

ASSESSMENT OF WATER QUALITY IN SELECTED LAKES OF MADAVARA LAKE SERIES, BENGALURU NORTH TALUK, KARNATAKA

Swathi₁, Raghavendra M₂, and K L Prakash₃

1- M.Sc Student, Department of Environmental Science, Bangalore University. Bengaluru 560056.

E-mail: swathiusdswathi@gmail.com

2- Teaching faculty, Department of Environmental Science, Bangalore University.

Bengaluru 560056. E-mail - draghavendra@bub.ernet.in

3- Professor, Department of Environmental Science, Bangalore University, Bengaluru 560056

klpenvi@bub.ernet.in

Corresponding Author: M Raghavendra, E-mail - draghavendra@bub.ernet.in

ABSTRACT

Urban lakes are important freshwater resources that support groundwater recharge, biodiversity, and ecological balance and are susceptible to urbanization, sewage discharge, and anthropogenic activities. The study assess the water quality of Dasarahalli, Madavara, and Chikkabanavara lakes of Madavara Lake Series of Bengaluru North taluk during April and May 2026 by analyzing key physico-chemical parameters of pH, turbidity, electrical conductivity, total dissolved solids (TDS), hardness, nutrients, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) as per Standard Methods (APHA). The result of pH, electrical conductivity, chloride, fluoride, and nitrate were found within permissible limits, whereas TDS, turbidity, hardness, phosphate, BOD, and COD were elevated in some locations, indicating deterioration in water quality due to entry of urban runoff, solid waste dumping, and nutrient enrichment. Madavara Lake shows signs of eutrophication, while Dasarahalli Lake recorded higher turbidity and pollution level, and Chikkabanavara Lake affected by encroachment and waste accumulation. The findings reveal that increasing anthropogenic pressures degrades the ecological health of the lakes and may affect aquatic biodiversity. The study recommends strengthening sewage treatment preventing direct wastewater discharge, control of encroachment, removal of solid waste and invasive weeds, regular water quality monitoring, and promoting community participation to ensure the long-term conservation and sustainable management of lakes.

Key words: pollution, urbanization, anthropogenic, urban sprawl

1. INTRODUCTION

Lakes are important freshwater ecosystems that provide numerous ecological, economic, and social benefits and serve as sources of drinking water, irrigation, fisheries, recreation, and biodiversity conservation. Lakes also regulate hydrological cycles, recharge groundwater, and support a wide variety of aquatic organisms, making them essential components of the natural environment (Wetzel, 2001). Freshwater ecosystems, including lakes, play a critical role in maintaining ecological balance and supporting human livelihoods worldwide (Dodds & Whiles, 2020). Lakes are facing environmental pressures from both natural and anthropogenic activities at alarming rate. These threats adversely affect water quality, biodiversity, ecosystem functioning, and the sustainability of freshwater resources. Discharge of untreated domestic sewage, industrial effluents, agricultural runoff, and solid waste dumping, excessive nutrients, heavy metals, pesticides, and toxic chemicals into lakes. These pollutants degrade water quality, alter aquatic habitats, and negatively affect aquatic organisms (Carpenter et al., 1998). High nutrient concentrations stimulate excessive growth of algae and aquatic macrophytes, resulting in harmful algal blooms, reduced water transparency, oxygen depletion, fish mortality, and loss of biodiversity (Smith et al., 1999). Schindler (2006) identified eutrophication as one of the most widespread environmental problems affecting freshwater ecosystems globally. Excessive sedimentation reduces lake depth, increases turbidity, and affects aquatic habitats by limiting light penetration and smothering benthic organisms (Wetzel, 2001; Strayer, 2010). Habitat fragmentation also contributes to the decline of native flora and fauna (Dudgeon et al., 2006). Freshwater species are declining at a faster rate than many terrestrial and marine species, making lakes among the most threatened ecosystems globally (Dudgeon et al., 2006). Plastic debris affects aquatic organisms through ingestion and entanglement and release harmful chemicals into the aquatic environment. Accumulation of solid waste alters the aesthetic and recreational value of lakes (UNEP, 2021). Land use changes in lake catchments often lead to increased nutrient loading, sedimentation, and habitat degradation, thereby affecting Lake Ecosystem health (Allan, 2004). The study evaluates the lake water quality and pollution level to understand the lake status and conservation of urban lakes.

2. MATERIALS AND METHODS

Bengaluru district is situated in the heart of the South-Deccan plateau in peninsular India to the South-Eastern corner of Karnataka State. Bengaluru is drained by three major valley systems: Hebbal, Koramangala–Challaghatta, and Vrishabhavathi. Within these valley systems, six major cascading lake series have been identified, namely Varthur, Puttenahalli, Hulimavu, Byramangala, Yellamallappa Chetty, and Madavara (Figure 1). The lakes series hydrologically interconnected, forming a chain of reservoirs that facilitate the downstream movement of water. This cascading network plays a vital role in storm water drainage, groundwater recharge, flood mitigation, and the maintenance of the urban aquatic ecosystem, making the valley systems the primary repository of Bengaluru's interconnected lakes. (Ramachandra, 2009). The selected Madavara Lake Series comprises approximately ten interconnected lakes located along the northwestern periphery of Bengaluru, Karnataka, and forms part of the Hebbal Valley drainage system. The lake series extends approximately between 13.0448°–13.0529° N latitude and 77.3149°–77.4722° E longitude. The excess water from the downstream lakes flows towards the Arkavathi River, which ultimately contributes to the Thippagondanahalli (TG Halli) Reservoir.

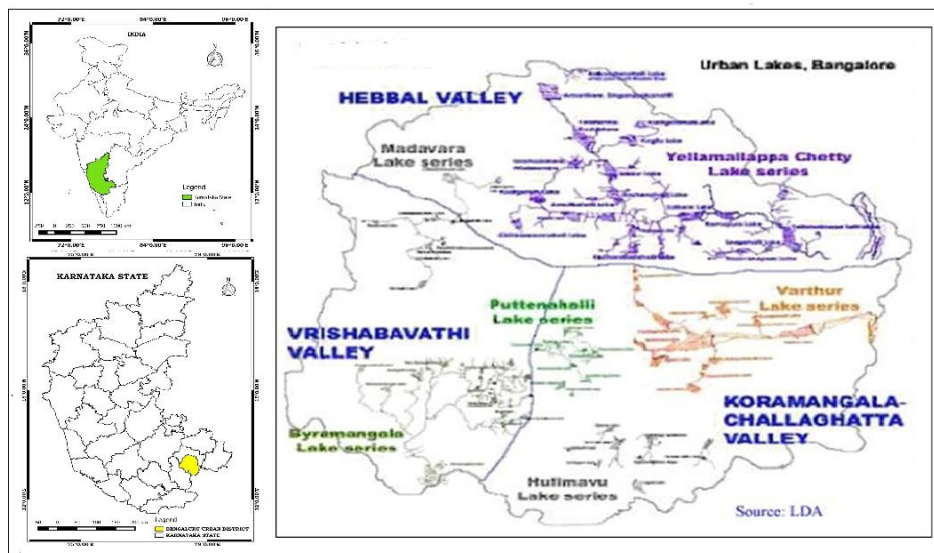


Figure 1. Map depicting the Madavara lake series of study area

To assess the water quality and environmental status of the Madavara Lake Series, three representative lakes, namely Dasarahalli Lake, Madavara Lake, and Chikkabanavara Lake, were selected. (Figure.2). Dasarahalli Lake is an urban lake in Bengaluru maintained by the BBMP Spread across about 15.4 acres, the lake supports groundwater recharge, local biodiversity, and recreation for nearby residents through walking paths and green surroundings. The lake receives treated water from a 1 MLD sewage treatment plant (Figure.3). Madavara Lake is currently under environmental stress due to sewage inflow, pollution, and weed growth, which have affected its water quality and ecosystem health. It is part of the interconnected lake network that supports storm water drainage and groundwater recharge in the region of about 49 acres (Figure.4).

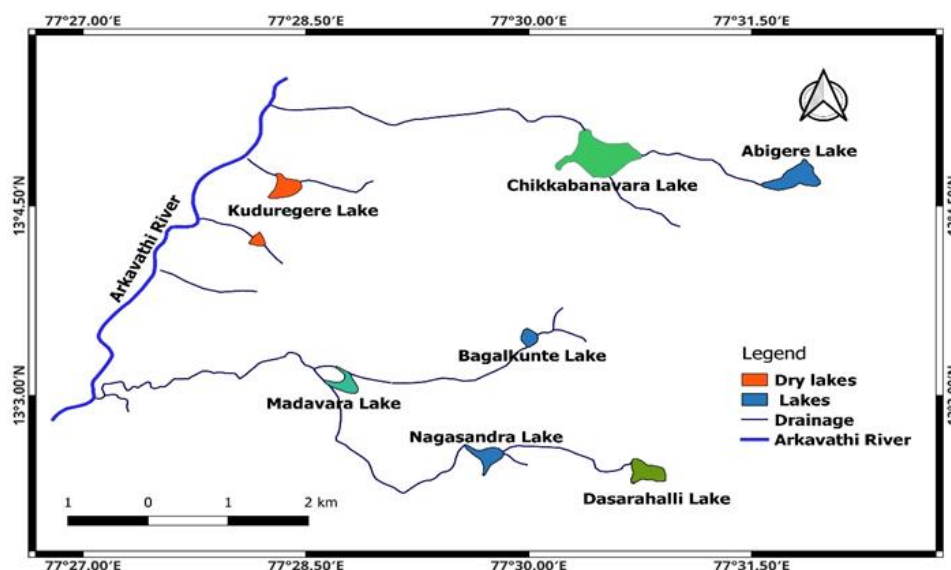


Figure 2. Location map of selected lakes in Madavara lake series



Figure 3. Google Earth View of Dasarahalli Lake



Figure 4. Google Earth view of Madavara lake

Chikkabanavara Lake is also a urban lake in northwestern Bengaluru spread across approximately 83.9 acres, the lake was originally constructed for rainwater storage, irrigation, and groundwater recharge for nearby villages and agricultural lands. Chikkabanavara Lake affected by urban pressures such as sewage inflow, pollution, and encroachment, which have influenced its water quality and ecological condition (Figure.5).



Figure 5. Google Earth view of Chikkabanavara lake

The water samples collected during the months of April and May 2026 during the morning hours from the selected lakes. The sampling locations were chosen to represent the overall water quality of each lake and to capture spatial variations in water characteristics. The selected sampling points included the inlet, where feeder channels discharge into the lake; the centre, representing the general water quality of the lake; the outlet, where overflow water exits the lake; and additional locations influenced by anthropogenic activities, such as domestic sewage discharge, urban runoff, and other potential sources of pollution. This sampling strategy ensured a comprehensive assessment of the physicochemical characteristics and pollution status of the study lakes. Lake water samples collected in pre-washed one-liter polyethylene containers from approximately 30 cm below the water surface at each sampling station to assess various physicochemical parameters. A total of five sampling points were selected from Madavara Lake (Figure.3) and Dasarahalli Lake (Figure.4), while four sampling points were selected in Chikkabanavara

Lake (Figure.5). Field parameters, including pH and electrical conductivity (EC), measured on-site, and dissolved oxygen (DO) was fixed immediately at the sampling locations. The water samples transported to the laboratory for detailed physicochemical analysis. All laboratory analyses were performed in accordance with the Standard Methods for the Examination of Water and Wastewater (APHA, 2022).

3. RESULTS AND DISCUSSION

Table 1 Physical-chemical characterization of lake water samples

Sl. No	Lake Variables	Dasarahalli Lake					Madavara Lake					Chikkabanavara Lake				IS Standard
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	
1	pH	7.44	6.73	6.6	6.73	6.85	7.95	7.93	7.89	7.77	7.27	6.54	6.5	6.91	6.93	6.5 – 8.5
2	EC	1550	1156	1130	1134	1143	1509	1513	1523	1507	1532	936	966	1023	1140	-
3	TDS	996.7	743.3	726.6	729.2	734.9	970.3	972.9	979.3	969.0	985.1	601.8	621.1	657.8	733.0	500
4	Turb	5.48	61	45.53	30.23	14.29	1.59	5.4	1.08	1.41	4.14	2.92	0.84	2.94	6.45	5
5	TH	450	184	288	186	178	352	366	334	370	360	280	276	266	282	300
6	CH	282	100	120	100	112	170	170	172	156	158	132	146	152	166	-
7	MH	168	84	168	86	66	182	196	162	214	202	148	130	114	116	-
8	Cl ⁻	233.2	233.2	180.7	270.1	237.0	233.2	144.8	240.9	233.2	270.1	148.6	152.3	206.0	165.2	600
9	F ⁻	1.08	0.98	0.88	0.86	0.92	0.85	0.9	0.88	0.97	0.71	0.68	0.76	0.54	0.66	1.5
10	SO ₄ ²⁻	267	234	293	281	277	336	324	369	345	336	147	129	167	179	400
11	NO ₃ ⁻	26.7	43.4	29.3	28.1	27.1	44.7	43.2	39.6	34.5	33.6	14.7	12.6	16.3	17.5	50
12	PO ₄ ³⁻	5.7	5.4	3.9	3.8	4.7	6.4	6.5	6.1	4.6	5.8	3.5	3.6	4.5	4.8	-
13	Na ⁺	75	54	67	58	51	64	73	61	56	58	53	50	45	48	-
14	K ⁺	27	21	22	29	27	21	33	26	19	23	19	17	15	15	-
15	DO	3.6	4.2	5.6	2.8	4.4	5.2	5.6	6.2	6.4	6.6	7.2	6.6	4.2	4.8	<5
16	BOD	33.7	30.5	25.7	35.6	30.8	35.2	34.7	31.3	30.9	20.3	15.6	18.7	12.3	30.7	>3
17	COD	244.3	160.3	186.6	106.4	159.9	186.9	266	239.4	292.3	212.6	106.3	56.7	149.3	133.1	250

All variables values are in mg/L except pH, Turbidity and EC. EC in $\mu\text{mhos/cm}$; Turbidity in NTU

pH- Potential of hydrogen, EC-Electrical conductivity, TDS-Total Dissolved Solids, Turb-Turbidity, TH-Total Hardness, CH-Calcium Hardness, MH- Magnesium Hardness, Cl⁻-Chlorides, F⁻-Fluorides, SO₄²⁻-Sulphates, NO₃⁻-Nitrates, PO₄³⁻-Phosphates, Na⁺- Sodium, K⁺- Potassium DO- Dissolved Oxygen, BOD-Biochemical Oxygen Demand, COD- Chemical Oxygen Demand

pH

pH is the scale of intensity of acidity and alkalinity of water and measures then concentration of hydrogen ions. The result of pH value ranging between 6.50 to 7.95, maximum pH of 7.95 was recorded from sample S6 Madavara Lake and minimum pH of 6.5 was in S11 in Chikkabanavara Lake. The relatively alkaline nature of Madavara Lake suggests higher photosynthetic activity by aquatic plants and algae, which consume dissolved carbon dioxide, thereby increasing pH. The slightly acidic conditions observed at some stations in Dasarahalli and Chikkabanavara Lakes attributed to decomposition of organic matter, microbial respiration, and inflow of domestic wastewater. All samples exhibited pH values within the permissible range of 6.5–8.5, as prescribed by IS: 2296–1982 for inland surface waters.

Electrical Conductivity

Electrical conductivity is the measure of the ability of a solution to conduct an electric current and the EC values obtained were ranged between 936 $\mu\text{S/cm}$ and 1550 $\mu\text{S/cm}$. The maximum EC of 1550 $\mu\text{S/cm}$ was in sample S1 Dasarahalli Lake and the minimum EC of 936 $\mu\text{S/cm}$ was in sample S11 Chikkabanavara Lake. The tolerance limits as per IS: 2296-1982 for Inland Surface Waters for EC is 2250 $\mu\text{S/cm}$. Electrical Conductivity level in Dasarahalli, and Madavara Lakes indicate a higher concentration of dissolved ionic substances such as chlorides, sulphates, bicarbonates, calcium, magnesium, sodium, and potassium. These originate from sewage discharge and urban runoff. Chikkabanavara Lake exhibited comparatively lower EC, suggesting lower anthropogenic influence due to rejuvenation of lake.

Total Dissolved Solids

The Total dissolved solids (TDS) in water consist of inorganic salts and dissolved materials. The TDS values ranged between 601.8mg/L to 996.7mg/L, the maximum TDS value of 996.7mg/L in Dasarahalli Lake and the minimum value of 601.8 mg/L in Chikkabanavara Lake. The lake water samples were exceeded the tolerance limits as per IS: 2296-1982 for Inland Surface Waters for TDS is 500 mg/L. High values of TDS may be due to urban waste water discharges. The increase in TDS increases the apparent color of the water, water temperature and decreases the rate of photosynthesis (Chauhan and Sagar, 2013).

Turbidity

Turbidity caused by suspended solids that scatter light (CPCB, 2008), the turbidity was ranged from 1NTU to 61NTU. The maximum turbidity of 61NTU was recorded in sample S2 of Dasarahalli Lake and minimum of 0.84NTU in S13 of Chikkabanavara Lake. The high turbidity in Dasarahalli lake is due to storm water runoff from surrounding areas, as well as from

human activities, the silt, clay and other suspended particles enter the lake reduces light penetration, adversely affects photosynthesis and aquatic biodiversity.

Total Hardness

The hardness of water depends mainly on the presence of dissolved calcium and magnesium salts (Central Water Commission, 2011). The Total hardness results show the maximum value of 450 mg/L in S1 and the minimum value of 178 mg/L in sample S5 outlet of Dasarahalli Lake. The values observed in the Dasarahalli Lake sample (S1) and all samples from Madavara Lake were higher than the permissible limit of 300 mg/L recommended by IS: 2296–1982 for inland surface waters. High values are due to more of dissolved Calcium and magnesium, and the inflow of wastewater into the Lake.

Calcium Hardness [Ca]

The result of calcium hardness shows the maximum of calcium hardness value in Dasarahalli lake was 282 mg/L and minimum value of 100 mg/L. The higher calcium concentrations indicate the possible contamination from domestic sewage, urban runoff, and other anthropogenic activities.

Magnesium Hardness (Mg)

Calcium and magnesium are nutritive trace elements, which is essential for growth of pathogenic bacteria. Lake with high concentrations of calcium and magnesium is the hard water Lakes, while those with low concentrations of these ions are called soft water Lakes. The result shows higher value of magnesium hardness is 214 mg/L in Madavara Lake S9 and minimum value of 66 mg/L in Dasarahalli lake S5. Among the three lakes, Madavara Lake exhibited the highest magnesium levels, indicating a greater influence of hardness-causing substances. Elevated magnesium concentrations may negatively affect overall water quality and the ecological health of the aquatic ecosystem.

Chlorides

Chlorides are widely distributed in nature, usually in the form of sodium, potassium, and calcium salts (NaCl, KCl, and CaCl₂), although many minerals contain small amounts of chloride as an impurity. (Central Water Commission, 2011). The result shows maximum range of Chlorides in lake is 270.1 mg/L in samples both S4 and S10 and minimum value of 149 mg/L in sample S7. The chloride values are within the tolerance limits prescribed standards of IS: 2296-1982 inland surface water of 600mg/L.

Fluoride

Fluoride is a common element but it does not occur in the elemental state in nature because of its high reactivity. The result shows maximum range of fluorides in lake is 1.08 mg/L in sample S1 Dasarahalli lake and minimum value of 0.71 mg/L in sample S10 Madavara lake. The fluoride values of lakes are within permissible limits. As prescribed by IS: 2296-1982 tolerance limits of fluorides for inland surface water is 1.5mg/L.

Sulphate

Sulphate minerals are widely distributed in nature, and most sulphate compounds are readily soluble in water. The result the shows maximum range of Sulphates in Madavara lake is 369 mg/L in sample S8 and minimum value of 129 mg/L in sample S12. Lake water samples are within permissible limits as prescribed by IS: 2296:1982 the tolerance limit of sulphate for inland surface water is 400mg/L.

Nitrate

Nitrogen is also an important nutrient for plant and algal growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. The result shows maximum range of Nitrate in lake is 44.7 mg/L in sample S6 and minimum value of 12.6 mg/L in S12. The nitrate values are not exceeded the permissible values as per the prescribed standards of IS: 2296-1982 Nitrate in inland surface water of 45 mg/L. The principle sources of nitrate contamination in water are fertilizers, animal waste, include human sewage, livestock manure and septic tank wastes especially from feedlots. High concentrations of nitrogen in water bodies are usually the result of human activities (Agarwal, 2011).

Phosphate

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates, in particles or detritus or in the bodies of aquatic organisms. The result shows that maximum range of Phosphate is 6.5 mg/L in S7 Madavara lake and minimum value of 3.5 mg/L in Chikkabanavara lake inlet. The observed concentrations are extremely high and indicate severe nutrient enrichment resulting from detergents, sewage, fertilizers, and organic waste. Such elevated phosphate concentrations can accelerate eutrophication, excessive algal growth, oxygen depletion, and ecological degradation. Phosphate is an essential plant nutrient and most often controls aquatic plants (algae and macrophyte) growth in fresh water (Patricia et al., 2005).

Sodium (Na⁺)

Sodium ranks sixth among the elements in order of abundance and is present in most natural water. The sodium concentration recorded ranged from 45mg/L to 75 mg/L. The maximum sodium concentration of 75mg/L was recorded in S7 Madavara lake and the minimum sodium concentration of 58mg/L in S13 Chikkabanavara lake. According to WHO, 2002, the source of sodium concentration is from Mineral deposits, discharge of sewage and movement of agricultural fertilizers, transport of animal and human waste.

Potassium (K^+)

Potassium is an important element in both plant and human nutrition and occurs in ground waters as mineral dissolution, decomposition of organic matter and agricultural runoffs in lakes (CWC, 2011). The potassium concentration recorded in the ranged from 15mg/L to 33 mg/L. The maximum potassium content of 33 mg/L was recorded in sample S7 Madavara lake and Minimum 15mg/L in Chikkabanvara lake was at middle in sample S12. The higher potassium value is indicating the greater nutrient enrichment, due to domestic wastewater discharge, agricultural runoff, and decomposition of organic matter (Wetzel, 2001).

Dissolved oxygen

Dissolved Oxygen (DO) is the measure of the amount of oxygen dissolved in the water, The result shows maximum range of DO in Chikkabanavara lake is 7.6 mg/L and minimum value of 3.2 mg/L in Madavara lake sample S6. DO is a very important parameter for the survival of fishes and other aquatic organisms. DO values should be more than 5 mg/L as per IS: 2296:1982 for inland surface water. DO is considered to be the factor that reflects the biological activity in a water body and determines the biological changes, which are brought about by the aerobic or anaerobic organisms.

Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The result shows maximum range of BOD in Dasarahalli lake is 35.6 mg/L in sample S4 and minimum value of 12.3 mg/L in Chikkabanavara lake. BOD values greater than 10 mg/L indicate significant organic pollution. All lakes exhibited elevated BOD, particularly Dasarahalli and Madavara, suggesting control sewage inflow and microbial decomposition. Chikkabanavara displayed comparatively lower organic pollution. The BOD has three major applications. First, it is an indicator of the conformity of the wastewater discharge and the waste treatment procedure to the current regulations. Second, in wastewater treatment plants, the ratio between BOD5 and COD (Chemical Oxygen Demand) indicates the biodegradable fraction of an effluent. Third, the ratio COD/BOD5 is an indicator of the size of a wastewater treatment plant required for a specific location (Jouanneau et al., 2014).

Chemical Oxygen Demand

COD is the oxygen required by the organic substances in water to oxidize by a strong chemical oxidant. The COD is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation and thus is an index of organic pollution (Khairwal et al., 2003). The result shows maximum range of COD in lake is 292.3 mg/L in sample S9 and minimum value of 56.7 mg/L in sample S12. The samples are exceeded the tolerance limit of 250mg/L. High COD indicates significant concentrations of oxidizable organic and inorganic pollutants. Madavara Lake exhibited severe organic pollution, while Chikkabanavara demonstrated comparatively better water quality. The high COD values correspond well with elevated BOD, confirming the anthropogenic contamination. COD is the indication of organic loads due to increase in household wastewater and waste discharge (APHA, 2005).

4. CONCLUSION

Among the three lakes, Madavara Lake exhibited the highest nutrient enrichment (phosphate, sulphate, nitrate) and the highest COD, indicating severe eutrophication and organic pollution. Dasarahalli Lake showed the highest EC, TDS, hardness, turbidity, chloride, fluoride, sodium, and BOD, reflecting significant mineralization and domestic sewage influence. Chikkabanavara Lake recorded lower concentrations of most physicochemical parameters, higher dissolved oxygen, and comparatively lower BOD and COD, suggesting relatively better water quality. Madavara, Dasarahalli and Chikkabanavara lakes face pressures from human activities, pollution, and climate change like many other lakes in urban and semi urban areas of Bengaluru. Lack of proper management strategies will eventually lead to loss of lakes around Bengaluru. Solving the problem at the end is a temporary measure with more serious repercussions. The solution is to tackle this problem at source points with strict enforcement of environmental laws and regulations. Overall, the findings indicate varying degrees of pollution across all three lakes, emphasizing the need for effective sewage management, nutrient load reduction, and regular water quality monitoring to restore ecological health.

REFERENCES

- [1] Agarwal, S. K. 2011. *Water Pollution*. New Delhi, India: APH Publishing Corporation.
- [2] American Public Health Association (APHA). 2022. Standard methods for the examination of water and wastewater (24th edition) American Public Health Association.
- [3] Allan, J. D. 2004. Landscapes and riverscapes: The influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematics*, 35, 257–284. <https://doi.org/10.1146/annurev.ecolsys.35.120202.110122>
- [4] Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., & Smith, V. H. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications*, 8(3), 559–568.
- [5] Central Pollution Control Board (CPCB). 2008. Guide manual: Water and wastewater analysis. Ministry of Environment, Forest and Climate Change, Government of India.
- [6] Central Water Commission (CWC). 2011. Water quality monitoring guidelines. Government of India.
- [7] Chauhan BS and Sagar SK 2013. Impact of pollutants on waterquality of river Sutlej in Nangal area of Punjab, India. *BiolForum* 5 (1) 113–123.
- [8] Dodds, W. K., and Whiles, M. R. 2020. *Freshwater ecology: Concepts and environmental applications of limnology* (3rd ed.). Academic Press.

- [9] Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Lévêque, C., Naiman, R. J., Prieur-Richard, A. H., Soto, D., Stiassny, M. L. J., & Sullivan, C. A. 2006. Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews*, 81(2), 163–182. <https://doi.org/10.1017/S1464793105006950>
- [10] Jouanneau, S., Recoules, L., Durand, M. J., Boukabache, A., Picot, V., Primault, Y., ... & Thouand, G. 2014. Methods for assessing biochemical oxygen demand (BOD): A review. *Water research*, 49, 62-82.
- [11] Khaiwal, R. and Anubha, K. 2003. Seasonal variations in physicochemical characteristics of River Yamuna in Haryana and its ecological best-designated use. *Journal of Environmental Monitoring*, 5: 419-426.
- [12] Patricia M. Glibert, Sybilseitzinger, Cynthia A. Heil, Joann M. Burkholder, Matthew W. Parrow, Louis A. Codispoti, & Andvince Kelly. 2005. The Role of in the Global Proliferation of Harmful Algal Blooms-New Perspectives and New Approaches, by *Oceanography*, 18(2): 198 – 209.
- [13] Ramachandra, T. V.; Mujumdar, Pradeep P. 2009. "Urban Floods: Case Study of Bangalore". *Journal of the National Institute of Disaster Management*. 3 (2): 1–98.
- [14] Schindler, D. W. 2006. Recent advances in the understanding and management of eutrophication. *Limnology and Oceanography*, 51(1, Part 2), 356–363. https://doi.org/10.4319/lo.2006.51.1_part_2.0356
- [15] Smith, V. H., Tilman, G. D., & Nekola, J. C. 1999. Eutrophication: Impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. *Environmental Pollution*, 100(1–3), 179–196. [https://doi.org/10.1016/S0269-7491\(99\)00091-3](https://doi.org/10.1016/S0269-7491(99)00091-3)
- [16] Strayer, D. L. 2010. Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. *Freshwater Biology*, 55(Suppl. 1), 152–174. <https://doi.org/10.1111/j.1365-2427.2009.02380.x>
- [17] United Nations Environment Programme (UNEP). 2021. Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity and Pollution Emergencies. Nairobi: United Nations Environment Programme.
- [18] Wetzel, R. G. 2001. *Limnology: Lake and river ecosystems* (3rd ed.). Academic Press.
- [19] World Health Organization. 2002. *Guidelines for drinking-water quality*. 2nd ed. Vol. 2.

Copyright & License:

© Authors retain the copyright of this article. This work is published under the Creative Commons Attribution 4.0 International License (CC BY 4.0), permitting unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.