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Assessment of Total Hardness, pH, and Chemical Oxygen Demand in Selected Urban Lakes of Bengaluru, India

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Abstract

This study aims to assess the physicochemical quality of nine urban lakes in Bengaluru and nearby regions using total hardness, pH, and chemical oxygen demand (COD) as key indicators of chemical condition and pollution pressure. Rapid urbanization, untreated sewage inflow, industrial discharge, and surface runoff have increasingly degraded lake water quality in the region, highlighting the need for systematic chemical assessment. Total hardness reflects the concentration of dissolved calcium and magnesium ions derived from geological formations and anthropogenic sources and influences alkalinity balance, scaling tendency, and overall chemical stability. COD represents the amount of organic and oxidisable matter present and is widely used to evaluate pollution arising from sewage discharge, industrial effluents, and urban runoff. pH governs the acid–base balance of aquatic systems and strongly affects chemical reactions, metal solubility, nutrient availability, and biological processes. Water samples were collected from all nine lakes and analyzed using standard laboratory methods. Total hardness was determined by EDTA titration, COD by the dichromate reflux method, and pH using an electrometric approach. The results revealed considerable spatial variation among the lakes. Total hardness values ranged from 22to190mg/L, pH varied between 6.9and 7.8 and COD levels ranged from 7.0 to 10mg/L, indicating differing degrees of mineral enrichment and organic pollution. Elevated hardness suggests increased mineral dissolution and domestic or agricultural inputs, while high COD values indicate significant organic contamination and oxygen-demanding processes. These findings support the need for regular monitoring and lake specific management strategies to ensure sustainable urban lake use..

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1.Introduction

Freshwater lakes play an important role in meeting domestic water needs, supporting irrigation and industry, recharging groundwater, and maintaining ecological balance in urban environments.

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In rapidly developing cities such as Bengaluru, continuous urban expansion, population growth, untreated sewage inflow, and surface runoff have placed considerable stress on lake ecosystems. As a result, the quality of lake water in many parts of the city has gradually declined, making regular assessment of water quality increasingly necessary.

Water quality is commonly evaluated using physicochemical parameters that reflect both

natural processes and human influence. Among these, total hardness, chemical oxygen demand (COD), and pH are widely used indicators to understand the chemical condition of freshwater systems. Total hardness mainly represents the presence of calcium and magnesium ions, which originate from geological weathering as well as anthropogenic sources such as domestic wastewater and agricultural runoff. Changes in hardness can affect scaling behavior, alkalinity balance, and metal solubility, and may also provide insight into catchment characteristics and pollution pathways.

Chemical oxygen demand (COD) is a useful parameter for estimating the amount of organic and oxidisable matter present in water. It indicates the quantity of oxygen required for the chemical oxidation of organic substances and is commonly expressed in mg/L. COD analysis is frequently applied to surface waters such as lakes and rivers, as well as wastewater, to assess the impact of organic pollution[1–3]. Higher COD values generally suggest increased organic loading from sources such as sewage discharge, decaying vegetation, industrial effluents, and urban runoff, which can negatively affect dissolved oxygen availability and aquatic life.

The pH of water is another critical factor that controls the acid–base balance of aquatic systems and influences chemical reactions, nutrient availability, and biological activity. In most natural freshwater bodies, pH values lie between 6.5 and 8.5. Deviations from this range are often associated with anthropogenic disturbances, including sewage inflow and industrial discharges, and can alter the chemical behavior of lake water [4–6].

Although several studies have examined individual water quality parameters, comprehensive and comparative evaluation of hardness, pH, and COD across multiple urban lakes in Bengaluru is still limited. Given the increasing anthropogenic pressure on these water bodies, there is a clear need for integrated assessment using key physicochemical indicators.

Therefore, the present study aims to evaluate and compare the total hardness, pH, and chemical oxygen demand of selected lakes in and around Bengaluru to assess their chemical quality and pollution status using standard laboratory methods.

The results of this study provide baseline information that may be useful for future monitoring and management of urban lake systems [7–10].

2. Methodology

2.1 Sample Collection and Preservation

Water samples were collected from selected urban lakes in Bengaluru and nearby regions. Sampling was carried out during the morning hours (08:00–10:00 h) to minimize diurnal variation. Samples were collected from approximately 30–50 cm below the surface at each site using pre-cleaned polyethylene bottles (1 L capacity). Prior to sampling, bottles were rinsed three times with site water. Samples for chemical oxygen demand (COD) analysis were preserved by acidification with concentrated sulfuric acid to pH < 2 and transported to the laboratory in an ice box. All analyses were completed within 24 hours of collection, following standard protocols.

2.2 Determination of Chemical Oxygen Demand (COD)

COD was determined using the dichromate reflux titrimetric method as described in APHA Standard Methods for the Examination of Water and Wastewater.

A 25 mL aliquot of the water sample was transferred into a conical flask. To this, 5 mL of standard potassium dichromate ($K_2Cr_2O_7$) solution and 10 mL of 1 N sulfuric acid (H_2SO_4) were added. The mixture was allowed to react, followed by titration with standard ferrous ammonium sulfate (FAS) using ferroin indicator. The endpoint was indicated by a color change from bluish-green to reddish-brown.

A blank titration was performed using 25 mL of distilled water under identical conditions. COD was calculated and expressed as mg/L using the standard formula:

$$\text{COD (mg/L)} = \frac{(A - B) \times N \times 8000}{V}$$

Where:
A = volume of FAS used for blank (mL)
B = volume of FAS used for sample (mL)
N = normality of FAS
V = volume of sample (mL)

2.3 Determination of Total Hardness

Total hardness was estimated by the EDTA titrimetric method following APHA guidelines. A 25 mL water sample was taken in a conical flask, to which 1–2 mL of ammonium buffer solution (pH 9–10) was added. A small amount of Eriochrome Black T (EBT) indicator was introduced, producing a wine-red color. The solution was titrated against standard EDTA solution until the color changed from wine-red to clear blue, indicating the endpoint.

$$\text{Total Hardness (mg/L as } CaCO_3) = \frac{V_{EDTA} \times M_{EDTA} \times 1000}{V_{sample}}$$

where V_{EDTA} is the volume of EDTA used (mL), M_{EDTA} is the molarity of EDTA, and V_{sample} is the volume of the sample (mL).

Total hardness was calculated and expressed as mg/L of $CaCO_3$.

2.4 Determination of pH

pH was measured using a calibrated digital pH meter following standard procedures. The instrument was calibrated using standard buffer solutions of pH 4.0, 7.0, and 9.2 prior to analysis. Measurements were recorded at room temperature.

3. Results and Discussion

The physicochemical characteristics of water samples collected from nine lakes in and around Bengaluru are summarized in Table 1.

Total hardness values varied across the lakes, ranging from 22 to 190 mg/L (ppm) as $CaCO_3$. Lower hardness values were observed in Lalbagh, Yediyur, and Ulsoor lakes, while higher values were recorded in Kommaghatta and Cubbon Park lakes (Fig 1). These results indicate differences in mineral content among the selected lakes.

The pH of the water samples ranged from 6.9 to 7.8, indicating slightly acidic to mildly alkaline conditions. Most lakes exhibited pH values within the generally acceptable range for freshwater ecosystems. Similar pH values were observed for Ulsoor, Hesaragatta, and Banavara lakes (Fig 2).

The chemical oxygen demand (COD) values ranged from 7 to 10 mg/L. Lower COD values were observed in Yediyur and Kommaghatta lakes, while relatively higher values were recorded in Banavara and Koduru lakes (Fig 3). Overall, COD values showed limited variation among the lakes studied.

The observed variation in total hardness among the lakes may be influenced by differences in local geology, catchment characteristics, rainfall patterns, and anthropogenic activities. Lower hardness values in certain lakes could be attributed to dilution effects caused by rainfall and surface inflow, whereas higher hardness levels may result from mineral dissolution and urban runoff. Although some lakes exhibited comparatively higher hardness values, they remained within ranges generally considered acceptable for freshwater use.

The pH values recorded in the present study suggest relatively stable acid–base conditions across the lakes. Near-neutral to slightly alkaline pH is typically favorable for aquatic organisms. Minor differences in pH among lakes may be associated with biological activity, surface runoff, and variations in buffering capacity.

Chemical oxygen demand (COD) provides an estimate of the organic load present in water. The relatively low COD values observed indicate a limited presence of oxidisable organic matter at the time of sampling. However, COD alone does not provide a comprehensive assessment of pollution, as it does not account for microbial contamination or nutrient enrichment. Variations in COD may be influenced by surface runoff, decaying organic matter, and localized anthropogenic inputs.

Table 1: Total hardness, pH, COD

Lake	Total Hardness (mg/L as $CaCO_3$)	pH	COD (mg/L)
Lalbagh	22	7.5	8
Ulsoor	90	7.2	9
Yediyur	70	7.4	7
Hesargatta	125	7.3	9
Banavara	162	7.2	10
Koduru	107	7.8	10
Kommaghatta	185	7.7	7.7
Anchepalya	123	6.9	8
Cubbon park	190	7.4	9

Urban lakes are often affected by domestic sewage and industrial effluents. While the present results suggest comparatively low COD levels in the selected lakes, water quality conditions can

vary with season, rainfall, and human activity. Therefore, the findings represent a snapshot of the chemical condition of the lakes and highlight the need for continued monitoring using additional parameters.

Table 1 presents a comparative overview of total hardness, pH, and chemical oxygen demand for the nine lakes studied. Among the lakes, Lalbagh exhibited the lowest total hardness (22 mg/L as $CaCO_3$), while Cubbon Park (190 mg/L) and Kommaghatta (185 mg/L) showed the highest hardness values, indicating greater mineral enrichment. Lakes such as Yediyur (70 mg/L) and Ulsoor (90 mg/L) displayed moderate hardness levels. The pH values across the lakes remained within a narrow range, with Anchepalya recording the lowest pH (6.9) and Koduru showing the highest pH (7.8), suggesting generally stable acid–base conditions.

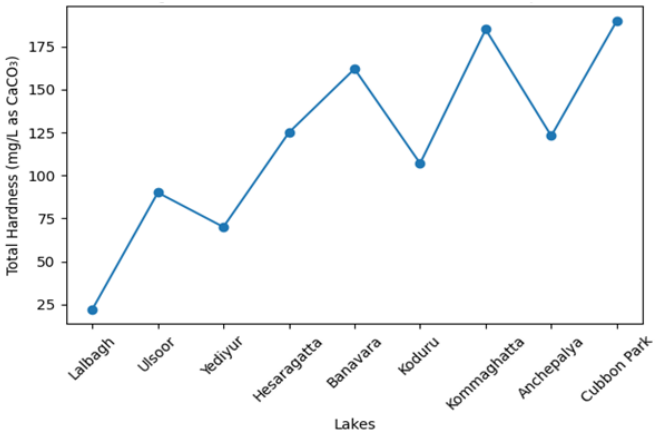

Fig 1. Total hardness of Lake Water Samples

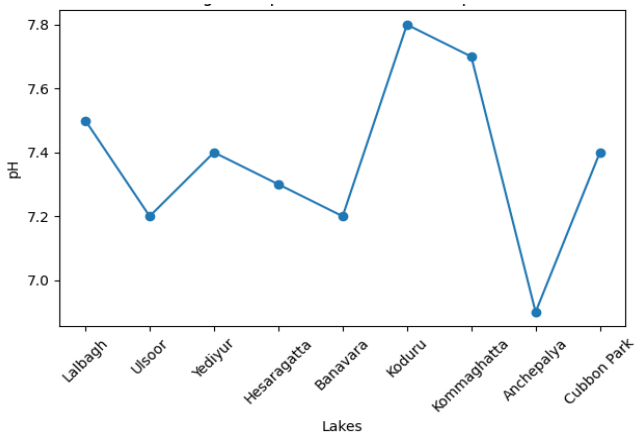

Fig 2. pH of Lake Water Samples

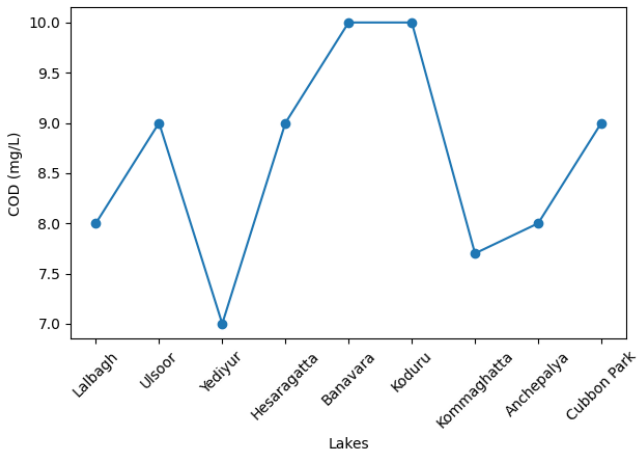

Fig 3. COD of Lake Water Samples

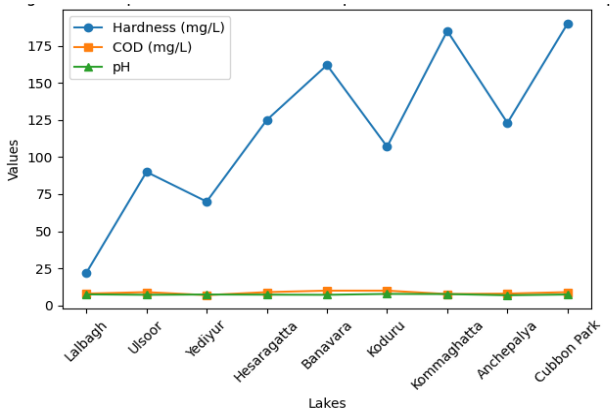

Fig 4. Comparison of Total hardness, pH and COD of Lake Water Samples

Chemical oxygen demand values showed comparatively limited variation, ranging from 7 mg/L in Yediyur to 10 mg/L in Banavara and Koduru, indicating differences in organic load among the lakes. Overall, the comparative data in Table 1 highlight noticeable spatial variation in hardness and COD across the lakes, while pH values remained relatively consistent.

Conclusion

This study evaluated the water quality of nine lakes in and around Bengaluru using selected physicochemical parameters, namely total hardness, pH, and chemical oxygen demand (COD). The findings indicate that pH values across all sampled lakes remained within the acceptable range for surface waters, reflecting near-neutral conditions. Total hardness exhibited site-specific variation, with Lalbagh, Yediyur, and Ulsoor lakes recording comparatively lower hardness levels than the other locations, suggesting differences in geological influence and anthropogenic inputs. COD values for all samples

were below 10 mg/L, indicating a low concentration of chemically oxidizable organic matter at the time of sampling.

All measured parameters were found to be within the permissible limits specified by the Bureau of Indian Standards (BIS: IS 10500) and the water quality guidelines prescribed by the Karnataka State Pollution Control Board (KSPCB). However, the assessment of overall water quality is constrained by the limited number of parameters considered in this study. Critical indicators such as microbial load, nutrient enrichment, and heavy metal contamination were not included, and the influence of seasonal variations was not examined.

Consequently, while the results suggest acceptable physicochemical conditions for the parameters analyzed, they are insufficient to conclusively rule out contamination from domestic sewage, industrial discharges, or biological sources. Future studies should incorporate microbial indicators, nutrient analysis, heavy metal assessment, and multi-seasonal monitoring to enable a comprehensive and reliable evaluation of lake water quality and pollution status.

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