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WATER QUALITY ASSESSMENT IN LAIKONPAT LAKE AT KHONGHAMPAT, IMPHAL WEST DISTRICT, MANIPUR, NORTHEAST INDIA

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ABSTRACT: Assessment of physico-chemical characteristics of water was carried out during January, 2024 to January, 2025 in Laikonpat Lake at Khonghampat, in Imphal West District, Manipur (Northeast India) for various characteristics like surface temperature, pH, transparency, electrical conductivity, total dissolved solid (TDS), alkalinity, salinity, chloride, dissolved oxygen and free carbon dioxide. The surface temperature during the study period ranged from 15.91±0.5°C to 29.99±0.3°C showing subtropical nature. The pH value ranged from 6.87±0.1 to 7.49±0.1. Transparency ranged from 10.71±1.1 cm to 22.59±2.2 cm. Electrical conductivity ranged from 72.82±1.4 (µs/cm) to 131.66±3.7 (µs/cm). Total dissolved solids (TDS) values varied from 36.4± 0.7 ppm to 65.83 ±1.8 ppm. The values of alkalinity ranged from 42.57 ± 1.3 mg/L 101.10± 4.2 mg/L. The values of salinity ranged from 41.30± 2.8 mg/L to 60.84± 5.8 mg/L. The values of chloride ranged from 22.86 ±1.6 mg/L to 60.84± 5.8 mg/L. The concentrations of dissolved oxygen in all the sites during the study period varied between 3.26 ±0.3 mg/L 6.67± 1.7 mg/L. The concentrations of free carbon dioxide ranged from 9.95± 1.2 mg/L to 18.56± 1 mg/L. The findings indicated that most of the physico-chemical characteristics of the water of Laikonpat Lake were within the WHO limits for drinking water except for dissolved oxygen values during some months especially during summer months during the study period.

Keywords: Physico-chemical characteristics, water quality, Laikonpat Lake, Manipur.

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1.INTRODUCTION

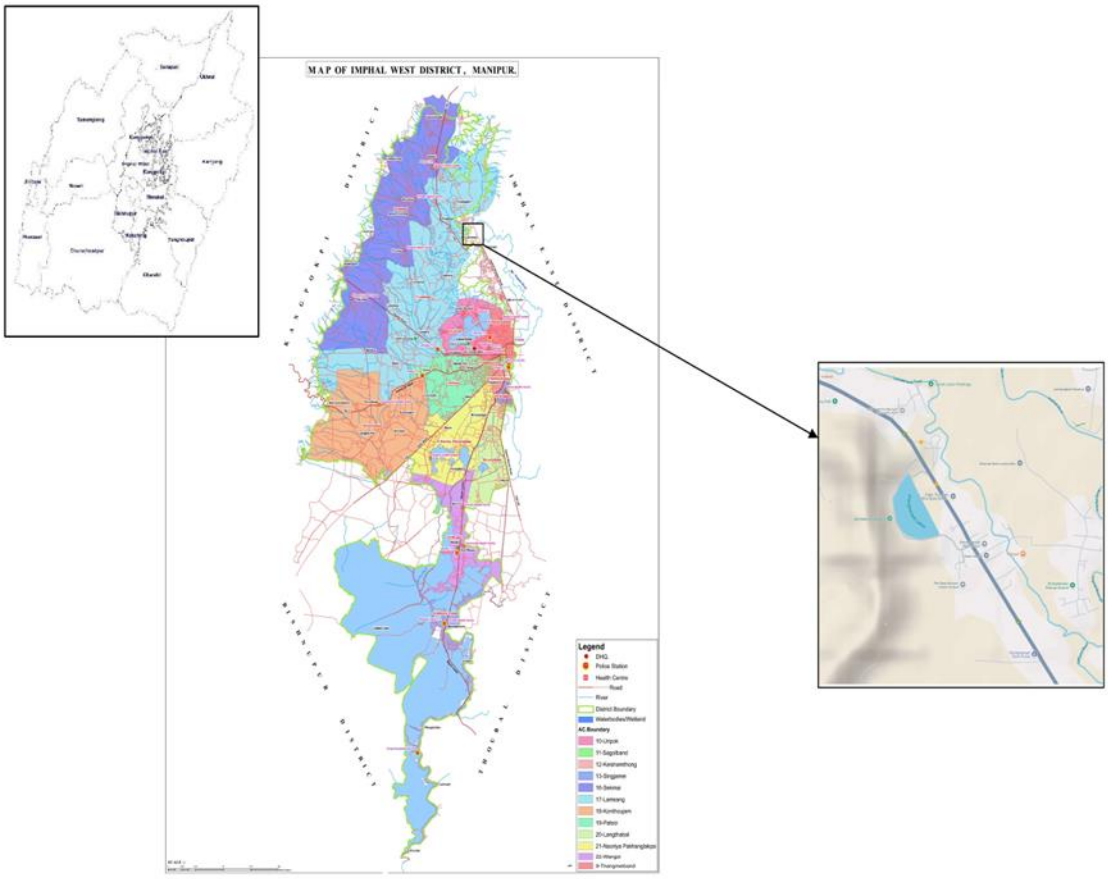
Water is among the most essential element that the Mother Nature provides to sustain life on this planet. It is used in a variety of ways at different levels by human beings. Even though, it covers 75% of Earth's surface, the amount of water available for human use is very limited. 97.2% of total world water is contained in the oceans and other saline bodies of water which is not readily usable for most purposes, while only 2.80% is fresh water [1]. Over exploitation of surface and underground water resources for the agricultural, industrial and other purposes plus the adverse effects of climate change have resulted in sharp reduction of the available water resources [2]. Only about 0.3% of the total fresh water on the earth is concentrated in reservoirs, lakes, ponds and river system and this is the most accessible form of water to mankind for their needs. This portion of water needs extra attention through regular assessment of its quality and undertaking timely remedial and conservation measures. Monitoring water quality is essential to determine the water quality status and to improve the environmental conditions and the related public health [3]. Lakes are one of the important sources of fresh water involved in ground water recharge, maintaining energy exchange and supporting the aquatic life [4]. However, lakes throughout the world have been gravely altered or degraded at a pace much more significant than their restoration [5]. The lakes here in Manipur are no exception to this change. It is believed that there were about 500 lakes in the valley of Manipur in the beginning of the 20th Century. According to the report made by the Environment and Ecology Office of Manipur, the number has got reduced to only 55 Lakes in the state by 1950s. Almost all the freshwater lakes of Manipur are much degraded and they have reached the status of wetlands [6]. As per a survey conducted by Remote Sensing Application Centre (RSAC) of Government of Manipur in 2015, the number of lakes in the state has fallen to just 19. Thus, many invaluable lakes in Manipur had already disappeared which is one reason for frequent floods occurring in most parts of Imphal city (Manipur) even with little rain falls. Periodic assessments and investigations of freshwater bodies of Manipur have been carried out by various researchers to ascertain the water quality status of water bodies in Manipur, like Waithou Lake, Manipur [7]; Physico-chemical characteristics of water and sediment in Loktak lake (a Ramsar Site), Manipur [8]; Sanapat Lake, Manipur [9]; Ikop Lake, Manipur [10]; Utrapat Lake [11]; Awangsoipat Lake, Manipur [12,13]. Oksoipat Lake, Manipur [14]; Poiroupat Lake, Manipur [15]; surface water quality of some freshwater lakes in the valley districts of Manipur [16]. Hidenkompat Lake (Bishnupur), Manipur [17]; Yenapat Lake (Bishnupur), Manipur [18]. Kharungpat Lake, Manipur [19]; Khumanpat lake, Manipur [20]. Most the lakes in Manipur have been scientifically studied, but no scientific studies have been conducted so far on the Laikonpat Lake. This paper is the first scientific assessment of the lake. The present study is an attempt to characterise the monthly variation in physico-chemical characteristics of water in Laikonpat Lake, Manipur. The functioning of an aquatic ecosystem and its stability to support life forms depend, to a great extent, on the

physicochemical characteristics of its water [21]. The physico-chemical analysis is the prime consideration to assess the quality of water for its best utilization like drinking, irrigation, fisheries and industrial purpose [22].

2. MATERIALS AND METHODS

Study area

The present study site, Laikonpat Lake is an old lake located at Khonghampat, a village in Imphal



Study area

West District of Manipur which is approximately 13km away from the state Capital Imphal. It lies in the intersection of 24°89'32" N latitude and 93°89'31" E longitude at an altitude of 782m above mean sea level. It has an area of about 0.076 sq.km (7.6 hectares), occupying 3.05% of the village area. The lake is a tourist spot of the village and high footfall is recorded during lotus (Nelumbo nucifera Gaertn.) bloom season (from June to September) every year. Lot of fishing activities is carried out by the locals and they also use the water of the lake for domestic purposes and agriculture.

Experimental design and sample collection

Sampling involved both in situ measurements and sample collection from four sampling sites in the Lake from January, 2024 to January, 2025. The four sampling sites were selected in order to ensure uniformity and they cover the entire area of the lake. Sampling for Physico-Chemical characteristics

was done once monthly for 13 months during the morning hours between 06:00-8:00am on each sampling day. Surface water samples for chemical parameters were collected from all sampling stations in 2.5 L opaque plastic bottles in a replicate of three of each sampling site. All the analyses were carried out in the Ecology Research Laboratory, Department of Botany, Dhanamanjuri University (Manipur). Three replicate measurements or analyses were performed for each Physico-Chemical characteristics per sample.

Determination of physico-chemical parameters

Analysis of the physico-chemical characteristics of water was carried out by following the standard methods and techniques [23, 24, 25]. At the sites, surface water temperature was measured using a hand-held mercury thermometer, pH was measured using a portable pocket-sized pH meter (Hanna instruments, Model: HI98107), electrical conductivity (EC) and total dissolved solids (TDS) were measured using a hand-held EC and TDS Meter (INKBIRD, Model: ITDS-01) and transparency was measured by a Secchi disk. Remaining characteristics were analyzed at the laboratory.

3. RESULTS AND DISCUSSION

The variations in physico-chemical characteristics of the water samples of Laikonpat Lake assessed from January, 2024 to January, 2025 are reflected in the table. Surface water temperature is one of the most significant parameters which control inborn physical qualities of water [26]. The surface water temperature during the study period ranged from 15.91 ± 0.5°C to 29.99 ± 0.3°C showing subtropical nature. The maximum temperature was recorded in the month of July, 2024 whereas the minimum temperature was recorded in the month of January, 2025. Lower surface water temperature during winter months and high surface water temperature during summer months can be linked to atmospheric cooling and heating. During summer months, water gets heated up due to high solar intensity thereby increasing the temperature. Variations in the surface water temperature of Laikonpat Lake are presented in the Table. The variation in surface water temperature is comparable with results reported for Khumanpat Lake, Manipur (India) [20], Poiroupat Lake, Manipur (India) [15], Oksoipat lake, Manipur (India) [14], Awangsoipat Lake in Manipur (India) [13] and Sanapat Lake, Manipur (India)[9]. pH quantitatively measures the values of the concentration of the hydrogen ions. It is an important index of acidity and alkalinity [27]. The pH of water is an indicator of its health [28]. It can affect the productivity of aquatic ecosystem [29]. The pH value ranged from 6.87±0.1 to 7.49±0.1. The maximum value was observed in the month of June, 2024 and the maximum value was observed in the month of December, 2024 as shown in the table. The water was found to be alkaline during the study period except during the months of May, June and August, 2024 when the pH dropped below 7.00. Several experts found that the majority of lakes are alkaline, especially in India [30, 31]. The pH values are within the WHO standard limits of 6.50-8.5. The pH of a water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity [32].

Table 1: Variation in the Physico-chemical characteristics of water in Laikonpat Lake

Month	Temp. (°C)	pH	Transparency (cm)	EC (µs/cm)	TDS (ppm)	Alkalinity (mg/L)	Salinity (mg/L)	Chloride (mg/L)	DO (mg/L)	Free $C0_2$ (mg/L)
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
January'2024	**17.36±0.7**	**7.39±0.1**	**22.59±2.2**	**80.82±2.4**	**41.16±0.4**	**82.18±1.6**	**49.09±6.3**	**27.18±3.5**	**6.61±0.4**	**18.56±1**
February	**18.88±0.4**	**7.35±0.1**	**20.46±1.7**	**87.16±2.3**	**43.58±.11**	**101.10±4.2**	**41.30±2.8**	**22.86±1.6**	**6.67±1.7**	**16.78±3.5**
March	**18.40±0.6**	**7.28±0.1**	**17.28±1.6**	**87.15±1**	**43.57±0.5**	**72.45±3.5**	**75.60±16.6**	**44.37±5.3**	**5.80±0.3**	**15.86±3.9**
April	**21.99±0.2**	**7.02±0.2**	**14.89±1.3**	**104.33±1**	**52.16±0.4**	**50.32±2.2**	**53.46±7.9**	**29.60±4.4**	**4.00±0.7**	**12.37±2.7**
May	**25.93±1**	**6.87±0.1**	**12.01±1.8**	**131.66±3.7**	**65.83±1.8**	**51.61±3.1**	**54.81±6.4**	**30.35±3.6**	**3.82±0.5**	**10.95±1**
June	**29.90±0.1**	**6.95±0.5**	**10.71±1.1**	**115.83±2.6**	**59. 50±1.0**	**60.38±3.8**	**70.90±10.6**	**39.26±5.9**	**3.26±0.3**	**11.90±1.8**
July	**27.83±0.3**	**7.24±0.1**	**10.97±1.3**	**117.98±0.5**	**58.99±0.3**	**49.43±2.1**	**53.33±4.6**	**29.52±2.5**	**3.95±0.8**	**9.95±1.2**
August	**29.99±0.3**	**6.99±0.1**	**11.3±1.9**	**113.33±2.7**	**56.66±1.3**	**46.99±1**	**61.41±9**	**34.00±5**	**5.31±0.6**	**13.84±2.1**
September	**29.05±0.1**	**7.32±0.1**	**14.14±1.4**	**104.16±2.9**	**51.99±1.4**	**51.5±1.5**	**74.26±5.6**	**41.13±3.1**	**5.00±1**	**15.58±1.8**
October	**25.56±0.4**	**7.08±0.4**	**13.25±2.1**	**83.49±1.7**	**41.74±1**	**43.1±3**	**89.62±5.2**	**49.63±2.9**	**4.38±0.4**	**10.85±1.3**
November	**22.23±0.6**	**7.07±0.1**	**15.65±1.4**	**81.49±1**	**40.83±0.6**	**42.57±1.3**	**109.84±10.5**	**60.84±5.8**	**4.67±0.8**	**11.56±1.1**
December	**16.10±0.2**	**7.49±0.1**	**17±1.5**	**80.83±2.1**	**40.41±1.1**	**65.60±2.8**	**97.50±4.7**	**53.83±2.4**	**5.04±1.2**	**16.49±2.6**
January'2025	**15.91±0.5**	**7.28±0.1**	**19.55±1**	**72.82±1.4**	**36.4±0.7**	**60.81±2.9**	**83.12±6**	**46.03±3.3**	**5.97±0.5**	**14.42±2.1**
WHO limits	**30-35**	**6.5-8.5**	**N/A**	**750**	**500**	**120**	**200**	**250**	**5.0-7.00**	**22**

Water transparency, as measured by Secchi disk depth, is a vital and sensitive ecological indicator that reflects the turbidity and trophic status of aquatic environments [33, 34, 35]. During our study period the transparency values ranged from 10.71 ± 1.1cm to 22.59 ± 2.2cm. The maximum value was recorded in the month of June, 2024 and the minimum value was recorded in the month of January, 2024. Lake water transparency is a multifaceted parameter influenced by physical, chemical, and biological processes [36]. The variations in the transparency values are reflected in the table. Higher values were recorded in summer months and lower values were observed during the winter months. The observed values are found to comparatively lower than those reported from Khumanpat Lake, Manipur (India) [20] and Yenapat Lake, Manipur (India) [18]. Electrical conductivity (EC) is the measure of capacity of a solution to conduct electric current through it. For shallow lakes, conductivity is an important pollution indicator [37]. and assesses the trophic status of aquatic systems [38]. The EC value ranged from 72.82 ± 1.4µs/cm to 131.66 ± 3.7µs/cm. The variations in EC values are reflected in the table. The maximum value was recorded in the month of May, 2024 and the minimum value in the month of January, 2025. The suitability of water for the irrigation and domestic purpose is based on the electrical conductivity of water [39]. It depends on

the concentration of ions and nutrients loads of the water. The EC values during the study period were within the permissible limits of 750µs/cm. In natural water bodies, dissolved solids consist of inorganic salts, small amount of organic matter and dissolved materials [40]. The variations in total dissolved solids (TDS) values during the study period are reflected in the table. TDS depend on various factors such as geological character of watershed, rainfall and amount of surface runoffs and gives an indication of the degree of dissolved substances [41]. TDS values varied from 36.4 ± 0.7ppm to 65.83 ± 1.8ppm. The maximum value was observed in the month of May, 2024 and the minimum value in the month of January, 2025. Similar trend was also observed from various surface water bodies in Coimbatore City, Tamil Nadu (India) [42] and in Sahapura Lake, Bhopal (India) [43]. A very low TDS (<50mg/L) makes osmoregulation difficult for fish and crustaceans [44] and a very high TDS (>1,000 mg/L) in freshwater species can cause stress, dehydration, and mortality [45]. The variations in alkalinity values during the study period are reflected in the table. Total alkalinity in water is primarily due to the presence of salts of weak acids and bicarbonates, especially in highly alkaline water [46]. The values of alkalinity ranged from 42.57 ± 1.3mg/L 101.10 ± 4.2mg/L. The lowest alkalinity is recorded in the month of February, 2024 while the highest is observed in the month of November, 2024. The values are in conformity with the total alkalinity values reported from the water of Loktak Lake (a Ramsar Site) at five selected sites [26]. The decomposition of dead plants and other living organisms in the water releases CO2, which increases carbonate and bicarbonate levels, thereby elevating alkalinity. The variations in salinity values during the study period are reflected in the table. The values of salinity ranged from 41.30 ± 2.8mg/L to 60.84 ± 5.8mg/L. The maximum value was recorded in the month of November, 2024 and the minimum value in the month of February, 2024. Chlorides are one of the major inorganic ions in the natural water and waste water [47]. The main sources of chlorides in lake water are sewage and industrial waste [48]. Chloride concentration is an essential parameter to regulate salinity of water and it exert osmotic stress on biota. High level of chlorides in water bodies is an indicator of pollution load of animal origin [49]. The variations in salinity values during the study period are reflected in the table. The values of chloride ranged from 22.86 ± 1.6mg/L to 60.84 ± 5.8mg/L. The maximum value was recorded in the month of November and the minimum value in the month of February. The values were within the WHO standard limits of 200mg/L [50]. The variations in the concentration of dissolved oxygen during the study period are reflected in the table. In aquatic ecosystem, dissolved oxygen (DO) content plays an important role in supporting life. It is an important limnological parameter indicating level of water quality and organic pollution in the water body [51]. The main source of dissolved oxygen in water is diffusion of oxygen from air which mainly depend on temperature, salinity, total dissolved salt and water movements [52]. The concentrations of dissolved oxygen in all the sites during the study period varied between 3.26 ±0.3 mg/L to 6.67± 1.7 mg/L. The maximum concentration was observed in the month of February, 2024

and the minimum concentration in the month of June, 2024. The concentration values for dissolved oxygen during some summer months during the study period were below the WHO limits of 5.0-7.00 mg/L. Similar values and trends were also reported from Bibi Lake, Ahmedabad, Gujarat (India) [53]. As the rates of biological oxidation increase with temperature and oxygen demand increases accordingly, high temperature condition where dissolved oxygen is least soluble, can be of concern during the summer months when temperatures are high and solubility of oxygen is low [42]. Water without adequate dissolved oxygen may be considered waste water [40]. Free carbon dioxide is indispensable for photosynthesis in aquatic bodies and its main sources are respiration and decomposition of organic substances [54]. The variations in the concentration values of free carbon dioxide during the study period are reflected in the table. The concentrations of free carbon dioxide ranged from 9.95± 1.2 mg/L to 18.56± 1 mg/L. The values were well within the WHO limits of 22 mg/L. The maximum concentration was observed in the month of January, 2025 and the minimum concentration in the month of July, 2024. The observations were in contrast to the findings from Kurhada Lake at Pauni, Bhandara District, Maharashtra, where maximum free carbon dioxide concentration was observed in summer and minimum during winter [55].

4. CONCLUSION

The present paper is an attempt to analyze the water quality in relation to its physico-chemical characteristics. Physico-chemical characteristics are fundamental in evaluating and managing the water quality. They provide comprehensive insights to the physical, chemical, and biological properties of water. Continuous monitoring of parameters like temperature, pH, dissolved oxygen, free carbon dioxide, alkalinity, electrical conductivity, and pollutant levels is considered important to preserve the lake ecological balance. During the study, significant seasonal variations in some physico-chemical characteristics were observed and most of them were in the normal range. To safeguard both human health and the environment from the impacts of pollution and other water-related challenges, regular assessment of these characteristics is considered essential as it can aid in early detection of water quality degradation and support informed decision making for sustainable use and conservation of lake water resources.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals or humans were used for the studies that are based on this research.

CONSENT FOR PUBLICATION

Not applicable.

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CONFLICT OF INTEREST

The authors claim that there is no conflict of interest.

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