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Freshwater Ecosystems in India: A Limnological Review

Hitesh S. Jadhav[1] Prof. Dr. Madhukar. B. Patil*
[1]Research Scholar**. (**Department of Botany); J.E. S's, Arts, Science and Commerce College, Nandurbar-425412 (M.S), India. Email: hjadhav661@gmail.com
*Member of Academic Council; Chairman of Board of Studies (Botany) North Maharashtra University Jalgaon.
Professor Head Department of Botany for UG, PG, Research
J.E. S's, Arts, Science and Commerce College, Nandurbar-425412 (M.S), India.

ABSTRACT:

India's freshwater ecosystems are vital to the country's biodiversity, economy, and cultural heritage. This review provides a comprehensive examination of the current state of limnological research in India, focusing on the diversity, distribution, and dynamics of inland water bodies such as rivers, lakes, reservoirs, and wetlands. We explore the unique characteristics of these ecosystems, their ecological significance, and the key factors influencing their health and sustainability. The review highlights the major challenges faced by Indian freshwater systems, including pollution, habitat degradation, invasive species, and the impacts of climate change. Additionally, we assess the progress made in conservation and management efforts, identifying gaps in knowledge and areas requiring further research. By synthesizing existing studies, this review aims to enhance our understanding of India's freshwater ecosystems and support the development of effective strategies for their protection and restoration.

KEYWORDS: Limnology, Phytoplankton, rivers, lakes, wetland.

INTRODUCTION

India is home to a diverse array of freshwater ecosystems, including rivers, lakes, reservoirs, and wetlands, which play a crucial role in supporting biodiversity, providing water resources, and sustaining the livelihoods of millions of people. These ecosystems are integral to the country's ecological and socio-economic fabric, influencing agriculture, fisheries, and water supply for domestic and industrial use. Despite their significance, India's freshwater systems face numerous threats, including pollution, over-extraction of water, habitat degradation, invasive species, and the impacts of climate change. Limnology, the study of inland waters, offers essential insights into the functioning, health, and sustainability of these aquatic environments. In India, limnological research has revealed critical information about the physical, chemical, and biological properties of freshwater bodies, contributing to our understanding of their ecological dynamics and guiding conservation efforts.

The study's focus is mostly on the creatures themselves, including their biology, life cycles, populations, and communities' Abiotic variables are essential elements of the freshwater ecosystem that are not alive but impact living creatures. The ability of newly emerging creatures to survive and procreate in an empty and barren ecosystem depends on favorable environmental circumstances. Biologic factors are those that occur when a range of species coexist in an environment and their actions have an impact on the well-being of other species nearby. Variations in the angle at which sunlight reaches the water's surface, cloud cover, season, and location all significantly impact the kinds of creatures that inhabit freshwater habitats (S.H. Basavarajappa et al. **2013).**

CRITICAL DISCUSSION

The primary focus of limnology, as it developed as a distinct field of study, is freshwater ecology. Physical and chemical conditions, as well as their interactions, are the variables that control the development of algae. A significant development in the science of limnology, **Victor Hensen's** discovery of plankton in (1887) opened up new possibilities. The first person to study the algal periodicity of tiny ponds was **Fritsch (1907)**, who co-authored the "Research on the growth and multiplication of British Freshwater Algae in Nature" series with **Rich (1932)**.

According to **Borse and Bhave (2000)**, the amount of dissolved carbon dioxide varied with the season, reaching its peak in the summer and its lowest in the winter. It was also influenced by the pH of the water as well as the carbonates and bicarbonates present in it**. Nandan et al. (2001)** found that a greater concentration of dissolved carbon dioxide, carbonates, total alkalinity, phosphates, and chlorides was responsible for the prevalence of blue green algae in their study of seasonal fluctuations in Jalgaon's Hentala Lake. In a contaminated lake, **Nagarathna and Hosmani (2002)** investigated the variables affecting the Nitzschia obtusa bloom. The majority of the physico-chemical characteristics were shown to be inversely correlated with the growth of diatoms, according to correlation matrix and cluster analysis; the presence of a few desmid species suggested that the water was contaminated. Few species of Desmids were observed in contaminated water, according to **Pejavar et al. (2002).** Their findings provide an explanation for fluctuations in the phosphorus and carbon dioxide concentrations in Lake Ambegosale.

Khan (2002) assessed the variety of freshwater macroinvertebrate communities connected with macrophytes in certain lakes and ponds in southern West Bengal, finding 49 macro-invertebrate fauna and 17 macrophytic species in the lakes. The results showed that the decreased species variety of macrophytes in the pond was mostly due to dense development of the water hyacinth, Eichhornea sp., which covered the pond and prevented other macrophytes from growing; water hyacinths are an indication of eutrophicated waterways. **Raut and Pejaver (2003)** studied biodiversity of macrophytes in lakes of thane city. According to the study, a high level of water contamination causes pollution-tolerant species to predominate, which alters the lake's biodiversity. Significant variations were observed in the concentrations of DO (1.53–9.69 mg/L), CO_2 (0–28.16 mg/L), PO_4–P (0.0029–0.3000 mg/L), and NO_3–N (0.086-0.330 mg/L). Comparably, out of the 35 phytoplankton species that were seen, 19 were found in infested and uninfested lakes, whereas 16 were found only in infested lakes and 12 exclusively in uninfested lakes. In two tropical freshwater lakes, Baghdara and Udai Sagar, which receive runoff from urbanized areas of Udaipur, Rajasthan, and undisturbed woodlands, respectively, **Pandey and Verma (2004)** studied the chemical and biological characteristics with influence of catchment. The results of the physico-chemical and biological analysis of both lakes show that Udai Sagar was polluted and approaching eutrophic condition, while Baghdara remained unpolluted. This finding further suggests that dredging of sediment containing phosphorus could be a useful strategy for the restoration of dryland lakes or eutrophic lakes.

Sukund and Patil (2004) investigated the water quality of Lake Belgaum (Karnataka), and the study found that in summer, total hardness is higher due to the high temperature, which causes rock breakup. Based on the Langlier's index, **Mahadev and Hosmani (2004)** evaluated the water quality and found that one of the lakes tended toward hard water with light scale deposition, while the other showed a propensity toward heavy scale deposition. **Hosmani and Mahadev (2005)** They noticed that the growth of phytoplankton in wet environments tends to change the pH of the water. Moreover, blue green algae and chlorococcales dominated waters that were prone to light scale deposition. The amounts of organic contamination were confirmed by these findings.

Nandan and Aher (2005) studied algal populations to evaluate the water quality of the Haranbaree dam (Maharashtra) and identified genera of different groups that are tolerant of contamination. The species belonging to Navicula, Oscillatoria, and Euglena were the most resilient to pollution. According to **Hosmani's (2006)** calculation of the Trophic State Indices for the lakes in Mysore, values between 40 and 50 were classified as mesotrophic (moderate pollution), values

over 50 as eutrophic (very productive), and values below 40 as oligotrophic. **Muley D.V. and Patil I.M. (2006)** examined the chemical and physical characteristics of the Pauna River and discovered that low levels of DO indicate high levels of organic.

Tiwari and Chauhan (2006) conducted seasonal research on phytoplanktonic diversity at Kitham Lake from January 2000 to December 2001. The study identified 73 algae species. A small number of species were documented throughout the year, while others were distributed in different seasons, primarily in the winter and summer. The researcher noticed. During the winter, Chlorophyceae were the most prevalent group, followed by Bacillariophyceae, while Cyanophyceae and Euglenophyceae were the most prominent in the summer. Pandorina morum, Pediastrum tetras, Gonium sp., Chlorella vulgaris, Scendesmus quadricauda, Oedogonium cardiocum, Synedra ulna, Oscillatoria agardhii, and Euglena gracilis were all seen throughout the year. Some species, including Chlorella, Stigeoclonium, Pandorina, Micratinium, Oscillatoria, Anacystis, Nitzschia, and Cymbella, have been recognized as water pollution indicators. Myxophyceae development is significantly influenced by sunlight, phosphates, nitrates, oxygen, and CO_2, according to research done in the lakes of Mysore by **Thomas and Deviprasad (2006)**. They stated that Chlorococcales members could withstand extremely high nutrient concentrations. **Ranjan et al. (2007)** examined the physico-chemical characteristics of Ghariyarwara Pond in Nepal and noted that the other phytoplankton varied seasonally while Chlorophyceae remained dominant year-round. Barak Pond in Assam was the subject of a hydrobiological investigation by **Venkata Subramani et al. (2007)** found that the water's increased sulfate content and chloride levels suggested pollution from sewage runoff. Organic debris caused water's dissolved oxygen levels to fluctuate continuously. **Khare et al. (2007)** came to the conclusion that dissolved oxygen levels in waterbodies are continuously altered by organic materials. **Smitha et al. (2007)**, high sodium levels can cause salinity issues when combined with levels of calcium and magnesium.

Jena and Adhikary (2007) examined Chlorococcales (Chlorophyceae) from several water bodies in eastern and northeastern India. They recorded 56 taxa of Chlorococcales grouped into 21 genera, such as Chlorococcum, Truebaria, Pediastrum, Hydrodictyon, Botrycoccus, Coenochloris, Radiococcus, Coenocystis, Oocystis, Glaucocystis, Chlorella, Kirchneria, Kirchnereilla, Ankistrodesmus, Coelastrum, Actinastrum, Tetrastrum, Crucigenia, Crucigeniella, Desmodesmus, and Scenedesmus and concluded that out of 56 species 16 were reported for the first time from India, and all of these species were recorded. **Bhuiyan J.R. and Gupta S., (2007)** conducted hydrobiological research on nine ponds in rural Barak Valley, Assam. They discovered that parameters like DO, Free CO2, pH, conductivity, alkalinity, nitrate, phosphate, Ca, Mg, Cu, and Zn were within the permissible level of drinking water quality. Still, iron content was found higher in most of the ponds, implying an indirect relationship between iron concentration and Euglenoids, including that these ponds could be an excellent source of water for drinking, household purposes, and fishing. **Narayan et al. (2007)** analyzed 18 water quality measures at Taxi Temple Pond in Etawah, Uttar Pradesh, including seasonal fluctuations. They reported the highest CO2 value (37.0 mg/l) during the summer, while the lowest concentration (5.5 mg/l) was measured during the monsoon season. The concentration of phosphate was likewise found to be greater in the summer and decreased in the winter. **Ganesan and Khan (2008)** investigated the physicochemical conditions and abundance of zooplankton species in a floodplain wetland in West Bengal, India. The investigation showed that the lake water was alkaline, with a pH ranging from 7.5 to 8.4. The water was somewhat hard, with nutrients present only in trace amounts. Over 70 species of zooplankton were identified, including Rotifera, Cladocera, Copepoda, and Ostracoda. Rotifers were discovered to dominate the zooplankton ecosystem in terms of species diversity.

Pradhan et al. (2008) investigated phytoplankton diversity as an indication of water quality for fish culture in East Calcutta Wetland. They suggested that plankton growth may be a major factor driving increased fish productivity. They found that some useful plankton include Chlorella, Crucigenia, Spirulina, Nitzchia, Scenedesmas, Cyclotella, Microcystis, Coelastrum, Melosira, Navicula,

Anabaena, Chlamydomonas, Tetraedron, Euglena, Endorina, Ankistrodesmus, Cosmarium, Fragilaria, Pediastrum, and Synderaw, all of which play an important role in bioremediation. **Shyamala et al. (2008)** investigated the physicochemical properties of ground water in Telungupalayam village, Coimbatore, Tamil Nadu, India. The pH, Cl, TH, Ca, and COD levels were all within the permitted range. It is found that the ground water of Telungupalayam, while suitable for residential and drinking purposes, requires treatment to reduce contaminants, particularly alkalinity. **Paulose and Maheshwari (2008)** investigated seasonal variations in the zooplankton community structure of Ramgarh Lake in Jaipur and discovered that high temperatures promote metabolic rate, which increases the speed of multiplication and thus increases the number of zooplankton in the high-temperature environment. **Sharma B.K. (2009)** examined the composition, quantity, and ecology of phytoplankton communities in Loktak Lake (Ramsar site), Manipur, India. He identified 75 phytoplankton species belonging to six categories in the lake, with Chlorophyta being the main group, Dinophyta > Bacillariophyta being sub-dominant groups, and Euglenophyta > Cyanophyta > Chrysophyta being the lowest density group. The main quantitative group, Chlorophyta, had winter maxima, with Closterium > Staurastrum > Gonatozygon > Micrasterias species contributing considerably to their abundance. **Bade B. B et al (2009)** studied the physico-chemical characteristics of the Sai reservoir, light changes have been noted during the research period. the crucial elements, such as total hardness, bicarbonate alkalinity, dissolved oxygen, and TDS. The levels of phosphate, nitrate, and chloride stay below and within the WHO recommended range. **Kumar and Verma (2009)** investigated the quantitative and qualitative data on the seasonal change of zooplankton in certain lotic systems of Jharkhand, India, based on the nutritional data index of chosen physico-chemical variables and plankton abundance. **Choudhury et al. (2009)** investigated the state of phytoplankton in Begusarai, North Bihar. They discovered that Chlorophycean taxa such as Spirogyra, Oedogonium, Closterium, Chlorella, and Cosmerium were prominent genera during the research period. Cyanophyceae populations peaked in the summer and dropped dramatically in the winter. The major species were Anabaena sp., Microcystis sp., and Oscillatoria sp. Bacillariophyceae were most prevalent in the summer and least common in the winter. The most common species were Fragilaria sp. and Navicula sp. **Laskar and Gupta (2009**) studied phytoplankton diversity, dynamics, and connections with physicochemical parameters in Chatla floodplain lake, Barak Valley, Assam. A total of 34 phytoplankton taxa were identified, including Chlorophyceae, Cyanophyceae, Bacillariophyceae, and Euglenophyceae. The highest number of species was found in pre-monsoon (29) and the lowest in winter (23). They have also conducted a correlation study between phytoplankton groups and physico-chemical parameters. The correlation study revealed a substantial positive link between total phytoplankton density, transparency ($p < 0.01$), total suspended particles, total hardness, and calcium ($p < 0.05$). Thus, it was established that phytoplankton development was influenced by clarity, total suspended particles, calcium, and total hardness. **Rout and Borah (2009)** investigated the algal diversity of the Chatla wetland in the Cachar region of Assam. They reported 39 algal species from 25 genera. Diatoms had the highest population with 23 species and 13 genera. Other algal groups, including Chlorophyceae, Cyanophyceae, and Euglenophyceae, were observed. They also looked at physical parameters including pH, DO, alkalinity, free CO2, conductivity, light, and water temperature. They discovered that algae were more abundant at higher pH levels. **Patra et al. (2010)** studied the seasonal limnology and physicochemical parameters of water in Santragachi and Joypur Jheel, West Bengal, India. The increased nutrient content (nitrate, phosphate) in Santragachi Jheel, as well as the marked seasonal fluctuations in water parameters in both Jheels, may indicate eutrophication and poor water quality.

R. S. Sawant et al. 2010 investigated physicochemical properties of Kolhapur, Maharashtra's Atyal Pond from October 2007 to September 2008. The pond has become eutrophic due to the observation that the water in Atyal Pond is rich in nutrients. Owing to a variety of activities occurring in and around the water body, the pond exhibits an elevated degree of pollution. **Bhosale et al. (2010)** studied the diversity of plankton in water bodies of Miraj district, Maharashtra, they found

significant changes in the phytoplankton population along with physico-chemical complexes. **Sawanth et al. (2010)** discovered a eutrophic, nutrient-rich pond in Kolhapur, Maharashtra, after studying the limnological parameters of the Atyal Pond**.**

Garg et al. (2010) investigated the seasonal variation in water quality of Ramsagar reservoir, MP, India, and discovered that nutrients such as silicates (0.65-8.42 mgl-1), sulphates (1.50-8.87 mgl-1), phosphates (0.013-0.054 mgl-1), nitrates (0.011-0.033 mgl-1) and potassium (1.97-4.86 mgl-1) are insufficient for the growth of aquatic organisms in the reservoir. Ramsagar Reservoir has been classified as a mesotrophic water body with a moderate inclination toward eutrophication. **Sharma and Capoor (2010)** assessed water quality at the Patna Bird Sanctuary Lake in Bihar, focusing on both biotic and abiotic components. They found that the water quality in the beel was significantly alkaline (131 - 428 mg/l) and had a higher BOD level (18 - 44.07 mg/l). The highest numbers of Rotifers and Cladocera were seen in May and June. However, the biggest concentrations of Copepods and Ostracods were recorded in December. In conclusion, they stated that the lake water was low-quality and inappropriate for consumption. **Rajagopal et al. (2010)** investigated the variety of phytoplankton in relation to physicochemical parameters and the pollution status of two perennial ponds in the Sattur district of Tamil Nadu. They discovered fifty species of Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae. In the Chinnapperkovil pond, they found high physicochemical parameters but low phytoplankton diversity, while the Nallanchettipatti pond had low physicochemical values but high phytoplankton diversity. They discovered that the class Chlorophyceae dominated both ponds in terms of quality and quantity. They found that the abundance of Closterium acerosum, C. dianae, C. lineatum, Anabaena aequalis, Oscillatoria angusta, and Navicula membranacea in the Chinnapperkovil pond, as well as Merismopedia glauca in the Nallanchettipatti ponds, served as pollution indicators. **Puri et al. (2010)** examined the interpretation of physicochemical characteristics of lake water quality in Nagpur city (India), and the findings revealed Conductivity primarily rises during summertime because of surface evaporation of water, which results in rising concentrations of salts, whereas conductivity decreases during winter due to sedimentation and mineral use by developing phytoplankton and macrophytes.

Shinde et al. (2010) in Harsul Sawangi Dam and **Pawar and Sonawane (2011)** Kanher Dam of Satara District found that magnesium hardness is maximum in summer as opposed to the yearly average of magnesium hardness due to plant deterioration. Most of the magnesium is utilized by vast vegetation in monsoon and winter. **Ahmad et al. (2011**) investigated the zooplankton diversity in relation to physicochemical variables in a sewage-fed pond in Aligarh (UP), India. The observation revealed significant levels of nutrients such as phosphate (0.435 mg/l to 1.02 mg/l), nitrate (0.106 mg/l to 0.198 mg/l), and a wide pH range (8.3 to 9.1). They discovered 20 zooplankton species divided into four groups: Cladocera (4 species), Copepoda (3 species), Rotifera (11 species), and Ostracoda (2 species). The presence of zooplankton species such as Asplanchna, Brachionus, Keratella, Fillinia, Cyclops, and Diaptomus in the water body of this investigation indicated organic pollution. **Arulmurugan et. al., (2011)** investigated freshwater algae at the University of Madras Guindy campus in Chennai and discovered 35 genera and 62 species of Chlorophyceae, Bacillariophyceae, and Cynophyceae. **Sharma et al. (2011)** conducted seasonal surveys in two yearly cycles, 2005–06 and 2006–07, in Lake Pichhola in Udaipur, Rajasthan, India, to investigate the physico-chemical characteristics, planktonic, and fish diversity. According to their research findings, the water samples had low mean values: pH 7.5, electrical conductance of 0.39 mS/cm, TDS of 237.5 mg/l, chloride of 176 mg/l, hardness of 174.33 mg/l, alkalinity of 207.16 mg/l, dissolved oxygen of less than 5.75 mg/l, and levels of nitrate and phosphate at 3.70 mg/l and 2.79 mg/l, respectively. With 15 different species of fish, 58 different kinds of phytoplankton, and 104 varieties of zooplankton, they recorded a high rate of primary production of 302.08 mgc/m/hr. **Bhat et al. (2011)** studied Lake Pangong, which is located in eastern Ladakh at an elevation of 4,266 m and is frozen for about three months during the winter. The study's findings indicate that the lake's biodiversity is reduced by excessive salinity and unfavorable environmental factors.

Joshi (2011) conducted a study on the zooplanktons in the Dhanora (Hattipaul) Lake in the Buldhana region of Maharashtra. The study identified four primary types of zooplankton, including 20 genera: Ostracoda, Copepod, Cladocera, and Rotifera. The monsoon season is thought to have the lowest density of zooplankton, which might be caused by the dilution effect, high turbidity, and reduced primary producer photosynthetic activity. The winter season was when Rotifera was at its densest, while Ostracoda did not exhibit any notable seasonal variations. **Kumar and Oommen (2011)** studied the phytoplankton composition in connection to the hydrochemical characteristics of a tropical community wetland in Kanewal, Gujarat, India. As a result, 45 species of Cyanophyceae, Chlorophyceae, and Bacillariophyceae were identified. They discovered that sulfate and nitrate correlated positively with phosphate, whereas dissolved oxygen correlated negatively with phosphate, sulphate, and nitrate. Bacillariophyceae species were found to be the most common in comparison to others, indicating that the wetland was largely unpolluted.

Joshi Prasanna 2011, researcher conducted qualitative and quantitative investigations from February 2010 to January 2011 on zooplanktons in Rajura Lake, Buldhana district. This work used microscopic taxonomical investigations of zooplankton to demonstrate the presence of 20 genera belonging to four major groups: Rotifera (five genera), Cladocera (six genera), Copepoda (six genera), and Ostracoda (three genera). **Pareek et al. (2011)** researched various freshwater diatoms in Galta kund, Jaipur, India. They identified 24 diatom species from eleven genera, including Cyclotella (2), Melosira (2), Navicula (4), Achnanthes (2), Amphora (1), Synedra (2), Nitzschia (5), Gomphonema (3), Hantzschia (1), Pinnularia (1), and Fragillaria (1), and proposed that diatoms grow at their peak in the winter and gradually decline in the summer, reaching their lowest point during the rainy season. The zooplankton diversity of Pune's Nira left bank canal in Shardanagar Tal Baramati District was assessed by **Ghantaloo et al. (2011)** using physicochemical parameters. Additionally, they examined Physicochemical parameters such as pH, dissolved oxygen, water temperature, air temperature, and minimum Summertime had the highest levels of dissolved oxygen, which peaked during the monsoon. Ten Rotifer species, eight Cladocera species, five Copepoda species, and two Ostracoda species were among the twenty-five species that have been documented. **Abujam et al. (2011)** investigated the plankton diversity of an oxbow lake in the Dibrugarh area of Assam. They identified 31 phytoplankton species and 61 zooplankton species, with Chlorophyceae being the most dominant class in phytoplankton (54.84%), followed by Cyanophyceae (25.81%) and Bacillariophyceae (19.35%), and Rotifera accounting for 75.41 percent, Copepoda (11.48%), and Cladocera (13.11%). Their observations revealed that the seasonal abundance of plankton populations was related to certain lake physicochemical factors.

Harkal et al. (2011) conducted research on micro invertebrates and littoral macrophytes in Aurangabad's Kagzipura Lake. The report included 28 species of micro invertebrates from five groups: Protozoa, Rotifera, Copepoda, Cladocera, and Ostracoda, as well as sponges, bryozoa, nematodes, and insect larvae. Protozoa colonies such as Stentor and Verticella were found on the edges of dissected macrophyte leaves, whereas rotifera colonies were found on macrophyte branching regions, and they concluded that the study will be useful in understanding the true picture of community structure in limnetic ecosystems. **Yasmin et al. (2011)** studied the planktonic desmid flora of the South of the Eastern Himalayas and recorded a total of 38 taxa of desmids, including the genera Closterium (8), Cosmarium (10), Euastrum (5), Micrasterias (5), Netrium (1), Tortitaenia (2), Gonatozygon (2), Pleurotaenium (5), and Staurastrum (5), which were new records from the South of the Eastern Himalayas. They determined that the presence of Closterium and Cosmarium indicated the water bodies' oligotrophic character.

Thirupathaiah et al. (2012) investigated the physical and chemical properties of Lower Manair Reservoir in Karimnagar District, Andhra Pradesh. The criteria were confirmed to be within permitted levels and suitable for residential, irrigation, and pisciculture usage after monthly monitoring. **Koli and Muley (2012)** investigated zooplankton diversity and seasonal

variation in the Tulshi reservoir of Kolhapur district (MS), India, and discovered 39 species of zooplanktons, including fifteen Rotifer species, twelve Copepod species, ten Cladocera species, and two Ostracoda species, as well as seasonal variations in the reservoir. They found that the zooplankton population had a positive significant correlation with physicochemical parameters such as temperature, alkalinity, phosphate, hardness, and BOD, but a negative correlation with rainfall and salinity. **Shah and Pandit (2012)** measured a number of limnological parameters for Wular Lake in Kashmir; their research shows that the lake is eutrophic, with high records of the physico-chemical characteristics of the water. A range of values is found for the transparency: 0.2 to 2.2 m; pH: 7.8 to 8.8; dissolved oxygen: 3.4 to 11.5 mg/L; total alkalinity: 47 to 257 mg/L; free CO_2: 8 to 28 mg/L; ammonical nitrogen: 49 to 542 µg/L; total phosphate: 102 to 297 µg/L; orthophosphate: 13.0 to 36 µg/L; and nitrate nitrogen: 146 to 483 ´Hg/L.

Rafiullah M. Khan et al. (2012) studied physico-chemical parameter to understand the water Triveni Lake of Amravati district. He conducted an analysis of the following parameters: air temperature, pH, humidity, conductivity, free CO2, total solid, dissolved oxygen, total alkalinity, total hardness, caco3, ca++, and mg++. He found that most of the parameters were within the normal range, indicating higher-quality lake water. Several of the physicochemical parameters showed significant seasonal variation.

Raina et al. (2013) Studied limnology of the Samrat Ashok Sagar reservoir in Madhya Pradesh, with a focus on zooplankton diversity and physicochemical parameter. They observed that temperature has a beneficial influence on the development of the zooplankton population. Temperature has been identified as one of the key variables contributing to the number of zooplankton in freshwaters, particularly in shallow waterways where the bottom temperature varies significantly, especially as the warm season progresses. Their examination of the reservoir's physicochemical features indicated its alkaline nature. **Chalotra Priyanka et al. (2013)** identified four species of pond scum, Zyghemopsis Skuja, from several water bodies in Jammu & Kashmir. The species were taxonomically classified based on vegetative and reproductive structure. **Khanna et al. (2013)** studied the fish diversity and limnological quality of the Ganga River system in Uttarakhand's Garhwal Himalaya foothills. They reported 53 species from 11 fish families. Temperature, velocity, turbidity, conductivity, total dissolved solids, pH, alkalinity, free CO2, DO, BOD, chlorides, calcium, and magnesium were all measured. They determined that fish in the numerous rivers of the Ganga River system in Garhwal Himalaya are completely dependent on physicochemical conditions. Although all of the criteria were determined to be favorable for fish survival, increases in turbidity during the monsoon season resulted in an increase in the number of fish mortality. **Jagadeeshappa and Kumara (2013)** investigated the impact of physicochemical factors on plankton species diversity in the wetlands of Tiptur Taluk, Tumkur District, Karnataka, India. They investigated water quality metrics such as temperature, pH, EC, DO, BOD, COD, free carbon dioxide, total alkalinity, total hardness, calcium and magnesium hardness, chloride, phosphate, sulphate, and nitrate, as well as the wetland's planktonic composition. The increased concentration in physicochemical parameters and plankton diversity was greater in the pre-monsoon than in the post-monsoon and monsoon seasons, indicating that the physicochemical parameters of the water fluctuated, possibly due to the entry of rain water and changes in temperature and salinity as the season changed.

At Bhimtal, (Nainital), Uttarakhand, **Bisht et al. (2013)** investigated the limnological characteristics of three distinct water bodies in the winter. Their research with earthen ponds, cemented ponds, and lakes suggested that the parameters, which range from 12 to 17.5 °C in temperature, pH 6.5 to 8.8, DO 5.7 to 8.0 mg/L, Alkalinity 38 to 63 mg/L, ammonia 0.01 to 0.23 mg/L, Nitrite 0.02 to 0.15 mg/L, free CO_2 0.36 to 2.7 mg/L, nitrates 0.4 to 4.3 mg/L, phosphate 0.36 to 2.38 mg/L, silicate 0.4 to 158 mg/L, TH 31 to 46 mg/L, and total nitrogen 1.0 to 2.2 mg/L, respectively. In Dal Lake Srinagar, **Mushatq et al. (2013)** observed 21 physical and chemical properties of surface water on a monthly basis from June 2010 to April 2011 at six distinct sites dispersed throughout four lake basins. The degradation of potability brought about by human movements and urbanization was highlighted by their research findings. **Jose John et al. (2013)** found 19 new

Chlorophyceae taxa in the Indian subcontinent's Idukki District, Kerala. **Mishra et al. (2013)** evaluated the physicochemical properties of Bhamka Pond in Hanumana, Rewa District, MP (India). Temperature, pH, dissolved oxygen, nitrate, phosphate, biological oxygen demand, chemical oxygen demand, and total alkalinity were all evaluated monthly. They noted that the pond water was in the extremely hard range. **Sarma et al. (2013)** investigated the ecology of two riverine wetlands in Goalpara district: Urpod beel and Hasila beel. They examined the physicochemical characteristics and plankton diversity of the beels and discovered that both were dominated by Chlorophyceae. They discovered that the phytoplankton population of the Urpod beel accounted for 58.82% to 65.52% of the total plankton, whereas the zooplankton community accounted for 34.48% to 41.18%. **Bera et al. (2014)** researched the physicochemical properties of the water at Kangsabati reservoir, West Bengal, India. They found that the physicochemical parameters were in the desired, permitted, and acceptable ranges indicated by WHO, FAO, BIS, NRAC, SRAC, and ICAR guidelines. They had also conducted statistical analysis, determining correlation coefficients between various factors. They discovered a substantial positive association between air and water temperature, dissolved oxygen, and transparency; hardness with calcium, magnesium, and phosphate; salinity and chloride; free CO2; and conductivity. A significantly negative association was discovered between water temperature, dissolved oxygen, and phosphate; total inorganic nitrogen, PH; and phosphate and transparency.

Pradhan et al. (2014) used planktons to investigate the state of Cuttack's major Eastern belt river, the Mahanadi. It is determined that water quality indicators such as pH, dissolved oxygen, carbon dioxide, total hardness, phosphate, and orthophosphate are the primary contributing variables. They identified Rotifera as the main group in zooplankton and Bacillariophyta in phytoplankton. **Sayeswara (2014)** investigated the variety of phytoplankton species in Chikkamalappanakere Tank, Shivamogga, Karnataka, India, and discovered 45 species of phytoplankton representing five taxonomic groups: Chlorophyceae, Cyanophyceae, Euglenophyceae, Bacillariophyceae, and Desmids. The percentage of phytoplankton in the Chikkamalappanakere tank was found to be highest among Cyanophyceae (31.1%), followed by Bacillariophyceae (24.4%), Chlorophyceae (20%), Euglenophyceae (13.3%), and Desmids (11.1%). The presence of Scenedesmus quadricauda and Merismopedia glauca was the most prevalent pollution indicator observed in tank water. **Bhanja et al. (2014)** explored the plankton community in two unmanaged ponds in West Bengal, India, and identified 14 zooplankton species (Copepoda 5, Cladocera 3, and Ostracoda 1) and 15 phytoplankton taxa (Chlorophyceae six, Cyanophyceae five Bacillariophyceae three and Euglenophyceae one). He determined that the presence of rotifers such as Keratella and Brachionus indicated the pond's eutrophic state. **Bini Das and Bindi (2014)** investigated soil samples from Jaisamand Lake (Rajasthan). Their research revealed that the soil pH ranges from 8.25 to 9.00, whereas the ideal pH is between 7.5 and 7.8. This suggests that the soil of Jaisamand Lake is slightly alkaline, causing salts to rise to the surface as a result of excessive water evaporation in dry areas. Water quality data from a lake is disclosed by **Inaotombi and Gupta (2014)**, who find that the water quality is below the acceptable level for human consumption based on a number of indicators. For the purpose of producing fish by artificial culture, it can thus be utilized. **Mahajan and Billore's (2014)** investigation, which took place between July 2008 and June 2010 of Nagchoon pond of Khandwa District, water bodies are starting to eutrophicate because physico-chemical parameters including phosphate, nitrate, and chloride are beyond the permissible limit. **Kumari et al. (2014)** conducted a thorough investigation of two dams near the Narmada River regarding a variety of limnological data. According to their investigation, 45 taxa of phytoplankton were found, of which 21 belonged to the Chlorophyceae family, 14 to the Bacillariophyceae family, and 10 to the Cyanophyceae family.

Manickam et al. (2014) identified 55 species of zooplankton from the Perennial Reservoir in Thoppaiyar, Dharmapuri district, South India, including 19 Rotifera, 13 Cladocera, 15 Copepoda, and 8 Ostracoda. Rotifera were the most abundant zooplankton, followed by Copepoda, Cladocera, and Ostracodas. **Sharma B.K. and Sharma S. 2014**

conducted research on the planktonic rotifers found in Northeast India's floodplain lakes, which included 15 floodplain lakes in Manipur and 30 in Assam. They discovered 238 species belonging to 50 genera and 23 families. They found that Assam has the largest zooplankton diversity of any state in India (>50.0% of all Indian species).

According to research by **Sharma J. N. et al. (2015)**, the amount of organic and inorganic pollutants in Dal Lake (Kashmir) is likely to cause eutrophication because it's resuming macrophytic growth, lowering biological oxygen demand (BOD), and degrading water quality. In the Bhoj wetland, a Ramsar site in Bhopal, India, **Bhat et al. (2015)** investigated the water quality and phytoplankton group. They discovered that the dominant group was Chlorophyceae, followed by Bacillariophyceae, Cyanophyceae, and Euglenophyceae, with Pyrophyceae and Chrysophyceae being the least abundant. They added that the higher concentration of nutrients (phosphorus and nitrogen) and higher abundance of Closterium, Pediastrum, Scenedesmus, Navicula, Anabaena, Microcystis, and Phacus during the dry and wet periods were likely due to higher levels of organic pollution in the Bhoj wetland.

Watkar and Barbate (2015) analyzed all the limnological parameters of Chandrabhaga River in Kalmeshwar, Maharashtra. They found that, with the exception of a few minor variations, the parameters were within a tolerable range. The river is suitable for irrigation and fishing, but appropriate precautions must be taken to maintain its potability and prevent water contamination. **More and Ramaiah (2015**) estimated Physico-Chemical Properties of the Water from Shivan Dam, Nandurbar Dist, Maharashtra and observed monthly variation of water quality and concluded the parameters are within range of WHO standards. **Kamble (2015)** investigated the impact of ecological and environmental factors on aquatic algal forms, namely Chlorophyceae algal forms, in the Nirguda river at Wani in the Yavatmal region of Maharashtra. He observed abundance in chlorophyceae over the summer and concluded that low nitrate concentrations affect desmids. He also discovered that temperature and nutrients in the water had an impact on algae growth. **Murulidhar and Murthy (2015)** examined the seasonal dynamics of phytoplankton and physicochemical characteristics in Gulur wetland, Karnataka, India. They identified 66 phytoplankton species from 37 genera across 5 classes. The phytoplankton classes demonstrated the following order of dominance: Diatoms (41.67%) are followed by blue-green algae (27.78%), Chloroccales (13.89%), and euglenoids and desmids (8.33%). Physicochemical factors had a substantial positive association with phytoplankton groupings.

Mankar and Bobdey (2015) investigated Sonala Dam's physicochemical characteristics, such as temperature, conductivity, pH, total dissolved solids (TDS), dissolved oxygen, nitrate, and phosphate. Phosphate (0.3220 mg/l), DO (10.37 mg/l), TDS (561.24 mg/l), pH 7.66, conductivity (627.58 mg/l), and temperature were all observed at 31.07. As a consequence, he came to the conclusion that the Sonala Dam's water reservoir is not very contaminated on average. In a study conducted by **Patil S.V. et al. (2015)**, the water quality and algal growth of Venna Lake in Mahabaleshwar were examined. Monthly assessments of the lake's physicochemical and biological characteristics, including temperature, pH, total alkalinity, dissolved oxygen, free CO_2, total hardness, phosphate, silica, and algal biodiversity, were made between October 2013 and September 2014. The data from this investigation have demonstrated the relationship between the physicochemical characteristics and algae in the area. Certain bloom-forming algae, such as Microcystis, were only found during the summer, whereas Euglenoids were more prevalent during the winter. Members of the Chlorophyceae family including Pediastrum, Scenedesmus, and Staurastrum, exhibited steady occurrence throughout the year. **Mishra S. et al. (2015)** examined the water quality of Surha Lake Uttar Pradesh. Based on physiochemical parameters, the study discovered that the average CPI (comprehensive pollution index) was 0.98, 1.11, and 1.16 in 2006, 2007, and 2008, while the NSFWQI (National Sanitation Foundation Water Quality Index) was 47.25, 49, and 49.88. The findings show that water quality is degraded and has steadily increased from modest to moderate over 2006-08, owing to increased input of household garbage and agricultural runoff from lake catchments.

As a result, the lake water is unsuitable for drinking, bathing, and other life-sustaining activities.

Deshmukh B. S. (2015) investigated the physical and chemical characteristics of the Pravara River, a tributary of the Godavari River in Maharashtra. The parameters tested were water temperature, pH, free CO2, dissolved oxygen, BOD, TDS, total hardness, chlorides, phosphate, sulphate, nitrate, calcium, and magnesium, and it was discovered that the pH of water is somewhat alkaline in nature (6.49 - 7.87). The highest concentration of TDS was found throughout the summer, and it decreased during the wet season. DO had a substantial negative connection with temperature. The broad range of CO2 concentrations, as well as increasing nitrate, phosphate, and chloride concentrations, were caused by increased sewage pollution in the river basin. The lowest nitrate levels were reported throughout the summer, most likely owing to high phytoplankton development. **Barman et al. (2015)** investigated the seasonal fluctuation of physicochemical properties of wetlands in West Garo Hill, Meghalaya. To measure the quality of water, 11 physicochemical characteristics of wetlands were recorded across many seasons. The parameters were water temperature, pH, EC, DO, BOD, COD, TSS, TDS, TH, NO3, and PO4. The water indicated a minor alkalinity. DO was confirmed to be normal, as indicated by WHO. COD and TSS levels above the allowable limit. The BOD level was slightly higher than the allowed limit, indicating that while the water in wetlands was not now contaminated, it will be polluted in the future. It might be due to the addition of sewage or other agricultural leftovers. The current state of wetlands is below the level of contamination. The phytoplankton abundance and species diversity in Ranjit Sagar wetland, Punjab was studied by **Brraich and Saini (2015)** and revealed that Bacillariophyceae constituted (12 genera) the dominant group, whereas Chlorophyceae (11 genera) and Cyanophyceae (3 genera) formed sub dominant groups besides the phytoplankton and observed that Cyanophyceae appeared with least number of species throughout the year, but they show their maximum abundance during monsoon and summer seasons. They concluded that low temperature and reduced photoperiod during winter season may be responsible for their minimum appearance in this period.

Kulkarni and Mukadam (2015) reported that zooplankton species like Acrocalanus species, Eucalanus pileatus, Lucicatia flavicornis, Mesocyclops species and Pontellina plumata were dominated in the estuarine region of Ratnagiri, Maharashtra. **Brraich and Kaur (2015)** investigated the communities of phytoplankton structure and species diversity in the Nangal wetland in Punjab, India. They found 49 genera belonging to three major classes: Chlorophyceae (21 genera), Bacillariophyceae (19 genera), and Cyanophyceae (13 genera). The finding of the highest numerical abundance in summer and the lowest during the winter suggested that a substantial phytoplankton population was present in the Nangal wetland, which increased the wetland's productivity.

Deshmukh (2016) studied hydrobiological parameters of Godavari River near Paithan stated that sewage, household and agricultural waste, and the use of both organic and inorganic fertilizers may be the cause of eutrophication and physicochemical characteristics are also significant in the distribution of phytoplankton. **Kar & Kar (2016)** explored the zooplankton diversity of Madhura anua, an oxbow lake in Cachar, district Assam, and discovered a wide variety of zooplankton in the lake. Three primary groups of zooplankton were identified: Cladocera, Copepoda, and Rotifera. A total of 37 taxa were recorded, with 20 from Rotifera, 13 from Cladocera, and 4 from Copepoda. Rotifera has a greater abundance percentage (58%) in the wetland, according to a quantitative examination of zooplankton. The increased prevalence of Rotifera indicates pollution, which will cause to eutrophication in the near future.

Tayade (2016) carried out hydrobiological study on Gomai river of Nandurbar district of Maharashtra and found that during the study period, the soluble salts sodium, potassium, calcium, magnesium, and chlorine were reported to dissolve sparsely. From July 2011 to December 2011, there was an increase in the density and biodiversity of algal forms, with greens, blue greens, and diatoms dominating the landscape until the conclusion of the post-monsoon period. The dominant blue-green organisms were Microcystis, Oscillatoria, Nostoc, and Anabaena. Green species included Spirogyra, Zygnema Oedogonium, and prominent species throughout the study period were Synedra,

Ulva, Navicula, and Pinnularia. Chlorophyceae and Cyanophyceae make up the majority of the algal flora. Different species of Cyanophyceae become common when water flow slows and becomes stagnant, owing to the eutrophic influence of some blue green algae, whereas species of Chlorophyceae were abundant during the early monsoon. **Pavan et al. (2016)** explored the zooplankton diversity in Lake Bhandam, Warangal, TS, and India, identifying four primary types of zooplankton: 12 species of Rotifers, 6 species of Copepods, 7 species of Cladoceran, and 4 species of Ostracodes. The prominent species, such as Brachinous sp, Keratella tropica, and Mesocyclops leuckarti, clearly demonstrated that the lake waters were nutrient-rich and hence eutrophicated.

Devi M. B. et al. (2016) conducted an ecological study on the phytoplankton population of Lake Baskandi anua, Cachar District, Assam. They evaluated phytoplankton chlorophyll concentration, biomass, and the lake water's physicochemical characteristics. They found that 41 genera of phytoplankton were classified into five groups: Chlorophyceae, Cyanobacteria, Bacillariophyceae, Euglenophyceae, and Dinophyceae. Chlorophyceae were most abundant in the winter, Cyanobacteria and Euglena in the monsoon, and Bacillariophyceae in the pre-monsoon season. Their ANOVA study found considerable seasonal changes in water's physicochemical characteristics such as temperature, pH, conductivity, dissolved oxygen, free CO2, total alkalinity, calcium, chloride, nitrate, and ammonia. The study utilized the Canonical Correspondence Analysis (CCA) approach to investigate the correlation between phytoplankton groups and environmental factors. They also stated that the lake was covered in Hydrilla and other macrophytes such as Eichhornia, Trapa, Alternanthera, Polygonum, and Ludwizia sp. They found that Lake Baskandi Anua was eutrophic**.**

Sharma and Singh (2016) monitored the physico-chemical characteristics of the water from August 2014 to May 2015, in Pani Ki Dharamsala (Jhasi). February was the lowest for pH, salinity, temperature, and EC, and August was the highest; nevertheless, may has an inclination in turbidity, TDS, alkalinity, and hardness. Different seasonal variations are seen for DO and BOD; DO reaches its minimum in May and reaches its maximum in February, whereas BOD reaches its maximum in May and minimum in August.

Sharma I. et al. (2017) looked at the limnological properties of lentic water bodies in the Mid-Himalayan region. They came to the conclusion that there are seasonal fluctuations in the water's temperature, alkalinity, dissolved oxygen content, pH, transparency, free carbon dioxide, total dissolved solid content, total hardness, and nitrate. In order to increase fish production in water bodies, small-scale aquaculture techniques can be employed. The correlation findings of many physico-chemical parameters showed that allowable limits were discovered in pH, free CO_2, dissolved oxygen, and nitrate. **Deepika and Singh (2017)** studied the physico-chemical characteristics and water quality of Lake Bhalswa. Their findings suggest that the lake's water is suitable for recreational purposes because it has been contaminated in accordance with Central Pollution Control Board (CPCB) standards. Water samples reveal a high concentration of organic matter, algal growth, slightly elevated pH, and BOD. Because of the excess concentration of phosphorous and total nitrogen, which increases the lake's productivity and is reflected in the abundance of floating algae, Bhalswa Lake has a threshold level of eutrophication and a nutrient-enriched lentic environment for water quality.

Shah et al. (2017), stated that human activities in the Horesker Wetland in the Jammu and Kashmir area are causing the water quality to decline and eutrophication. They also concluded that it is challenging to estimate the quantitative impact of wetland restoration with instances of high flow as nutrient removal varies greatly and between wetlands. **Kengar and Bansode (2017)** examined the physicochemical parameters of the Hingangaon water reservoir, situated in Kadegaon Tahsil in the Sangli district of Maharashtra. They did this by measuring a number of significant parameters over the course of a year, from July 2015 to June 2016, including air temperature, water temperature, transparency, pH, dissolved oxygen, total alkalinity, total hardness, chlorides, sulphates, and total dissolved solids. All parameters were determined to be within allowable limits in the current investigation. This indicates that the reservoir is suitable for residential use, fish farming, and agriculture and is not

contaminated. **Patil C.V. et al. (2017)** investigated the Tapi River's physiochemical and Cyanophyceaen algal flora, which was taken from various Prakasha Barrage depths. Physical and chemical parameters that were measured were pH, water, temperature, BOD, COD, DO, TDS, Ca, Mg, Al, Na, K, NO3, PO4, SO4, and Cl. The results demonstrated that all parameters are within allowable limits and that the majority of dominating species include Spirulina, Oscillatoria, Phormidium, Lyngbya, Nostoc, and Anabaena. According to the findings, the water is clean.

Amaraneni et al. (2018) studied the geographical 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, the vehicle, farming, and aquaculture practices disrespect the environment of Kolleru Lake. 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. **Vajravelu et al. (2018)** explored the seasonal effects of physiochemical factors on phytoplankton. According to their observations, plankton are more abundant in the pre-monsoon period than during the monsoon. The number of Coscindiscophyceae and Bacillariophyceae is enormous. The CCA results revealed that temperature, salinity, silicate, dissolved oxygen, and inorganic phosphate all had a substantial effect on phytoplankton abundance. **Kumari and Sharma (2018)** studied limnological factors at Prashar Lake in Himachal Pradesh during the five seasons of winter (November–February), spring (March–April), summer (May–June), monsoon (July–August), and autumn (September–October). These variables included water temperature, pH, conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen, Hardness, Chloride, Nitrate, and Phosphate. Their research findings indicate that the winter season has the highest DO and pH levels, while the summer season has the highest TDS and BOD levels, and the monsoon season has the highest conductivity, nitrates, and phosphorus levels. **Durge et al. (2018)** studied the limnological parameters in Ghugus town (Chandrapur), Maharashtra of a pond. The parameters were collected monthly and represented seasonally with standard deviation. The parameters included humidity, atmospheric and water temperature, pH, electrical conductivity, total dissolved solids, dissolved oxygen, biochemical oxygen demand, total alkalinity, bicarbonate alkalinity, total hardness, calcium hardness, chloride, nitrate-nitrogen, and phosphate. The study's findings show that the pond's water quality is below the eutrophication threshold.

According to research by **Basu et al. (2018),** unplanned settlements caused a substantial amount of organic matter to be deposited into Motijheel Lake, an important body of water in the Murshidabad area both ecologically and economically. As a result of cultural eutrophication, the aquatic environment is undergoing permanent structural changes, and inhabitants who drink tainted lake water may face health risks. These effects are now being shown by the waterbody. **Gothwal and Gupta (2018)** carried out a summertime limnological investigation at Mount Abu's Nakki Lake. The study's findings indicate that the water is rather alkaline, with a pH of 7.08 and an alkalinity of 102.16 mg/L. Additionally, the mean values of other limnological parameters, such as TDS (161.83 mg/L), hardness (95.66 mg/L), and chloride (109.73 mg/L), were low. Whereas the average levels of nitrate and sulphate were 31.19 mg/L and 123.73 mg/L, respectively, the average amounts of dissolved oxygen were 5.75 mg/L. The water quality measurements indicate that Nakki Lake has a high potential for eutrophication.

Rupendra Bhagde et al (2019) studied physicochemical characteristics, they discovered that acidity ranged from 13 mg/l to 48 mg/L. The range of 166 mg/L to 506 mg/L was shown to be the alkalinity. The range of dissolved carbon dioxide was determined to be 11.44 mg/L to 22 mg/L. It was discovered that the dissolved oxygen ranged from 2.03 mg/L to 7.64 mg/L. It was discovered that the pH ranged from 7 to 9.5. The range of electrical conductivity was determined to be 0.17 to 0.61 mS. Between 100 and 310 ppm of TDS was discovered. **Gogoi P. et al. (2019)** explored the seasonal effects of physiochemical factors on phytoplankton and integration patterns in Khilash

Khul, Sunderbans, India. They detected 36 phytoplankton taxa and a large number of species abundance in the pre-monsoon period, followed by the monsoon and monsoon. **Meshram et al. (2019)** conducted study on the physicochemical characteristics and plankton biodiversity of the Purna River water environment. Results indicated that the levels of conductivity, pH, total dissolved solids, and dissolved oxygen in water are all within reasonable bounds. Natural alkalinity was present in the river water. The saline stretch of the river watershed was considered to have higher levels of electrical conductivity, total dissolved solids, chloride, sodium, and potassium. Nitrate, fluoride, and hardness were all determined to be within the acceptable ranges according to Indian norms. According to the chemical and biochemical oxygen demand estimates, the catchment area's pollution was to blame. River water turbidity and water currents were blamed for the modest density of phytoplankton and zooplankton. **Shah et al. (2019**) observed, there has been an increase in limnological parameters in the Hokersar wetland in Jammu and Kashmir, primarily for dissolved oxygen, nitrogen, and phosphorus. Their research viewpoint demonstrates that the natural discharge of agricultural and household wastewater leads to wetland contamination and cultural eutrophication, both of which negatively impact the aquatic environment.

Ishtiyaq and Abdul (2020) discovered that an increase in nutrient and sediment loads from its catchment region degrades water quality in Dal Lake due to unprecedented land use/land cover (LULC) changes. LULC change research across five time periods revealed that the dominating land cover in the forest class was 135.72 km2 in 1980, 131.84 km2 in 1992, 126.83 km2 in 2000, 120.63 km2 in 2010, and 118.30 km2 in 2018. Aquatic vegetation expanded by 180.65% within the lake, from 2.03 km2 in 1980 to 5.70 km2 in 2018, whereas agricultural land decreased by 30.02%, from 34.44 km2 in 1980 to 24.10 km2 in 2018. **Venkatesh et al. (2020)** examined the limnological parameters of the Kanigiri reservoir in Nellore District, Andhra Pradesh. The investigation revealed It is alkaliphilic (pH: 7.70 to 8.45), a medium to high productive reservoir (TDS: 131.5 to 227.5 mg/L), experiences moderate domestic pollution with chlorides (70-129 mg/L), and may enhance fish growth and survival (D.O: 4.6 to 8.35 mg/L, CO2: 0 to 6 mg/L, total ammonia: 0.02 to 0.21 mg/L). **Sirsat and Kamble (2020)** investigated the Bendsura River's physiochemical characteristics. TDS (795-800 mg/l), chloride (275-284 mg/l), and alkalinity (167-179 mg/l), according to his observations, show that the water is unfit for drinking, residential use, or agricultural use. **Hazarika et al. (2020)** conducted a limnological examination of the plankton and fish of Tasek Lake in East Garo Hills, Meghalaya (India). The limnological examination found that the abundance of plankton population ranged between 1027 u/L in May and 5377 u/L in January. During the study period, 43 fish species from eight orders and twelve families were discovered. **Tijare and Kunghadkar (2020)** studied limnological parameters of Kunghadabandh Lake and Chamorshi Lake, Dist.-Gadchiroli (MS). The study revealed Kunghadabandh Lake minimum average of Free CO2 (5.04±0.22) was recorded in winter and maximum average of free CO2 (6.12±0.31) in summer as compared to the annual average of free CO2 (5.58±0.52) this is due to less temperature in winter as if water is too warm (summer), there may be high free CO2 in it. The free CO2 was mostly declines in winter and increases in summer. **Kate et al. 2020** analyzed the water quality in fourteen distinct wards in Urun-Islampur City of Maharashtra, using three water samples per ward. The parameters they analyzed were pH, conductivity (µMho/cm), TDS (ppm), residual chlorine (mg/L), chloride (mg/L), and hardness (mg/L). Permittable levels of water quality within the range of 80 to 90 in the Water Quality Index (WQI) under the test from all fourteen wards are indicated by the findings of physico-chemical analysis by the World Health Organization (WHO) standard. **Gorghate et al.2020** studied the Gondia district's Chichtola Lake through a comparative examination of seasonal change, he discovered that the lake is not heavily contaminated by human and animal interference, religious rites, or any other anthropogenic activity. The lake's overall physico-chemical parameters indicate high-quality water. Both are benefited by biodiversity. **Verma and Prakash (2020)** investigated the physicochemical properties of water at Semara Taal, District Siddharthnagar. The researchers noted that water temperature ranges from 12.8-35.4°C, transparency ranges from 28.6-38.8 cm, dissolved oxygen ranges

from 6.1-9.4 ppm, free carbon dioxide ranges from 15.0-28.0 ppm, pH ranges from 7.1-9.8, total alkalinity ranges between 137.0 and 296.0 ppm, total solids range between 34 and 116 ppm, nitrate ranges between 1.08 and 1.41 ppm, and phosphate ranges from 1.02-1.08 ppm. A total of 25 phytoplankton species and 24 zooplankton species were identified. The seasonal fluctuation of plankton was bimodal, with a primary high in July and a secondary peak in January.

Verma (2020) investigated phytoplankton in the Muntjibpur pond in Prayagraj, Uttar Pradesh. The study identified 16 phytoplankton species. Six of them are in the Chlorophyceae (Coelastrum, Scenedesmus, Colosterum, Crucigenia, Ulothrix, and Chlorella); five are in the Bacillariophyceae (Synedra, Navicula, Cymbella, Pinnularia, and Asterionella); four are in the Cyanophyceae (Anabaena, Spirulina, Cloecapsa, and Oscillatoria); and one is in the Euglenophyceae (Euglena). Cyanophyceae dominated the yearly phytoplankton cycle, accounting for 37.41% of total phytoplankton, followed by Chlorophyceae (31.91%), Bacillariophyceae (26.60%), and Euglenophyceae (4.08%).

Tambe and Tapale (2020) examined the relationship between algal diversity of Ambit Dam. 81 algal species from three locations of the Ambit dam, spanning 24 families and 13 orders and 53 genera, were discovered during the investigation. The greatest number of algae, namely Chlorophyceae, were discovered to be present from December to April and to a lesser level in May.

Bhagde et al. (2020) studied Two water ponds from the Sangamner taluka were determine the seasonal fluctuations in temperature, free carbon dioxide, dissolved oxygen, alkalinity, hardness, and pH. The results showed that the ranges for alkalinity (140 mg/L to 330 mg/L), hardness (41 mg/L to 130 mg/L), free carbon dioxide (33.8 mg/L to 50.0 mg/L), and dissolved oxygen (3.6 mg/L to 7.9 mg/L) were recorded. Upon examination of all the factors, he concluded Nimon Pond ecological state is worse than Nizerneshwar Pond**. Kumar Sarvesh 2020** studied the hydrobiology of the Burhi Gandak River. The majority of the indicators showed considerable seasonal fluctuations, and the water was determined to be hard, contaminated, and unsuitable for household, agricultural, or fish growth. He also observed the algal groups Bacillariophyceae, Cyanophyceae and Chlorophyceae, in which Bacillariophyceae and Cyanophyceae were abundant.

Gangwar and Bhadauriya (2020) analysed physiochemical parameters of river Deorania all three seasons; the study revealed all parameters temperature, colour, TSS, transparency, pH, DO, free CO2, COD, BOD, TDS, and salinity are beyond the permissible limit high alkalinity river water, it is not suitable for agriculture The highest values in winter may be attributed to increase industrial discharge from industries. Chemical oxygen demand (COD ranged 11.0 to 90.5) was observed much higher than biological oxygen demand (BOD ranged 2.9 to 18.5) indicates that most of the pollution in Deorania, in the study zone, is caused by presence of non-biodegradable organic and inorganic compounds in the river.

Tijare and Kunghadkar (2021) examined 20 physicochemical characteristics of water and discovered seasonal variations. The findings indicated that the majority of chemical parameters had higher concentrations in the summer, which had a negative impact on the population of most faunal components.

Brraich et al. (2021) Study on water quality characteristics of the Harike Wetland Punjab's many water quality metrics include: water temperature, pH, alkalinity, dissolved oxygen, total dissolved solids, nitrates, and phosphates. The study found that the overall water quality of Harike wetland is "poor" due to human activities and pollution load (industrial effluents), which impair its quality and quantity. The water quality rating is 53.56, which is considered poor by the WQI. **Krishnamoorthyet et al. 2021** examined the water quality of Tiruvanai Kaval: Brahma theertham, Srirangam temple pond, and Cauvery River. The study found that the water quality index values of Thiruvanai Kaval: Brahma theertham were slightly better (25-49) than Srirangan temple pond, which had a water quality index of (50-69).

More R. R. (2022) conducted research on the eutrophication state and its consequences, concluding that urban, industrial, and agricultural activity inside the water bodies are the primary causes of water pollution. This hastened the growth of phytoplankton

(algal blooms) due to eutrophication. Particular attention should be taken when specific algae species, such as Chlorella, Chlorococcum, Tetaedron, Scenedesmus, Navicula, Euglena, and Microcystics, are present in blooms since they are indicators of water contamination.

K.S. Raut., and S.E. Shinde (2022) an analysis was conducted on the physicochemical characteristics. The findings demonstrated that variations in the lake's physicochemical properties occurred throughout the year. Lake Hinglajwadi in the Hinglajwadi district has a very significant positive and negative association ($p < 0.01$) as well as a strong positive and negative relationship ($p < 0.05$) according to the correlation coefficient. He also found that the range of phosphate was 0.25 to 40.71 mg/L; the winter had the lowest values and the monsoon had the highest, at 0.79 ± 0.05 mg/L. Because of the rainfall influx, it was determined that phosphorus is necessary for eutrophication and the growth of algae. substantial negative correlations were seen between phosphate and nitrate, whereas substantial positive correlations were observed with TDS, TSS, and sulphate. **Kumar et al. (2022)** investigated physiochemical characteristics, he discovered significant amounts of nitrate, sulphate, and chloride ions in water bodies caused by agricultural runoff, industrial waste, municipal sewage, and synthetic detergents in the Gomti River. **Veena et.al. (2022)** evaluated the environmental state of Hosakote Lake, including its physiochemical properties and heavy metal contamination. The samples were tested for and the average range of pH (7.95), Total Dissolved Solids (345.8ppm), Electrical Conductivity (831.8µs/cm), Turbidity (1.72NTU), Alkalinity (258.33mg/L), Hardness (192.57mg/L), Calcium (137.09mg/L), Magnesium (55.34mg/L), Nitrate (0.273mg/L), Phosphate (0.344mg/L), Fluoride (0.977mg/L), Sulphide (0.501mg/L), Ch The quality of the water was severely polluted, and strict conservation techniques are required for the lake's long-term growth.

Barskar and Jawalkar (2022) evaluated the limnology of Bisnoor Pachdhar Reservoir regarding phytoplankton diversity. The current study examines phytoplankton's taxonomic diversity and seasonal abundance and their physicochemical characteristics. They detected Chlorophyceae (37%), Cyanophyceae (27%), Bacillariophyceae (19%), and Euglenophyceae (17%) during the monsoon season, and Chlorophyceae (37%), Cyanophyceae (25%), Bacillariophyceae (23%), and Euglenophyceae (15%) during the post-monsoon season. Chlorophyceae (37%), Cyanophyceae (26%), Bacillariophyceae (24%), and Euglenophyceae (13%), all contributed throughout the winter season. In the summer, the percentage composition is Chlorophyceae (36%), cyanophyceae (24%), Bacillariophyceae (20%), and euglenophyceae (20%).

Sureka et al. (2022) evaluated the physicochemical properties of Mukkudi village water. The water's temperature ranges from 29 to 37°C, transparency ranges from 28.4 to 37.8 cm, dissolved oxygen ranges from 7.9 to 9.1 ppm, free carbon 12.8 to 14.7 ppm, a pH range from 6.7 to 7.5, total alkalinity ranges from 178 to 205 ppm, the total solids 97 to 109 ppm, nitrates between 1.01 and 1.12 ppm, and phosphates between 0.88 and 0.99 ppm were recorded by the authors. Over 20 species of phytoplankton and zooplankton have also been discovered. A bimodal pattern of seasonal fluctuation in plankton was found, with a main peak between June and August and a secondary peak in December 2021.

Sunil et al. (2022) studied water quality of Anasagar lake, while studying the result showed Anasagar lake is leading remains to conditions of eutrophication with massive loading of nutrients during monsoon. The physio-chemical parameter were temperature (24.500C to 33.900C), pH (7.9 to 8.2), electrical conductivity (2.07 to 2.49 mS/cm), dissolved oxygen (7.53 to 8.73 mgL-1), total alkalinity (101 to 109 mgL-1), total hardness(121 to 150 mgL-1), total dissolved solid (1344.00 to 1617.00 mgL-1), nitrate (0.88 mg L-1 to 1.02 mgL-1), phosphate (0.67 mgL-1 to 0.76 mgL-1), average visibility during the study period was 48.92 cm**.**

Jadhav and Patil (2023) studied physico-chemical parameters of Sarangkheda barrage of Nandurbar District stated that seasonal fluctuations, human activity, and natural processes might all be responsible for the observed variations in water quality indices. Agricultural runoff and industrial discharges might be connected to the elevated BOD and COD during the monsoon season. Reduced aeration and the breakdown

of organic materials can be the cause of low D.O. levels. There might have been an invasion of pollutants or a natural breakdown of minerals that caused the July surge in TDS. Increased amounts of calcium, magnesium, and alkalinity might affect aquatic life and have an impact on water treatment.

Tak et al. (2023) investigated the limnological details of Pushkar Lake in Rajasthan, India. The analysis found that TDS levels ranged from 332ppm to 462.37ppm. Throughout the research period, Pushkar Lake had a minimum total hardness of 185.75mg/lt. The Pushkar Lake's WQI grade ranged between 94.67 and 124.01, suggesting that the water was unfit to drink. Calcium and magnesium from surface runoff during the rainy season are the primary sources of hardness in Pushkar Lake.

Dahegaonkar (2023) conducted an investigation on the limnological profile of the Erai River in Chandrapur. The findings of the study indicated that the water's pH and physicochemical characteristics were consistently alkaline. Significant numbers of Spirogyra and Zygnema species were found, which may suggest that they are genera that can withstand pollution. Myxophyceae, or blue-green algae, are thought to be extremely adaptable since they have been known to colonize even warmer, dirty water. There are eight species known, several of which are in the genera Anaebena, Rivularia, Oscillatoia, and Anacystis. There were seven species in the Bacillariophyceae family, with the genera Diatoma, Pinnularia, Navicula, and Fragillaria being the most prevalent. Compared to zooplankton species, phytoplankton species were both greater in number and diversified.

Makde and Kale (2023) examined the phytoplankton variety and abundance in the Pothara River for the Chandrapur district between February 2014 and January 2016. 34 genera were discovered, and during the year, reports of species such as Euglena sp., Pediastrum sp., Chlorella sp., Oedogonium sp., and Oscillatoria sp. were made. It has been determined that Anacystis, Oscillatoria, Chlorella, and Nitschia are indicators of water contamination.

Padmanabha et al. (2023) examined the seasonal fluctuations in phytoplankton and physico-chemical parameters in Karanja Reservoir. The research was conducted over a one-year period, from June 2016 to May 2017. Winter had the highest concentration of phytoplankton, whilst the monsoon season saw the lowest occurrence. The post-monsoon season had high levels of phytoplankton species richness and diversity indices, whereas the monsoon season saw low levels. During the investigation, 54 genera of phytoplankton were found, categorized into 4 groups: Chlorophyta, Cyanophyta, Chrysophyta, and Rhodophyta. Leading the phytoplankton grouping, Chlorophyta, contributed around 63.14%. Cyanophyta, Chrysophyta, and Rhodophyta followed with 23.78%, 11.37%, and 1.69% of the total.

Devi and Bhatnagar's (2023) study compared the dynamics of phytoplankton and evaluated the water quality in a few lentic water bodies in Haryana. The examination of phytoplankton and physicochemical parameters revealed a correlation between them, indicating the eutrophic and productive characteristics of the locations. The study examined the relationship between various phytoplankton groups and physicochemical factors. The results indicated that Cyanophyceae had a significant negative correlation with pH, while ortho-phosphate had a significant positive correlation with Desmids and Bacillariophyceae and a positive correlation with Xanthophyceae. Pollution indicators include the presence of Microcystis aeruginosa, Oscillatoria sp., Rivularia sp., Pediastrum sp., Scenedesmus, Spirogyra s., Synedra sp., Navicula spp., and Nitzschia sp.

Athira S. et al. (2023) investigated the algal diversity and water quality status of four different freshwater resources, two paddy fields in Thalakkulathur and two natural ponds in Kayanna, Kozhikode district, Kerala, for six months. In conclusion, a total of 54 algal species were observed, comprising 11 Cyanophycean, 17 Chlorophycean, 2 Eugleninean, 23 Bacillariophycean, and 21 Xanthophycean members. The water quality assessments conducted revealed the presence of organic pollution in all four sample.

Lal A and Lal N (2023) investigated the influence of monsoons on water quality in Chota Nagpur lakes. The study found that both lakes are eutrophic, with high levels of alkalinity and hardness. Which demonstrates the combined effect of sewage pollution and

insufficient rains. This study indicated that the monsoon has a limited influence on the physicochemical features of urban lakes, whereas semi-urban lakes showed extensive changes throughout both pre- and post-monsoon seasons. This also demonstrates that monsoons may restore plateau lakes. **Gaidhane (2023)** investigated Limnology of Mul Lake. The study found temperature-26 to 350C, pH-7-8.5, dissolved oxygen-480-645 mg/l, free carbon dioxide-514-691mg/l, total alkalinity-260-309mg/l, electrical conductivity- 889-905 ms, total dissolved solids-170-204 ppm, Calcium hardness-32-36 mg/l and Magnesium hardness-16-20 mg/l. Total 10 parameters were studied.

Sharma S and Sharma G (2023) investigated the limnology of Man Sagar Lake and discovered that the greatest number of total cololiform was 1180/100 ml in mid-July and the lowest number of coliforms was 800/100 ml in July. The highest number of total faecal coliform present was 1230/100 ml in August, whereas the lowest quantity was 750/100 ml in July. Gram-positive and gram-negative bacteria were counted in Man Sagar Lake. The phytoplanktonic range of algae groups like Cynophycean (such as Oscillatoria, Nostoc sp., Anabaena sp., and so on). Bacillariophycean (Diatoms such as Cyclotella, Pinnularia, Synedra, Epithemia, etc.) and Chlorophycean (Chlorella, Chlorococcum) were found in the lake water. **Reddy and Swamy (2024)** examined Nizamsagar Reservoir's physicochemical characteristics. He examined fifteen parameters, and his results indicated that reservoir water was within the permitted limits. He also analyzed various physicochemical parameters and computed correlation coefficients to ascertain the connections between the various physicochemical parameter types. The temperature of the water (WT) and the atmosphere (AT) are found to have a significant positive correlation of 1.00, indicating a direct link. There is a significant negative connection (-0.95) between transparency and turbidity, meaning that greater turbidity levels are linked to less transparent water. Strong positive correlations (0.91) between TDS and electrical conductivity in water indicate that a higher mineral content causes a higher electrical conductivity. Total Alkalinity shows a substantial positive association with both Chlorides (0.75) and Phosphates (0.88), suggesting that the two have a common relationship that may be connected to the mineral composition of water. **Singodia et al. (2024)** investigated the water quality at Kot Dam in Rajasthan's Jhunjhunu district. He discovered that dam water was contaminated owing to organic pollutants, agricultural runoff, and garbage dumping by locals, particularly during the summer (Water Quality Index-WQI=87.18) and monsoon seasons (WQI=85.38). **Sharma, A. et al. (2024)** investigated the hydrobiology of the Pargwal Wetland Ecosystem. Data were collected seasonally for one year, and deteriorating parameters were evaluated. Based on the water quality metrics, the wetland turned out to be fairly alkaline in nature, and WQI demonstrated poor water quality throughout the research.

Tiwari and Mahor (2024) conducted study on physiochemical parameters of Tighra Reservoir of Gwalior. During study, water body shows good oxygenation, low organic pollution, and stable pH, which is essential for a healthy aquatic environment. The study revealed some of the parameters with high readings like TDS 80 mg/l to 400 mg/l, COD 12 mg/l to 72 mg/l, Chloride 35.89 mg/l to 84 mg/l, Magnesium 10 mg/l to 66 mg/l, Total hardness 50 mg/l to 458 mg/l, Total solids 88 mg/l to 765 mg/l.

Singh A. et al. (2024) extensively investigated the qualitative and quantitative analysis of plankton diversity and physicochemical water quality indicators in the Yamuna River. The study found that Bacillariophyceae had the most genera (18), followed by Chlorophyceae (20), Cyanophyceae (9), Euglenophyceae (2), and Dianophyceae (1 genus). Chlorophyceae are the most common groupings. The observed water quality parameters, including temperature, pH, electrical conductivity, and dissolved oxygen levels, differed across the barrages, suggesting the possible effect of numerous variables such as industrial and municipal waste disposal and wastewater effluents.

CONCLUSION:

India's freshwater ecosystems are indispensable to its ecological balance, economic development, and cultural heritage. The limnological review of these systems underscores their complexity and the multifaceted challenges they face. Pollution, habitat degradation, over-extraction, invasive species, and climate change collectively threaten the health and sustainability of rivers, lakes, reservoirs, and wetlands across the country. Despite significant advances in limnological research, there remain critical gaps in our understanding that must be addressed to develop effective conservation and management strategies. Enhanced monitoring, interdisciplinary research, and the integration of traditional knowledge with scientific approaches are essential to address these challenges. Conservation efforts must prioritize restoring ecological balance, improving water quality, and protecting biodiversity. Collaborative approaches involving government agencies, local communities, and scientific institutions are vital to ensuring the long-term sustainability of India's freshwater resources. The review has been done while avoiding too early data and taking into consideration references accessible from (2000) to the present (2024). In conclusion, safeguarding India's freshwater ecosystems requires a concerted effort driven by robust scientific research, informed policy-making, and active community participation. By building on the existing body of limnological knowledge and addressing the pressing issues identified in this review, we can work towards a future where India's freshwater ecosystems continue to thrive and support the myriad forms of life that depend on them.

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