variation in the abundance of total zooplankton.

Naik *et al.,* (2012) [31] have studied the physicochemical characteristics of Kunigal Lake, Karnataka. Twenty-four of the water sample's physical and chemical parameters were examined, and the results indicate fluctuations throughout the course of the two sampling years (2007–2009). Kunigal's water is unsafe for human consumption due to higher levels of alkalinity, pH, total dissolved solids, low dissolved oxygen, and excessive turbidity.

Gaythri *et.al* (2013) studied impact of climate change on water quality of Shoolkere Lake, Bangalore. The results revealed that the condition of this Lake in different seasons showed fluctuations in physico-chemical parameters. Correlation coefficient showed positive and negative relationships between the physico-chemical parameters and also showed high significant positive relationship ($p<0.01$ level) and significant positive relationship ($p<0.05$ level).

Gayathri *et al.,* (2014) [9] have conducted a study on the population dynamics of the zooplankton community in Doddavoderahallilake, Bangalore

Mahadeva Murthy and Poornima Devi (2015) [26] insight into limnological regime of Mandya lakes, Karnataka. The investigation of lake water reveals that total alkalinity and electrical conductivity have the strongest association, with magnesium and total hardness. The lowest correlation was seen with Chemical oxygen demand, calcium, pH, total hardness, total dissolved solids, chloride, magnesium, iron, and sulphate were all within the range specified by the WHO.

Temporal Variation in Bandematta Hosakere Lake Water Quality Parameters in the Peri Urban Area of Bengaluru,

Karnataka, was reported by Bheemappa *et al., (*2015) [5]. The findings showed that Bandematta Lake has a high organic load. Due to anthropogenic activity and wastewater discharge, significant alterations in a number of physico-chemical parameters were observed. According to their study findings, water sample had high amounts of EC, TDS, BOD, Nitrate-Nitrogen, and Total Hardness were measured at 1387.50 µS/cm, 912.43 mg/L, 4.45 mg/L, 12.73 mg/L, and 342.93 mg/L, respectively. Excess sodium and potassium levels have impacted agriculture. It is concerning that the water quality metrics for Bandematta Lake have shown a significant degree of temporal variation, which will be challenging to maintain.

Murulidhar and Yogananda Murthy (2015) [28] examined the dynamics of phytoplankton and their correlation with physicochemical characteristics in Gulur Wetland, Tumakuru District, Karnataka, India. Based on the available data, the study concludes that the phytoplankton population of the chosen wetland is closely associated with seasonal variations in hydrography, and that its diversity, distribution, and richness are nearly identical to those of other significant wetland systems in India.

Khan *et al.,* (2016) [22] have investigated zooplankton diversity and seasonal variations in Gogi Lake, Karnataka. Throughout the course of the investigation, 22 different species of zooplanktons were identified. There are fifteen species in the phylum Rotifers, including three species each of Cladocera, Copepoda, and Ostrocoda. The highest number of species occurs during the summer and the lowest number occurs during the rainy season, according to a season-wise analysis.

The diversity of aquatic insects and the physico-chemical parameters of Kelageri Lake in Dharwad, Karnataka, were researched by Pavan Yargal *et al*. (2017) [35]. According to the physico-chemical parameter study, the data indicate that the water body is in good condition because they are within an acceptable range. To help with the conservation and management of any body of water, routine monitoring of aquatic insects and physico-chemical parameters is required.

Prasad *et al.,* (2017) [36] investigated limnological aspects of the physico-chemical properties of Chowkhalli Tank Water, which is situated in Bidadi Hobli, the Ramanagara District of Karnataka, approximately 43 km from Bangalore City and close to the Bidadi industrial region.

Amaraneni *et al*., (2018) [1] investigated the spatial distribution of air and water contaminants in Lake Kolleru using GIS mapping. The study's conclusion shows that, during the summer, the average distribution of the lake's TDS, Hardness, Chloride, Sodium, BOD, and COD water quality parameters is higher in the eastern zone than in the western zone. The water samples were taken three times a year for a total of three years. Trade, driving, farming, and aquaculture practices all degrade Kolleru Lake's environment. As a result, there is an increase in hardness, TDS, Sodium, Chloride, COD, and BOD, which impacts how drinkable lake water is and causes a decline in soil quality and aquatic life.

Parimala and Asiya Nuzhat (2018) [33, 34] investigated Avifaunal Diversity and status of Kaggaladu Bird sanctuary of Tumkur district, Karnataka, and Bhimasandra pond, Tumakuru district, Karnataka. They concluded that birds are noticeable elements in wetland ecosystem visually and auditory.

Mahadev *et al*., (2020) [25] Studied Water Chemistry and Trophic State of Seven Lakes of Mandya District, Karnataka, India. The Diversity and Abundance of Zooplankton in Gundalli Tank, Shahpur, Yadagir District, were examined by Nagbhushan Reddy *et al.,* in (2020) [30]. Zooplankton are heterotrophic planktonic creatures that float in water. This research also shows that distinct zooplankton groups have distinct peak densities, which are influenced by the local environmental factors that are present at that particular time.

The study conducted by Revankar *et al*., (2021) [38] examined the diversity of zooplankton as well as physical and chemical conditions in the Bommanahalli reservoir located in the Uttara Kannada District of Karnataka. There were 31 zooplankton species identified in all, with eleven species, Rotifera was the most well-represented category.

Harsha and Girish (2021) [11] explore seasonal variations in zooplankton abundance in the Kadasgatti Minor Irrigation Tank of Bailhongal, Belagavi District, Karnataka, India. They discovered 52 zooplankton species, totalling 14327 individuals with a relative abundance of 35.42%. The study provides baseline data on the current state of the water body, suggesting that anthropogenic activities, particularly agricultural runoff, are the primary causes of eutrophication. To protect the water body, long-term and comprehensive conservation policies must be implemented.

Vijaya *et al.,* (2022) [47] Assessing zooplankton with a focus on seasonal variation and selected physic-chemical factors in Somalapura water tanks in Hosapete, Karnataka. The study emphasizes the importance of using zooplankton as an appropriate and effective biomonitoring technique for assessing lentic water quality levels. Venna et al., (2022) studied Environmental Status of Hosakote Lake, Bengaluru, Karnataka, India found that the major sources of contaminants due to sewage discharge and effluents from the surrounding places.

Dharma Guru Prasad (2021) [6] Studies on Physicochemical Aspects and Zooplankton Diversity in Marehalli Lake, Mandya District, Karnataka, India. Numerous studies concluded that the largest density of zooplanktons was recorded during the summer season due to the rate of evaporation, while the lowest density was found during the winter season due to the rate of evaporation.

Shivashankar *et al*., (2023) [42] have studied Physico chemical parameters of lakes in and around Arsikere Taluk, Hassan District, Karnataka. The study found that water quality varies by season, affecting local flora, fauna, and biodiversity. Pond water has seasonal fluctuations in its physicochemical qualities, requiring continuous monitoring to ensure public safety and local biodiversity restoration.

Kavitha *et al*. (2024) [21] assessed the physicochemical quality and challenges of municipal sewage water in Manchalapur village, Karnataka, India. The data showed that for the monsoon and post-monsoon periods, every measure of water quality, with the exception of BOD, COD, DO, and turbidity, fell within the recommended range of irrigation standards. Farmers and agricultural researchers may find the data helpful in advising them on how to effectively manage and use tank water.

Assessment of Physico-chemical Parameters and Zooplankton Community at Gopalaswamy Tank, Chitradurga, Karnataka by Basavaraj and Girish Kadadevaru (2024) [3] Examined that algal bloom has caused the water body to lose transparency, and its average pH

value was 8.77, with a maximum pH value of 10.1. The water body's excess nutrient load is shown by the highest values of phosphate, sulphate, and nitrate. Although the electric conductivity readings are within acceptable bounds, the eutrophic state of the water body is indicated by the algal bloom, alkalinity, and nutrient load. Water was not suitable for potability, according to the evaluation of physico-chemical parameters.

## Conclusion

The ongoing research and technological advancements in limnology hold promise for a deeper understanding and more effective preservation of freshwater ecosystems. By addressing critical issues such as pollution, biodiversity loss, and climate change, limnologists contribute to the sustainable management of water resources, ensuring their availability and quality for future generations. Total Hardness was observed some evidence indicates that heart diseases and kidney stone formation, as it causes unpleasant taste and reduce ability of soap to produce lather. Hard water is unsuitable for domestic use. The suggested measures to improve the ground water quality includes total ban on the activities that causes pollution, avoid use of pesticides and prevent entrance of sewage in to ground water. Water quality assessment shows that the most of the water quality parameters slightly higher in the wet season than in the dry season. This review concludes that physical chemical parameters impact water quality, as well as the biotic flora and fauna of the aquatic ecosystem. This study provides valuable insights into how physical and chemical features impact the quality of water. The purity of the water is crucial for aquatic survival. This study includes limnological examinations of freshwater bodies within Indian subcontinent and Karnataka state. Freshwater is a vital resource for various ecosystems, agriculture, industry, and human consumption. Ensuring access to clean freshwater is a global challenge, and sustainable water management practices are necessary to meet the needs of both current and future generations. Still there is a research deficit in small areas of Karnataka, since freshwater lakes and ponds must be examined.

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