

Comparative Assessment of Water Quality of Ikop Lake and Its Peripheral Fish Farms

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Abstract The paper investigates a comparative assessment of water quality of Ikop Lake which is a fresh water lake of Manipur and its peripheral fish farms. Rapid population expansion and corresponding anthropogenic activities of the surrounding villages of Ikop lake play crucial role in contamination of water. It enhances degradation of water quality of this fresh water lake. The level of contamination can be evaluated either from physical and chemical or from biochemical attributes. Present study was undertaken to assess the water quality status of Ikop lake and its peripheral fish farms during June to September, 2022 by using different physiochemical parameters such as, temperature, pH, free carbon dioxide (CO₂), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total hardness, total alkalinity, chloride, conductivity, turbidity, sodium, potassium, phosphate, total coliform etc. The result values of different parameters showed variations in lake water and farm water. It also indicated deteriorating quality of both water bodies.

Keywords: parameters, ikop lake, contamination, water quality, peripheral fish farms

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1. Introduction

Wetlands or lakes are the main source of livelihood for the nearby inhabitants since time immemorial. About 0.3% of our fresh-water are found in the lakes, rivers and swamps [1]. The water bodies like rivers, lakes, and estuaries are continuously subject to a dynamic state of change with respect to their geological age and geochemical characteristics [2]. Bio-diversity within such places play major role in sustainable ecological balance. However anthropogenic changes have ensured a great loss of habitat and diversity over earth. The lakes and reservoirs all over the country without exception are in facing varying degrees of environmental degradation due to encroachment and eutrophication from domestic and industrial effluents and silts [3]. Manipur one of the seven sister states of North- East India is blessed with many enticing freshwater lakes. At present there are 17 lakes and 2-ox bow lakes in Manipur [4]. Ikop lake is one among the important lakes of Manipur. This freshwater lake had been degraded its pristine nature due to excessive influx of sediments formed by Heirok-Wangjing river, Arong river and Khelakhong canal. Previous physicochemical analysis revealed highly polluted water condition of the lake [5]. Main feeder streams of the Ikop lake are Arong river and Heirok-Wangjing river. This lake was home to various kinds of migratory birds and wild

animals which can fascinate the viewers. However, this enchanted lake is right now in the midst of heavy anthropogenic activities after the construction of ring road between Athokpam and Leishangthem. Over the past few decades many fish species are not appeared and some are declining their numbers. Earlier there were large areas of wetland surrounding the lake. Gradually these wetlands were converted into agricultural land by the surrounding inhabitants. More than one-third of agricultural lands around the lake were converted into fish farms by the farmers. These farms are ponds surrounded by thick earthen wall of about 3m in height and 2m wide at the top. The main sources of water for the farms are rain water, the lake through small canals and from rivers. Rearing of cattle, piggery and poultry are done in farms as well as the peripheral areas of the lake. During rainy season waste water from farms discharged into the lake. Exotic fish species like exotic Grass carp (*Ctenopharyngodon Idella*), Rohu (*Labeo rohita*), Tilapia (*Oreochromis mosambicus*), Scale carp (*Cyprinus carpio*) are commonly cultured in the fish farms. The fishes are cultured using artificial and natural feeds.

For finding a solution of management strategy to protect and conserve the biodiversity of the lake, it is important to investigate physiochemical parameters of water body of the lake and its peripheral fish farms. Consequently, this study was undertaken to determine water quality status of Ikop lake and its peripheral firms.

In Section 2, the sampling area, materials and methods of the study are given. In Section 3, the parameter values

of each month and relevant graphs are shown. Using one-tail t-test, the parameter values of the lake and its peripheral farms are compared with the corresponding WHO recommended parameter values and a conclusion is given in section 4.

2. Description of the Study Area

Ikop lake is situated in Thoubal district, Manipur at a distance of 40 km. in the south-eastern direction from Imphal. The lake is situated in between latitudes $24^{\circ}35'36''\text{N}$ and $24^{\circ}59'32''\text{N}$, and longitudes $93^{\circ}52'\text{E}$ and $93^{\circ}54'\text{E}$. This lake is 772m above the sea level, the maximum depth is about 1.59m and an area of 13.5km² (7.5km length and 1.8 km in breadth). Total area of the lake was around 166.95 km² based on 1989- 1990 survey data. This lake is surrounded by the villages, viz.:Leishangthem, Khekman, Moijing and Thoudam on the Northern side; Athokpam, Khangabok, Tentha on the Eastern side; Khelakhong on the Southern side; and Irong Thokchom and Maibam on the Western side. This lake is seasonally flooded by Arong river, Heirolk-Wangjing river and occasionally flooded due to breakage of Thoubal river bank.

Materials and Methods

This study was conducted during monsoon season

(June to September, 2022). Surface water samples of the lake and its peripheral farms were collected from different five (5) sites of the lake and five (5) sites of peripheral fish farms. The names of the sites with their code numbers (code numbers are for convenience only) are given below (Table 1):

Table 1. Sample collection sites of Ikop Lake and its peripheral farms

Water sampling sites of Ikop lake.				
Sl.No.	Site	Code	Latitude	longitude
1.	Leishangthem	L1	24.62°N	93.93°E
2.	Irong Thokchom	L2	24.63°N	93.92°E
3.	Khangabok	L3	24.61°N	93.94°E
4.	Athokpam	L4	24.61°N	93.94°E
5.	Tentha	L5	24.59°N	93.94°E
Water sampling sites of fish-farms.				
Sl No.	Site	Code	Latitude	Longitude
6.	Leishangthem fish farm	F1	24.62°N	93.93°E
7.	Irong Thokchom fish farm	F2	24.63°N	93.92°E
8.	Khangabok fish farm	F3	24.61°N	93.94°E
9.	Athokpam fish farm	F4	24.61°N	93.94°E
10.	Tentha fish farm	F5	24.59°N	93.94°E

*The location details are based on NoteCam version 5.15.4 mobile App

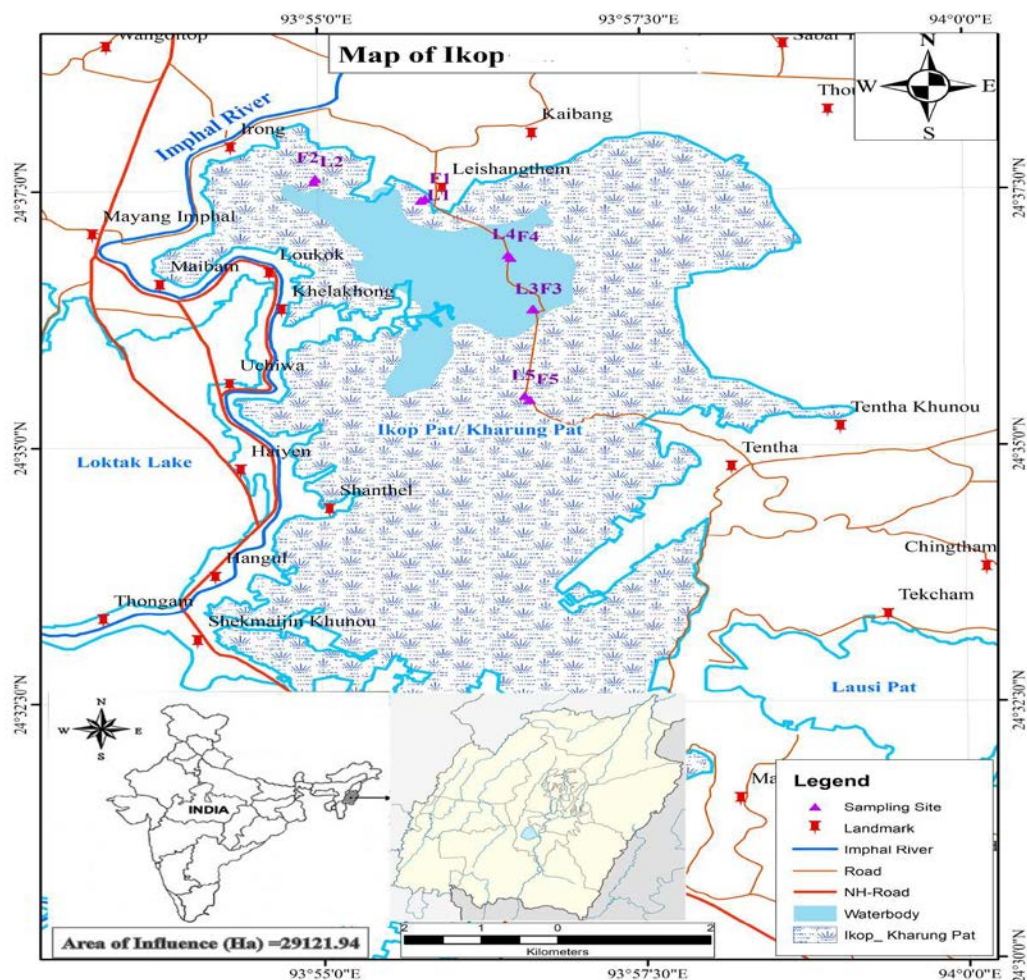


Figure 1. Map of Ikop Lake and sampling sites

Fifteen physico-chemical parameters such as, temperature, pH, free carbon dioxide (CO_2), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total hardness, total alkalinity, chloride, conductivity, turbidity, sodium, potassium, phosphate and total coliform were considered for the water quality analysis. Analysis was carried out using standard methods and techniques described by Trivedi and Goel (1984) and APHA (2005). Water samples were collected in one-litre bottles which were de-ionized with distilled water before using them. Water temperature was determined using digital thermometer and electrical conductivity was determined using a portable pen type pH meter. Parameters like Temperature, pH, dissolved oxygen (DO), free CO_2 , electrical conductivity was determined in-situ while other parameters were determined in the laboratory.

The results of analysis of the parameters of the water samples collected from the sites (Table 1) during June to September, 2022 are given below:

pH

pH measures the intensity of acidity or alkalinity and also measures the concentration of hydrogen ion in water [6]. The value of pH indicates quality of water and also determines the sustainability of water for intended purposes, drinking, suitability to support aquatic life [7]. The lowest pH value (5.8) in the lake was recorded in L5 (June 2022) and highest value (7.3) in L1 (September 2022) (Figure 2). On the other hand, the minimum pH value (6.0) in the farm water was recorded in F3 (June 2022) and the highest (8.1) in F1 (September 2022). The mean pH values of both lake and farm water were within the permissible range of WHO (Table 2&3). However, its value below neutral level (7) shows slightly acidic condition of both water bodies during study period. A pH between about 5 and 6.5, sub lethal effects on many streams species may result in reduced fecundity, growth and population size [8].

Water Temperature

Water temperature is one of the important factors for aquatic life. Temperature influences several parameters and can alter the physical and chemical properties of water [9]. The mean water temperature of lake and farm water were ranged from 25°C to 27°C . The highest temperature value (29.5°C) in the farm was recorded in F3 (July 2022). The water temperature recorded in the farms were generally higher than the lake water temperature (Table 2&3). This is because of stagnant condition of farm water coupled with low concentration of dissolved oxygen. Since the concentration of dissolved oxygen is inversely related to water temperature [10], the amount of dissolved oxygen thus affects water temperature.

Free CO_2

Free CO_2 is an essential gas for macrophytes. It is present in water as dissolved form, which is derived from different sources such as atmosphere, respiration by the organisms and bacterial decomposition of organic matter etc. [11]. The average values of CO_2 in both farm water and lake were negligibly different from the WHO standard value (Table 2&3). Even though the highest value of the CO_2 were recorded in the L3 (88 mg/l) and F4 (110 mg/l) both in September 2022. High carbon dioxide in water

indicates higher microbial pollution rate [12]. This high value of CO_2 ($>35\text{mg/l}$) in L3 and F4 water shows the highly polluted condition of water especially in these sites. The value of CO_2 may inversely related to pH value since higher amount of free CO_2 in water may decrease the pH value due to the formation of carbonic acid.

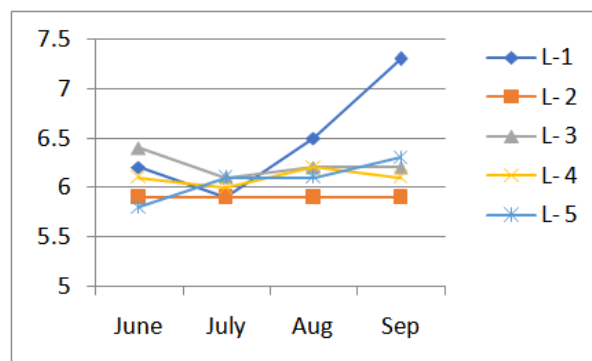


Figure 2. Monthly variation of pH of Ikop Lake

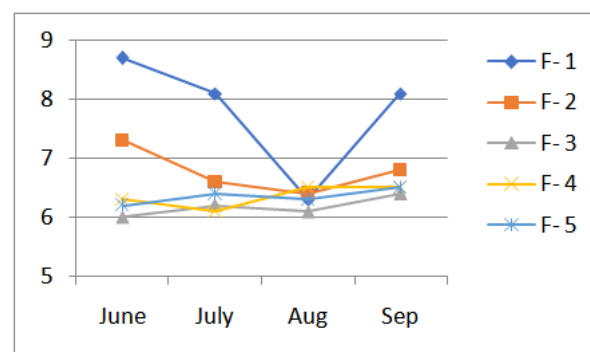


Figure 3. Monthly variation of pH of Ikop Lake peripheral farms

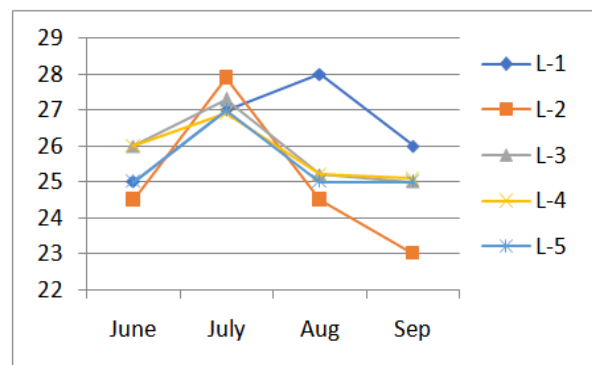


Figure 4. Monthly variation of Temperature of Ikop Lake

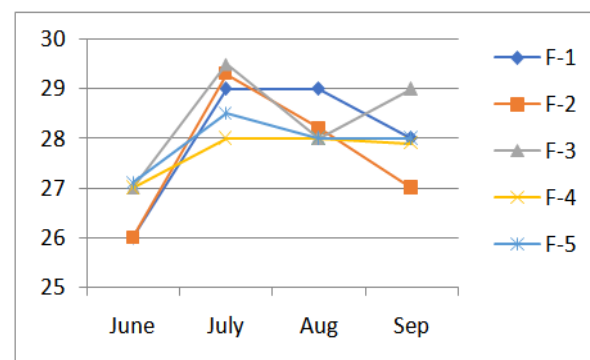


Figure 5. Monthly variation of Temperature of Ikop Lake peripheral farms

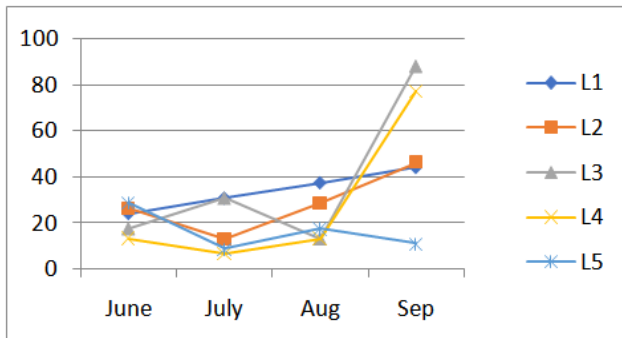


Figure 6. Monthly variation of Free CO₂ in Ikop Lake

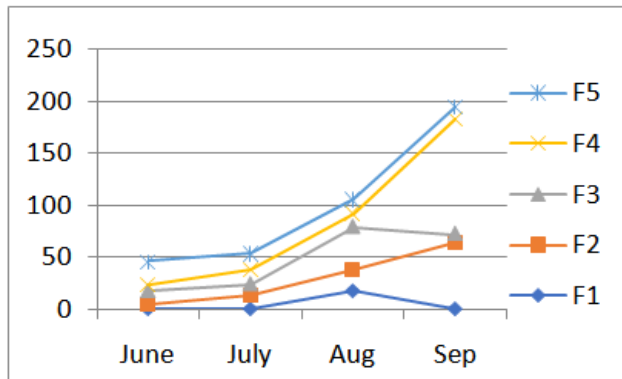


Figure 7. Monthly variation of Free CO₂ in Ikop Lake peripheral farms

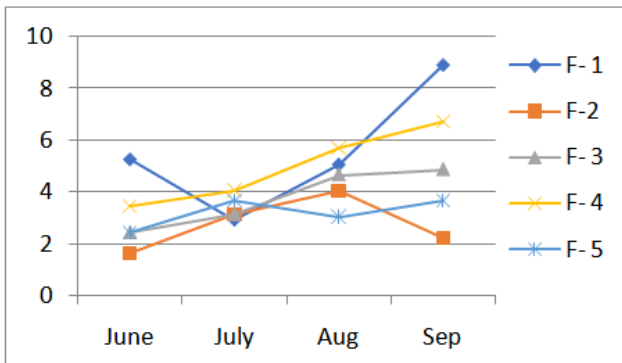


Figure 8. Monthly variation of DO (mg/l) in Ikop Lake

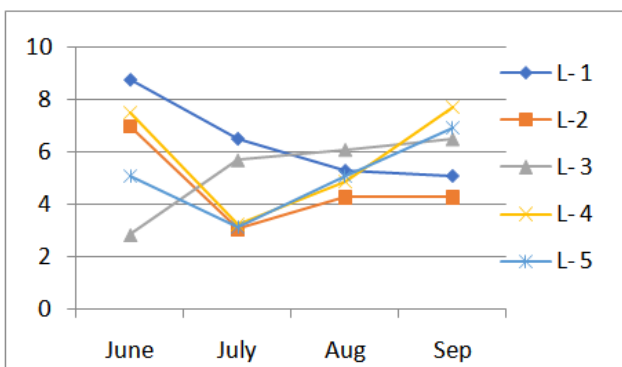


Figure 9. Monthly variation of DO (mg/l) in Ikop Lake peripheral farms

Dissolved Oxygen

Dissolved oxygen indicates quality and sustainability of aquatic life. The average dissolved oxygen value of lake (4.04mg/l) was below the WHO standard value (Table 2&3). It shows the stressful condition of fish [13]. Moreover, L2 had the lowest DO value (1.62mg/l) in June

2022 which was less than permissible limit while L1 and F1 recorded highest values (8.91mg/l) in September 2022 and (8.74mg/l) in June 2022 respectively. The low level of dissolved oxygen in water is a sign of contamination and is an important factor in determining water quality, pollution control and treatment process [14]. Due to influx of organic waste, especially domestic sewage from nearby inhabitants and livestock might be one of the important factors for low level of DO in L2 site.

BOD

Biological oxygen Demand (BOD) is the amount of oxygen required by bacteria and other micro organisms to break down organic materials under aerobic condition [15]. F5 and L2 had the highest BOD values of 17.63mg/l and 10.95mg/l respectively in September 2022. Water with BOD less than 4mg/l is considered as unpolluted, while, more than 10mg/l regarded as polluted [1]. The average BOD of farm water (6.47mg/l) during study period was above the standard value of WHO (Table 2&3). The observed increase in BOD value in monsoon season might be due to biological activities at elevated temperatures in rainy season [16]. Allochthonous input from surface runoff during rainy season might be key factor for high level BOD in lake water and farm water.

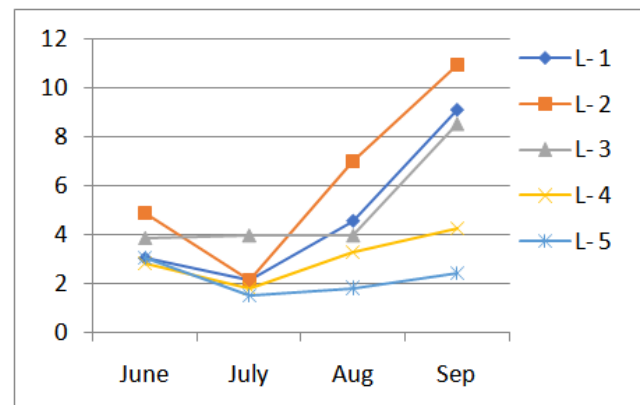


Figure 10. Monthly variation of BOD (mg/l) in Ikop Lake

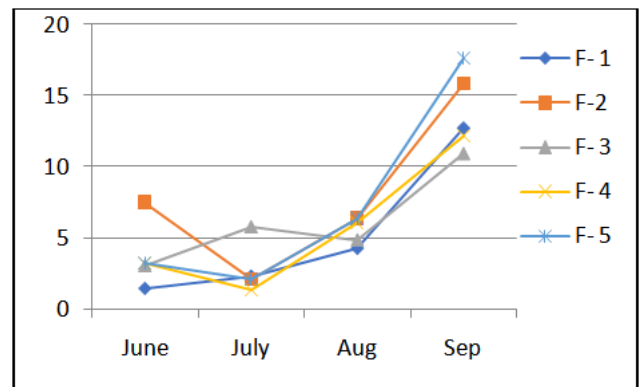


Figure 11. Monthly variation of BOD (mg/l) in Ikop Lake peripheral farms

COD

Chemical Oxygen Demand (COD) is an indicative measurement of the amount of oxygen that can be consumed by chemical pollutants or compounds in a measured solution [17]. COD detection can be used to easily quantify the amount of organic matter. The mean COD values of farm (12.89mg/l) and lake (9.35mg/l) were

about standard value of WHO (Table 2&3). However, F5 and L2 had the highest value of 22.36mg/l (September 2022) and 22.21mg/l (August 2022) respectively. F2 and L4 had the lowest value of 1.21 mg/l and 3.30 mg/l respectively in the monsoon season. The COD values of F5 and L2 were above permissible limit (20mg/l).

Total Hardness

Total hardness is the measurement of the mineral content in water sample that is irreversible by boiling [18]. It is caused due to dissolved calcium, magnesium and other ions such as iron and manganese [19]. L1 and F2 had highest values of 250 mg/l in September and F2 had the highest value of 198 mg/l in June. However, the average total hardness value of both lake water and farm water were within the standard value of WHO (Table 2 & 3).

Total Alkalinity

Total alkalinity is the measure of water's ability to neutralize acids. Alkalinity in freshwater is mainly derived from the dissolution of limestone, calcium silicate and feldspar minerals [20]. The mean values of total hardness in lake and farm water were within the standard value of WHO (Table 2&3). However, value of alkalinity was highest in site L1(215mg/l) and F2(250 mg/l) both in June. Higher alkalinity in lake water may result due to waste discharge, microbial decomposition of organic matter in the waterbody [21].

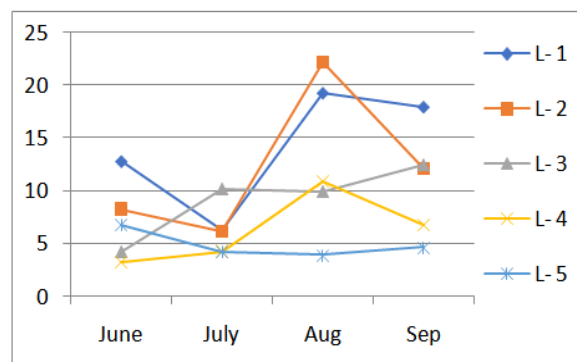


Figure 12. Monthly variation of COD(mg/l) in Ikop Lake

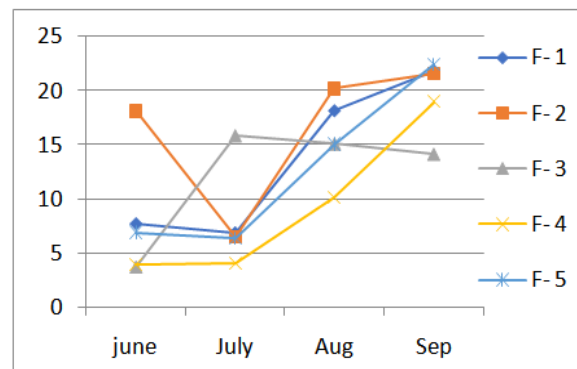


Figure 13. Monthly variation of COD(mg/l) in Ikop Lake peripheral farms

Table 2. Physicochemical parameters of the water samples of Ikop lake(June to September, 2022)

SL NO.	PARAMETERS	WHO recommended value	L1	L2	L3	L4	L5	Mean	SD	t-score	Critical t-score with 95% confidence level
1.	pH	8.5	6.48	5.90	6.23	6.10	6.08	6.16	0.21	-26.00	2.777
2.	Temperature ($^{\circ}$ C)	≤ 250	26.50	24.98	25.88	25.80	25.50	25.73	0.56	2.92	
3.	Free CO ₂ (mg/l)	35	24.20	28.60	37.40	27.50	16.50	26.84	7.57	2.41	
4.	DO (mg/l)	5	5.55	2.76	3.77	4.97	3.19		1.18	-1.79	
5.	BOD (mg/l)	5	4.46	5.32	5.07	3.05	2.20	4.25	1.35	1.25	
6.	COD (mg/l)	20	14.06	12.24	9.23	6.31	4.91	9.35	3.86	-6.16	
7.	T.Hardness (mg/l)	180	174.50	89.00	83.00	72.75	83.00	100.5	41.81	-4.25	
8.	T. Alkalinity (mg/l)	120	121.25	63.75	60.00	51.88	85.00	76.38	27.91	-3.50	
9.	Chloride (mg/l)	250	88.04	52.54	47.22	45.09	49.70	56.52	17.84	-24.25	
10.	Conductivity (μ S/cm)	250	406.00	228.00	174.50	160.50	172.00	228.2	102.76	-0.47	
11.	Turbidity (NTU)	5	19.20	18.60	20.00	25.60	12.90	19.26	4.52	7.06	
12.	Sodium (mg/l)	50	26.80	13.30	13.70	9.45	11.48	14.95	6.84	-11.45	
13.	Potassium (mg/l)	20	4.40	1.90	1.53	1.63	1.40	2.17	1.26	-31.84	
14.	Phosphate (mg/l)	0.3	0.18	0.15	0.12	0.12	0.11	0.13	0.03	-17.00	
15.	Total coliform (MPN/100ml)	No relaxations-on	326.03	835.47	636.20	236.80	320.09	470.93	254.35	4.14	

Note: All the values are in mg/l, except Temperature and pH.

Table 3. physicochemical parameters of the water samples of peripheral fish farms of Ikop lake(June to September, 2022)

SL NO.	PARAMETERS	WHO recommended value	F1	F2	F3	F4	F5	Mean	SD	t-score	Critical t-score with 95% confidence level
1.	pH	8.5	7.80	6.78	6.18	6.35	6.35	6.69	0.66	-6.03	2.777
2.	Temperature ($^{\circ}\text{C}$)	≤ 250	28.00	27.63	28.38	27.73	27.90	27.93	0.29	22.54	
3.	Free CO_2 (mg/l)	35	4.40	25.30	18.70	36.03	15.40	19.97	11.74	-2.86	
4.	DO (mg/l)	5	6.39	4.63	5.27	5.83	5.04	5.43	0.69	1.43	
5.	BOD (mg/l)	5	5.19	7.96	6.16	5.71	7.35	6.47	1.15	2.88	
6.	COD (mg/l)	20	13.65	16.62	12.20	9.31	12.69	12.89	2.64	-6.03	
7.	T.Hardness (mg/l)	180	82.00	128.50	98.25	72.00	84.00	92.95	21.97	-8.86	
8.	T.Akalinity (mg/l)	120	54.38	99.38	84.38	50.63	70.00	71.75	20.40	-5.27	
9.	Chloride (mg/l)	250	58.58	64.61	56.45	48.64	59.29	57.51	5.80	-74.32	
10.	Conductivity($\mu\text{S}/\text{cm}$)	250	209.00	329.0	229.00	169.50	196.00	226.5	61.23	-0.86	
11.	Turbidity (NTU)	5	6.60	95.40	31.30	32.20	25.15	38.13	33.63	2.20	
12.	Sodium (mg/l)	50	19.88	16.80	17.00	11.15	14.90	15.95	3.22	-23.65	
13.	Potassium(mg/l)	20	0.95	15.55	8.83	2.03	3.00	6.07	6.11	-5.10	
14.	Phosphate (mg/l)	0.3	0.10	0.12	0.13	0.10	0.09	0.105	0.02	-19.00	
15.	Total coliform (MPN/100ml)	No relaxation	433.96	375.65	397.56	458.96	544.33	442.09	65.58	15.07	

Note: All the values are in mg/l, except Temperature and pH.

Chlorides

Chloride is one of the major inorganic anions which is found in both fresh water and saltwater [22]. Chloride in water generally due to sodium, potassium and calcium salts [23]. Chlorides can also be found when chloride salts dissolved in an aqueous solution [24]. The highest value of chloride was recorded in L1 and F2 with 95.14mg/l and 85.2mg/l respectively. However, the average value of chloride in farm and lake water were within the standard value (Table 2&3). Increased salinization and chloride concentrations can induce a variety of ecological effects within both aquatic and terrestrial eco systems [25]. Chlorides have mild effect on living organisms, however values higher than recommended limit ($<250\text{mg/l}$) may cause some serious damage or poisoning to living body [34]

Electrical Conductivity

Electrical conductivity (EC) is a measure of water's ability to pass electric current [13]. The average conductivity values of both water bodies were within the standard value of WHO (Table 2&3). Water temperature can cause conductivity to fluctuate daily [26]. L1 and F2 had the highest conductivity value 446mS/cm and 424mS/cm in September and June respectively. The high value of conductivity indicates higher amount of impurities (dissolved substances, chemicals, and minerals) are in the water [27].

Turbidity

Turbidity is the measurement of water clearness (transparency). Turbidity in natural water is caused by clay, silt, fine organic and inorganic compounds, algae and other microscopic substances [28]. The F2 and L1 had the highest values of 150.4 NTU and 34.8 NTU respectively in September. However, the average values of turbidity in lake water(19.26mg/l) and farm water(38.13mg/l), which is beyond permissible limit of

WHO (Table2&3) indicates low water clarity. The high value of turbidity decreases the photosynthetic activity of macrophytes resulting into low level of oxygen concentration in water. This high value of turbidity in lake water in monsoon may be considered due to soil erosion, surface run off, waste discharge from surrounding inhabitants and muddy water from eroded banks of Arong river and Heirok-Wangjing river.

Sodium

Sodium is one of the important naturally occurring cation which is abundant in industrial waste, domestic sewage and its concentration increased in natural water after disposal [6]. The average value of sodium in lake water and farm water were found as 14.95 mg/l and 15.95mg/l respectively. But highest values were recorded in L1 and F2 with 32.80mg/l and 31.7mg/l respectively in June. This higher value at L1 might be due to dissolved fertilizers and pesticides from agricultural catchment fields, domestic waste and sewage from inhabitants at periphery site of the lake.

Potassium

Potassium is the fourth naturally occurring anion in freshwater ecosystem and is always recorded in lesser value than sodium, calcium, magnesium [29]. The average values of potassium in lake water(2.17mg/l) and farm water(6.07mg/l) were within the permissible limits of WHO ((Table 2&3). The highest values were recorded in L1 and F2 with 7.9mg/l and 36.9mg/l in June. The potassium losses from agro ecosystem led to an increasing K^+ concentration in the surface water [30].

Phosphate

Phosphate is charged ion particle that contain mineral phosphorous. It is a vital nutrient for both plants and animals for growth and development, but too much phosphorous in water leads to excessive growth of algae

and aquatic plants leading to eutrophication state of water [13]. The average phosphate values of farm water (0.34mg/l) and lake water (0.3mg/l), were within the acceptance range of WHO (Table 2&3). The values of phosphate was highest in L1 and F3 with 0.34mg/l and 33mg/l in June and July respectively. Agricultural runoff and organic sewage from nearby inhabitants are the source of phosphate in lake water [10].

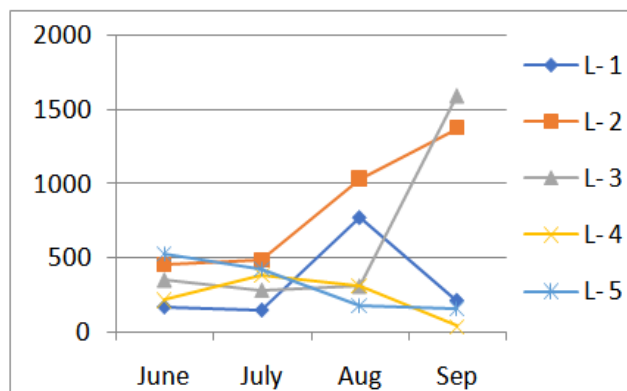


Figure 14. Monthly variation of Total Coliform (MPN/100ml) in Ikop Lake

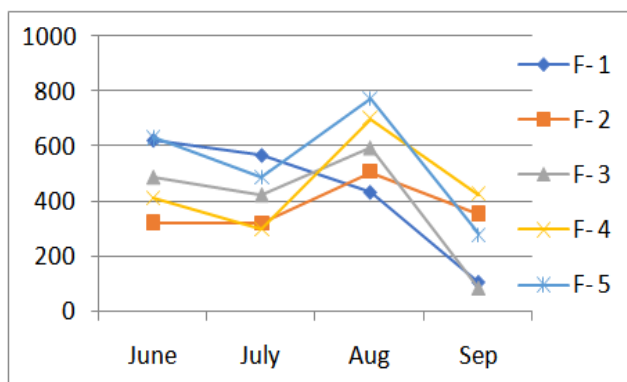


Figure 15. Monthly variation of Total Coliform (MPN/100ml) of peripheral farm

Total Coliform.

Total coliform includes all kinds of coliform bacteria that are found in our surroundings. Coliform bacteria are present in the faeces of all warm-blooded animals and humans [31]. It is also found in the environment (nutrient-rich waters, soil and decaying plant material) as well as in the drinking water with relatively high concentration [32]. The average value of total coliform in farm water and lake water were ranged from 442 MPN to 470 MPN. The highest values were recorded in L3 with 1600 MPN/100ml in September and L5 with 774.19 MPN/100ml in August. The presence of total coliform in water sample indicates the environmental contamination [33]. The elevated values of total coliform in lake water and farm water suggested that disease-causing organisms might also be present

3. Result of t-test

For each site of the Ikop lake the 'mean' of the values of each physiochemical parameter of the water samples

collected during the period from June to September, 2022 were calculated. Corresponding to each physiochemical parameter value, there were fifteen (15) sample spaces each having five (5) sample points. Then the Mean and Standard Deviation (SD) of each parameter corresponding to the sample points are calculated. Then (using one-tail t-test) the t-score and critical t-score at a 95% confidence level for each sample parameter are also calculated. All those results including the WHO recommended standard Physiochemical parameter values of water quality are shown in Table 2.

Similarly, the results of 'mean', Standard Deviation, t-score and critical t-score at a 95% significance level and WHO recommended standard Physiochemical parameter values of water quality for each parameter of the peripheral fish farms are also calculated and shown in Table 3.

The observed absolute value of t-score (Table 2) & (Table 3) of the parameters: Free CO₂, DO, BOD, Conductivity and Turbidity were found less than the critical t-score, indicating that they belonged to Null Hypothesis, that is, they were not statistically different from the corresponding WHO recommended water parameter values. The absolute t-score of other parameters, viz. pH, Temperature, COD, T. Hardness, T. Alkalinity, Chloride, Sodium, potassium, Phosphate and Total coliform were found greater than the critical t-score and hence, they belonged to Alternate Hypothesis, and statistically different from the corresponding WHO recommended water parameter values.

Table 4. Absolute t-score values of Physiochemical parameters of Ikop lake and its peripheral fish farms

Parameters	Ikop Lake Absolute value of t-score	Comparison	Peripheral fish farm Absolute value of t-score.	Critical t-score with 95% confidence level
pH	26.00	>	6.03	2.777
Water temperature (0 C)	2.92	<	22.54	2.78
Free CO ₂ (mg/l)	2.41	<	2.86	2.78
DO (mg/l)	1.79	>	1.43	2.78
BOD (mg/l)	1.25	<	2.88	2.78
COD (mg/l)	6.16	>	6.03	
Hardness (mg/l)	4.25	<	8.86	2.78
T. Alkalinity (mg/l)	3.50	<	5.27	2.78
Chloride (mg/l)	24.25	<	74.32	2.78
Conductivity (μS/cm)	0.47	<	0.86	2.78
Turbidity (NTU)	7.06	>	2.20	2.78
Sodium (mg/l)	11.45	<	23.65	2.78
Potassium (mg/l)	31.84	>	5.10	2.78
Phosphate (mg/l)	17.00	<	19.00	2.78
Total coliform MPN/100ml)	4.14	<	15.07	2.78

Moreover, the absolute values of t-score of the parameters of the lake such as pH, DO, COD, Turbidity, and Potassium were found greater than those of corresponding parameters of the peripheral farms. The other remaining ten parameters, viz. water Temperature, Free CO₂, BOD, Hardness, Alkalinity,

Chloride, Conductivity, Sodium, Phosphate and Total-coliform were less than those value of corresponding parameters of the peripheral farms (Table 4).

4. Conclusion

The result shows that the parameters for both the lake and its peripheral fish farms which are not statistically different from the WHO recommended quality standards for various purposes are Free CO₂, DO, BOD, Conductivity and Turbidity while those that have exceeded the quality standards are pH, Temperature, COD, T. Hardness, T. Alkalinity, Chloride, Sodium, potassium, Phosphate and Total coliform. The increase in parameters that have exceeded the maximum quality standard derived from natural resources, agricultural fertilizers, inappropriate fisheries management and an increasing human population using more fish and domestic waste from community activities is quite high.

Further seasonal studies on the water quality of the lake as well as the peripheral farms will supplement the present findings and give clear status of the contamination level of Ikop lake which is also one of the important wetlands of Manipur.

References

- [1] Research Educator Guide. National Geographic Society 2022, Earth's Freshwater.
- [2] Patel, H. and Vashi, R.T., 2015, Characterization and Treatment of Textile Wastewater. Elsevier.
- [3] Reddy, M.S. and N.V. Char 2004, Managements of lakes in India.
- [4] Envis Hub Manipur, 2015. Status of Environment and Related Issues.
- [5] Lakepedia.com. 2016, "Ikop Pat-Facts Map, Activities" (<http://www.lakepedia.com/lake/ikop-pat.html>).
- [6] Trivedi, R.K. and Goal, P.K., 1984. Chemical and Biological Methods for Water Pollution Studies. Environmental publications. United States Geological Survey, Science for a Changing World 2018. U.S Department of the Interior.
- [7] Patil G., S. Goroba, C.S., Suhas, J.A., Raut, P.D., 2011, Study Of Physicochemical and Biological Characteristics of Lakes from Shivaji University Campus, Kolhapur, Maharashtra. Advances in Applied Science Research 2(6): 505-519.
- [8] EPA, 2022. United States Environmental Policy Agency. C, ADDIS Volume, pH Overview. When to List, Ways to Measure, Conceptual Diagram.
- [9] Singh, A.K., Kumari., Singh, D.K., (2017) Assessment of water quality using physico-chemical parameters in two floodplain Lakes (Chauri), North Bihar, India.
- [10] USGS 2018, Water Science School HOME: Water Properties, Water Quality Topics, Phosphorus and Water.
- [11] Laishram J and M.Dey, 2014, Water Quality Status of Loktak Lake, North East India and Need for Conservation measures: A Study on Five Selected villages. International Journal of Scientific and Research Publications 4(6), pp 1-62.
- [12] Laishram Ch.S., Bharti B., Sanamacha M., Kojam M.B.S., Md.Z.Sh., and Onil L., 2022, Water Quality Assessment of Kongba River, Manipur, India. Poll Res. 41(4): 1-5. EM International.
- [13] EPA 2023, United States Environmental Protection Agency. National Aquatic Resource Surveys. Indicators: Dissolved Oxygen. What is dissolved Oxygen?
- [14] Bozorg-Haddad, O.ed, 2021. Economical, Political and Social issues in Water Resources. Elsevier.
- [15] Cristina Tuser, 2021, Waste water Digest, Champion Trust Fights Corrosion, Utility Management. What is Biological Oxygen Demand.
- [16] Solanki, V.R., Murthy, S.S., Kaur, A., Raja.S.S., 2007, Variations in Dissolved Oxygen and Biochemical Oxygen Demand in two Freshwater Lakes of Bodhan, Andhra Pradesh, India. Nature Environment and Pollution technology, Technoscience Publications Vol.6. No. 4. Pp. 623-628. 29.
- [17] Li, D., Shuangyin, L., 2019, Water Quality Detection for Inland Lakes. Water Quality Monitoring and Management. (pp221-231).
- [18] Raghavendra G, 2021, Corrosionpedia, Total Hardness: What Does Total Hardness Mean?
- [19] Sidi Huang and Miskelly Diane, 2016 in Stream Breads, Major Ingredients for Dough 3.6.2 Hardness.
- [20] Boyd, E.C., 2017 The Impact of Atmospheric Carbon dioxide, Alkalinity in freshwater, aquaculture.
- [21] Kumar V.A. 2008, Sowjanya V., Ravitra M., Gayatri P., Unnisa S.A., and Mukhanti K., IJEP, 2008, 28(9). Pp.816-81.
- [22] Khateeb, R., A., 2014, Influence of Chloride Concentration On Water Quality. International Journal of Applied Engineering Research and Development (IJAERD) Vol.4, 63-68 JJPRC Pvt. Ltd
- [23] Sharma, B.M. 1999. Wetland Ecosystems of Manipur. And ecological appraisal. In: R.K.R. Singh and H. P Sharma (Eds) Wetland, of Manipur-I, Manipur. Association for Science and Society (MASS). Imphal, Manipur. (12-19).
- [24] Corrosionpedia, 2018. What Does Total Alkalinity (TA) Means.
- [25] Kausal, S.S., 2004. Chloride Encyclopedia of Inland Water, Pp 23-29.
- [26] Salahuddin, 2015, Analysis of Electrical Conductivity of Ground Water at Different Locations of Dildar Nagar of U. P. India. Advances in Applied Science Research, 6(7): 137-140.
- [27] Atlas Scientific, 2022. What causes the High conductivity in Water?
- [28] Minnesota Pollution Control Agency, 2008, Water Quality / Impaired Waters #3.21. Turbidity: Description, Impact on Water Quality, Sources, Measures Pg-2.
- [29] Siddiqi, S.Z., 2007. Limnological Profile of high-Impact Motor Crater Lake Lunar, Buldana, Maharashtra, India, an Extreme Hyper alkaline, Saline Habitat, Proceedings of Taal, 2008.
- [30] Skowron, P., Skowronska, M., Meilniczule, U.B., Filippek, T., Igras, J., Juska, A.K., Krzepitko, A. 2018. Anthropogenic Sources of Potassium in Surface water: The case study of the Bystrzyca river catchment, Poland Agriculture, Ecosystem & Environment. Volume 265. Pg. 454-460.
- [31] Washington State Department of Health (2016), "Division of Environmental Health Office of Drinking Water".
- [32] Adebisi, A. A., (1981). The physico-chemical hydrology of atropical seasonal river -Upper Ogun river. *Hydrobiology*, 79(2), Pp. 157-165.
- [33] Niyoyitungiye, L., Giri, A., Ndayisenga, M., 2020, Assessment of Coliform Bacteria Contamination Lake Tanganyelea as Bioindicators of Recreational and Drinking Water Quality. Academic Leadership, Article no. SAJRM.57764. 6(3). pp-9-16. PIB. 2012.

