Assessment of Physico-chemical Characteristics of Lakshmipuram Lake, Anakapalli Dist., Andhra Pradesh, India

ABSTRACT

Lakes are dynamic systems that respond to various physico-chemical characteristics. This paper deals with the physico-chemical analysis of lakshmipuram Lake of lakshmipuram village, Anakapalli Dist., Andhra Pradesh, India. This study was carried out for the period of one year (January – December 2024) to know the quality of water by examining levels of varying physio-chemical parameters such as temperature, pH, turbidity, conductance, alkalinity, DO, BOD, COD, salinity, TDS, TSS, TH, calcium, magnesium, chloride, nitrate-nitrogen, and phosphate. All the key water quality parameters are studied by following standard APHA analytical techniques. The results revealed that there was significant seasonal variation in some physico-chemical parameters and most of the parameters were in a normal range and they are present in the prescribed limits of WHO and National Lake Water Quality Criteria and Standards. It has been identified that the water is of better quality for fish farming and irrigation.

KEYWORDS

Lakshmipuram Lake, Physico-chemical parameters, Water quality.

1. INTRODUCTION

Water is essential for life and flourishing of all living things on the Earth. Lakes provide significant water resources for household, commercial, and agricultural uses. It is the most important element that has a significant impact on life. Meanwhile, anthropogenic activities such as rapid industrialization, over development, and the extensive use of chemical pesticides and fertilizers in agriculture declining the water quality around the world. (Dr. Arvind Prasad Dwivedi, 2017), (Raad and Dawood, 2023). This affects the physico-chemical quality and then systematically destroys microbial and plankton communities thus leading to ecological imbalance (Mohammad, 2021). Evaluating physicochemical characteristics of lake water is very important to the suitability for drinking and other purposes, since water contamination is a global public health threat that places human and aquatic lives at health risk (Nwaka and Avwiri, 2021). It is typically described based on its physical, chemical, and other properties. Environmental factors including temperature, color, odor, pH, turbidity, and TDS can be used to assess water quality, while chemical tests should be conducted to

determine its BOD, COD, dissolved oxygen, alkalinity, hardness, and other characteristics. (Patil. P.N, Sawant. D.V, Deshmukh. R.N, 2012).

In this study, we examined Lakshmipuram Lake water quality by selecting various physico chemical parameters that are commonly used to determine water quality in comparison to water quality standards of various organizations (WHO., 1999), (National Hydraulic Research Institute of Malaysia).

2. MATERIALS AND METHODS

2.1 Study area

Lakshmipuram Lake is located in Lakshmipuram village of Chodavaram Mandal, Anakapalli district, Andhra Pradesh, India. It has 650 acres of area which is very beneficial to all the farmers of surrounding villages. Under this lake around 1500 acres are cultivating successfully every year. It is near to National Highway 16 having a facility for road transportation. It is situated at 22.090N 82.150E and has an average elevation of 30 meters above sea level. The climate of the area is tropical and the average temperature and humidity ranged from 24.2^{o}C to 30^{o}C and 61% recorded respectively. The population is 2981 according to 2011 census and the number of houses are 807.

2.2 Sample collection and Analysis

The study was conducted during the time of January 2024 to December 2024. Water Samples were collected monthly from the lakshmipuram lake through the study period. Water samples were collected from selected sites in a clean polythene bottle by taking necessary precautions (Ansari Gulista et.al., 2021). The bottles were washed with detergent and immersed in 1:1 HNO3 for a whole day. (Dr Arvind Prasad Dwivedi, 2017), (Baghel and Tiwari, 2016). Before being filled with the samples, bottles were rinsed two or three times. Rinsed bottles were submerged in lake water to get samples. Every sample had a label with the source date and collection time. A few samples were taken in BOD bottles to measure DO, BOD, and COD. The Standard Method was used to evaluate the content of heavy metals of the lake (APHA, 1985). Analysis of water samples for various water quality parameters was done in the field and laboratory.

2.3 Physio-Chemical parameters: -

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Some physical tests performed to test its physical appearance such as temperature, pH, and turbidity, while chemical tests performed for its BOD, COD, dissolved oxygen, alkalinity, hardness, and other characteristics (Varsha Nigam et.al. 2013). These tests are performed based on Standard Methods for the Examination of Water and Waste (APHA., 1985).

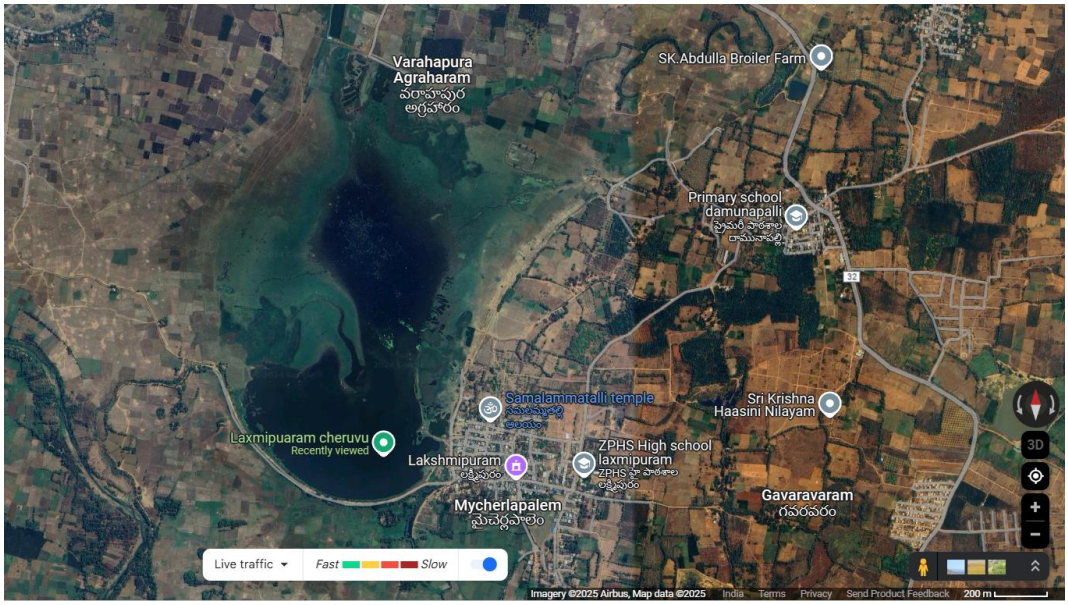

Figure 1: Satellite image of Laxmipuram lake, Laxmipuram village, Chodavaram Mandal, Anakapalli district, Andhra Pradesh. Image credits to Google Maps.

Figure 2: Laxmipuram lake, Laxmipuram village, Chodavaram Mandal, Anakapalli district, Andhra Pradesh, India.

Temperature (T):

Temperature is one of the most important ecological factors, which controls the physiological behavior and distribution of organisms. Temperature also strongly affects various physico

chemical characteristics of water like oxygen solubility and other gases, rates of chemical reaction and toxicity, and microbial activity (Osama Abdul Majeed, Nashaat, and Ahmed (2022). Drastic temperature changes can be fatal to fish (Patil. P.N, Sawant., 2012). The temperature was recorded using a Mercury thermometer on site. According to National Lake Water Quality Criteria and Standards the standard temperature of the lake is about 28^{o}C (Zati Sharip, 2015).

pH:

The pH refers to its level of acidity or alkalinity, which is a measure of the concentration of hydrogen ions (H^{+}) in the water. The pH scale ranges from 0 to 14, whether water is acidic (pH < 7) alkaline (pH > 7), or neutral (pH=7). It is most important to determine the biological activity, pollution, CO2 levels, and minerals in a lake. Naturally, lakes usually have a pH range of 6.5 – 9.5 (Zati Sharip, 2015). The estimation of pH was done by a digital pH meter. It is very important to determine because it influence the most biological and chemical interactions (L. Arul Pragasan and T. Gomathi, 2024).

Turbidity (Tur):

Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, and plankton and other microscopic organisms (APHA, 1985). It is an optical property characterized by the absorption and scattering of light in water (L. Arul Pragasan and T. Gomathi, 2024). It was measured by a nephelometric method which gives measurements as nephelometric turbidity units (NTU). The standard turbidity is about 70 NTU (Zati Sharip, 2015).

Electrical conductance (Cond):

It is the ability of a water sample to carry electric current in water. Conductivity reflects the Nutrient status of the water and the distribution of macrophytes (Mohammad., 2021). The units of conductance is µs/cm and the standard value is around 2000µs/cm (Zati Sharip, 2015) to to 2500 µs/cm (EPA). Electrical conductivity is measured with the help of an EC meter. Electrical conductivity (EC) increases as concentration of ions in water samples increases and is related to TDS content of water (Nwaka and Avwiri, 2021).

Alkalinity:

Alkalinity is the measure of water's capacity to neutralize acids or resist changes in pH, primarily due to the presence of bicarbonate, carbonate, and hydroxyl ions. Alkalinity is essential for fish and aquatic life because it protects or buffers against rapid pH changes (Osama Abdul Majeed, Nashaat, and Ahmed., 2022). It is determined by simple diluted HCl titration in the presence of phenolphthalein and methyl orange indicators. The standard measure of alkalinity is 200ppm (Patil. P.N, Sawant., 2012).

Dissolved Oxygen (DO):

DO is the amount of oxygen gas (O_2) dissolved in water. It is necessary for respiration and important for aquatic life (Azifa Parvaiz et.al., 2024). It is a critical parameter for assessing water quality, as it directly affects the health of aquatic organisms and the ecological balance of

water bodies. It is usually expressed in milligrams per liter (mg/L). National Lake Water Quality Criteria recommended 4.5 – 10.3 mg/L as an optimum for lakes. It was estimated by the standard volumetric Winkler's method.

Biological Oxygen Demand (BOD):

BOD is a measure of the amount of oxygen required by microorganisms to decompose organic matter in water over a specified period, typically 5 days at 20°C. It is a key indicator of organic pollution in water and is used to assess water quality and its ability to support aquatic life. Typically, the test for BOD is conducted over five days, and determined by standard method (APHA., 1985). It is usually expressed in milligrams per liter (mg/L) and the standard value of BOD is 6mg/L (Zati Sharip, 2015).

Chemical Oxygen Demand (COD)

COD is a measure of the total amount of oxygen required to chemically oxidize organic and inorganic substances in water. It is an essential water quality parameter used to assess the pollution level, especially in wastewater, as it represents the potential for water to consume oxygen. It is expressed in milligrams of oxygen per liter (mg/L). Both BOD and COD are key indicators of the environmental health of a surface water supply and determined by the APHA method. The optimum value of COD was 25mg/L as an optimum for lakes (Zati Sharip, 2015).

Salinity:

Salinity is an indicator of the total amount of dissolved ions in water (Osama Abdul Majeed, Nashaat, and Ahmed (2022). It was measured in parts per thousand (ppt) and the standard optimum is <1 (Zati Sharip, 2015). The salinity of the water sample was determined by measuring chlorinity (Sivanantham Mohanraj and Jeganathan Pandiyan 2022).

Total Dissolved Solids (TDS):

TDS refers to the total concentration of dissolved substances in water, including inorganic salts (e.g., calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and organic matter (Osama Abdul Majeed, Nashaat, and Ahmed (2022). TDS is an important water quality parameter that affects taste, usability, and aquatic ecosystem health. TDS is typically expressed in milligrams per liter (mg/L) or parts per million (ppm). It was measured by a TDS meter (Raad, Alsalman, and Dawood., 2023). The amount of TDS can classify lake water as: freshwater <500 mg/L (often <200 mg/L) TDS, brackish water 1,000–10,000 mg/L TDS, or saline water 10,000–50,000 mg/L TDS.

Total Suspended Solids (TSS):

TSS is the measure of the concentration of solid particles suspended in water, which can include silt, clay, organic matter, algae, and other particulate matter. TSS is a critical parameter for assessing water quality, particularly in natural water bodies, wastewater, and industrial effluents. TSS is typically expressed in milligrams per liter (mg/L) and the optimum value is 200mg/L (Zati Sharip, 2015). TSS is considered a significant factor in observing water clarity.

The less transparent the water is the more solids it contains (Osama Abdul Majeed, Nashaat, and Ahmed (2022).

Total Hardness (TH):

TH refers to the concentration of divalent metal cations, primarily Calcium ($Ca2^{+}$) and Magnesium ($Mg2^{+}$) in water. It is a key water quality parameter that affects water's usability for domestic, industrial, and agricultural purposes. Hardness reduces the effectiveness of soaps and detergents and leads to the development of scale in pipes and boilers (Osama Abdul Majeed, Nashaat, and Ahmed., 2022). Total hardness is the sum of calcium and magnesium and its concentration expressed in milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$). TH is measured by titration method by standardized EDTA solution. Egemen classified water bodies into six categories; soft (hardness less than 50 CaCO 3 mg L–1), moderately soft (from 50 -100 CaCO3 mg L–1), slightly hard (from 100-150 CaCO3 mg L–1), moderately hard (from 150-250 CaCO3 mg L–1), hard (from 250-350 CaCO3 mg L–1) and very hard (from >350 CaCO3 mg L–1) (Egemen, O., 2011).

Calcium ($Ca2^{+}$):

Calcium is an essential mineral in lakes, influencing both the chemical properties of the water and the health of aquatic ecosystems. Its concentration in lake water depends on natural geological processes, biological activity, and human influences. It is required as a micronutrient for algae and an important nutrient for the metabolism of plants (Monika Dubey, Tiwari, and Ujjania., 2013). It is measured by complexometric titration with a standard solution of ETDA. Calcium concentration generally ranges from 5 to 50 mg/L, depending on local geology and inputs. Calcium ion is the most common cause of hardness in water, and because of its buffering properties, it also acts as a pH stabilizer (Osama Abdul Majeed, Nashaat, and Ahmed., 2022).

Magnesium (Mg^{2+}):

Magnesium is a naturally occurring mineral in lake water, along with Calcium and Magnesium it contributes to the hardness of water. It is vital for aquatic ecosystems, geochemical processes, and human water usage. It was determined by Complexometric Titration with a standard solution of EDTA using Eriochrome black T as an indicator under the buffer conditions of pH 10.0 (Patil. P.N, Sawant., 2012). The standard value Mg concentration ranges from 5 to 50 mg/L.

Chloride (Cl^{-}):

Chloride is a naturally occurring anion found in lake water. It originates from various sources and plays a significant role in determining the chemical and ecological properties of freshwater and saline lakes. Chloride was determined in a natural or slightly alkaline solution by titrimetric method with standard silver nitrate, and potassium chromate was used as an indicator. Silver chloride was quantitatively precipitated before red silver chromate was formed (Sivanantham Mohanraj and Jeganathan Pandiyan., 2022). The standard limit of chloride is 250mg/L (WHO. 1999).

Nitrate-nitrogen (NO_3-N):
Nitrate-nitrogen refers to the nitrogen component of the nitrate ion. It is a critical nutrient for aquatic plants and algae but can cause ecological problems when present in excessive concentrations. The impact of elevated nitrate concentrations on water quality has been identified as a critical issue of a healthy environment for the future (Osama Abdul Majeed, Nashaat, and Ahmed., 2022). Typically, NO_3-N ranges from 20-50 mg/L (WHO., 1999).

Phosphate (PO_4^{3-}):
Phosphates are forms of phosphorus, a critical nutrient in freshwater ecosystems. While small amounts of phosphate are essential for aquatic life, excessive levels can lead to environmental problems such as eutrophication. Mostly, orthophosphate is the bioavailable form for algae and aquatic plants. It was determined by Calorimetrically by using ascorbic acid. It is usually expressed in milligrams per liter (mg/L) and the optimum value is 0.035mg/L (Zati Sharip, 2015).

Table 1: Various Physico-Chemical parameters, along with their analytical Techniques and recommended values according to various Organizations (WHO., 1999; National Hydraulic Research Institute of Malaysia, 2015).

S. No	Parameter	Units	Abbreviation	Technique used	Standard Limits
1	Temperature	^oC	T	Mercury thermometer	28^oC
2	pH		pH	Digital pH meter	6.5 – 9.5
3	Turbidity	NTU	Tur	Nephelometric method	70 NTU
4	Conductance	µs/cm	Cond	EC meter	2000µs/cm
5	Alkalinity	PPM		Acid-Base titration	200PPM
6	Dissolved Oxygen	mg/L	DO	Winkler's method	4.5 – 10.3 mg/L
7	Biochemical Oxygen Demand	mg/L	BOD	Winkler's method	6mg/L
8	Chemical Oxygen Demand	mg/L	COD	Open Reflux Method	25mg/L
9	Salinity	PPT		Acid-Base titration	<1
10	Total Dissolved Solids	mg/L	TDS	TDS Meter	1000mg/L
11	Total Suspended Solids	mg/L	TSS	Glass Fiber Filter method	200mg/L
12	Total Hardness	mg/L	TH	Complexometric titration	200mg/L
13	Calcium	mg/L	Ca_2^+	Complexometric titration	5 to 50 mg/L

14	Magnesium	mg/L	Mg_2^+	Complexometric titration	5 to 50 mg/L
15	Chloride	mg/L	Cl^-	Titrimetric method	250mg/L
16	Nitrate-nitrogen	mg/L	NO_3-N	Complexometric titration	20-50mg/L
17	Phosphate	mg/L	PO_4^{3-}	Colorimetric method	0.035mg/L

3. RESULTS:

Seventeen physico-chemical parameters were determined in lakshmipuram lake during the study period. The monthly variations of physio-chemical parameters of lakshmipuram lake from January to December 2024 were summarized in Table 2. The temperature in the study area varied from a minimum of 24.5°C ± 0.5 in Dec to a maximum of 37.5°C ± 1.2 in May and the mean temperature was recorded as 28.93°C ± 1.2 (Table 2 and Figure 1). The pH was recorded as a minimum of 7.4 ± 0.02 in Mar, Apr, and May and a maximum of 8.53 ± 0.35 in Aug and Dec, and the mean pH was 7.88 ± 0.2 (Table 2 and Figure 2). The turbidity of the lake was lowest in Nov 5.25 ± 0.5 NTU and highest in May 11.5 ± 0.5 NTU and the mean turbidity was 7.75 ± 0.5 NTU (Table 2 and Figure 3). The conductance varied from a minimum of 447.75 ± 2.62 µs/cm in Jan to a maximum of 501.75 ± 1.25 µs/cm in Apr and the mean conductance was 473.81 ± 3.38 µs/cm (Table 2 and Figure 4). The alkalinity of the study area varied from a minimum of 210.75 ± 0.95 ppm in Jan to a maximum of 227.5 ± 2.08 ppm in Sep and the mean alkalinity was recorded as 218.12 ± 1.33 ppm (Table 2 and Figure 5).

The dissolved oxygen of the lake was low at 2.85 ± 0.05 mg/L in May and high at 4.5 ± 0.08 mg/L in Nov and the mean DO was recorded as 3.49 ± 0.10 mg/L (Table 2 and Figure 6). The biological oxygen demand varied from a minimum of 2.4 ± 0.14 mg/L in Oct and a maximum of 3.75 ± 0.23 mg/L in May, and the mean BOD was recorded as 2.91 ± 0.13 mg/L (Table 2 and Figure 7). The chemical oxygen demand was recorded as low at 11.25 ± 0.5 mg/L in Jan and high at 18.25 ± 1.25 mg/L in Apr, and the mean COD was recorded as 14.39 ± 0.63 mg/L (Table 2 and Figure 8). The salinity of the study area varied from a minimum 0.33 ± 0.01 ppt in Aug and maximum 0.61 ± 0.01 ppt in May and the mean salinity was recorded as 0.44 ± 0.01 ppt (Table 2 and Figure 9). The total dissolved solids were recorded as low 279.25 ± 0.5 mg/L in Dec and high 322.25 ± 2.21 mg/L in May and the mean TDS was 298.29 ± 1.44 mg/L (Table 2 and Figure 10). The total suspended solids were recorded low of 93.75 ± 3.5 mg/L in Jan and high 151.5 ± 1.29 mg/L in May and the mean TSS was 122.39 ± 1.66 mg/L (Table 2 and Figure 11). The total hardness varied from a minimum of 113 ± 0.81 mg/L in May and a maximum of 152 ± 0.81 mg/L in Aug and the mean TH was recorded as 133.60 ± 1.04 mg/L (Table 2 and Figure 12).

The calcium level in the lake varied from a minimum of 59.5 ± 1.29 mg/L in Jan and a maximum of 119.75 ± 0.95 mg/L in Oct and the mean Ca_2^+ was 85.02 ± 1.4 mg/L (Table 2 and Figure 13). The magnesium level in the lake was recorded as low 46.25 ± 1.5 mg/L in Jan and high 81.5 ± 0.95 mg/L in Sep and the mean Mg_2^+ was 63.62 ± 1.20 mg/L (Table 2 and Figure 14). The chloride level varied from a minimum of 76.75 ± 1.25 mg/L in Jul and a maximum of 141 ± 0.81 mg/L in May and Sep and the mean Cl^- was 115.5 ± 1.02 mg/L (Table 2 and Figure 15).

The nitrate-nitrogen was recorded as low 0.21 ± 0008 mg/L in Jan and high 0.62 ± 0.02 mg/L in Jun and the mean NO_3-N was 0.37 ± 0.01 mg/L (Table 2 and Figure 16). The phosphorus was varied from a minimum of 0.12 ± 0.004 mg/L in Mar to a maximum of 0.16 ± 0.02 mg/L in May (Table 2 and Figure 17) and mean phosphorus was 0.16 ± 0.02 mg/L.

Table 2: The monthly variations of Physico-chemical parameters of Lakshmipuram lake from January-December 2024.

Sl. No	Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean ±
1	Temperature (°C)	27.25 ± 1.5	29.75 ± 0.95	32.75 ± 2.06	35.25 ± 2.5	37.5 ± 1.2	31 ± 1.8	28 ± 0.8	26 ± 1.1	25.25 ± 0.5	25 ± 0.8	25 ± 08	24.5 ± 0.5	28.93 ± 1.2
2	pH	7.5 ± 0.4	7.7 ± 0.18	7.4 ± 0.02	7.4 ± 0.04	7.7 ± 0.20	7.6 ± 0.16	7.6 ± 0.18	8.5 ± 0.35	8.4 ± 0.05	7.6 ± 0.15	8.2 ± 0.23	8.5 ± 0.35	7.88 ± 0.2
3	Turbidity (NTU)	6.5 ± 0.57	6.25 ± 0.5	7.75 ± 0.5	10.5 ± 0.57	11.5 ± 0.57	9 ± 0.8	7.75 ± 0.5	6.5 ± 0.5	5.75 ± 0.5	7.5 ± 0.5	5.25 ± 0.5	8.75 ± 0.5	7.75 ± 0.5
4	Conductance (µs/cm)	447.75 ± 2.62	489.25 ± 2.98	501.5 ± 1.29	501.75 ± 1.25	482 ± 3.91	482 ± 4.69	464.5 ± 4.65	455.75 ± 2.62	485.25 ± 3.30	456.25 ± 3.59	452.75 ± 5.56	467 ± 4.08	473.81 ±3.38
5	Alkalinity (PPM)	210.75 ± 0.95	212.5 ± 2.08	218.5 ±1.29	216.5 ± 1.29	212.5 ± 1.29	221.5 ± 1.29	219.75 ± 0.95	223.5 ± 1.29	227.5 ± 2.08	223.25 ± 0.95	219 ± 081	212.25 ± 1.70	218.12 ± 1.33
6	Dissolved Oxygen (mg/L)	3.6 ± 0.12	4.125 ± 0.09	3.45 ± 0.05	2.85 ± 0.05	2.925 ± 0.05	3.075 ± 0.05	3.375 ± 0.18	3.125 ±0.05	3.6 ± 0.21	4.125 ± 0.09	4.5 ± 0.08	3.225 ± 0.09	3.49 ± 0.10
7	Biological Oxygen Demand (mg/L)	2.77 ±0.09	2.5 ± 0.08	3.15 ± 0.20	3.475 ± 0.09	3.75 ± 0.23	3.15 ± 0.20	2.525 ± 0.09	3.15 ± 0.20	2.525 ± 0.09	2.4 ± 0.14	2.5 ± 0.08	3.075 ± 0.09	2.91 ± 0.13
8	Chemical Oxygen Demand (mg/L)	11.25 ± 0.5	11.75 ± 0.5	17 ± 0.81	18.25 ± 1.2	18 ± 0.81	13.75 ± 0.5	12.75 ± 0.5	14.5 ± 0.57	14.5 ± 0.57	13.75 ± 0.5	12.75 ± 0.5	14.5 ± 0.57	14.39 ± 0.63
9	Salinity (PPT)	0.35 ± 0.03	0.44 ± 0.005	0.51 ± 0.01	0.60 ± 0.009	0.61 ± 0.01	0.51 ± 0.008	0.42 ± 0.008	0.33 ± 0.01	0.34 ± 0.02	0.41 ± 0.009	0.43 ± 0.01	0.42 ± 0.01	0.44 ± 0.01
10	Total Dissolved Solids (mg/L)	293 ± 2.1	309.5 ± 0.5	314.25 ± 0.9	318.25 ± 0.9	322.25 ± 2.2	304 ± 1.15	294.25 ± 3.7	295 ± 1.15	285.75 ± 2.21	282 ± 0.81	282 ± 0.81	279.25 ± 0.5	298.29 ± 1.44
11	Total Suspended Solids (mg/L)	93.75 ± 3.5	122.25 ± 2.21	132 ± 1.41	143.25 ± 1.70	151.5 ± 1.29	143 ± 1.82	135.5 ±1.29	126.75 ± 1.25	121.25 ±1.25	98.5 ± 1.29	98.25 ± 1.25	102.75 ± 1.70	122.39 ± 1.66
12	Total Hardness (mg/L)	140.25 ± 0.95	150.75 ± 0.95	114.25 ± 0.5	115.5 ± 0.57	113 ± 0.81	131 ± 0.81	151 ± 0.81	152 ± 0.81	149.75 ± 0.95	133 ± 1.82	119 ± 0.81	133.75 ± 2.69	133.60 ± 1.04
13	Calcium (mg/L)	59.5 ± 1.29	71.25 ± 0.95	75 ± 0.81	101.75 ± 0.95	76.5 ± 1.29	62 ± 1.82	75.5 ± 1.73	86.5 ± 2.38	102 ± 0.81	119.75 ± 0.95	112 ± 2.16	78.5 ± 2.64	85.02 ± 1.4
14	Magnesium (mg/L)	46.25 ± 1.5	48.75 ± 0.95	50.75 ± 0.95	60.75 ± 0.95	63.5 ± 0.57	52 ± 1.82	65.5 ± 1.73	76 ± 1.82	81.25 ± 0.95	81.5 ± 0.57	76.75 ± 1.25	60.5 ± 1.29	63.62 ± 1.20
15	Chloride (mg/L)	131.25 ± 0.95	87.75 ± 0.95	121 ± 0.81	131 ± 0.81	141 ± 0.81	130.5 ± 0.57	76.75 ± 1.25	89.75 ±0.95	141 ± 0.81	110.5 ± 1.29	125 ± 0.81	101.25 ± 2.21	115.5 ± 1.02
16	Nitrate-nitrogen (mg/L)	0.21 ± 0.008	0.23 ± 0.21	0.31 ± 0.009	0.43 ± 0.018	0.54 ± 0.018	0.62 ± 0.02	0.53 ± 0.01	0.425 ± 0.017	0.34 ± 0.014	0.23 ± 0.022	0.24 ± 0.03	0.32 ± 0.02	0.37 ± 0.01
17	Phosphate (mg/L)	0.138 ± 0.002	0.123 ± 0.004	0.148 ± 0.006	0.130 ± 0.002	0.160 ± 0.002	0.148 ± 0.005	0.16 ± 0.008	0.125 ± 0.005	0.126 ± 0.005	0.14 ± 0.014	0.131 ± 0.002	0.143 ± 0.005	0.16 ± 0.02

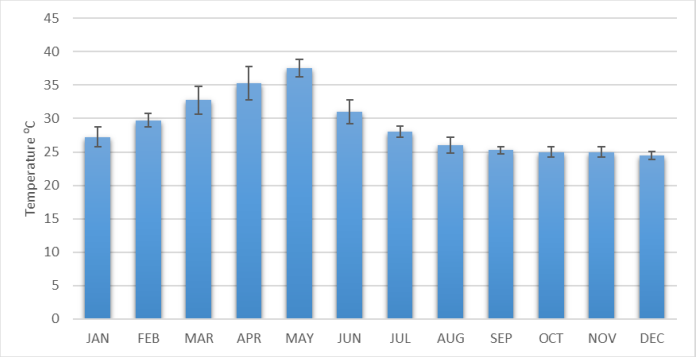

Figure 1: The monthly variation of Temperature in Lakshmipuram Lake during the study period.

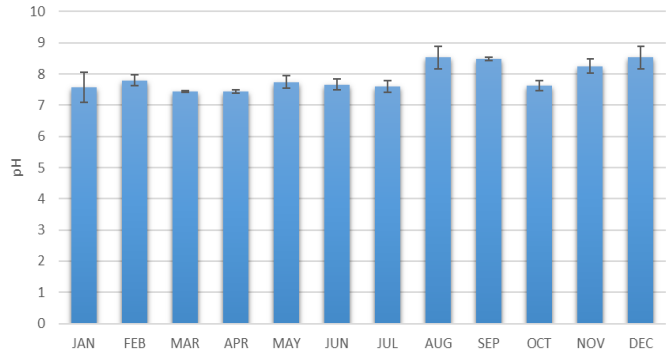

Figure 2: The monthly variation of pH in Lakshmipuram Lake during the study period

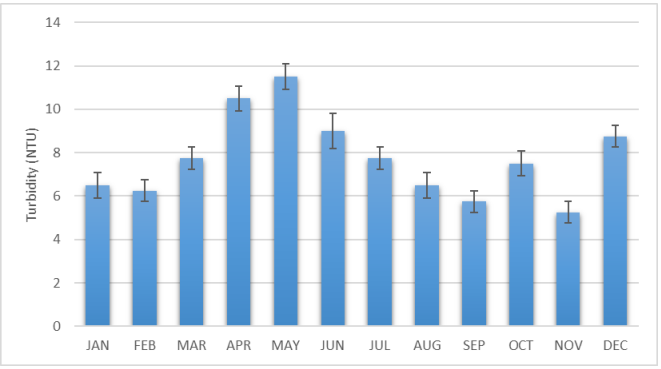

Figure 3: The monthly variation of Turbidity in Lakshmipuram Lake during the study period.

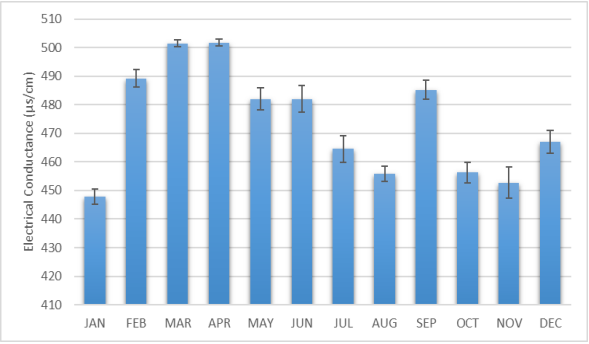

Figure 4: The monthly variation of Conductance in Lakshmipuram Lake during the study period.

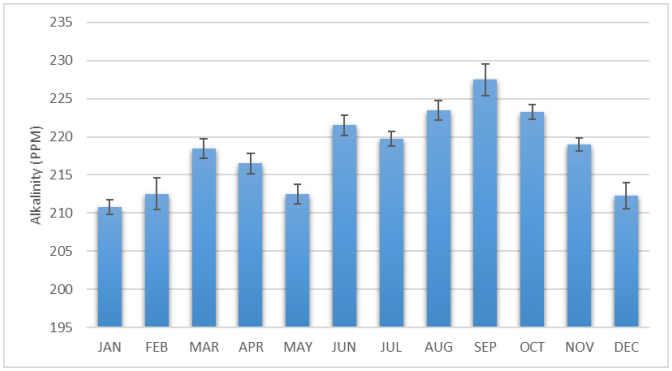

Figure 5: The monthly variation of Alkalinity in Lakshmipuram Lake during the study period.

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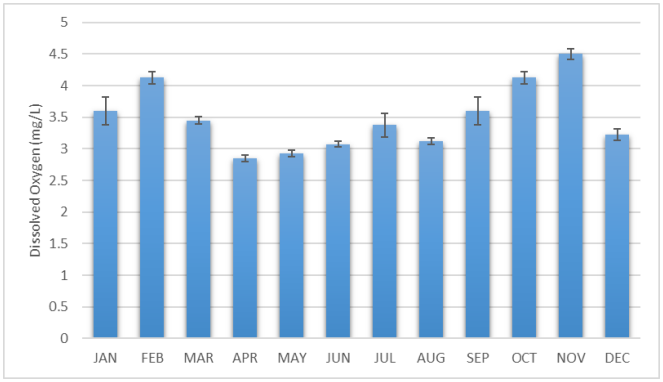

Figure 6: The monthly variation of DO in Lakshmipuram Lake during the study period

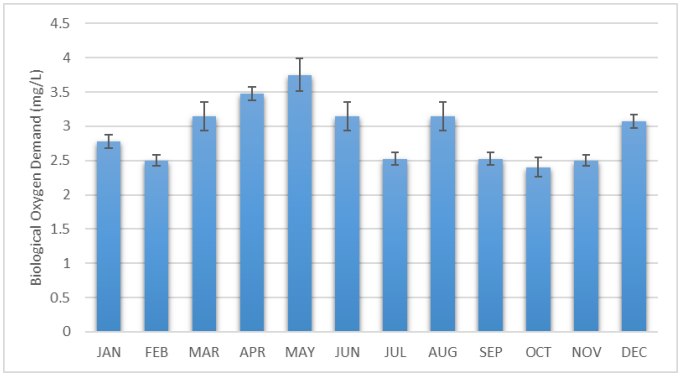

Figure 7: The monthly variation of BOD in Lakshmipuram Lake during the study period.

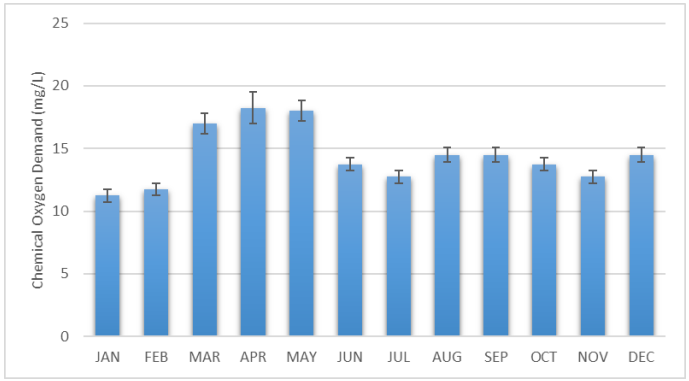

Figure 8: The monthly variation of COD in Lakshmipuram Lake during the study period.

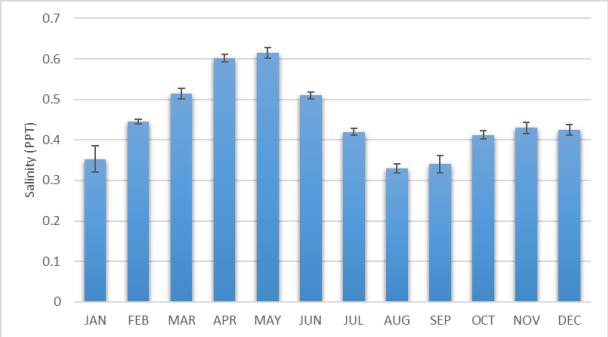

Figure 9: The monthly variation of salinity in Lakshmipuram Lake during the study period.

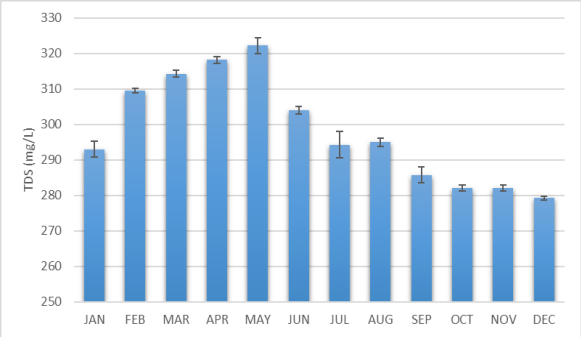

Figure 10: The monthly variation of TDS in Lakshmipuram Lake during the study period.

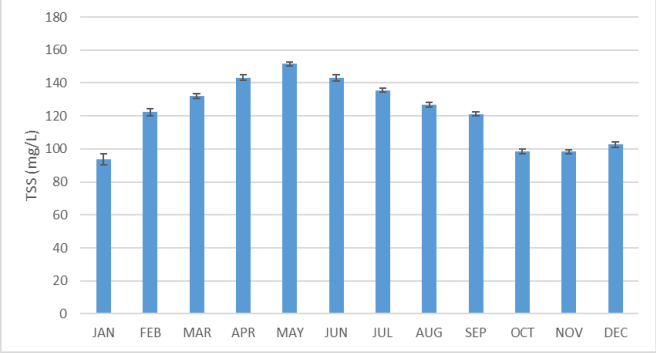

Figure 11: The monthly variation of TSS in Lakshmipuram Lake during the study period.

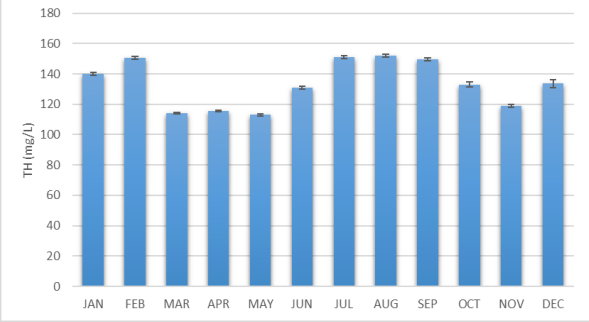

Figure 12: The monthly variation of TH in Lakshmipuram Lake during the study period.

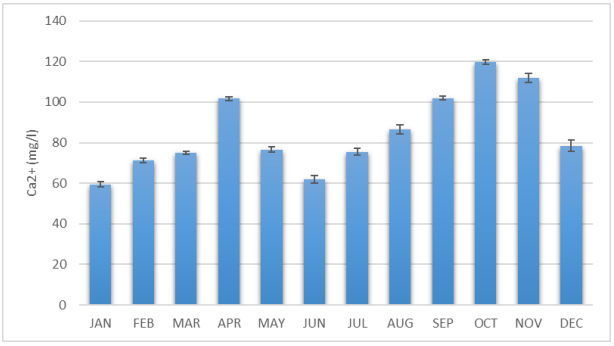

Figure 13: The monthly variation of Ca_2^+ in Lakshmipuram Lake during the study period.

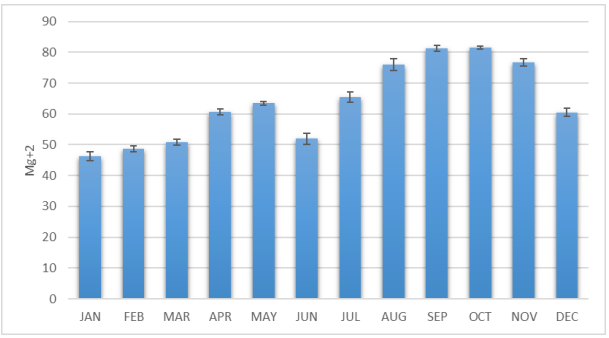

Figure 14: The monthly variation of Mg_2^+ in Lakshmipuram Lake during the study period.

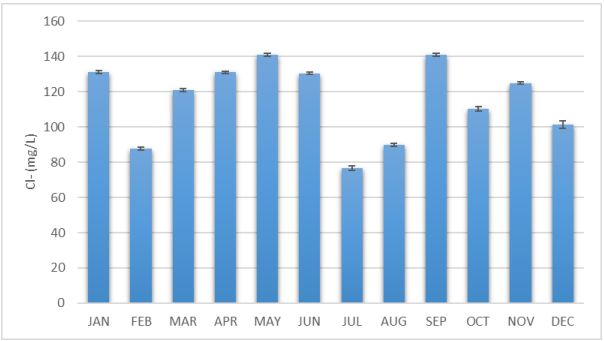

Figure 15: The monthly variation of Cl^- in Lakshmipuram Lake during the study period.

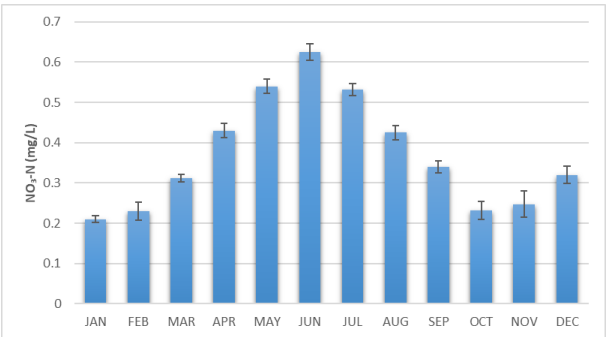

Figure 16: The monthly variation of NO_3-N in Lakshmipuram Lake during the study period.

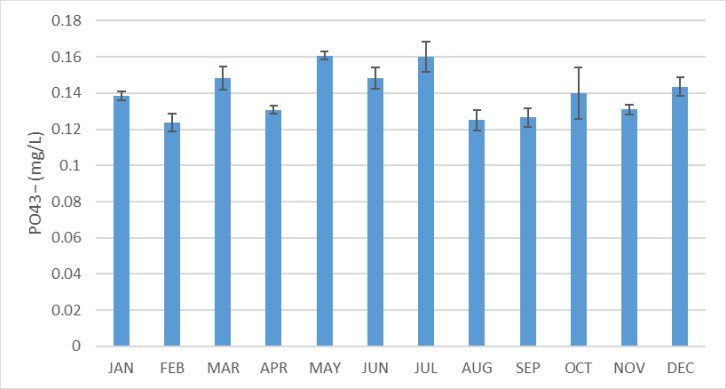

Figure 17: The monthly variation of PO_4^{3-} in Lakshmipuram Lake during the study period.

4. DISCUSSION

The physico-chemical parameters were evaluated to understand the characteristics of a lake for a suitable environment for all living beings. As the observations are done, the temperature was higher 37°C in the summer and lower 24°C in the winter due to seasonal changes. Even though there was a moderate variation the mean temperature was maintained at a standard limit which is 28°C shows the optimum range for the growth of aquatic flora and fauna. pH regulates most of the biological processes and biochemical reactions (Monika Dubey, Tiwari, and Ujjania., 2013). The pH range varied between 7.4 neutral in summer and 8.5 slightly basic in rainy and winter seasons, lower value was observed in summer due to enhanced temperature and human interference and also high salinity. Higher salinity can influence pH indirectly by affecting the buffering capacity of water. According to National Lake Water Quality Criteria and Standards, 2021, a pH between 7.4 - 8.5 is favourable for growth. The turbidity of the lake was higher at 11.5 NTU in summer due to suspended organic matter in the lake and lower at 5.5 NTU in winter which was reflected in the parameter of TSS. Several reporters have reported that seasonal variation of conductivity showed a maximum (4949ms/cm) in summer in Tawa reservoir, Madhya Pradesh (Mohammad 2021). In this present study, conductivity ranged from 501 µs/cm to 447 µs/cm which is a moderate value. Alkalinity in freshwater bodies results from the evolution of CO2 during the decomposition of organic matter (Ansari Gulista et.al., 2021). During the present study, the value of alkalinity was recorded between 210.75 mg/L to 227.5 mg/L, the minimum value was observed in the winter season, and the maximum value was observed in the rainy season of the Lakshmipuram Lake.

Dissolved oxygen (DO) plays a major role in water quality determination by the entering of either organic or inorganic materials causing depletion of DO levels of water bodies (Mohammad 2021). During this study, DO levels are in between 2.95 -4.7 mg/L. High levels in winter are due to higher rates of photosynthesis while low levels in summer are due to high temperatures and increased microbial activity in water. These DO results are reviewed from the observations of Sahapura Lake (Monika Dubey, Tiwari, and Ujjania., 2013). Higher concentration of D.O. at this site also play a significant role in lowering EC values as reported in Dal Lake, Kashmir paper (Azifa Parvaiz et al., 2024).

Biological oxygen demand determines the amount of oxygen required for the biological oxidation of organic matter with the help of microbial activities. (Monika Dubey, Tiwari, and Ujjania., 2013). In this study, the BOD levels are higher in winter and lower in summer. Due to high temperatures, the BOD was low in summer this reflects DO values. COD of the lake was found to rise in summer and drop in winter for the same reasons as BOD. Salinity is a critical parameter that significantly influences various parameters. It increases conductivity and reduces the solubility of oxygen in water also alkalinity by altering the concentrations of carbonate and bicarbonate ions. In this study, the salinity of the lake was higher in summer and lower in rainy and winter seasons. This result was verified with other above parameters. TDS and TSS were increased in summer due to various dissolved substances and decreased in the winter season. Based on Egemen's (2011) classification the hardness of Lakshmipuram Lake is slightly hard with a range of 113 -152 mg/L (Egemen O, 2011). This study revealed that highest total hardness values were found in the summer and lowest values were found in the winter months in the entire study of the year. In this study, High Calcium 119 mg/L was observed in Oct. In general, the higher values of Calcium may be due to the decomposition of organic materials that release the carbon-di-oxide which brings Calcium into the system (Mohammad 2021), and high Magnesium was observed in Oct 8.15 mg/L. The higher chloride concentration was found in May and Sep and it could be higher organic pollution. Nitrate-nitrogen concentrations of this lake were found to increase in May, June, and July but decrease in other months during the study period. The mean NO_3-N was 0.37 (Table 2) which is very low. Phosphate is one of the most important nutrients and limiting factor in the maintenance of lake fertility. This may be due to acidic and basic salt in water from the soap and detergents being used by local people around the lake (Ansari Gulista et.al., 2021) the values are not constant over the period of study. The mean of phosphate was found similar 0.16 in the paper of physico-chemical parameters of Okposi Okwuand Uburu Salt Lakes, Ebonyi State, Nigeria (Nwaka and Avwiri, 2021).

Lakshmipuram Lake's water quality was evaluated in this study, which is crucial for efficient management and long-term planning. The lake water is mostly used in irrigation. The study's findings can therefore be applied to the management of other bodies of water in addition to this lake.

5. CONCLUSION

The current study provides comprehensive information on the water quality and physico-chemical properties of Lakshmipuram Lake. It was assessed for one year (January – December 2024). Parameters were analyzed based on the APHA methods and compared with standard organization (WHO., 1999), (National Hydraulic Research Institute of Malaysia, 2015). The seasons of summer, the rainy season, and winter exhibit seasonal variations in several physico-chemical characteristics. In this present study, all the parameters were in the permissible limit temperature (28.9^{o}C), pH(7.8), turbidity (7.7 NTU), conductance (473.8µs/cm), alkalinity (218.1 ppm), DO (3.82 mg/L), BOD (3.06 mg/L), COD (14.25 mg/l), salinity (0.44 ppt), TDS (298.2 mg/L), TSS (122.3 mg/L), TH (133.6 mg/L), calcium (85.02 mg/L), magnesium (63.6 mg/L), chloride (115.5 mg/L), nitrate-nitrogen (0.37 mg/L) and phosphate (0.16 mg/L). Hence,

the current Lake water is beneficial for both fish farming and irrigation. The lake is nutrient-rich, according to the water characteristics. Continuous monitoring of pollution levels and maintenance of the ideal circumstances necessary for fish culture, growth, and reproduction as well as necessary to improve the quality of the water.

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Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.,) and text-to-image generators have been used during writing or editing of this manuscript.