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Quality of Lake Water in Bangalore and Subterrain Aquifers Recharge.

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Abstract

Lakes are critical freshwater ecosystems that sustain biodiversity, regulate hydrological cycles, and support urban life. Bangalore, located on the southern Indian Deccan plateau, historically relied on a network of man-made lakes for water supply and aquifer recharge. However, rapid urbanization and industrialization have led to severe lake degradation through domestic and industrial waste discharge. This review compiles data from 2000–2022 on the water quality of major lakes—Madiwala, Varthur, Bellandur, and Hebbal—and evaluates their role in groundwater recharge. Physico-chemical and microbial analyses reveal high BOD (up to 56 mg/L), heavy metal contamination, and unsafe coliform levels, indicating critical ecological imbalance. The study highlights the potential of phytoremediation and biomanipulation as sustainable restoration approaches. Strengthening urban lake management policies and integrating biodiversity-based monitoring are essential for restoring Bangalore's freshwater systems and ensuring long-term water security.

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Bangalore Lakes; Biomanipulation; Eutrophication; Groundwater Recharge; Lake Pollution; Phytoremediation; Urban Water Sustainability.

Abbreviations

DO	Dissolved Oxygen
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TDS	Total Dissolved Solids
EC	Electrical Conductivity
MLD	Million Litres per Day
LPCD	Litres per Capita per Day
GIS	Geographic Information System
BBMP	Bruhat Bengaluru Mahanagara Palike
BWSSB	Bangalore Water Supply and Sewerage Board

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Introduction

Bangalore's heritage reflects a strong legacy of water management, earning it the title "Land of a Thousand Lakes." From Kempegowda's early tanks—Dharmambudhi, Kempambudhi, and Sampangi—to British-built reservoirs like Sankey Tank, the city developed a thriving microclimate sustained by interconnected lakes and valleys such as Hebbal, Koramangala, and Vrishabhavathi. These systems once supported domestic and agricultural needs, with over 600 lakes recorded in the 1986–87 Minor Irrigation census.[1] However, rapid urban expansion and piped water supply led to the neglect of lakes and their feeder channels (rajakaluves).[2] Encroachments, solid waste dumping, and industrial effluents have since disrupted drainage and degraded water quality. Bangalore now generates nearly 5000 metric tonnes of waste daily, with about 37% entering lakes through storm drains.[3] Despite interventions like BWSSB's 2007 sewage integration, poor management continues to threaten the city's once self-sustaining hydrological network.[1]

1) Dharmambudhi lake converted to Kempegowda bus station, 2) Akkitimmanahalli lake to Hockey Stadium, 3) Sampangi Lake to Kanteerava Sports Complex, 4) Challaghatta lake to Karnataka Golf Association, 5) Sholay Lake to Football stadium, 6) Koramangala lake to National games complex, 7) Siddikatte lake to K.R.Market, 8)Karanji tank to Gandhibazaar, 9) Nagashettihalli lake to Ambedkar Medical Collect, 10) Domulur lake to BDA layout, 11) Millers lake to Gurunanak Bhavan Badminton stadium, 12) Subhashnagar lake, 13)Kuruburahalli lake, 14) Kodihalli lake, 15) Sirivaigalu lake, 16) Marenahalli lakes to residential layouts etc. In the months of June and July 2010, lake samples were tested at the Laboratory of the Directorate of Mines and Geology for standard parameters including temperature, hydrogen ion concentration (pH), aqua dissolved oxygen, aqua total dissolved solids, heavy metals, microbiological. Spot temperature and pH study revealed that 23 of the 96 lakes samples tested were significantly polluted with heavy metals and coliform bacteria, indicating that they were unsafe for consumption.[4]

Peeking into Bangalore's water crisis, the city's rapid expansion has increased the city's water demand, with the average BWSSB pumping 1,500 MLD (million litres per day) from the Kaveri River, unevenly distributed among the population of over 10 million. It is estimated that 4,444 city dwellers have access to 75 LPCDs, but international standards suggest that citizens such as Bangalore residents need access to around 150,200 LPCDs.[5] Indian standard guideline for fresh drinking water is : pH range from 6.5 to 8.5, turbidity 1-5, Total dissolved solute (TDS) 500-2000 mg/l, aluminium 0.03 to 0.2 mg/l, ammonia 0.5 mg/l, anionic detergents 0.2 to 1 mg/l, Barium 0.7 mg/l, Boron 0.5 to 1 mg/l, calcium 75 to 200 mg/l, chloramines 4 mg/l, chlorides 250 to 1000 mg/l, copper 0.05 to 1.5 mg/L, fluoride ranging between 1–1.5 mg/L, residual chlorine from 0.2–1 mg/L, iron up to 0.3 mg/L, magnesium 30–100 mg/L, manganese 0.1–0.3 mg/L, mineral oil 0.5 mg/L, nitrate 45 mg/L, phenolic compounds 0.001–0.002 mg/L, selenium 0.01 mg/L, silver 0.1 mg/L, sulphate 200–400 mg/L, sulphide 0.05 mg/L, and zinc ranging from 5 to 15 mg/l, Total alkalinity as calcium carbonate 200 to 600 mg/l, and Total hardness as calcium carbonate 200 to 600 mg/l.6 This demand for water has led the government to think of the lake as a resource. The vast community of irrigation reservoirs was built in the 13th and 19th centuries and became a major refuge for both native and migratory waterfowl. They had huge flora in the catchment: A larger part of biodiversity is under constant pressure. Some of them are pre-equipped with temple aquariums that strictly protect fish, turtles, and various biomes. Most of this sacred water was our bio reservoir, but we do not enjoy such safety now. Large reservoirs built in the last century have been biologically depleted. All these waters are generally home to a small number of farmed fish species, including catla and tilapia.7 We will also see the important role lakes play in terms of their contribution to diversity, subterranean recharge points and water cycle.

Materials and Methods

This review synthesizes published research articles, government reports, and environmental assessments related to Bangalore's lakes. The purpose of this section is to establish a structured analytical framework to evaluate the physico-chemical, microbial, and ecological conditions of major lakes and their contribution to groundwater recharge.

Sources of Data

Information was compiled from peer-reviewed journal articles, government environmental reports (GoK 2003, 2008, 2015, 2019), and field-based studies that assessed the physicochemical and biological characteristics of Bangalore's lake systems.

Inclusion Criteria

- Studies between 2000 and 2022
- Research specifically focused on lakes within Bangalore urban and peri-urban regions.
- Articles addressing lake water quality, pollution, biodiversity, or groundwater recharge.
- Reports containing measurable physico-chemical, microbial, or ecological parameters.

Parameters Analysed

Physico-chemical

pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), heavy metals (Ni, Cd, Cr, Pb)

Microbial

Total coliforms, *E. Coli, Enterococcus* spp.

Ecological

phytoplankton and zooplankton diversity, macrophyte distribution, avifauna and fish population diversity

Recharge - Related

aquifer classification, soil permeability, percolation rate, GIS based groundwater recharge modelling.

The gathered datasets were comparatively analyzed to identify pollution trends and ecological responses across multiple lakes. Where applicable, results were benchmarked against the findings were compared with the standards prescribed by the Bureau of Indian Standards (BIS, 2012) and the World Health Organization (WHO) for evaluating water quality. This comparative synthesis approach enabled the evaluation of Bangalore's lake health and their functional linkage to sub-surface aquifer recharge.

Emphasis on Lake Waters

Assessment of few large lake water analysis are as follows: Madiwala lake: Madiwala lake assed in 2018 during the period of festival, test was performed before and after the festival. It was found that the pH varies from 7.15 to 6.2, electrical conductivity between 1 to 1.32 dSm^{-1}, the important metals such as calcium, copper, ferrous, zinc manganese, magnesium ranged between 1.6 to 9.31 $meqL^{-1}$, 0.018 to 0.039 ppm, 0.745 to 1.386 ppm, 0.108 to 0.193 ppm, 0.16 to 0.45 ppm 0.8 to 4.6 $meqL^{-1}$[8] and heavy metals such as nickel, chromium, cadmium and led ranging between 0.001 to 0.0056 ppm, 0.0012, 0.0020, 0.0029 analysed through atomic absorption spectroscopy shows the increase contamination of lake water.[9] Adding the microbial assessment of lake water through membrane filter technique and the most probable number (MPN) analysis indicated the occurrence of coliform bacteria, including *E. coli*, *Enterobacter aerogens*, and *Enterococcus fecalis* with high number to be 38. The standard safe for drinking is 4 coliforms per 100 ml, and 2 *Enterococcus* bacterial colonies per 100 ml of the sample.[8,30]

Varthur Lake

Lakes fall into three different series of Bangalore valleys, and they are interconnected to support and thrive. Varthur is the second largest lake in Bangalore, in 2015 assessment of the water showed high contamination and pollution due to untreated sewage entry of approximately 500 MLD and industrial effluents. The sample analysis is as follows: temperature 27.1ºC, TDS 448 mg/l, EC 749 µS, pH 7.46, DO 2.6 mg/l, BOD 24.39 mg/l, COD 40 mg/l, Alkalinity 336 mg/l, Chloride 117.86 mg/l, Total hardness 206 mg/l, phosphates 1.263 mg/l, Nitrate 0.541 mg/l, sodium 169.5 mg/l, potassium 35 mg/l. The nitrates had reduced due to high bacterial and algae growth, with increased foaming of the lake water with pungent odour and death of aquatic life. Over growth of macrophytes belonging to Eichhornia spp., Alternanthera sp., Typha sp., Lemna sp.; Algae from Chlorophyceae, Cyanophyceae, Bacillario-phyceae, Euglenophyceae were high in number.[10] 2020 microbial assessment of lake water presented information of 197 types of bacteria, out of which 31 were pathogenic and 17 were opportunistic pathogens, 5 commensal, 1 zoonotic bacterium and 8 true pathogenic bacteria.[11]

Bellandur Lake

Physio-chemical investigation of lake water was performed for the parameters colour, odour, pH, temperature, turbidity, total alkalinity, TDS, calcium, magnesium, chlorides, sulphates, nitrates, DO, BOD, COD. A high pollution contamination of the lake water ignited fire in 2017. The sample collection was in the early morning between 8am to 10 am, and test for three months on continuous manner between February and April. The observed temperature values varied between approximately 26.2 °C and 29.8 ºC, pH 7.2 to 7.63, turbidity 16 to 19.3 ntu, EC 1062 to 1196.6, TDS 689 to 776.62 mg/l, total hardness 269 to 336 mg/l, calcium 76 to 140 mg/l, magnesium 193 to 196 mg/l, sulphates 46 to 50.83 mg/l, nitrates 47 to 49 mg/l, chloride 178 to 190 mg/l, alkalinity 541 to 577 mg/l, DO(dissolved oxygen) 2.4 to 2.85 mg/l, BOD 51 to 56.4 mg/l, COD 143 to 146 mg/l. where TDS, COD, total hardness, chlorides, nitrate and turbidity were higher when compared to permissible limits.[12]

Lake Hebbal

Water Quality Index Assessment in 2019, 24 mg ... / l to 45.3 mg / l compared to the standard water acidity level of Lake (30 mg/L), non-uniform distribution of minerals due to ingress of water This caused the alkalinity distribution to fluctuate. TS, TSS, and TDS were within the standard range, and the overall hardness was also within the standard range of 70200 mg/L. In addition to these chlorides, sulphate, pH, and DO were within acceptable limits, but BOD was actually very high, from 35.8 mg/L to 115 mg/L, due to the increased amount of organic matter in the lake.[13] According to large lakes mentioned, studies show tremendous pollution, and drying and invasion of lakes has not only ravaged the lake's watershed, but also destroyed biodiversity through pollution and increased weeds.

Legitimate Indicators and Sanitation Methods

Biodiversity is constantly under pressure from lake catchments and water from human activities in and around lakes. Extensive irrigation lakes were built between the 13th and 19th centuries and played many roles in human life.[7] In 1985, there were 51 healthy lakes observed in Bangalore, and in 2008 the number was reduced to 17. The recorded biodiversity such as water snakes (non-venomous) are an excellent indicator of water quality, and about 9 species of them have been observed. From herbs to trees, 90 different floral patterns have been found to support the ecosystems in and around the lake area.[14] An average of 120 bird species belong to 19 families, a ccounting for 40% of the total bird population. These birds depended on lakes for habitat and survival.[15] Phytoplankton and zooplankton are the foundations of a complex wetland food chain, and between 1985 and 1995, the phytoplankton diversity decreased from 22 to 19 species, depleting these organisms dangerously. It poses a serious threat to environmental sustainability and the natural capacity of wetlands for restoration.[14] Other observed diversity was 10 species of crustaceans, 41 species of butterflies in 5 families, and 22 species of fish in 4 families. This biodiversity of living organisms from micro to macro represents the health and maintenance of food chains in these micro-ecosystems.[14,16] Lakesides are rich in endangered ecosystems and serve as an interface between terrestrial and aquatic systems, filtering sediment, nutrients and supporting other life. Geographical landscape has also been shown to influence bird colonies. Complex biodiversity has also contributed significantly to the natural purification processes occurring within the lake ecosystem.[14]

Phytoplankton and zooplankton serve a crucial function within the aquatic ecosystem with seasonal effect, during the monsoon season the dissolved oxygen is high in the surface and created anoxic zone at lakebed which favors Chlorophyceae and other planktons. Phytoplankton families are as follows: 27 species from Chlorophyceae, 1 species form euglenophyceae, 2 species from baclliariophyceae, 6 species from cyanophyceae, 1 species from Charophyceae and 1 species from Dinophyceae. The abundance of phytoplankton enabled optimum growth of fishes, a way to clean fresh water bodies where agricultural wastes flow into lake water by biomanipulation.[17] Similarly, the role of zooplankton is also affected by the seasonal cycles and is highly sensitive. Zooplankton families that fluctuated due to seasonal effect are as follows: 7 taxa belonging to the Rotifera group, six taxa of Cladocera, 5 taxa of Copepod, 2 taxa of Ostracoda. Cladocera taxa play a crucial role as nutritive group of crustaceans for higher member of fishes in the food chain, which can play role in biomanipulation for cleaning lake water.[18] Phytoremediation is gaining insights into current research trends for bioremediation of contaminated freshwater sources such as a lake. Organic chemical waste, heavy metals and heavy metals-based preservatives leach out through industrial effluents or product disposal in the lake. A natural approach to extract organic chemicals, heavy metals, and heavy metal-based preservatives such as bisphenol A, cadmium, cobalt, chromium, copper, ferrous, manganese, nickel led, zinc, arsenic, pentachlorophenol, and chromate copper arsenate through phytoremediation.[29] *Pistia stratiotes, Phalaris arudinacea, Typha angustifolia, two subspecies of Phragmites australis, Toxiphyllum barbieri, and Eichhornia crassipes*[19] have shown high potential uptake of these contaminants even in the stressed condition and implemented as biofilters for remediation.[20] An impactful method of treating biomanipulation in eutrophication lakes studied in China; they observed four steps to treat and control the pollution: 1) Screening the lake and its initial biomass was determined. 2) Reestablishing food web with currently disturbed food web due to pollution. 3) Implanting four different levels of organisms - submerged plants, fish, macrobenthos, and zooplankton communities. 4) Observe the development and growth, control the plant disease, change in animal communities, adjust their time to make them form a stable community in the food web. These steps reduced the total phosphate and nitrogen positively and allowed a reduction in eutrophication 3.

Subterrain Recharge

Bangalore consists major part of land space as wetland, and no natural lakes were observed; lakes/tanks were built by the rulers, developers, and the government in authority. To understand the role of groundwater recharge from the lake, one must consider classification, factors of water bodies and rate of water percolation based on the soil/geological features. Lakes in Bangalore are anthropogenic lakes according to Hutchinson (1957) classification.[21] Features to be considered are as follows: 1) depth of the lake, 2) size of the topographically defined basin, hydraulic conductivity, 3) connectivity with surficial aquifers, 4) thickness of unsaturated zone, 5) recharge rate to the surficial aquifer, 5) pore size of the lakebed.[22] Another factor is that the plantation density around water bodies matter as they also play a role in water percolation to groundwater recharge.[23] Type of aquifer in Bangalore is crystalline granite aquifer.[16] For ages surface, water and aquifers are described as independent bodies, as there is a development and increased research interest in understating the contribution of hydrological cycles it has provided insights but lack complete understanding. The process of aquifer recharge through the lake is called lacustrine groundwater recharge, also is influenced seasonally.[24] Precipitation is not the only source for groundwater recharge; studies have identified surface reservoirs such as lakes also contribute significantly to a certain type of groundwater.[2] Cyclative nature of water from subsurface to surface and vice versa investigation provides insight to model ground water interactions and velocities, it will also play a role is understanding seasonal recharge and discharge.[25] Research studies not including site-specific soil infiltration rates influence water percolation from the surface waters. The prediction of the geographical layer was prepared from LANDSATS picturing using the AreGIS method, soil composition consisting of quarts and dolerite act as a barrier for water movement. The study recorded data implied that water percolation was faster through larger pores in the soil; siltation played a role in the reduced inflow of groundwater recharge.[26]

Results

Lake Water Quality Findings

Madiwala Lake

pH dropped from 7.15 to 6.2 during festivals; heavy metals (nickel, chromium, cadmium, lead) increased; coliform count reached 38/100 mL (unsafe).

Varthur Lake

Received ~500 MLD untreated sewage; low DO (2.6 mg/L); BOD 24.39 mg/L; COD 40 mg/L; algae blooms and foaming with foul odour.

Bellandur Lake

Severe pollution (BOD 51–56 mg/L, COD ~145 mg/L); lake caught fire in 20Assessment of few large lake water analysis are as follow7 due to organic load and chemicals.

Hebbal Lake

BOD ranged 35–115 mg/L; though other parameters were within range, organic matter was high.

Biodiversity and Ecological Indicators

- Bangalore had 51 healthy lakes in 1985, reduced to 17 by 2008.
- Biodiversity observed: 9 species of water snakes, 90 floral species, 120 bird species, 22 fish species, 41 butterfly species.
- Phytoplankton diversity declined from 22 to 19 species (1985–1995).

- Seasonal variations in DO created stratification affecting Chlorophyceae and zooplankton.
- Cladocera and copepods supported fish populations, playing a role in biomanipulation.

Table 1: Comparative summary of key water quality parameters across major Bangalore lakes (data compiled from[8, 27,12,11,28]).

Lake	BOD (mg/L)	COD (mg/L)	DO (mg/L)	Coliforms (/100 mL)
Madiwala	10–25	30–45	3.2	38
Varthur	24	40	2.6	>30
Bellandur	51–56	145	2.5	>50
Hebbal	35–115	—	3.0	—

Pollution and Remediation Approaches

- Phytoremediation using *Pistia stratiotes*, *Eichhornia crassipes*, Typha angustifolia showed high heavy metal uptake.
- Biomanipulation (reintroducing submerged plants, fish, macrobenthos, zooplankton) in Chinese case studies reduced eutrophication.
- Bangalore lakes show potential for similar interventions but require consistent monitoring.

Subterranean Recharge

- Lakes In Bangalore Are Anthropogenic, Built Over Granite Aquifers.
- Recharge Depends On Soil Permeability, Connectivity With Aquifers, And Vegetation Density.
- Studies (Landsat + Gis) Indicate Siltation And Encroachment Reduce Recharge Capacity.
- Seasonal Recharge From Lakes Contributes Significantly To Groundwater Despite Reduced Efficiency.

Discussion

The analysis of Bangalore's major lakes—Madiwala, Varthur, Bellandur, and Hebbal—reveals severe degradation driven by rapid urbanization, domestic sewage inflow, and industrial waste discharge. Physico-chemical data show that BOD levels range between 24–56 mg/L and COD between 40–145 mg/L, far exceeding the BIS (≤3 mg/L and ≤10 mg/L respectively) as well as with the World Health Organization (WHO) permissible limits. Dissolved oxygen often drops below 3 mg/L, confirming organic overload and low self-purification capacity. Trace elements, including Ni (nickel), Cd (Cadmium), Cr (Chromium), and Pb (lead) were detected above safe limits in Madiwala and Bellandur Lakes.[8,12]

Ecological indicators further substantiate this deterioration. Biodiversity assessments show a reduction of healthy lakes from 51 in 1985 to 17 by 2008.[10] Phytoplankton diversity has declined from 22 to 19 species, accompanied by losses in zooplankton, fish, and avifauna populations.[17,14,1] High organic loading and eutrophication have led to algal blooms dominated by *Eichhornia, Lemna,* and *Typhaspecies*, altering trophic balance and accelerating habitat loss.

Comparative studies indicate that similar eutrophic conditions in China and Egypt have been mitigated through integrated biomanipulation and phytoremediation. Field trials demonstrate pollutant reductions of up to 80% in total phosphate and nitrogen via biomanipulation,[13] and heavy metal removal efficiencies between 70–90% using *Eichhornia crassipes* and *Pistia stratiotes*.[19,9] These approaches, when combined with catchment restoration and waste interception, could substantially improve Bangalore's lake water quality.

Groundwater interactions underscore the broader hydrological impact. Most Bangalore lakes, constructed over crystalline granite aquifers, contribute to lacustrine recharge where soil permeability and vegetation cover permit infiltration.[16,23] However, siltation and encroachments now obstruct percolation pathways, reducing recharge efficiency.[26,6] Integration of GIS-based recharge models with lake restoration programs could thus enhance both surface and subsurface water sustainability.

Overall, the findings highlight an urgent need for continuous monitoring of physico-chemical and biological parameters, adoption of ecosystem-based restoration, and stronger enforcement of waste management regulations. Linking biodiversity restoration with groundwater recharge modeling offers a holistic pathway for rebuilding Bangalore's hydrological resilience.[13]

Conclusion

Rapid urbanization and mismanagement have led to the deterioration of Bangalore's lake ecosystems, with 23 out of 96 sampled lakes showing heavy metal and coliform contamination. Physico-chemical analyses revealed high BOD (24–56 mg/L), COD (40–145 mg/L), and low dissolved oxygen (<3 mg/L), exceeding BIS and WHO standards. Microbial load, particularly *E. coli* and *Enterococcus* counts above 30–50 CFU/100 mL, confirm severe faecal contamination. Biodiversity assessments recorded a decline in phytoplankton diversity from 22 to 19 species and a reduction of healthy lakes from 51 (1985) to 17 (2008). Despite these alarming trends, restoration studies demonstrate that phytoremediation using *Eichhornia crassipes* and *Pistia stratiotes* can remove 70–90% of heavy metals, while biomanipulation can lower total phosphate and nitrogen levels. Strengthening monitoring frameworks, protecting catchment buffers, and integrating biodiversity-based restoration with groundwater recharge models are essential to ensure ecological resilience and sustainable freshwater security for Bangalore's future.

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Informed Consent Statement

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Permission to Reproduce Material from Other Sources

Not Applicable

Author Contributions

The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing, and final approval of the manuscript.

References

1. Singh UV, Hebale D. Lakes: The heritage of Bengaluru through birds' eye. *Research & Reviews: Journal of Ecology and Environmental Sciences.* 2019;7(3):26–38. https://www.rroij.com/open-access/lakes-the-heritage-of-bengaluru-through-birds-eye.pdf
2. Wakode HB, Baier K, Jha R, Azzam R. Impact of urbanization on groundwater recharge and urban water balance for the city of Hyderabad, *India. Int Soil Water Conserv Res.* 2018;6(1):51-62. doi:10.1016/j.iswcr.2017.10.003
3. Vaddiraju AK, Change E. Urban governance in Karnataka and Bengaluru: global changes and local urban governance. 2017.
4. Gorain B, Parama VRR, Paul S. Heavy metals contamination in Madiwala and Lalbagh lakes of Bengaluru, Karnataka: effect of idol

immersion activities. *Int J Curr Microbiol Appl Sci.* 2018;7(10):2254-2263. doi:10.20546/ijcmas.2018.710.260
5. Goldman M, Narayan D. Water crisis through the analytic of urban transformation: an analysis of Bangalore's hydrosocial regimes. Water Int. 2019;44(2):95-114. doi:10.1080/02508060.2019.1578078
6. Bureau of Indian Standards (BIS). Indian Standard Drinking Water Specification (Second Revision): IS 10500. 2012. Accessed November 25, 2025. http://cgwb.gov.in/Documents/WQ-standards.pdf
7. Government of Karnataka (GoK). State of the Environment Report and Action Plan. 2003.
8. Anupama B, Jumbe AS, Nandini N. Assessment of water quality in Madiwala Lake, Bangalore in relation to fecal contamination. *Nature Environ Pollut Technol.* 2009;8(3):497-501.
9. Demers E, Kõiv-Vainik M, Yavari S, et al. Macrophyte potential to treat leachate contaminated with wood preservatives: plant tolerance and bioaccumulation capacity. Plants. 2020;9(12):1774. doi:10.3390/plants9121774
10. Status A, Wetlands OF. Pathetic status of wetlands in Bangalore: ENVIS Technical Report 93. Centre for Ecological Sciences, Indian Institute of Science. 2015.
11. Sarah Isaac T. Bacterial community analysis of seven polluted lakes in Bangalore, India: the foam stops here. Tulane Univ Dig Library. 2020;5(1):43-54. http://www.akrabjuara.com/index.php/akrabjuara/article/view/919
12. Pravathi KS, Kumar SP, Gupta VK. Evaluation of water quality in Bellandur Lake. *Int J Eng Technol Res.* 2018;5(1):1758-1762.
13. Chen Z, Zhao D, Li M, Tu W, Luo X, Liu X. A field study on the effects of combined biomanipulation on the water quality of a eutrophic lake. *Environ Pollut.* 2020;265:115091. doi:10.1016/j.envpol.2020.115091
14. K B, N N. Biodiversity study of lake shorelines of Bengaluru peri-urban area and its management. *Int J Adv Res.* 2018;6(9):763-781. doi:10.21474/ijar01/7732
15. Government of Karnataka (GoK). Karnataka State Water Policy. 2019.
16. Krishnamurthy P, Hegde GV. Groundwater hydrogeology and groundwater quality in and around Bangalore City. *J Geol Soc India.* 2011. http://ischolar.info/index.php/JGSI/article/viewFile/94639/83996
17. M RM. Phytoplankton diversity in Bangalore lakes: importance of climate change and nature's benefits to people. *J Ecology Nat Resources.* 2018;2(1). doi:10.23880/jenr-16000118
18. Nayaka BMS. Zooplankton diversity and distribution in Yelahanka Lake, Bangalore, Karnataka, India. 1998:22-24.
19. Eid EM, Shaltout KH, Moghanm FS, et al. Bioaccumulation and translocation of nine heavy metals by Eichhornia crassipes in the Nile Delta, Egypt: perspectives for phytoremediation. Int J Phytoremediation. 2019;21(8):821-830. doi:10.1080/15226514.2019.1566885
20. Government of Karnataka (GoK). State of Environment Report. 2015.
21. Filatov N, Rukhovets L. Ladoga Lake and Onego Lake. In: Encyclopedia of Earth Sciences Series. Springer; 2012. doi:10.1007/978-1-4020-4410-6_197
22. Lee TM. Factors affecting groundwater exchange and catchment size for Florida lakes in mantled karst terrain. US Geological Survey Report. 2002.
23. Ilstedt U, Bargués-Tobella A, Bazié HR, et al. Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics. Sci Rep. 2016;6:21930. doi:10.1038/srep21930
24. Lewandowski J, Meinikmann K, Krause S. Groundwater–surface water interactions: recent advances. *Environ Sci Technol.* 2020;1-7.
25. Sundararajan N, Sankaran S. Groundwater modeling of Musi Basin, Hyderabad, India: a case study. *Appl Water Sci.* 2020;10(1):1-22. doi:10.1007/s13201-019-1048-z
26. Surinaidu L, Rahman A, Ahmed S. Distributed groundwater recharge potentials assessment based on GIS model in crystalline rocks of South India. *Sci Rep.* 2021;1-16. doi:10.1038/s41598-021-90898-w
27. Raj MP, Mustafa M, Sethia B, Namitha KM, Harshitha Shree SA. Phytoremediation of

the endocrine disruptor bisphenol A using Pistia stratiotes. *Res J Pharm Biol Chem Sci.* 2015;6(1):1532-1538.

28. Varun CV, Kumar VS, Pallavi M. Studies of water quality assessment of Hebbal Lake. *International Journal of Engineering Science and Computing.* 2019;9(6):22799-22802.

29. Papadia P, Barozzi F, Migoni D, et al. Aquatic mosses as adaptable biofilters for heavy metal removal from contaminated water. *Int J Mol Sci.* 2020;21(13):4769. doi:10.3390/ijms21134769

30. Government of Karnataka (GoK). State of Environment Report: Bangalore. 2008.