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Limnological Study Of Fresh Water Bodies Of Rajasthan: A Brief Review

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ABSTRACT
The lakes of Rajasthan, despite being located in an arid region, host diverse and unique limnological features and planktonic communities, shaped by varying climate, geology, and anthropogenic influences. This review consolidates research on the limnology and plankton diversity of these lakes, examining physicochemical properties which significantly influence species composition and ecosystem function. Key findings highlight the roles of these planktonic communities in nutrient cycling, food web dynamics, and lake productivity, as well as the impacts of seasonal fluctuations and anthropogenic pressures, including pollution and eutrophication. This review underscores the need for further research and conservation efforts to maintain the ecological integrity of Rajasthan's lake ecosystems, as they are crucial for local biodiversity and water resources in this semi-arid landscape.

KEY WORDS: Physico-chemical parameters, biological characteristics, limnology, plankton diversity, eutrophication.

INTRODUCTION

Water is fundamental to life on Earth and plays a crucial role in the chemical makeup of all living organisms. The significance of water as essential to life was acknowledged as early as 640-546 B.C., when the Greek philosopher Thales of Miletus expressed this idea through his famous saying, "Water is best." This reflects the ancient recognition of water's fundamental role in sustaining life. It is one of the most diverse ecosystems on the earth. The aquatic ecosystem is broadly classified into two main categories i.e. freshwater ecosystem and salt water ecosystem. The freshwater ecosystem comprises of rivers, ponds and lakes whereas salt water comprises of oceans, sea and salt lakes. The study of these water habitats is known as limnology.

The term "Limnology" comes from the Greek word *limne*, meaning marsh or pond. It focuses on understanding how the physical, chemical, and biological factors interact to influence these aquatic environments.

"Water quality" refers to the properties and conditions of water, including its physical, chemical, and biological properties. The physical properties of water encompass turbidity, taste, temperature, color, odor, solids, and electrical conductance. Chemical factors include pH, acidity, alkalinity, chloride, chlorine residue, sulphate, nitrogen, fluoride, iron, manganese, copper, zinc, dissolved oxygen, and biochemical oxygen demand.

The biota and the physico- chemical characteristics of water are dependent on the temperature or the warmth of water. The solubilisation of gases, salts, rate of photosynthesis and algae in water are also governed by variation in water temperature. According to several researches, temperature is positively correlated with TDS, pH, BOD, COD, Conductivity, Alkalinity, free carbon dioxide and nitrates. For the sustenance of aquatic ecosystem, the threshold temperature is typically around 35ºC. Turbidity of water is basically the hindrance caused in the amount of light reaching to the bottom of the water column by various reasons such as dissolved and suspended biological and non-biological materials, mud, silt and micro-organisms.

pH is expressed as the amount of hydrogen ions present in water. It measures the acidic or alkaline nature of water. The permissible limit of pH in water according to ISI is 6.5 to 8.5. This range of pH in water is the most suitable for the

aquatic biota to flourish. The concentrates of carbonates and bicarbonates in water is the expression of total alkalinity. In other words, it is the capability of water to nullify acids. 200 to 600 ppm is the acceptable limit for usable water.
Total hardness refers to the amount of dissolved calcium and magnesium ions in water. It can be classified into two types: temporary and permanent hardness. Temporary hardness is caused by the presence of calcium and magnesium bicarbonates, whereas, permanent hardness is caused due to sulphates of these two ions. The ISI acceptable range of hardness in water is 300-600 ppm.
The capability of water to pass electric current through it is measured as electrical conductance. Electrical conductance is completely related to the amount of ions present in the water. Due to this summer season records high levels of electrical conductance. The organic and inorganic compounds suspended in water are measured in the form of total dissolved solids in water. For drinking water, the ISI acceptance range of total dissolved solids is 500- 2000 ppm.
Dissolved oxygen is the quantity of oxygen present in water. It is essential in water as it is required by microorganisms for their respiration. The ISI acceptable range of dissolved oxygen in potable water is 3-7 ppm. Biological Oxygen Demand is the quantity of oxygen used by the aerobic bacteria to disintegrate the organic matter in water. The ISI acceptance range of Biological Oxygen Demand in water is 0-5 ppm.
The state of Rajasthan is situated at latitude $23^0$3`N -$30^0$12`N and longitude $69^0$30`E-$78^0$17`E in the west province of India. It is the largest state of India with 343 x 103 km^2 area. It is located in a tropical region so it's annual temperature is of about 20°C. The May and June months are the hottest months nearly 40°C average temperature and December is the coolest month with an average temperature of about 10°C. Rajasthan is the driest state, with about 70% of its land categorized as arid and semi-arid regions. The average rain fall of Rajasthan is 575 mm /year, so state face scarcity of water resource. Ground water availability in the state is highly variable and limited depending on hydrological condition.
The deterioration of lakes in Rajasthan in recent years has become a significant environmental issue, driven by both natural and human factors. The major causes of this deterioration are reduced rainfall and increased temperatures have led to the shrinking of water bodies, disrupting the natural recharge of lakes, rapid expansion of cities has resulted in increased encroachment on lakes and wetlands, altering their natural ecosystems, construction, deforestation, and pollution from industries and sewage are major contributors.

Discussion:

Fresh water habitat or the lentic habitat embraces lakes as well as ponds. The abiotic elements that encompass the physical and chemical facets of a distinct water body present the mount in which the aquatic biota reside. The vital abiotic elements portraying this mount comprise turbulence, temperature, pH, habitat persistence, available light, nutrients, oxygen and carbon. The estimation of the physico-chemical parameters of a water body provides the assessment of its trophic status, productivity and sustainability.

Water contamination is a sincere issue at present as all water reserves are at the edge of confrontation owing to unintended urban and industrial expansion (Singh *et al.*, 2002). It is well accepted that all flora and fauna, encounter an array of issues resulting from different types of environmental pollution (Petak,1980).
A large number of works has been done on the physico-chemical parameters of lakes in Rajasthan.

Rao and Durve (1987) investigated the phytoplankton community in Lake Jaisamand, revealing that both temperature and nutrient levels played a crucial role in influencing plankton production. Out of the 52 identified taxa, Chlorophyceae algae were the most prevalent. The peak plankton density of 6,172 cells/ml occurred in July. Moreover, the researchers observed a strong positive correlation between dissolved oxygen and Cynophyceae, while phytoplankton abundance showed an inverse relationship with water transparency.
Vyas and Kumar (1968) studied the productivity and seasonal variations of phytoplankton in Indrasagar tank, Udaipur, with a focus on its physicochemical characteristics. They determined that the tank exhibits eutrophic conditions. Their research showed that Chlorophyceae exhibited a broad capacity for adaptation, while diatom growth was supported by

the availability of nitrates, silicates and phosphates. Furthermore, the proliferation of Chlorophyceae was influenced by factors in the environment, like H^+ ion concentration and water temperature.

In a separate study, Bohra et al. (1978) analyzed fifteen months of water temperature data from the vertical profiles of Padamasagar and Ranisagar lakes located in the semi-arid zones of West Rajasthan. They noted a substantial variation in water temperature between the surface and lower layers especially in the summer months (particularly in June), with a variation of 9.5°C at Ranisagar and 12°C at Padamasagar. This temperature gradient led to the development of a pronounced thermocline, limiting the movement of nutrients, carbon dioxide and dissolved oxygen within the water. However, during winter, the water became isothermal, allowing circulation. This was the first recorded observation of a thermocline in any Indian lake or reservoir, attributed to the absence of water mixing due to the lakes' low surface-to-depth ratio and protection from wind by high rock formations on their eastern and western sides.

In 1994 study conducted on the water of Goverdhan Sagar Lake in Udaipur, Rajasthan, Mishra and Bakre examined various limnological parameters, primary productivity, and the diversity of phytoplankton. Their results showed that Chlorophyceae were the most dominant group present in the lake. The mean gross primary productivity (GPP) was recorded at 0.42 g/cm²/h, while the net primary productivity (NPP) was 0.26 g/cm²/h. Both the lake's primary productivity and the diversity of phytoplankton were found to have a positive impact on fish production.

Sharma (1996) documented a significant rise in nitrate nitrogen concentrations across several lakes, with Rangsagar showing levels between 0.2 and 1.22 mg/l, Swaroopsagar ranging from 0.40 to 1.88 mg/l, Fatehsagar between 0.7 and 1.46 mg/l, and Pichhola from 0.34 to 1.19 mg/l. In 2000, Sharma and colleagues assessed the pH (7.2–10.07), total alkalinity (120–2 mg/l), and orthophosphate concentrations (0.002–0.005 mg/l) in the Berach river system. By 2007, Sharma et al. observed that dissolved oxygen levels reached their highest in Lakes Jaisamand and Pichhola during the monsoon, likely due to the influx of oxygen-rich stream water. They also noted that nitrate and orthophosphate levels peaked in summer and were lowest during winter, a trend attributed to evaporation reducing water volume. Additionally, Sumitra et al. (2007) found that Lake Pichhola exhibited low dissolved oxygen and moderate nitrate and phosphate concentrations.

Jakhar et al. (1990) carried out research on two saline lakes in Rajasthan, Sambhar Lake and Didwana Lake. Their study revealed a wide variation in salinity levels, ranging from nearly fresh water at 1.80‰ to hypersaline conditions reaching 300‰. The highest total alkalinity observed was 2162 mg/l in Sambhar Lake & 2090 mg/l in the water of lake Didwana. The levels of oxygen dissolved in water fluctuated greatly, from totally negative states to peaks of 11.68 mg/l recorded in Sambhar lake and 7.29 mg/l in Didwana lake. The researchers also found that nutrient enrichment in both lakes was generally low.

Pandey et al. (1995, 1998) studied the Kosi River and the Lake Fateh Sagar, concluding that nutrient inflows and the resulting algal growth had a detrimental effect on water quality. They further observed that the seasonal fluctuations and the abundance of phytoplankton were strongly influenced by the physicochemical conditions of the water.

Rawar and Jakhar (2003) investigated Takhat Sagar Lake and found that dissolved oxygen revealed a significant negative relation with water temperature ($r = -0.82$), which indicate that lower temperatures enhance its solubility. In contrast, free carbon dioxide exhibited a positive correlation with temperature ($r = 0.61$).

Pandey and Verma (2004) investigated the chemistry and biology of two freshwater lakes situated in the tropics i.e. Lake Baghdara and Lake Udai Sagar, in relation to their catchment areas. Lake Baghdara receives runoff from undisturbed woodlands, while Udai Sagar is influenced by runoff from the urban areas of Udaipur city. The physio-chemistry and biology of the lakes indicated that the water of Udai Sagar lake was adulterated and approaching towards eutrophication, on the other hand Baghdara remained free from pollution. This led to the conclusion that dredging sediments rich in phosphorus could serve as an effective strategy for restoring dryland or eutrophic lakes.

Paulose and Maheshwari (2008) analyzed the waters of Ramgarh Lake and found that the pH indicated alkalinity of water, ranging from 7.0 to 8.7 throughout the study period. They observed that dissolved oxygen levels peaked during

the summer, which they attributed to an increase in phytoplankton density. Zooplankton populations also exhibited seasonal fluctuations. Among the zooplankton, Rotifera was the most dominant group with 17 species, followed by Copepoda (12 species), Cladocera (10), Protozoa (5), Ostracoda (3), and Insecta (2). Both Rotifera and Ostracoda were positively correlated with nitrate concentrations in the lake water.

Sharma et al. (2008) examined the seasonal changes in the physico-chemical properties of the Jalmahal reservoir in Jaipur. They found that light penetration was extremely low (less than 10 cm) due to suspended particles and high phytoplankton density. Other parameters such as pH, electrical conductivity (EC), free CO2, BOD, COD, nitrates, and phosphates showed distinct variations due to seasonal weather changes, with their highest values occurring in summer and the lowest during the monsoon season. They identified 16 species of algae across three groups: Chlorophyceae (8 species), Bacillariophyceae (4), and Cynophyceae (4). Among the zooplankton, Paramecium sps., Euglena sps., Moina sps., Daphnia sps., Mesocyclops sps., Brachionus sps., Philodina sps., and Vorticella sps. were the most frequently recorded species.

Kumar et al. (2008) conducted a study on Kishore Sagar Lake and found it to exhibit tropical characteristics, with elevated water temperatures during the summer. Electrical conductivity was notably high during the rainy season, and dissolved oxygen levels remained consistently low throughout the study period. The researchers identified 42 species of diatoms, with the most dominant being *Flagillaria crotoneinsis*, *Melosira granulate*, *Coccones placentula*, *Diatomae longatrum*, *Ghomphone maolivaceum*, *Ghomphone sps.*, *Nitzschia sps.*, *Symedra ulna*, and *Navicula radios*. The abundance of diatoms, along with elevated physico-chemical parameters, pointed to the lake's gradual eutrophication.

Sharma and Chauhan (2008) evaluated the water quality of Budha Pushkar Lake and reported elevated levels of nitrates (1.53 mg/l) and phosphates (2.90 mg/l). They attributed these high concentrations primarily to agricultural runoff.

Srivastava et al. (2009) conducted a study on various lakes in and around Jaipur, uncovering that Jalmahal Lake earned the dubious distinction of being the most polluted. It exhibited alarmingly high levels of pH, free CO2, hardness, and total alkalinity, paired with disappointingly low dissolved oxygen levels. In contrast, Ramgarh Lake was boasting the cleanest water, with high dissolved oxygen and relatively low levels of free CO2, hardness, and alkalinity.

Sukhija (2010) examined the physico-chemical properties of Foy Sagar Lake and found significant seasonal variations, with peaks during the summer and lower values in the monsoon season. He noted that increasing human activities and pollution are rapidly degrading water quality. In terms of plankton, the highest density of zooplankton was recorded in June, while September showed the lowest density. The zooplankton species identified included *Paramecium sps.*, *Arcella sps.*, *Philodina sps.*, *Brachionus sps.*, *Keratella sps.*, *Asplanchna sps.*, *Moina sps.*, *Daphnia sps.*, *Simocephalus sps.*, *Ceriodaphnia sps.*, *Diaptomus sps.*, *Cypris sps.*, *Eucyclops*, *Cyclops*, and *Mesocyclops*.

Sharma et al. (2010) investigated the physico-chemical properties of Gundolav Lake in Kishangarh. They found elevated levels of electrical conductance (1756.49 µmhos/cm), total alkalinity (557.18 mg/l), total dissolved solids (TDS) (1334.25 mg/l), and biological oxygen demand (BOD) (49.42 mg/l) at a site near a Nala, which resulted due to domestic discharge of sewage into the lake. In contrast, measurements taken at another site near the temple showed comparatively lower values, indicating less environmental interference in that area.

Meenakshi Singh (2010) investigated the seasonal variations of diatoms in relation to the physico-chemical properties of Mansagar Lake in Jaipur. Their research identified 35 diatom species belonging to 22 genera, including *Coscinodiscus*, *Stephanodiscus*, *Gomphonema*, *Navicula*, *Cymbella*, *Melosira*, *Epithemia*, *Cyclotella*, *Amphora*, *Diadesmis*, *Falcula*, *Synedra*, *Rhopalopodia*, *Aulacoseira*, *Eunotia*, *Diatoma*, *Tabularia*, *Hantzschia*, *Surirella*, *Anomoneis*, *Nitzschia,* and *Fragillaria*. The total diatom density demonstrated a significant positive correlation with electrical conductivity and total dissolved solids ($p < 0.01$), as well as chemical oxygen demand ($p < 0.05$).

In 2011, Singh et al. conducted a study on the diversity, density, and distribution of diatoms in Lake Mawatha, Jaipur. They recorded 30 species belonging to 19 genera, with the highest diatom density observed during the post-monsoon season. Additionally, they calculated various biodiversity indices, including the Shannon-Weaver Index (H' = 1.372),

Evenness Index (J' = 0.903), and Berger-Parker Index (0.147).

Sharma et al. (2011) investigated the limnology, plankton and fish diversity in Lake Pichhola, (Udaipur, Rajasthan, India). Their study involved seasonal investigation for two years (2005-06 and 2006-07). Results indicated that the lake water was slightly alkaline, with a pH of 7.5. Other parameters such as electrical conductivity (0.3958 mS/cm), total dissolved solids (TDS) (237.5 mg/l), alkalinity (207.16 mg/l), chloride (176 mg/l), and hardness (174.33 mg/l) marked mean values on a relatively lower side. The mean dissolved oxygen values were measured at 5.75 mg/l, while mean nitrates (3.70 mg/l) and phosphates (2.79 mg/l) concentrations were recorded. Additionally, the researchers noted a higher proportion of primary productivity, averaging 302.085 mgC/m²/hr.

In 2011, Pareek et al. identified 24 species of diatoms in Galta Kund, Jaipur. Notably, they recorded several diatom species for the first time, including *Nitzschia* sp., *Amphora* sp., *Achnanthes* sp., and *Gomphonema* sp. The Shannon-Weaver diversity index was maximum in May month.

Sharma et al. (2012) conducted a study on the Kalisil River located within the Keladevi Wildlife Sanctuary in Karauli District, Rajasthan. They observed that the physico-chemical parameters varied seasonally. The study recorded a total of 36 algal genera comprising 60 species. The consistent presence of algae such as *Chlorogonium euchlorum*, *Chlorella vulgaris*, *Gonium compactum*, *Scenedesmus opoliensis*, *Merismopedia* sp., *Oscillatoria trichoides*, *Euglena acus*, and *Navicula minusa* throughout the study period indicated significant pollution in the river.

Sharma et al. (2012) reported that the average physical and chemical characteristics of water at Madar Tank were as follows: visibility depth 81.38 cm, pH 7.85, electrical conductance 0.745 mS/cm, chloride 115.83 ppm, dissolved solids (DS) 476.61 ppm, hardness 177.33 ppm, and alkalinity 124 ppm. The mean levels of oxygen dissolved in water was 6.9 ppm, while the mean concentrations of nitrates and phosphates were 3.478 ppm and 2.6802 ppm, respectively. The primary productivity measured 261.64 mgC/m²/hr. Overall, these parameters indicated that Madar Tank is classified as mesotrophic.

Jain and Singh (2013) observed seasonal fluctuations in the water temperature of Lake Anasagar, with minima and maxima recorded at 18.20 °C and 29.0 °C, respectively. pH values ranged from 8.9 to 7.3, which were compatible with earlier recordings by Wetzel et al. (1975), who noted that pH levels in Indian waters typically fall between 8 and 9. Elevated pH levels can encourage the formation of cyanobacterial blooms. The electrical conductivity (EC) ranged from 2140 to 3500 µmho/cm, indicating a high salt concentration. Dissolved oxygen values in the surface layers varied from 5.3 mg/l to 10 mg/l, while nitrate contents ranged from 11 mg/l to 19 mg/l. The presence of higher nutrient levels, particularly nitrates and phosphates, suggests eutrophication and a higher trophic status in the lake.

In 2013, Bhatnagar and Bhardwaj identified seventy algal species in the waters of the Chambal River at Kota. The majority of these species were from the Chlorophyceae group (34 species), followed by Cynophyceae (21 species) and Bacillariophyceae (12 species), with Euglenophyceae contributing the fewest (3 species). Additionally, they noted the presence of 12 species of diatoms.

Gaur et al. (2014) studied the limnobiotic stature of the Chambal River the Rana Pratap Sagar Dam and from the winter of 2008 to the monsoon season of 2009. They measured various physico-chemical characteristics, which included visibility depth, conductivity, temperature, TDS, chlorides, total alkalinity, total hardness, nitrates, phosphates, silicates, and primary productivity. Based on these observations, the Rana Pratap Sagar Dam exhibited eutrophic characteristics, in contrast to the Chambal River.

Sarang and Sharma (2014) observed the effects of domestic sewage discharged in Kota Barrage (Kota) over the water quality and benthic diversity. They reported that pollution, particularly from Thermal Power Plant effluents, significantly impacted the dam, as indicated by low dissolved oxygen levels (4 mg/l). The most common benthic species found included *Bellamya bengalensis*, *Melanoides tuberculata*, *Gyraulus convexiusculus*, *Lymnaea acuminata* and *Indoplanorbis exustus*.

A comparative study was conducted on four water bodies in Udaipur District: Pichhola Lake, Fatehsagar Lake,

Swaroopsagar Lake, and Rangsagar Lake. The research focused on assessing the microbial status of these lakes by using the Most Probable Number (MPN) technique to estimate the total and fecal coliform bacteria count. The results showed bacteria counts ranging from 345 to 2400 in Pichhola Lake, 124 to 2400 in Fatehsagar Lake, 167 to 2400 in Swaroopsagar Lake, and 60 to 2400 in Rangsagar Lake. These values exceed permissible limits and were primarily attributed to domestic and industrial waste being discharged into the lakes.

In 2019, Shivani et al. conducted an analysis of various physico-chemical parameters at Pichhola Lake, Udaipur. They recorded air temperatures ranging from 19.88°C to 36.88°C and water temperatures between 18.75°C and 30.90°C. Transparency levels varied from 15.91 cm to 72.27 cm, while pH ranged from 7.20 to 8.80. Dissolved oxygen levels were measured between 4.88 mg/l and 9.43 mg/l, with free carbon dioxide ranging from 0.00 mg/l to 11.75 mg/l. Total alkalinity was recorded between 145.50 mg/l and 177.25 mg/l, total hardness ranged from 144.00 mg/l to 183.50 mg/l, total dissolved solids from 187.51 mg/l to 273.51 mg/l, nitrate-N from 0.36 mg/l to 0.51 mg/l, and orthophosphate from 0.15 mg/l to 0.27 mg/l.

Mirdha, 2014 studied the Jessant sagar reservoir of Pichiyak, Jodhpur. The study revealed different physico-chemical characteristics including temperature (10 - 35 ^{0}C), pH (5.5 – 8.2), alkalinity (88 – 121mg/l), dissolved oxygen (1.10 – 5.93 mg/l), nitrates (0.67 – 2.61 mg/l), phosphates (3.41 – 7.1 mg/l) and florides (0.72 – 2.6 mg/l).

Suman et al. (2017) investigated several micro-watersheds in Banawara district. The average water quality parameters varied as follows: water temperature varied between 26.35°C to 32.95°C, pH levels were between 7.7 and 9.5, dissolved oxygen (DO) varied between 6.5 mg/l to 9.64 mg/l, salinity was between 0 and 0.1 ppt, free carbon dioxide (CO2) varied between 0.0 to 15 mg/l, TDS varied between 119.05 mg/l and 290.5 mg/l, conductivity ranged from 248 to 598 ms/cm, nitrate-nitrogen from 0.131 mg/l to 0.230 mg/l, orthophosphate from 0.05 mg/l to 0.12 mg/l, and ammonia from 0 to 1.845 mg/l.

Bisnoi et al. (2013) investigated the water of Gang Canal to explore the relationship between primary productivity and plankton diversity. The phytoplankton community in the canal consisted of 16 species across 15 genera, including Bacillariophyceae (8), Chlorophyceae (5), Myxophyceae (2), and Xanthophyceae (1). The overall average values for Gross Primary Production (GPP) and Net Primary Production (NPP) were recorded at 0.124 gc/m³/hr and 0.084 gc/m³/hr, respectively.

Nama and Dhanraj (2018) evaluated the water quality of Palasani Pond in Jodhpur district by analyzing various physico-chemical parameters. Their study recorded transparency ranging from 29.14 cm to 41.13 cm, temperatures between 19.4°C and 29.8°C, turbidity from 23.02 cm to 26.07 cm, pH levels between 7.2 and 8.3, dissolved oxygen fluctuated between 4.28 mg/l to 8.02 mg/l, phosphate concentrations from 0.3 mg/l to 1.2 mg/l, biological oxygen demand (BOD) between 3.3 mg/l and 4.6 mg/l, total alkalinity ranging from 43 mg/l to 91 mg/l, and total hardness from 102 mg/l to 180 mg/l.

A similar investigation was carried out on the waters of Pichhola by Mishra et al. in 2019. Their findings revealed that the air temperature was 28.30ºC, while the water temperature was recorded at 25.07ºC. The depth of visibility measured 85.56 cm, and the pH level was found to be 7.68. The electrical conductivity (EC) was 0.45 mS/cm, and values for dissolved oxygen were noted at 5.95 mg/l. Free carbon dioxide concentration was recorded at 17.08 mg/l, while total dissolved solids reached 296.83 mg/l. Carbonate levels were at 33.74 mg/l and bicarbonates at 136.67 mg/l, with total alkalinity measuring 156.13 mg/l. Additionally, orthophosphate levels were observed at 0.14 mg/l, nitrate-nitrogen at 0.60 mg/l, Gross Primary Production (GPP) at 0.39 g C m^3 h^{-1}, Net Primary Production (NPP) at 0.24 g C m^3 h^{-1}, and carbon respiration (CR) at 0.15 g C m^3 h^{-1}.

In a study by Kavindra et al. (2019), the mean air temperature (29.73±0.05°C) and water temperature (23.22±0.05°C) were reported at Jawai Dam. The average visibility was measured at 111.90 ± 3.91 cm, indicating a low nutrient level. Supporting these findings, Sharma et al. (2012) also observed a significant co-relation between visibility depth and various other water parameters. The mean pH value was found to be 8.09±0.05, which showed a significant co-relation

with TDS, electrical conductivity, total alkalinity, bicarbonates, nitrate-nitrogen, and orthophosphate. The mean electrical conductivity and total dissolved solids across every sampling sites were recorded at 0.41±0.005 mS cm^{-1} and 260.65±0.83 mg/l, respectively. The average dissolved oxygen level was measured at 8.08±0.15 mg/l. Correlations among dissolved oxygen and other parameters, such as air and water temperature, pH, electrical conductivity, carbonate and bicarbonates, total alkalinity, TDS, nitrate nitrogen, and orthophosphate were observed. The average total alkalinity value was 112.62±1.52 mg/l, indicating that the water body falls under the low to moderate productivity category. The average productivity levels were also low, with gross primary productivity (GPP) at 0.111±0.001 g C m^3 h^{-1}, net primary productivity (NPP) at 0.065±0.001 g C m^3 h^{-1}, and community respiration at 0.045±0.001 g C m^3 h^{-1}.

In 2016, Pradhan analyzed soil and water samples from Man Sagar Lake to assess various limnological characteristics. The study showed alkalinity of water, while TDS, DO, and BOD indicated a decline in water quality. Additionally, the soil samples taken from the lake bed were also alkaline, exhibiting medium moisture content. The levels of organic carbon and overall organic matter were found to be significantly high.

In 2017, Dangi and Sharma discovered that the levels of orthophosphate in Lake Pichhola were significantly elevated (ranging from 0.05 to 1.25 mg/l), surpassing the critical threshold. The lake exhibited high electrical conductance and total dissolved solids, indicating that it could be classified as eutrophic. Overall, the quality of water of Lake Pichhola turned out to be severely polluted.

Choubisa and Dubey in the year 2017 studied the physico-chemical characteristics of Kishore Sagar lake, Kota. According to the study the lake water showed higher values of Turbidity (10.91 NTU), TDS (311 mg/l), pH (8.67) and EC (293 µS/cm) and comparatively low average dissolved oxygen (6.93 mg/l). These high values contributed to high productivity of lake and therefore the lake was categorized as mesotrophic. With respect to phytoplankton study, 17 species of Cynophyceae group, 8 species of Chlorophyceae group and 8 species of Bacillariophyceae were reported.

Pareek et al. (2018) examined the limnological characteristics of the Ghaggar River. Their findings indicated a significant change in water color, attributed to several factors, including high electrical conductivity (EC) of 1285 mhos/cm due to ionized inorganic compounds. The total dissolved solids (TDS) ranged from 302 to 1275 mg/l, indicating normal salinity, while alkalinity averaged 261.25 mg/l, and biochemical oxygen demand (BOD) levels were measured at 6.29 mg/l. The Ghaggar River was found to be polluted from unidentified sources, leading to turbidity and TDS levels exceeding permissible limits.

In 2018, Sharma and Sharma conducted a study on the water quality of Lake Pushkar. They found that the lake was heavily polluted, exhibiting elevated levels of total dissolved solids (TDS), chlorides, electrical conductivity (EC), alkalinity, pH, phosphates, biochemical oxygen demand (BOD), and turbidity during December. This pollution was linked to the religious activities carried out by visitors at this sacred site. Additionally, the dissolved oxygen levels were notably low at 5.04 mg/l, while microbial concentrations were very high at 85 MPN per deciliter.

Gothwal and Gupta in the year 2018 investigated Nakki Lake in Mount Abu and reported that the water was alkaline, with an alkalinity of 102.16 mg/l and a pH of 7.08. Other limno-chemical values indicated low mean levels, including total dissolved solids (161.83 mg/l), chloride (109.73 mg/l), and hardness (95.66 mg/l). The mean level of dissolved oxygen was recorded at 5.75 mg/l, while average levels of nitrate and sulfate were 31.19 mg/l and 123.73 mg/l, respectively. According to these findings, Nakki Lake was classified as eutrophic.

In a study by Gothwal and Gupta (2019), Sant-Sarover Pond in Mount Abu exhibited low average values for several parameters, including hardness at 104.83 mg/l and total dissolved solids (TDS) at 142.0 mg/l. The water was found to be optimally alkaline, with a pH of 7.12 and alkalinity measured at 98.50 mg/l. The Secchi disc depth was recorded at 80 cm. Mean levels of nitrates and sulfates were 28.57 mg/l and 122.28 mg/l, respectively, and dissolved oxygen averaged 5.45 mg/l. On the basis of these limno-chemical characteristics, Sant-Sarover Pond was classified as eutrophic. Regarding phytoplankton, the study identified 19 species of algae, including 9 species from the Chlorophyceae group, 3 species from Xanthophyceae, 3 species from Myophyceae, and 3 species from Desmidiaceae.

Meena and Bareth (2019) investigated several limnological characteristics of Sambhar Lake. Their research indicated that rising water temperatures and increased carbon dioxide levels led to a decrease in dissolved oxygen. These changes created favorable conditions for a specific phytoplankton species, *Dunalialla salina*, promoting a balanced ecosystem.

Shwetanshumala et al. (2019) conducted a study on the Nandeshwar Dam in Udaipur, Rajasthan, and reported that the pH levels ranged from 7.13 to 8.53. The depth of visibility was found to vary between 34.47 cm and 63.27 cm, while dissolved oxygen levels fluctuated between 7.07 mg/l and 9.07 mg/l. Carbonate alkalinity was recorded in the range of 26.77 mg/l to 44.23 mg/l, and bicarbonate levels varied from 47.83 mg/l to 57.30 mg/l. Total alkalinity was recorded in the range of 75.13 mg/l and 101.27 mg/l. The average electrical conductivity was measured between 0.133 and 0.480 mS/cm, while total dissolved solids averaged between 85.33 mg/l and 309.33 mg/l. Nitrate-nitrogen levels were recorded amidst 0.043 mg/l and 0.099 mg/l, and the average orthophosphate concentration varied from 0.055 mg/l to 0.150 mg/l.

Vashishtha et al. (2020) evaluated the water quality of Goverdhan Sagar Lake in Udaipur. During their investigation, the mean values for water quality examination were as follows: temperature at 28.6 °C, with a disagreeable color and odor, pH of 9.0, electrical conductivity (EC) of 735 mS/cm, biochemical oxygen demand (BOD) at 3.8 ppm, chemical oxygen demand (COD) at 42.3 ppm, dissolved oxygen at 5.3 mg/l, nitrates at 7.1 mg/l, alkalinity at 245.9 mg/l, total hardness at 30.9 mg/l, calcium at 7.9 mg/l, magnesium at 23.0 mg/l, chloride content at 161.7 mg/l, fluoride content at 0.5 mg/l, and a total coliform count of 350 MPN/100ml. The study concluded that Goverdhan Sagar Lake has abundant nutrients and alkalinity, making it suitable for fishery purposes.

In 2020, Sharma and Shrivastava conducted a study on Badrana Johra in Laxmangarh and the Sadul branch of the Sirhind feeder canal in Hanumangarh. Their limnological analysis indicated that both water bodies were alkaline, hard, and well oxygenated. The transparency of the lotic water remained consistent throughout the study period, while the lentic water exhibited more variability. Notably, the lentic water was found to be more alkaline than the lotic water. Furthermore, the average values of electrical conductivity, dissolved oxygen, and hardness in the canal water were higher than those in the pond water. The study concluded that environmental factors and the limnological parameters significantly influence the quality of water.

Saraswat and Mathur (2021) conducted a study on the zooplankton diversity in Guda Bishnoiyan Pond in Jodhpur. They observed that the highest zooplankton population occurred in June 2019, with a count of 222,083 individuals per liter, while the lowest was recorded in October 2019, at just 11.11 individuals per liter. The dominance of zooplankton groups was ranked as follows: rotifers (62.37%), copepods (16.99%), cladocera (13.02%), and ostracods (7.6%). The average values for the Shannon-Wiener index, Simpson index, species evenness, species richness index, and Simpson dominance index were measured at 0.95, 0.47, 0.65, 0.68, and 0.53, respectively.

Qureshi and Dube (2021) investigated the cyclic fluctuations in physio-chemical parameters of Chandrasarovar Pond in Jhalawar. Their findings revealed that 90% of the samples for total dissolved solids, 46.6% for sodium, 90.6% for conductivity, and 91.4% for potassium exceeded the tolerable limits set by the WHO and Indian Standards for potable water.

Pachori (2022) conducted a comparative analysis of the chemical parameters of two lakes in Dungarpur District, namely Varanda and Ankarsol Ka Naka. The findings revealed that Ankarsol Ka Naka had a higher dissolved oxygen level of 6.8 mg/l, compared to Varanda's 5.6 mg/l. Additionally, Ankarsol Ka Naka exhibited a lower fluoride concentration at 0.05 mg/l, whereas Varanda had a higher level of 0.35 mg/l. The calcium concentration in Ankarsol Ka Naka was also lower, recorded at 28.0 mg/l, compared to 60.0 mg/l in Varanda. Both water bodies showed no significant nitrate content.

Chisty and Choudhary (2022) examined several ponds within the Berach River system, focusing on phytoplankton diversity and production. Their study identified 47 phytoplankton forms, including Chlorophyceae (17), Bacillariophyceae (14), Myxophyceae (10), Desmidiceae (3), Chrysophyceae (2), and Dinophyceae (1). Udaisagar Lake exhibited the highest gross primary production at 1.87 gc/m²/day, and it also recorded the greatest average phytoplankton density, measuring 4222.67 individuals per litre.

Choudhary et al. (2022) conducted a study on Kalyana Lake in Jodhpur, measuring various physico-chemical parameters. The recorded temperature fluctuated between 28.50°C to 31.50°C, while the mean visibility was 102.13 cm. The pH levels varied between 7.78 and 8.38, and electrical conductivity measured between 309.50 and 351.25 µS/cm. Dissolved oxygen concentrations were found to be between 7.50 and 8.90 mg/L, total alkalinity fluctuated between 24.75 to 28.25 mg/L, and total hardness varied between 140.00 and 166.50 mg/L. Total dissolved solids were recorded at levels from 199.00 to 226.50 mg/L, with nitrate concentrations ranging from 0.42 mg/L to 0.49 mg/L and phosphate levels between 0.26 mg/L and 0.34 mg/L. The lake's average primary productivity was measured at 0.30 gCm^3h^{-1} for gross primary productivity (GPP), 0.16 gCm^3h^{-1} for Net Primary Production (NPP), and Community Respiration (CR) across all stations was 0.13 gCm^3h^{-1}.

In 2022, Sharma et al. conducted a study on Annasagar Lake in Ajmer, Rajasthan, to evaluate the water quality and primary productivity of the lake. The researchers recorded various physico-chemical parameters, including temperature (ranging from 24.50°C - 33.90°C), pH (from 7.9 - 8.2), electrical conductivity (2.07 - 2.49 mS/cm), and dissolved oxygen (between 7.53 - 8.73 mg/L). They also measured total alkalinity (101 -109 mg/L), total hardness (121 - 150 mg/L), and total dissolved solids (ranging from 1344.00 - 1617.00 mg/L). Nitrate levels were found to be between 0.88 mg/L and 1.02 mg/L, while phosphate levels ranged from 0.67 mg/L - 0.76 mg/L. The average visibility during the study period was recorded at 48.92 cm. Based on their findings, the lake was classified as severely polluted and in a hyper-eutrophic condition, primarily due to anthropogenic activities in the surrounding area that contribute waste to the water.

Choudhary et al. (2023) assessed the limnological status of small rain-fed reservoirs in Nagaur district (Rajasthan, India). They measured various physical and chemical parameters, including odor, pH, carbonate and bicarbonate hardness, Total Dissolved Solids, Total Hardness, and Total Alkalinity. Additionally, organic characters like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and organic matter were analyzed. The Palmer Pollution Index was utilized for assessing the pollution levels by identifying algal and phytoplankton species. The findings indicated that one such metro regions, Jada Talab situatedin Nagaur city, exhibited poor status of water. In contrast, the village ponds showed significantly good water status during the rainy and winter seasons, although phytoplankton analysis in summer revealed deteriorating water quality.

Roat et al. (2023) examined Patela pond in southern Rajasthan to explore the connections between hydrological parameters, plankton communities, and fish populations. The survey identified 37 distinct phytoplankton species, with genera from Chlorophyceae and Cyanophyceae being more prevalent than those from Bacillariophyceae and Desmidiaceae. Additionally, 28 different zooplankton forms were documented, belonging to the phyla Copepods, Rotifers, Cladocerans, and Protozoa. The study measured various physico-chemical parameters from November 2022 to October 2023, including water temperature (ranging from 17.75°C to 42.15°C), pH (7.8 to 8.6), free CO2 (1.09 ppm to 3.48 ppm), dissolved oxygen (5.1 to 5.7 mg/l), nitrate levels (0.38 ppm to 0.95 ppm), and alkalinity (0.87 to 0.92).

Tak et al. (2023) examined Pushkar Lake in Ajmer, discovering that the lake faces rising levels of Biochemical Oxygen Demand (BOD), water hardness, alkalinity, fluoride, chlorine, and nitrate due to the influx of lakhs of visitors who bath and engage in various religious processes throughout the year. The Water Quality Index (WQI) values fluctuated between 94.67 and 124.01, indicating that the water is unsuitable for drinking purposes.

Gothwal (2023) conducted an investigation of Nakki Lake, focusing on annual data regarding the lake's limnological parameters from 2017 to 2019. This analysis aids in assessing the water's potability, as well as determining pollution and eutrophication levels. Such evaluations are crucial for maintaining appropriate water quality standards to support a healthy aquatic ecosystem. The study found that the average pH of Nakki Lake's surface water during the summer season was 7.06, while the bottom surface water recorded a pH of 7.12. The average Hazen scale values observed for Nakki Lake were between 0.64 and 0.68 in summer, 0.69 to 0.72 during the rainy season, and 0.62 to 0.61 in winter. The total alkalinity was found to range from 89.67 to 108.67 mg/l.

In 2024, Singodia et al. investigated the water quality of Kot Dam in Rajasthan, utilizing a water quality index. This

index was derived from different physico-chemical characteristics, like pH, total dissolved solids, hardness, alkalinity, dissolved oxygen, biological oxygen demand (BOD), chlorides, phosphates, nitrates, and conductivity. The findings indicated that the water was contaminated, primarily due to agricultural runoff and pollutants introduced by local communities, with organic pollutants being more prevalent during the summer and monsoon seasons. The recorded water quality indices for the two seasons were 87.18 and 85.38, respectively.

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