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Evaluation of the Water quality of Mallapura Lake, Chitradurga District, Karnataka

C. N. Venkatesh and Shashikanth H. Majagi*

*Department of Studies in Zoology,
Vijayanagara Sri Krishnadevaraya University, Ballari-583105 (India)
Email:majagish78@gmail.com

Abstract

In the present study, average monthly variations in physico-chemical parameters of surface water samples of Mallapura lake was assessed during January 2022 to January 2024. The pH of the water in the Mallapura lake was between 7.02 (January 2022) to 8.3 (December 22). Water temperature ranged from 19.6^{O}C (January 2023) to 24.2^{O}C (May 2022). Total phosphate content fluctuated from 0.33 mg/l in June 2023 to 4.87 mg/l during March 2023. The DO found in the lake samples was between 2.1 mg/l in January 2022 and 5.7 mg/l during November 2022.The total hardness samples ranged from 166.34 mg/l (October 2022) to 356.31 mg/l (February 2022). Electrical conductivity is the capacity of the solutions to conduct electricity and the values for lake water was ranged from 1065 (January 2022) to 1866 µmhos/cm (June 2023). Calcium content ranged from 124.54 in October 2022 to 245.49 mg/l during May 2022. Magnesium (mg) was in the range of 42.44 (October 2022) to 202.58mg/l (February 2022). Lowest chloride value was recorded with 143.95 mg/l during April 2022 and highest value with 231.53mg/l recorded in April 2023. CO_2 content fluctuated from 1.8 mg/l (December 2022) to 4.6 mg/l (February 2022). pH of the water samples were within the desired limit. Based on total hardness values, water falls under moderately hard to hard category. Calcium was above the desirable limit and magnesium is above the permissible limit. However, chloride level is within the permissible limit. Data subjected for statistical analysis for correlation and also done Principal Component Analysis (PCA) found to be useful technique to reveal the correlation of the data. Although over all parameters falls in the permissible limits the people do not use water for domestic and drinking purpose due to its color and unaesthetic reasons. However, further investigation is required to monitor the water body.

Key words : Mallapura lake, Chitradurga district, Mesotrophic, water quality, Sewage.

Lentic water bodies like pond, lake, dams etc are part of freshwater habitat and they are useful to mankind. The survival of life in the tank depends on the quantity and quality of water. Nevertheless, continuous inputs of various chemical pollutants from human activities has seriously deteriorated the quality of tank ecosystems in India. Water bodies are threatened due to point and nonpoint sources of pollution. Major factors for eutrophication include nutrients (Nitrate and phosphate) input and organic matter load, construction and logging activities[8].

Lakes and reservoirs across the country are exposed to various forms of environmental degradation. The causes of this deterioration are rapid population growth, increasing living standards, rapid industrialization and urbanization. Water is the most important yet scarce resource in India. Currently, the quality and availability of freshwater resources faces many environmental challenges at the national level. There are several sources of pressure on water resources, and their effects can take many forms. Approximately 16% of the world's population lives in India, which has only 4% of the world's water resources. Therefore, the pressure on India's water resources is very high[15].

Lakes are the dynamic ecosystems that reflect specific lake basin characteristics, climate change, and biological factors. The size, depth and volume of the lake basin and the quantity and quality of water flowing into the lake are important factors. Based on this information, lake management measures such as surface use regulations, ventilation, and management of native and exotic aquatic plants are implemented. Important water quality issues include lake biological productivity (trophic status), water chemical profile, regional water quality comparisons, nutrient concentrations, water clarity, specific contaminants, and historical trends. Lake management issues related to the physical properties of lakes require data on lake surface, shape, depth, and volume. Inlet and outlet characteristics and soil type are also important.

There are various issues regarding lakes, including: Examples: excessive input of sediment from lake catchments, discharge of untreated or partially treated sewage and industrial effluents/solid waste, input of diffuse nutrients from agriculture and forestry, inappropriate input of rainwater etc. Overuse of lakes for management, abstraction, and activities leads to lake water loss, coastal erosion, impacts on lake hydrology, water quality deterioration, biodiversity degradation, climate change, etc.[11].

It is very necessary and important to investigate the water before it is used for drinking, domestic, agricultural or industrial use. Water must be tested for various physico-chemical parameters. Water does contain floating, dissolved, suspended and microbiological impurities[4].

Water bodies are important resources used for inland fisheries and recognition of various fish fauna, which offers great prospects for the improvement and sustainable management of water bodies[12]. Water is a renewable natural resource and the basis of life. Lentic water is used for drinking and domestic purposes. Physico-chemical factors are created based on scientific data about the

impacts of pollutants on a particular use of water[21,28,29].

The environment impact of chemical compounds can be viewed as an aggravation in biological system as far as an expansion in convergence of ions or organic compounds beyond their natural level in plant and animals[9,22]. Water bodies are the fundamental needs for inland fisheries and comprehension of fish faunal assorted variety which is a significant viewpoint for its improvement and the sustainable administration. Indian wetlands sustain rich diversity of fish species, which thusly encourage the business capability of the fisheries[12].

The present study aims to know the variations in few physico-chemical parameters of Mallapura lake, Chitradurga district since recently no studies have been carried out on this aspect prevailing in this area.

Study area :

Chitradurga is a district head quarter (Figure 1) which is located on the valley of the Vedhavathi river in the central part of the Indian state of Karnataka. The area lies in between longitude 76° 24' to 76° 28' 5" E and latitude 14° 11' to 14° 17' N.

It is a perennial, natural fresh water body situated 2 km away from Chitradurga city. Total water spread area is 91.84 hectares and the depth of the water body is about 2.5 meters. The command area is 130 hectares. The water storage capacity is about 189 million cubic feet. This lake receives water from rainfall, municipal sewage and also agricultural runoff. The colour of water is bluish green. The water of this lake is used to cultivate the crops like Arecanut, Coconut, Jowar, Ragi and Maize, Green leaves and also vegetables. Besides this, water is also used for cattle

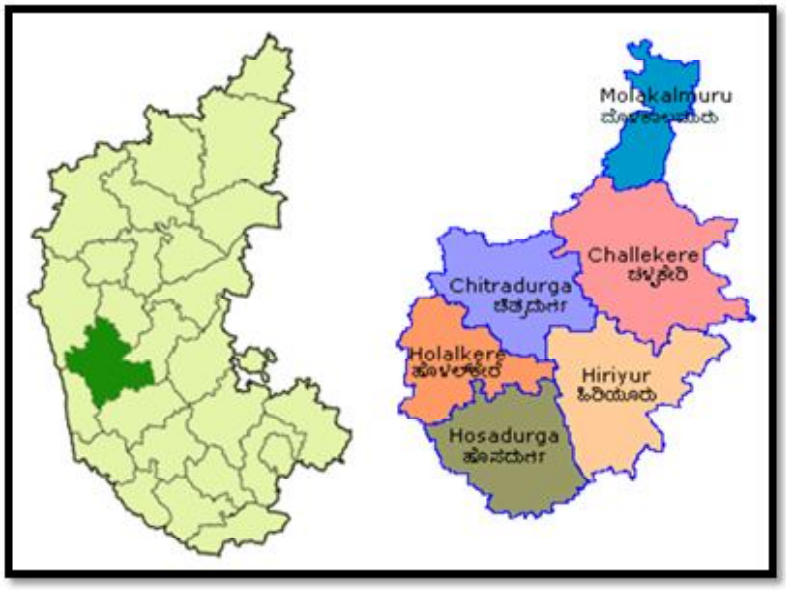

Figure 1. Study area map

bathing and other purposes.

Mallapura lake receives major sewage water especially from urban places of the city. The entire city sewage water is directly released to the water body, Which consists of pollutants, Chemicals, Hospital wastes, Pesticides, Heavy metals, and other poisonous substances.

Water analysis :

Water samples are collected in monthly wise form January 2022 to January 2024 and samples were analyzed as per standard methods[3]. Chemical solutions are used for the investigation of water samples made with distilled water. The samples were analyzed using standard methods for physico-chemical parameters namely; pH, electrical conductivity, total dissolved solids, total dissolved oxygen, total hardness, total alkalinity, calcium, magnesium, chloride and phosphate (PO_4).

Statistical analysis :

Correlation coefficient for average physico-chemical parameters of Mallapura lake is calculated for different water quality parameters by standard methods. Thus, some multivariate statistical techniques have been used to assist the monitoring of water quality, formulating a rapid response to aquatic pollution. Among these the Principal Component Analysis (PCA) is an analytical methodology used commonly in the scientific community as it allows reducing the dimensionality of a data set. The egine values presented in Table-3 shows the BIS drinking water standards. While, Figure 4 and Table-4 depicts the average physico-chemical properties of the surface water of Mallapura lake.

Atmospheric temperature varied from a minimum of 21.5^{O}C during November 2022 to a maximum of 26.1^{O}C in May 2022. The desirable limit of pH for drinking water is 6.5 to 8. The pH of the water sample in the Mallapura lake was between 7.02 (January 2022) to 8.3 (December 22). On average, the pH of the few months and sites were within the desirable limit prescribed by WHO and BIS standards. The water temperature ranged from 19.6^{O}C (January 2023) to 24.2^{O}C (May 2022). The TDS values of the Mallapura lake water samples ranged from 598 (January 2022) to 1027 mg/l (June 2023).

Nutrient like phosphate content fluctuated from 0.33 mg/l in June 2023 to 4.87 mg/l during March 2023. Total alkalinity values were comparatively moderate. Safe limit for household purpose an alkalinity was less than 200 mg/l. The value observed in the present study ranged from 246 (November 2022) to 498 mg/l (October 2023). The DO found in the Mallapura lake samples was between 2.1 mg/l in January 2022 and 5.7 mg/l during November 2022. Nevertheless, the highest desirable limit for dissolved oxygen was 5 to 8 mg/l.

The total hardness found in lake surface samples ranged from 166.34 mg/l (October 2022) to 356.31 mg/l (February 2022), showing that the water was hard. Hardness has no known adverse health effects. However, the maximum value prescribed for drinking water was 300 mg/l.. Based on this, the results shows that all samples were moderately hard to hard category. McGowan

(2000) reported that total hardness is expressed in milligrams of calcium carbonate equivalent/ litre. Water containing $CaCO_3$ at concentrations below 60 mg/l is consider as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard. Hence, the present Mallapura lake included under hard to very hard category.

The Electrical conductivity is the capacity of the solutions to conduct electricity and the values for lake water was ranged from 1065 (January 2022) to 1866 µmhos/cm (June 2023). The values of calcium of the Mallapura lake water samples ranged from 124.54 in October 2022 to 245.49 mg/l during May 2022. However, in all the sites the values of calcium are above the desirable limit (75 mg/l) of BIS standards for drinking water[5]. The magnesium (mg) content of the water samples are in the range of 42.44 (October 2022) to 202.58mg/l (February 2022). In few months the values are above the permissible limit (100 mg/l) of BIS standards for drinking water[5].

Regarding chloride lowest value was recorded with 143.95 mg/l during April 2022 and highest value with 231.53mg/l recorded in June 2023. The values of chlorides were within the desirable limit (250 mg/l) at all the sites. While all the sites are within permissible limit of BIS standards for drinking water.

Free carbon dioxide (CO_2) is soluble in water, primary wellspring of carbon way route in the nature, is contributed by the respiratory activity of creatures and can exist in water as bicarbonate or carbonates in the broken down or bound structure in earth crust, in limestone and coral reefs areas[2]. At the point when broken up in water it structures carbonic acids which decline the pH of any framework, particularly inadequately buffered frameworks, and this pH drop can be hurtful for aquatic living beings[2].

CO_2 content in this investigation fluctuated from 1.8 mg/l (December 2022) to 4.6 mg/l (February 2022). Bhatnagar *et al*. (2004) have reported 5-8 ppm for photosynthetic activity, 12-15 ppm was sublethal to fishes and 50-60 ppm is lethal to fishes. 5 mg/l of free carbon dioxide in water supporting fish population[2,23].

The sulfate concentration of the lake water samples varied from 25.95 to 131.07 mg/L in November 2022 and July 2022 respectively. The result should be that the lake water has a permissible range of sulfate ions, physico-chemical water quality constraints are substantial to the firmness of marine and other water ecologies[18,24].

The permissible limit of calcium is 75 mg/L. Calcium is responsible for the hardness of water and the addition of calcium in the freshwater system indicates that no removal has taken place; instead, it has precipitated in the lake water as the ionic strength has increased[10]. Calcium concentration in the water body varied from 124.54 to 245.49 mg/L. The results indicate that the samples were above the permissible limits of WHO[32].

The Magnesium concentration in the present study was also found (42.44-202.58 mg/L) to be well within the permissible limit. The major cations present in natural waters are calcium and magnesium. Its main source

is the leaching of rocks in the catchments. Its concentration restricts water use, while it is an important component in the exoskeletons of arthropods and shells in mollusks[8,16]. Next to calcium, another dominant cation in natural water is magnesium added to the lakes by leaching of rocks in the catchments. It is a vital component of chlorophyll. A very high concentration of magnesium imparts an unpleasant taste to the drinkable water[16].

Ajai Vyas *et al*.,[1] and Seema Tiwari[26] reported that the most of the fresh water bodies globally are tends to be polluted due to domestic sewage and industrial effluents, agricultural runoff and idol immersion. Rahashyamani Mishra *et al*.,[19] worked on the Rani lake water and they recorded minimum Dissolved oxygen. Their findings has showed that lake was eutrophic in nature due to discharge of sewage water and anthropogenic activity by the human beings.

Sathishagouda *et al*.,[25] have investigated the physico-chemical parameters and biotic factors of Chikkere water body of Sira during February 2020 and they analysed physico-chemical parameters like temperature, pH, EC, turbidity, DO, TDS, total hardness, Calcium, Magnesium, total alkalinity, Chloride and BOD. Their results revealed that except turbidity most of the physico-chemical parameters were within the permissible limits.

Our study on Mallapura lake revealed notable variations in water quality concentrations compared to broader research conducted across various regions in India. This aligns with findings from lakes across India, where water pollution poses significant risks to aquatic ecosystems and human health[13,20,30]. Additionally, industrial activities near water bodies, as observed near a thermal power plant in Udupi District, have contributed to heavy metal contamination of groundwater and soil[27].

Table-1. Showing the positive and negative correlation with the physico-chemical parameters in Mallapura lake

Parameters	Positively correlated with	Negatively correlated with
pH	DO, Cl, TH, Ca, Mg, TDS, EC	Total Phosphate, CO_2, SO_4. TA,
Total Phosphate		DO, CO_2, Cl, TA, TH, Ca, Mg, TDS, EC
DO	SO_4, Cl, TA, TDS, EC	CO_2, TH, Ca, Mg
CO_2	Cl, TH, Ca, Mg, EC	SO_4, TA, TDS
SO_4	Cl, TA, TH, Ca, Mg, TDS, EC	
Chloride	TA, TH, Mg, TDS, EC	Ca
Total Alkalinity	TDS, EC	TH, Ca, Mg
Total Hardness	Ca, MG, TDS, EC	
Calcium	Mg, TDS, EC	
Magnesium	TDS, EC	
TDS	EC	

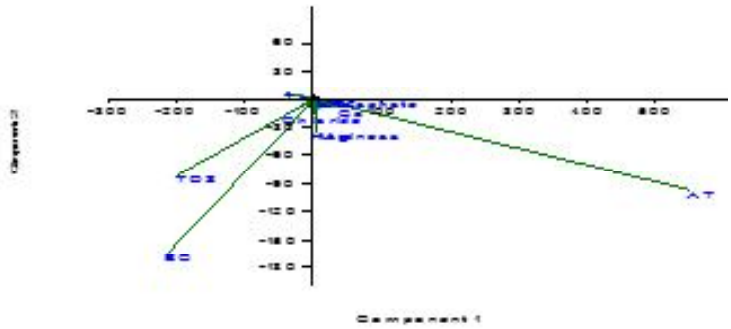

Figure 2. Principal Component Analysis(PCA) of the Physico-chemical parameters of Mallapura lake

Table-2. Drinking water quality standards

Parameter	Permissible limit	
	WHO, 1994	Bureau of Indian Standards (BIS,1991)
Colour, Hazen unit, max	Nil	5.0
Turbidity, NTU	5.0	5.0
Odour	Nil	Unobjectionable
Dissolved solids	500	500
Total hardness	100	300
Calcium hardness	75	75
Magnesium hardness	30	30
Alkalinity	200	200
Dissolved oxygen	4-6	4-6
Chloride	250	250
Nitrate	45	45
Iron	0.3	0.3
pH	6.5-8.5	-
BOD	5	-
Potassium	12	-

Table-3. Monthly average of physico-chemical parameters of Mallapura lake (mg/Lt)

MONTHS	AT	WT	PH	Total Phos-phate	DO.	CO_2	SO_4.	Chlo-ride.	Total Alka-linity	Total Hard-ness	Ca	Mg	TDS	EC µmhos /cm
January2022	23.8	21.2	7.02	3.53	2.1	4.2	48.91	169.54	300	293.86	178.56	115.3	598	1065
February	23.9	21.9	7.36	2.11	3	4.6	27.96	196.16	370	356.31	153.73	202.58	737	1312
March	24.2	22.4	7.54	1.08	2.5	2.7	82.61	169.54	378	283.45	188.97	94.5	720	1282
April	24.6	21.9	8.04	1.26	2.7	3.5	26.5	143.95	253	350.67	231.4	119.28	793	1390
May	26.1	24.2	7.77	1.8	3.1	3.4	35.79	148.75	281	338.71	245.49	163.89	769	1356
June	23.2	21.8	8.1	0.35	4.5	3.9	41.89	225.61	339	337.64	165.11	169.3	1014	1788
July	23.4	21.6	7.47	1.36	5.2	2.8	131.07	215.43	352	343.21	171.69	171.52	944	1580
August	24.2	21.9	7.73	2.2	5.5	2.7	44.83	154.33	374	238.19	166.95	71.24	720	1256
September	23.8	20.8	7.53	2.01	5.4	2.7	44.33	147.6	333	206.09	143.86	62.25	649	1213
October	22.2	20.3	7.45	0.99	4.2	3.4	40.5	149.93	250	166.34	124.54	42.44	629	1129
November	21.5	19.8	7.37	1.15	5.7	3.4	25.95	156.35	246	295.61	162.54	132.92	713	1276
December	23.4	20.1	8.3	2.31	4.2	1.8	33.17	171.55	275	297.07	169.75	127.33	752	1362
January 2023	21.6	19.6	8	2.82	3.6	4.3	26.82	183.08	269	294.13	167.49	125.22	753	1381
February	22.4	20.1	7.46	1.57	2.9	4.3	37.35	190.34	269	323.49	155.34	168.15	790	1414
March	22.6	20.4	8.21	4.87	3.2	2.5	26.29	180.08	292	294.14	154.42	139.74	788	1428
April	23.1	21.2	7.99	1.48	3.8	3.2	26.91	231.13	326	324.29	136.12	188.17	918	1625
May	22.8	21.9	7.92	1.15	3.8	3.5	33.47	226.63	348	330.7	147.33	183.36	934	1694
June	23.8	20.9	8.23	0.33	4.4	2.5	43.94	231.53	358	341.13	170.69	170.55	1027	1866
July	22.9	20.6	7.61	1.28	5.2	2.5	35	222.73	363	344.31	172.95	172.16	923	1594
August	22.1	20.1	8.12	1.98	4.8	2.9	41.02	172.42	369	278.23	152.01	92.08	790	1352
September	22.3	19.8	7.67	1.96	4.9	2.7	40.08	169.46	354	241.42	149.06	74.04	694	1294
October	21.8	20.2	7.69	1.82	3.1	2.9	39.08	162.41	498	214.82	143.02	73.03	682	1198
November	21.6	19.7	7.38	1.64	3.8	2.6	34.06	159.68	384	242.28	149.08	98.23	696	1214
December	21.1	20.3	7.84	1.61	2.9	2.4	31.05	162.48	342	264.28	152.01	103.42	714	1218
January 2024	20.1	20.2	7.68	2.34	2.4	2.7	42.86	174.68	312	295.26	169.46	112.23	694	1128

These findings emphasize the urgent need for continuous monitoring, assessment, and implementation of innovative treatment solutions to address pollution in Karnataka's aquatic ecosystems[6,17]. Figure 2 shows the principal components (PCs) and their eigen values and the percentage of variance of each PC. Figure. 2 depicts the positive correlations with variables.

Correlation coefficient for water quality parameters :

As per the Table-1, pH showed negative correlation with total Phosphate, CO_2 , SO_2, TA and positive relation among DO, Cl_2, TH, Ca, Mg, TDS and EC. However, total phosphate depicts negative relationship with DO, CO_2, Cl, TA, TH, Ca, Mg, TDS and EC. Most of the parameters shows positive correlation. DO showed positive correlation with SO_4, Cl_2, TA, TDS, EC and negative relation with CO_2, TH, Ca and Mg. However, CO_2 depicts positive correlation with Cl_2, TH, Ca, Mg, EC and negative correlation with SO_4, TA and TDS. Nevertheless, sulphate showed correlation with Cl_2, TA, TH, Ca, Mg, TDS and EC. Chloride shows positive relation among TA, TH, Mg, TDS and negative with calcium. Nonetheless, total hardness depicts positive correlation with calcium, magnesium, TDS and EC. But, total alkalinity and magnesium depicts positive relation with TDS and EC. However, TDS shows positive relation with EC. However, total alkalinity depicts negative correlation among TH, Ca and Mg (Table-1). PCA ((Principle Component analysis) was done egine values were extarxted those values represented the associated variance. The contribution of the original variables in the PCs is given by the factor loadings (Eigen vector coefficients), and the individual transformed interpretations are called scores (Singh et al. 2004).

Water samples from the Mallapura lakes in the city of Chitradurga was collected at various locations, tested and analyzed for various parameters are within the desired limit. As per total hardness value concerned water is moderately hard to hard category. Calcium value is above the desirable limit and magnesium data is above the permissible limit. But, chloride level is within the permissible limit of 1000 mg/l. In nutshell, we can concluded that the Mallapura lake is moderately polluted. The main reason for the ionic input into this lake can be attributed due to surface runoff from surrounding agricultural lands which are fed by chemical fertilizers, animal wastes and soil. In the light of standard of water quality recommended by BIS. fishing. Principal component analysis found to be useful techniques to disclose the trends of correlation in the data. Though the water quality parameters appears to be within permissible limit, nevertheless it is not used for drinking and other household purpose by the people due to color change and growth of algae. Further phytoplankton studies are required to monitor and reduce the load of pollution on the waterbody.

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