Indian J. Applied & Pure Bio. Vol. 39(3), 1964-1978 (2024). **ISSN: 0970-2091**
A web of Science Journal

Delving into Lake ecosystems: Assessing the Heavy metal profile, Physico-chemical and Biological characteristics of three water Bodies

[a*]K.M. Umadevi, [b]P.R. Shilpa, [c]K. Sharadadevi and [d]Kiran B.R.

[a,b,c]Department of Studies in Environmental Science, Davangere University, Shivagangothri, Davangere - 577007 (India)
[d]Department of Environmental Science, University SMR College of Arts and Commerce, Shankaraghatta-577451 (India)
Corresponding Author: K.M., Umadevi, Department of Studies in Environmental Science, Davangere University, Shivagangothri, Davangere - 577007 (India)

Abstract

Water is the lifeblood of lakes, sustaining diverse ecosystems and serving as a vital resource for countless organisms, including humans. The importance of water in lakes extends far beyond its role as a mere liquid; it regulates temperature, supports aquatic life, and facilitates essential processes like nutrient cycling. The study presents a thorough investigation into the physical, chemical, and biological parameters of five lakes in Karnataka, India: Madiwala Lake, Matada Kere and Mallapura Lake, shedding light on their overall health and pollution status. Notable findings include deviations from Indian Standards Institute [IS] benchmarks, suggesting potential environmental challenges. Elevated temperatures, objectionable odors, and disagreeable tastes hint at pollution sources impacting water quality. Chemical analyses reveal varying pH levels, electrical conductivity, and dissolved oxygen concentrations, reflecting the dynamic nature of these ecosystems. Biological assessments, particularly fecal coliform counts, unveil fluctuating contamination levels, necessitating continual monitoring and management efforts. The research underscores the urgency of implementing remedial measures to enhance water quality and preserve the ecological balance of these lakes. Sustained vigilance and proactive interventions are imperative to mitigate pollution risks and ensure the long-term sustainability of freshwater reservoirs in the region.

Key words : Biodiversity conservation, Chemical speciation, Contaminant levels, Lake waters, Physico-chemical analysis, Water quality assessment.

Water is indispensable to life, serving as the cornerstone for various biological, ecological, and societal functions. Its significance spans from being a critical component in the structure of animal and plant tissues, providing texture, chemical, thermal, and microbiological stability to food, to influencing health and lifespan Due to the fact of its quality[38].The distribution of water on Earth is both vast and varied, encompassing several reservoirs from the surface to the deep interior. Approximately 97% of Earth's water is found in the oceans, with the remaining 3% distributed among glaciers, ice caps, ground-water, and other freshwater sources. Notably, only about 1% of this water is accessible for human and biospheric needs, stored in rivers, lakes, and subsurface reservoirs[50]. The distribution of water on Earth is predominantly in the oceans, which account for about 97% of all water, leaving a mere 3% as freshwater. Of this freshwater, a significant portion, approximately 79%, is stored in polar ice caps and mountain glaciers, while 20% resides in aquifers or soil moisture, and only about 1% is accessible as surface water, primarily in lakes and rivers[50]. Freshwater lakes, wetlands, soil moisture, rivers, the atmosphere, and water within plants and animals contribute to the remaining freshwater resources, with groundwater, freshwater lakes, and rivers being the primary sources for human activities[7,31]. Despite the vastness of the oceans, their high salinity renders them non-potable, emphasizing the importance of freshwater sources for consumption and agriculture[15]. Lakes play a crucial role in various ecological, economic, and social dimensions globally. They are the largest repository of liquid surface freshwater, serving as vital sources for drinking water, agricultural irrigation, and supporting biodiversity[65].

Lakes in Karnataka play a crucial role in the state's ecological, economic, and social fabric, serving as vital water sources, supporting biodiversity, and enhancing human well-being. The importance of non-polluted water in the lakes of Karnataka is multifaceted, impacting ecological balance, public health, and economic activities. The need for surveying lakes for contamination in Karnataka is underscored by various studies highlighting the adverse impacts of urbanization, industrialization, and anthropogenic activities on lake ecosystems. Such surveys should measure a range of physiochemical parameters, heavy metal concentrations, and microbial contamination to provide a comprehensive understanding of water quality. This will enable the imple-mentation of targeted remediation strategies and the development of effective conservation and management plans to ensure the health of these vital freshwater ecosystems[3,54,69].

Understanding the quality of lake water requires the analysis of various physical, chemical, and biological parameters. These parameters provide valuable insights into the health, composition, and ecological condition of lakes. Key water quality parameters commonly analyzed in lake water include: Physical Parameters such as temperature, turbidity, color, and odor provide information about the visual appearance and sensory characteristics of water[48] / They can indicate the presence of suspended solids, algae, or pollutants. Chemical Parameters encompass a wide range of factors, including pH, dissolved oxygen, electrical conductivity, nutrients [nitrogen and phosphorus], heavy metals, organic pollutants, and various ions [e.g., chloride, sulfate]. These parameters help assess water chemistry, nutrient levels, acidity or alkalinity, and contamination levels[22]. Biological Parameters include indicators of microbial contamination [e.g., fecal coliforms, Escherichia coli], algae biomass, macro-invertebrate diversity, and overall ecosystem health. These indicators reflect the presence of pathogens, nutrient enrichment, and ecological disturbances[34,40,49]. Recognizing the critical importance of lake water quality and the pressing issue of pollution, the main aim of the study was to comprehensively assess the pollution status of lakes in the Chitradurga, and Bangalore regions of Karnataka. This involved identifying lakes where there is limited information available regarding pollution levels or scientific studies, thus addressing gaps in environmental monitoring and management efforts. The survey encompassed a range of scientific methodologies and interdisciplinary approaches to assess water quality, pollution sources, and ecological health.

Study area :

A comprehensive field survey was recently conducted to investigate the key parameters of lakes in 2 prominent locations: Bangalore and Chitradurga.

In Bangalore, the survey focused on Madiwala lake, which is situated in the BTM Layout at 12. 5428° North, 77.370° East in Bangalore city is one of the biggest lakes in Bangalore, India spread over an area of 114.3 hectare. The water in the lake was fit for drinking till the early 1990s. Since then it has become unfit for drinking due to industrial waste and sewage entering the water body [Figure 1].

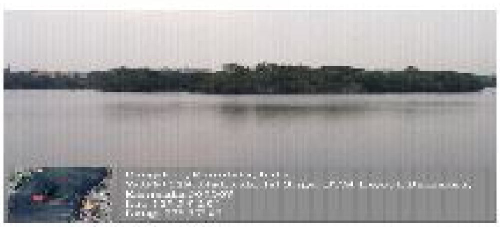

Figure 1: Geographical Location of Madiwala Lake, Bengaluru

Figure 2: Geographical Location of Matadakere Lake ,Chitradurga

Figure 3: Geographical Location of Mallapurakere, Chitradurga

The survey in Chitradurga included an evaluation of the Matada Kere, located at coordinates 14.23414° and 76.379761°in Garehatty Gram, Adarsha Nagar, Chitradurga, Karnataka. Additionally, the survey also focused on the Mallapura Lake, situated in Medahalli, Chitradurga, Karnataka, which spans approximately 4.37 kilometers. The Mallapura Lake is a natural water body situated at Latitude 14.253697°and Longitude 76.3947° [Figure 2 and 3].

Water sampling and laboratory analysis :

Samples of water from all the three lakes were methodically collected in 5 liter polythene bottles from the field sites and ferried to the laboratory for detailed analysis. These samples were meticulously handled to ensure the preservation of their integrity and to prevent any contamination during transit. Water temperature and pH were measured at the sampling site itself. To determine different physical and chemical properties of water standard methods were followed outlined in the Standard Methods for the Examination of Water and Wastewater[8]. Heavy metals are analyzed by using Atomic Absorption Spectrophotometer. Data was recorded to the nearest appropriate unit and quality control measures were implemented to ensure accuracy and reliability.

Madiwala lake water :

Madiwala Lake water samples revealed various parameters indicating the condition of the lake water. The analysis encompasses a wide range of physical, chemical, and biological parameters, providing insights into the overall health and pollution status of the lake. The results indicate that Madiwala Lake water exhibits certain deviations from the standards set by the Indian Standards Institute for specific parameters. While the color parameter falls within acceptable limits, the temperature is slightly elevated at 26°C. The presence of objectionable odour and disagreeable taste suggests potential contamination sources in the vicinity of the lake.pH levels are slightly alkaline at 7.54, falling within the permissible range of 6.5-8.5. Electrical conductivity is measured at 770 µs/cm,indicating moderate mineral content in the water. Turbidity levels are recorded at 30 NTU, suggesting some suspended particles present in the water column. Total Suspended Solids [TSS] and Total Dissolved Solids [TDS] are measured at 124 mg/L and 540 mg/L, respectively. Elevated TDS levels may indicate the presence of dissolved salts or pollutants in the water. Total Alkalinity as $CaCO_3$ is found to be 220.8 mg/L, while Calcium, Total Hardness, and Magnesium concentrations are within acceptable ranges.The presence of Oil & Grease at 4 mg/L indicates potential anthropogenic inputs into the lake. Sulphate, Chloride, and Nitrate concentrations are below permissible limits, while Fluoride levels are marginally above the standard threshold. Dissolved Oxygen levels are lower than the minimum requirement at 3.2 mg/L, indicating potential oxygen depletion in the water.COD and BOD values are recorded at 309.5 mg/L and 92 mg/L, respectively, suggesting organic pollution and oxygen-consuming substances present in the water. Heavy metal concentrations, including Manganese, Arsenic, Cadmium, Hexavalent Chromium, Lead, and Copper, are below permissible limits. An assessment of the fecal coliform parameter, is a crucial indicator of water quality and potential contamination by fecal matter. The results indicate that the fecal coliform count in the Madiwala Lake water sample is 5 MPN per 100 milliliters. This count falls within the range of 50 MPN /100ml, indicating relatively low levels of fecal contamination in the water. While the presence of fecal coliforms suggests some degree of pollution, the low count suggests that the water quality may be relatively good or only mildly contaminated. This suggests that the water sample meets the microbiological quality criteria for surface water, indicating minimal risk of fecal contamination and associated waterborne diseases. However, while the fecal coliform count is within acceptable limits, it's essential to continue monitoring water quality parameters regularly to maintain consistent adherence to standards. and to address any potential sources of contamination that may arise over time [Table-1].

Matada Kere water :

Matada Kere Lake in Chitradurga, encompasses a comprehensive assessment of various physical, chemical, and biological parameters. The findings offer valuable perspectives on the overall status of the lake water and potential environmental concerns. Starting with physical parameters, the color of the water is measured at 196, which exceeds the standard of 300 as per IS – 2296 "C". The temperature is recorded at 26°C, and while within acceptable range, it's noteworthy. Odor is objectionable, and the taste is disagreeable, indicating potential pollution sources impacting sensory aspects of the water. Chemical parameters reveal pH levels of 8.42, slightly on the alkaline side but still within the permissible range of 6.5-8.5. Electrical conductivity is relatively high at 1310 µs/cm, indicating a significant presence of dissolved ions. Turbidity is measured at 190 NTU, suggesting considerable suspended particles in the water column. TSS and TDS are recorded at 162 mg/L and 940 mg/L, respectively. Total Alkalinity, Calcium, Total Hardness, and Magnesium concentrations are also within measurable ranges. Biologically, the fecal coliform count is 7 MPN/50ml, which is well below the permissible limit of 50 MPN/ 100 ml. This indicates that the water is relatively free from fecal contamination and associated health risks. While some parameters such as pH and fecal coliform count are within acceptable limits, others like color, turbidity, and taste raise concerns regarding potential pollution sources and environmental degradation. The existence of objectionable odor also indicates possible organic contamination. Overall, the data highlights the need for continued monitoring and management efforts to address water quality issues in Matada Kere Lake. Remedial actions such as pollution source control, habitat restoration, and community engagement are essential to safeguard the ecological integrity and usability of the lake water for varied purposes [Table-1].

Mallapura Lake water :

Mallapura Lake water samples in Chitradurga, provides significant insights into the condition of the lake. The assessment covers various physical, chemical, and biological parameters, shedding light on potential environmental concerns and pollution levels. In terms of physical characteristics, the color of the water is measured at 124, which is within the acceptable range according to IS – 2296 "C". The temperature is recorded at 26°C, which is typical for surface water bodies. However, the odor is objectionable, and the taste is disagreeable, indicating potential contamination sources impacting sensory aspects of the water. Chemically, the pH level is slightly alkaline at 8.08, falling within the permissible range of 6.5-8.5. Electrical conductivity is relatively high at 1740 µs/cm, suggesting a significant presence of dissolved ions. Turbidity is relatively low at 4.7 NTU, indicating clarity in the water. TSS and TDS were recorded at 138 mg/L and 1064 mg/L, respectively. Total Alkalinity, Calcium, Total Hardness, and Magnesium concentrations are within measurable ranges. Biologically, the fecal coliform count is 13 MPN/100ml, which is well below the permissible limit of 500 MPN/100ml. This count exceeds the permissible limit of 50 MPN per 100 milliliters, suggesting a higher level of fecal contamination in the water. While the water quality parameters suggest overall acceptable levels, the objectionable odor and disagreeable taste raise concerns regarding potential pollution sources and environmental degradation. The elevated fecal coliform count indicates a potential risk to human health and indicates poor water quality. Continued monitoring and management efforts are necessary to address water quality issues in Mallapura Lake, ensuring its sustainability and usability for various purposes, including drinking water supply and recreational activities [Table-1].

The physical attributes of lake water, including color and temperature, exhibit notable variations across diverse studies and geographical settings, reflecting the complex interplay of environmental factors and human influences on these aquatic ecosystems[68]. Temperature, a pivotal parameter susceptible to external modifications, such as the implementation of floating photovoltaics [FPV], can alter irradiance and wind speed above the water surface, consequently affecting thermal stratification within the lake and potentially mitigating the impacts of climate change[26]. Comparing the color and temperature of Madiwala Lake, Matada Kere and Mallapura Lake, distinct variations are evident, offering insights into the unique characteristics of each water body. Madiwala lake and Matada Kere exhibit similar temperatures, both recorded at 26°C, suggesting comparable thermal conditions. However, Matada Kere stands out with a relatively higher color intensity, measured at 196, indicating potential disparities in suspended solids or dissolved substances compared to Madiwala Lake. Conversely, Our findings align with observations of water color in Bengaluru lakes, which generally adhere to prescribed limits, signifying minimal pollution, despite seasonal fluctuations affecting other physico-chemical parameters[14]. Similarly, studies on Puliyanthangal Lake note variations in water appearance from turbid to clear, influenced by the influx of tannery effluents and domestic waste[26]. In Maharashtra's Malijunga Lake, water temperature displays seasonal variability, indicating the influence of climatic changes on lake water temperature[36]. Although not explicitly addressing water color, research on Lake Bunyonyi reveals significant temporal temperature variations across study months, which remain within WHO standards for drinking water[28]. Investigations on Medchal Lake in Telangana indicate most physicochemical parameters, likely including color and temperature, within permissible limits, suggestive of improved lake water quality[53]. Conversely, the assessment of Lower Lake in Bhopal highlights severe contamination affecting water color and rendering it unsuitable for drinking, lacking specific temperature data[51]. Meanwhile, Thimmapur Freshwater Lake exhibits seasonal shifts in physicochemical parameters, including temperature, remaining within acceptable limits for various purposes[12].

The sensory attributes of lake water, notably odor and taste, are subject to diverse influences such as specific chemical compounds, seasonal shifts, and environmental contexts. Research indicates that the decomposition of aquatic vegetation can produce odor and taste [T&O] compounds like dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide, especially in regions with abundant plant biomass and aquaculture activities[19]. Comparative analysis of Madiwala Lake, Matada Kere and Mallapura Lake unveils notable distinctions and parallels in taste and odor profiles, offering insights into the sensory dimensions of each water body. Madiwala Lake, Matada Kere, and Mallapura Lake exhibit objectionable odor and disagreeable taste, suggesting potential contamination sources affecting water quality. Our findings resonate with studies on Lake GoverdhanSagar and Puliyanthangal Lake, which report similar issues with odor and color, indicating potential water quality challenges[30, 36,42]. Likewise, research on Thippayya Lake underscores variations in water quality parameters, including odor, which could influence the aesthetic and sensory properties of the water[64]. Investigations on water from various sites at Sharda University, Greater Noida, stress the significance of physical and chemical parameters, including odor and taste, in assessing water safety for human use[44]. A study on Chaohu Lake's littoral zones during algal blooms highlights the influence of algal biomass and degradation on odorous compound concentrations, potentially affecting water taste and odor[35]. Consistent with this, broader discussions on the aesthetic aspects of drinking water underscore challenges posed by taste and odor episodes for water supply acceptability[5]. Additionally, analyses of Varsity Lake in Malaysia reveal seasonal fluctuations in physico-chemical parameters that may impact water taste and odor, particularly variables like Dissolved Oxygen [DO] and pH, known to affect sensory properties[6]. Studies on Nigerian lakes draw correlations between physicochemical parameters and aquatic life, indirectly suggesting potential effects on water taste and odor through ecosystem impacts[41].

The chemical parameters of lake water, including pH, EC, TDS, and Turbidity, have been extensively investigated across various lakes, reflecting their diverse environmental conditions and anthropogenic influences[68]. When comparing the pH, electrical conductivity, TDS, and turbidity of Madiwala Lake, Matada Kere and Mallapura Lake with findings from other studies, Several noteworthy comparisons emerge. Our results show that Madiwala Lake exhibits a pH of 7.54, similar to findings from Pulicat Lake, which recorded a pH of 8.17, indicating slightly alkaline conditions[63]. Matada Kere's pH of 8.42 aligns with the alkaline nature observed in Lake GoverdhanSagar, with a mean pH value of 8.7 [29]. Additionally, Mallapura Lake's pH of 8.08 falls within the acceptable range, similar to the situation in Mominpet Lake, where most physicochemical parameters, including pH, were within WHO limits[64]. Electrical conductivity in Madiwala Lake [770 µs/cm] suggests varying mineral content, resembling observations in Medchal Lake, where water was deemed suitable for drinking based on permissible EC levels[47]. High TDS levels in Matada Kere [940 mg/L] and Mallapura Lake [1064 mg/L] are comparable to findings from Puliyanthangal Lake, indicating significant variability possibly due to pollution sources like tannery effluents and domestic waste [36]. Turbidity levels in lakes, particularly Madiwala Lake [30 NTU] and Mallapura Lake [4.7 NTU], differ from those in Thoniravu and Goonankuppam, where turbidity suggested possible contamination[10]. Moreover, our study underscores the importance of continued monitoring and management efforts to ensure the sustainability of freshwater resources, echoing the sentiments expressed in various studies emphasizing the significance of assessing physicochemical parameters for water quality and health implications[67,52].

The chemical parameters of lake water, specifically sulfate, chloride, nitrate, and fluoride, vary across different studies, reflecting the diverse ecological statuses and anthropogenic impacts on these water bodies. These variations highlight the complex interplay between natural processes and human activities in shaping the chemical composition of lake waters. Comparing sulfate, chloride, nitrate, and fluoride levels across Madiwala Lake, Matada Kere and Mallapura Lake reveals significant variations in these chemical parameters, indicating diverse pollution sources and ecological conditions. Madiwala Lake shows relatively lower levels of sulfate, chloride, and nitrate, suggesting minimal contamination. In contrast, Matada Kere and Mallapura Lake display varying concentrations, with some exceeding recommended standards, indicating potential pollution sources. Fluoride levels vary across the lakes, with Madiwala Lake and Matada Kere exhibiting marginal exceedance of standard thresholds. Mallapura Lake displays slightly elevated fluoride levels, These variations highlight the diverse chemical compositions and pollution sources affecting the lakes, emphasizing the need for targeted management strategies to mitigate contamination risks and safeguard water quality.

In comparison with other studies, our findings align with the assessment of Manchippa Lake, where sulfate, chloride, and nitrate levels were within permissible limits, indicating water quality suitable for human consumption[66]. However, in Lake Goverdhan Sagar, while chloride content was below permissible limits, elevated fluoride levels suggest unsuitability for potable and domestic uses due to high pollution status[42]. Similar concerns were observed in Keana Salt Lake, Nigeria, where although sulfate and chloride levels met WHO standards, elevated total dissolved solids [TDS] and electrical conductivity raise potential water quality issues[18]. Lake Batllava maintained most parameters within acceptable limits, except during precipitation seasons, implying occasional contamination events[62]. Haleji Lake displayed notable variation in sulfate and nitrate levels over time, indicating fluctuations in chemical parameters[27]. Conversely, Upper Manair Dam's water quality standards imply safe levels of sulfate, chloride, and fluoride, aligning with our findings[9]. The acceptable chloride and fluoride levels in Lake Badovci contribute to its moderate ecological status[18], contrasting with potential pollution impacts observed in Puliyanthangal Lake[36]. While specific data on sulfate, chloride, nitrate, and fluoride were not provided for Lake Pomacochas[33], our study's focus on these parameters adds depth to understanding water quality issues in different ecosystems. Lake Goverdhan Sagar's chloride and fluoride levels were below permissible limits, consistent with our findings, though sulfate and nitrate concentrations were not specified[42].

When comparing DO levels across Madiwala Lake, Matada Kere and Mallapura Lake significant variations in water quality indicators are evident. Madiwala Lake exhibits low DO levels at 3.2 mg/L, indicating potential oxygen depletion and compromised water quality. In contrast, various studies have shown a range of DO levels supporting aquatic life, such as 5.4 mg/l [52] and 5.65 ± 0.13 to 8.99 ± 0.19 mg/l [11]. Urban and rural lakes in Bangalore, including the cleanest one with a DO of 3.6 mg/L [42][Patida, 2022], exhibited lower DO levels, suggesting some degree of pollution. Similarly, DO levels in Lake GoverdhanSagar ranged from 5.4 ppm [52] to 7.69 mg/L in Lake Hayq[24]. These variations highlight differing levels of aeration and biological activity within these aquatic environments.

When comparing COD across Madiwala Lake, Matada Kere and Mallapura Lake, significant variations in water quality indicators are observed. Madiwala Lake exhibits a relatively high COD value of 309.5 mg/L, suggesting a notable organic pollution burden and the presence of oxygen-consuming substances. Lake GoverdhanSagar, on the other hand, showed a COD value of 45.88 ppm [24,64], reflecting a comparable organic pollution load. Similarly, in the study of Lake Beratan, COD levels exceeded quality standards, although specific figures were not provided[42]. These variations highlight fluctuations in water quality influenced by human activities. For example, during a lockdown period, a lake demonstrated COD levels within acceptable limits due to reduced human activities[43]. Conversely, tourist areas showed COD values surpassing quality standards, indicating pollution from domestic and agricultural activities[21].

BOD levels varied significantly among Madiwala Lake, Matada Kere and Mallapura Lake, indicating differences in organic pollution levels across these water bodies. Our findings are correlated with many studies who also reported varied levels of BOD, for instance, Lake GoverdhanSagar displayed a BOD of 3.96 ppm[33], slightly increasing to 4.02 ppm in a subsequent study[39], suggesting a moderate level of organic pollution. Conversely, Lake Beratan's BOD parameters met quality standards, indicating lower organic pollution levels[43]. In contrast, Lake Hayq exhibited a higher BOD of 6.40 mg/L [4], signifying a relatively more substantial organic load. These findings underscore the significance of monitoring and managing water quality to mitigate pollution and support aquatic ecosystems. Additionally, the complex interplay of chemical factors, such as BOD, COD, and others like electrical conductivity and alkalinity, underscores the need for comprehensive assessment approaches. Although the Malijunga Lake study primarily focused on physicochemical parameters, it indirectly suggested that factors like BOD and COD could influence water taste and odor by affecting overall quality[28]. Moreover, BOD levels within quality standards in Lake Beratan implied a moderate level of organic pollution[13], while a study on Lake GoverdhanSagar reported a higher BOD of 4.02 ppm, indicating a higher pollution status alongside elevated COD levels[61]. These collective

Table-1. Water Quality Analysis of three water bodies of Bangalore and Chitradurga districts

Parameters	Madiwala lake	Matadakere	Mallapura lake	Standards
Color	112	196	124	300
Temperature	26	26	26	-
Odour	Objectionable	Objectionable	Objectionable	Unobjectionable
Taste	Disagreeable	Disagreeable	Disagreeable	-
pH	7.54	8.42	8.08	6.5-8.5
Electrical Conductivity	770	1310	1740	-
Turbidity	30	190	44.7	-
Total Suspended Solids	124	162	138	-
Total Dissolved Solids	540	940	1064	1500
Total Alkalinity as $CaCO_3$	220.8	441.7	727.9	-
Calcium as Ca	44	31	83.2	-
Total Hardness as $CaCO_3$	167.2	285.6	440.6	-
Magnesium as Mg	13.8	50.5	56.6	-
Oil & Grease	4	6	6	0.1
Sulphate as SO_4	62	96.1	98.7	400
Chloride as Cl	131.1	245.1	247	600
Nitrate as NO_3	5.2	6.3	6.0	50
Fluoride as F	1.50	0.86	2.30	1.5
Dissolved Oxygen	3.2	3.0	2.8	Min 4
Chemical Oxygen Demand	309.5	634.8	1745.9	-
Bio-Chemical Oxygen Demand	92	190	523	3
Manganese as Mn	0.09	0.10	0.11	-
Mercury as Hg	Nil	Nil	Nil	-
Arsenic as As	<0.01	<0.01	<0.01	0.2
Cadmium as Cd	<0.001	<0.001	<0.001	0.01
Hexavalent Chromium	BDL	BDL	BDL	0.05
as Cr6+				
Lead as Pb	<0.002	<0.002	<0.004	0.1

Nickel as Ni	BDL	BDL	BDL	-
Copper as Cu	0.1	0.2	0.22	1.5
Zinc as Zn	0.4	0.5	0.54	15
Free Ammonia	BDL	BDL	BDL	-
Iron as Fe	0.26	0.28	0.28	0.3
Phosphates	0.1	0.1	0.1	-
Residual Chlorine	BDL	BDL	BDL	-
Fecal coliform	5	7	13	50

findings underscore the varying levels of BOD in lake waters, influenced by natural conditions and human activities, necessitating ongoing monitoring and management to preserve water quality.

When comparing fecal coliform levels in these three water bodies, notable differences in microbial contamination are evident. Madiwala Lake exhibits a relatively low fecal coliform count of 5 MPN/100ml, indicating minimal fecal contamination and suggesting acceptable microbiological quality for surface water. Matada Kere and Mallapura Lake display slightly higher fecal coliform counts at 7 MPN/100ml and 13 MPN/100ml, respectively, indicating a moderate level of contamination but still within acceptable limits for recreational water use. These variations highlight the diverse pollution sources affecting the lakes and underscore the importance of continued monitoring and management efforts to safeguard water quality and protect public health. Comparatively, fecal coliform contamination in lake water across Karnataka, India, presents a significant public health concern, as evidenced by various studies. For instance, in Gidada-konenahalli Lake, Bangalore, severe pollution levels were identified, although specific fecal coliform counts were not detailed, indicating severe pollution[55]. Similarly, in the Bangalore district, fecal coliforms, including *E. coli,* were detected in 60% of water samples, indicating widespread bacterial contamination[46]. The River Cauvery, a major drinking water source, showed high levels of fecal coliforms, posing a threat to public health and antibiotic efficacy due to multidrug-resistant isolates [58] . Studies in South India’s reservoirs and lakes have also shown pollution from fecal coliforms due to inadequate civic facilities, leading to the inflow of untreated wastewater[16]. Proximity of wells to open sewerage systems in Bangalore resulted in high levels of fecal coliform contamination, exceeding permissible limits [57]. Ramasandra Lake’s water samples revealed high microbial and fecal contamination, indicating a serious public health threat[32]. Research on FRNAPH genotyping in lake water suggested its relevance in identifying fecal contamination sources[60]. Monitoring of Vembanad Lake revealed E. coli prevalence throughout the year, adding urgency to contamination control efforts[1]. Studies in Vembanadu Lake showed sediments acting as reservoirs for pathogenic bacteria, posing risks during recreational activities[2]. Lastly, assessment of Mysore city's drinking water supply highlighted the presence of enteric bacteria, emphasizing the need for improved water hygiene practices[45].

Heavy metals in lake water pose significant ecological and health risks, with variations in contamination levels and sources across different regions and seasons. The sources of these heavy metals are varied, including agriculture, transportation, chemical industry, steel-making, and natural sources[70]. Research conducted across various regions in India has revealed concerning levels of heavy metal pollution in lake waters, posing significant risks to aquatic ecosystems and human health.

The analysis of water quality parameters across Madiwala Lake, Matada Kere and Mallapura Lake reveals diverse conditions and varying levels of pollution in these freshwater ecosystems. While, some parameters meet acceptable standards, such as pH and fecal coliform counts, others indicate potential environmental concerns, including elevated levels of turbidity, total dissolved solids and chemical oxygen demand. Additionally, the presence of objectionable odors and disagreeable tastes further underscores the impact of pollution sources on sensory aspects of the water. Understanding these differences is crucial for targeted management strategies to address water quality concerns effectively. Continued monitoring and mitigation efforts are essential to preserve the ecological balance and ensure the long-term sustainability of these freshwater ecosystems.

The authors are extend their sincere gratitude to the faculty and staff of the Department of Studies in Environmental Science, Davangere University for generously providing the essential space and facilities to carry out the research work. Ms, Umadevi, K.M. extend her sincere gratitude to the SC ST Cell, Davangere University, Davangere, for providing fellowship support, which was instrumental in facilitating this research endeavor.

References :

1. Abdulaziz, A., S. Sathyendranath, S. Vijayakumar, N. Menon, G. George, G. Kulk, D. Raj, K. Krishna, R. Rajamohananpillai, B. Tharakan, C. Jasmin, J. Vengalil, and T. Platt, (2023). *ACS Environmental Science & Technology Water*, *3*(6): 1561-1573.
2. Abhirosh, C., V. Sherin, A. P. Thomas, A.A.M. Hatha, and P. C. Abhilash (2010). *Water Quality, Exposure and Health*, *2:* 105–113.
3. Acharya, K., B. Sharma, and A. Dhakal, (2023). *Saptagandaki Journal, 14*(1): 112-135.
4. Aguilar-Torrejón, J. A., P. Balderas-Hernández, G. Roa-Morales, C.E. Barrera-Díaz, I. Rodríguez-Torres, and T. Torres-Blancas (2023). *SN Applied Sciences*, *5:* 118.
5. Akçaalan, R., R. Devesa-Garriga, A. M. Dietrich, M. Steinhaus, A. Dunkel, V. Mall and T. Kaloudis, (2022). *Chemical Engineering Journal Advances*, *12:*
6. Aliagha, U. G., and F. M. Begham, (2022). *Desalination and Water Treatmen*t, *269:* 249-261.
7. Alsharhan, A., and Z. Rizk, (2020). Water resources and integrated management of the United Arab Emirates. In Water

Resources and Integrated Management of the United Arab Emirates, Springer: Cham, [pp. 683–705].

8. American Public Health Association. (2005). Standard Methods for the Examination of Water and Wastewater [2st ed.]. Washington, DC: APHA.
9. Anjaiah, V., and K. Shailaja, (2023). *International Journal of Scientific Research in Science and Technology* [IJSRST], *10*(2): 332-341.
10. Anuradha, K., and Nirmala Babu Rao. (2021). *Annals of the Romanian Society for Cell Biology*, 5717–5733.
11. Arik, A. and I. Muliadiasa (2023). *Journal of Culinary Management*, *2:* 1-9.
12. Benarjee, G., and P. Gowri, (2018). Assessment of water quality using physico-chemical parameters: A study of a freshwater lake in Warangal District, Telangana State, India. Conference Proceedings,
13. Birla, S., and S. Vedashree, (2020). *International Journal of Engineering Applied Sciences and Technology*, *04*(10): 59-64.
14. Carrea, L., J. F. Crétaux, X. Liu, Y. Wu, B. Calmettes, C. R. Duguay and C. Albergel (2023). *Scientific Data*, *10*(1): 30.
15. Cazenave, A., N. Champollion, and J. Benveniste (2016). *Surveys in Geophysics*, *37:* 191–194.
16. Chandrashekar, H., K.V. Lokesh, J. Roopa, and G. Ranganna (2012). On Water Quality Aspects of Manchanabele Reservoir Catchment and Command Area [Karnataka]. Proceedings, 137-143.
17. Chatterjee, A., and S. Ganesh, (2020). *Annals of Limnology and Oceanography*, *5*(1): 001-007.
18. Chatterjee, R., and D. Lataye, (2020). Analysis of Water Quality Parameters and Their Variation for Surface Water Using GIS-Based Tools. In *Applications of Geomatics in Civil Engineering* [pp. 289-302].
19. Daija, L., X. Këpuska, S. Shallari, and L. Shehu (2016). *Journal of the Association-Institute for English Language and American Studies*, *2*(4): 326–330.
20. Danaher, C., T. Newbold, J. Cardille, and A. S. A. Chapman, (2023). *Conservation Biology*, *36*(5): e13914.
21. Fatimah, N., B. Yunita, B. Agam, M. Maryono, and D. Merdekawati, (2021). The Analysis of Aquatic Chemical Parameters in Kurapan Lake and Sambas River, Sepantai Village, Sambas, *Berkala-perikananterubuk,* 740-747.
22. García-Avila, F., P. Loja-Suco, C. Siguenza-Jeton, M. Jiménez-Ordoñez, L. Valdiviezo-Gonzales, R. Cabello-Torres and A. Aviles-Añazco, (2023). *Ecological Indicators*, *154:* 110924.
23. GarcíaMolinos, J., M. Viana, M. Brennan, and I. Donohue, (2015). *PLOS ONE*, *10*(1): 1-12.
24. Gobeze, A., T. Kaba, M. Tefera, T. Lijalem, M. Legesse, F. Engdaw, and A. Guadie, (2023). *Applied Water Science*, *13:* 103.
25. Haider, A., A. Roy, R. Sharma, V. Hegde and S. Kumuda, (2016). AquaPredicto — Freshwater quality management system for lakes, pp. 1-8.
26. Ilgen, K., D. Schindler, S. Wieland, and J. Lange, (2023). *Scientific Reports*, *13:* 7932.
27. Kashtanjeva, A., I. Vehapi, K. Kurteshi,, and M. Pacarizi, (2022). *Journal of Ecological Engineering*, *23*(9): 231-240.
28. Khune, C. J., M. B. Raut, and L. P. Nagpurkar (2021). *International Journal*

of Life Sciences, *9*(1): 114-118.

29. Kumar, M. S. (2023). *International Journal For Science Technology And Engineering*, *11*(6):
30. Kumar, P., A. Joshi, M. Mishra, T. Das, R. N. Sharma, Ram, and R. K. Srivastava, (2020). *National Academy Science Letters*-India, *43*(2): 403–407.
31. Kumari, N., K. Thakur, R. Kumar, D. Mahajan, D. Sharma, B. Brar, and B. Bhavna, (2023). *Water-Energy Nexus*, *6:* 18-31.
32. Latha, N., and Ramachandra Mohan, M. (2013). *International Journal of Advanced Research*, 1: 162-166.
33. Leiva-Tafur, D., GoñasMalluri, Culqui Lorenzo, Santa Cruz Carlos, RascónJesús, and Oliva-Cruz, M. (2022). *Frontiers in Environmental Science*, *10:* 885591.
34. Li, E., F. Saleem, T. A. Edge, and H. E. Schellhorn, (2021). A Review, *Processes*, 9(11): 2058.
35. Ma, S., B. You, L. Jiang, Y. Wu, D. Chen, H. Zhu, and K. Chen, (2023). *Journal of Lake Sciences*, *35*(4): 1203-1211.
36. Maheswari, M., and K. Sivachandrabose, (2023). *International Journal of Zoology and Animal Biology*, *6*(1): 000431.
37. Mauro, M., Lo Valvo, M., M. Vazzana, S. Radovic, A. Vizzini, R. Badalamenti, L. B. Hornsby, and V. Arizza, (2023). *Animals, 13*(23): 3687.
38. Mititelu, M., M. S. Neacşu, Ioniă-Mîndrican, C.-B. and G.I. Olteanu, (2023). *Farmacist.ro.*, *1*(1): 30-38.
39. Molla, A., M. Tewodrose, A. Metafet, E. Seid, and A. Girum, (2022). Assessing Physicochemical Parameters and Trophic Status of Lake Hayq, South Wollo, Ethiopia.
40. Omer, N. (2020). Water Quality Parameters. In *K. Summers*[Ed.], IntechOpen. DOI: 10.5772/intechopen.89657.
41. Onah, I., O. Ajanwachukwu, and P. Ubachukwu, (2022). *African Journal of Aquatic Science*, *47*(6): 1-10.
42. Patida, R. (2022). *International Journal for Science Technology and Engineering*, 10.
43. Premsudha, R., G. Tirupathi, G. Madhusudhan, L. Swaroopa, L. Sathyavathi, Naveenkumar Reddy, V., and M. Mahavish, (2022). *International Journal of Advanced Research in Science, Communication and Technology*, 543-550.
44. Priyanshi, Phiri, T. A., Prachi, Chhaya, Tomar, S., S. Sagar, Awasthi, A., and S. Sharma, (2023). *Journal for Research in Applied Sciences and Biotechnology*, *2*(2): 118–123.
45. Raju, N. S., C. Roopavathi, Ramachandra Kini, K., and S. R. Niranjana, (2011). Assessment of coliform contamination in drinking water from source to point of use in Mysore city of Karnataka, India. Loughborough University. Conference contribution.
46. Ramachandra, M., and N. Latha, (2014). *International Journal of Chemical Studies*, *2*(1): 12-18.
47. Randrianiaina, J.C.F., I. Rakotonirina, R. Ratiarimanana, and L. F. Razafindramisa, (2019). *American Journal of Geographic Information System, 8*(6): 221-227.
48. Rashid, R. F., S. Saler, and M. Z. Çoban, (2022). *Asian Journal of Fisheries and Aquatic Research, 16*(5): 35-44.
49. Sagova-Mareckova, M., J. Boenigk, and A. Bouchez, *et al.* (2021). *Water Research*, *191:* 116767.
50. Saini, A.K. (2022). *International Journal of Chemical Research and Development*, *4*(1): 35-38.

51. Salla, S., and S. Ghosh, (2014). *Archives of Applied Science Research*, *6*(2): 8-11.
52. Santhi, K., Lakshmi, N.U.C.M., and M. Noornissabegum, (2023). *Uttar Pradesh Journal of Zoology*, *44*(5): 68–75.
53. Saturday, A., T.J. Lyimo, and J Machiwa, (2021). *SN Applied Sciences*, *3:* 684.
54. Shashank, A. S., and K. Velayudhannair, (2023). *Environment and Ecology*, *42*(2): 479–491.
55. Shekar, G., L. Narayan, and M. R. Mohan, (2015). *Advances in Forestry Science*, *2*(1): 7-12.
56. Sikder, M. S., J. Wang, G. H. Allen, Y. Sheng, D. Yamazaki, C. Song, M. Ding, J.-F. Crétaux, and T. M. Pavelsky, (2023). *Earth System Science Data*, *15*(8): 3483–3511.
57. Singh, M. J., R. K. Somashekar, K. L. Prakash and K. Shivanna (2009). *Journal of Ecology and the Natural Environment*, *1*(6): 156-159.
58. Skariyachan, S., A.B. Mahajanakatti, N.J. Grandhi, A. Prasanna, B. Sen, N. Sharma, K. S. Vasist, and R. Narayanappa, (2015). *Environmental Monitoring and Assessment, 187*(5): 279.
59. Sladen, C., and D. Chiarella, (2020). Lake systems and their economic importance, In N. Scarselli, J. Adam, D. Chiarella, D. G. Roberts, & A. W. Bally [Eds.], *Regional Geology and Tectonics*, Chapter *13:* 313-342. Elsevier.
60. Śliwa-Dominiak, J. and B. Tokarz-Deptuła (2014). *Polish Journal of Environmental Studies*, *23:* 467-473.
61. Sukmawati, N. M. H., N. W. Rusni, and A.E. Pratiwi (2020). *Warmadewa Medical Journal, 5*(1): 8-15.
62. Sule, P. I., and O. Ivoms, (2020). *Science Journal of Analytical Chemistry*, *8*(3): 111.
63. Sumithraa, R., A. Vinoth, and N. Thirunavukkarasu, (2022). *Ecology, Environment and Conservation*, 422-427.
64. Suresha, N. S., N. Smitha, and D. Shiva Kumar (2023). *World Journal of Advanced Research and Reviews*, *17*(1): 1218–1228.
65. Suring, L. (2019). Lentic Freshwater: *Lakes*. 12074-3.
66. Swetha, S., and A. Maddela, (2023). *International Journal of Scientific Research in Science and Technology*, 696-703.
67. Tigga, T. M., and V. K. Pandey, (2023). *International Journal for Multidisciplinary Research*, *5,* 1:
68. Turunen, J., and J. Aroviita, (2024). *Water Research*, *250:* 121048.
69. Uddin, M., T. Kormoker, M. Siddique, M. Billah, A. R. Rokonuzzaman, Al Ragib, A., Proshad, R., M.Y. Hossain, M. Haque, and A. Idris (2023). *Urban Water Journal*, *20:* 261-433.
70. Yu, Liu, Chun Ou, Ning Zhang, and Xiaoli Wang. (2022). *Water supply*, *22*(5): 6821–6832.