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Application of Water Quality Index for Loktak Lake

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Water quality is a significant contributor to all spheres of life. It is vital to test the water before it is used for drinking, domestic, agricultural or industrial purposes. Loktak lake is the major freshwater wetland of Manipur (India) and was declared a Ramsar site in 1990. The study aimed to check the water quality status of Loktak lake. The results showed that the maximum pH was7.58 recorded at Sendra, and the minimum pH was 7.10 at Phubala. The maximum EC was 173 recorded at Komlakhong and the minimum was 99 recorded at Phubala. The DO was recorded maximum at Ningthoukhong at 7.9 mg/ l and minimum was 6.2 mg/l recorded at Mayang Imphal. The maximum BOD was 2.7 mg/l recorded at Mayang Imphal and the minimum was 1.9 mg/l recorded at Ningthoukhong. The maximum Total Hardness was 50 mg/l recorded at Komlakhong and the minimum 30 mg/l recorded at Phubala. The maximum total alkalinity was 78 mg/l recorded at Komlakhong, and the minimum was 50 mg/l recorded at Phubala. The maximum acidity was 20.1 mg/l recorded at Komlakhong and the minimum was 12.5 mg/l recorded at Phubala. The maximum

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chloride was 11.36 mg/l recorded at Mayang Imphal and the minimum was 6.10 mg/l at Phubala. The maximum TDS was 68 mg/l at Mayang Imphal and the minimum was 33 mg/l at Phubala. The maximum sulphate was 31 mg/l recorded at Sendra and the minimum was 18 mg/l recorded at Phubala. The maximum COD was 26 mg/l recorded at Mayang Imphal and the minimum was 7mg/l recorded at Ningthoukhong and Mayang Imphal. The present study revealed that most parameters are within the permissible limit when compared with BIS/WHO/ICMR. The value of the water quality index were good as per the National Sanitation Foundation Water Quality Index.

Keywords: DO; BOD; ecosystem; parameters; permissible; Ramsar; water quality index.

1. INTRODUCTION

Water pollution affects drinking water, rivers, lakes and oceans worldwide, consequently harming human health and the natural environment. The water bodies are becoming the dumping sources for the industrial and domestic wastes. As a result, the existing dynamic equilibrium among the environmental segments get affected [1].

Rapid industrialization, growing urbanization and other significant factors are responsible for numerous forms of water pollution [2]. Water quality is defined in terms of water's chemical, physical and biological contents. The water quality of rivers and lakes changes with the seasons and geographic areas, even when no pollution is present. To protect specific water uses, water quality guidelines provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen and carbon dioxide. Others are total suspended and dissolved solids, total alkalinity, acidity and heavy metal contaminates (Lawson, 2011).

Water pollution include sewage and waste water, industrial waste, oil pollution, marine discarding, atmospheric deposition, radioactive waste, underground storage leakages, global warming, eutrophication etc. [3]. Loktak lake is the major freshwater wetland of Manipur and declared a Ramsar site in 1990. A large number of people living in these communities utilized the water from the lake for drinking and other domestic purposes. Jogesh et al., [4] Concentrations of all kinds of pollutants have an influence on the water quality and also determine the use of water [5] Municipal waste, agricultural fertilizers, pesticides, bathing, washing cloths and utensils make the Lake polluted [6]. It is essential to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Selection of parameters for water testing solely depends on the purpose of utilization and the extent of its quality and purity (Patil et al*.,* 2012). Loktak Lake is considered the “lifelines for the people of Manipur” due to its importance in their socio-economic and cultural life. It serves not only as the source of water for drinking, power generation and irrigation but also a source of livelihood for the people living in the surrounding villages. With increase in urbanization and population the people dispose and dump the waste materials into the water body thereby polluting and degrading the quality of water. Thus the purpose of this study is to monitor the water quality is required in order to maintain quality standard of the water.

2. MATERIALS AND METHODS

Loktak Lake is located in Bishnupur district of Manipur covering an area of 246.72 km^2 (National Wetland Atlas, 2009). The lake lies between 93° 46’ –93° 55’E and 24° 25’ –24° 42’ N of Manipur. Five seasons are distinct in the state viz; summer (May-June), Rainy (Monsoon) (July-Sept), Autumn (Oct.-Nov), Cold winter (Dec.-Feb) and Spring (March-April). Since the onset, duration and amount of precipitation of the monsoon rain are erratic. Annual rainfall is sometimes as low as 975 mm and sometimes as high as 2,646 mm. The average relative humidity is between 36% and 100%.

The samples were collected from five different areas of Loktak Lake, Manipur for six months (January-June 2021) and three samples were collected each site of each month. The five selected areas are Ningthoukhong, Phubala, Sendra, Mayang Imphal and Komlakhong. The samples were collected from the lake’s sub surface and some parameters like dissolve oxygen, pH, EC, Transparency were measured on the spot. Analysis of the samples for physicochemical parameters was carried out in the laboratory of Manipur Pollution Control Board according to the prescribed guidelines.

Table 1. Details of sampling sites

Site notation	Site name	Lattitude & longitude
S1	NINGTHOUKHONG	24^{0}34’43”N.93^{0}45’52”E
S2	PHUBALA	24^{0}31’52”N.93^{0}45’36”E
S3	SENDRA	24^{0}30’52”N.93^{0}47’29”E
S4	MAYANG IMPHAL	24^{0}34’9”N.93^{0}50’47”E
S5	KOMLAKHONG	24^{0}31’22”N.93^{0}52’7”E

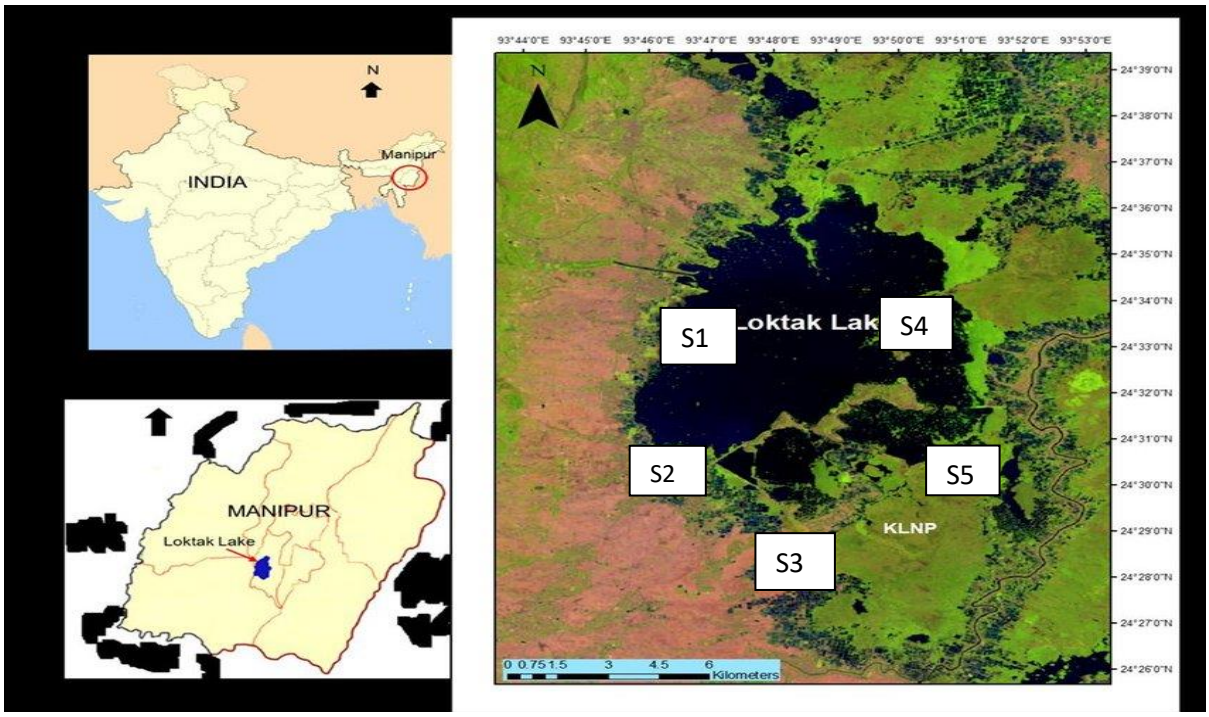

Fig.1. Map of the Study Area

3. RESULTS

The results are based on the data collected during the experimental investigation of the study and are presented through subjective analysis and tables. Discussions are made for elaborating the interpretation of the results. The chemical characteristics of the water sample from the different sites of Loktak Lake at Manipur have been collected and analyzed twice a month. The parameters include pH, EC, dissolve oxygen, biochemical oxygen demand, acidity, alkalinity, Hardness, chloride, total dissolved solids, Sulphate and chemical oxygen demand.

The maximum pH value for January was 7.4 at Komlakhong, whereas the minimum pH value was 7.1, as recorded at Phubala. The maximum pH value for February was 7.35 at Komlakhong, and the minimum pH value was 7.27 at Phubala. The maximum pH value for March was 7.35 at Komlakhong, whereas the minimum pH value was 7.27 at Phubala. The maximum pH value for April was 7.46 at Mayang Imphal, whereas the minimum pH value was 7.25 at Phubala. The maximum pH value for May was 7.58 at Sendra and the minimum pH value was 7.25 at Phubala. The maximum pH value for June was 7.48 at Sendra, whereas the minimum pH value was 7.26 at Mayang Imphal. It is important to check the pH water since it affects the solubility and availability of nutrients and its utility by aquatic organisms [2].

In January EC was recorded maximum at Komlakhong with 173 and minimum at Phubala with 93. The EC value of 160 for February was recorded maximum at Komlakhong and minimum value of 90 at Phubala.

The maximum value of EC for March was 160 at Ningthoukhong whereas the minimum value was 90 recorded at Phubala. The maximum value of EC for April was 160 at Mayang Imphal and

Komlakhong the minimum value was 110 as recorded at Phubala. The maximum value of EC for May was 160 at Mayang Imphal, the minimum value was 100 recorded at Phubala. The maximum value of EC for June was 156 at Ningthoukhong and Komlakhong whereas the minimum value was 106 recorded at Mayang Imphal. Salinity is determined by measuring the ability of water to conduct an electric current.

The maximum value of DO for January was 7.9 mg/l at Sendra whereas the minimum value was 6.3 mg/l as recorded at Komlakhong. The maximum value of DO for February was 7.9 mg/l at Komlakhong and the minimum value was 6.9 mg/l recorded at Mayang Imphal. The maximum value of DO for March was 7.5 mg/l at Komlakhong whereas the minimum value was 7.2 mg/l as recorded at Mayang Imphal. The maximum value of DO for April was 7.7 mg/l at Komlakhong and whereas the minimum value was 6.7 mg/l as recorded at Sendra. The maximum value of DO for May was 7.9 mg/l at Komlakhong whereas the minimum value was 6.7 mg/l recorded at Mayang Imphal. The maximum value of DO for June was 7.9 mg/l at Phubala whereas the minimum value was 7.4 mg/l recorded at Sendra. High DO concentration during winter may be due to low temperature rather than the photosynthesis activity of the phytoplankton because low temperature has a greater capacity to hold DO than warm water [4].

The maximum value of BOD for January was 2.5 mg/l at Ningthoukhong whereas the minimum value was 1.9 mg/l recorded at Komlakhong. The maximum value of BOD for February was 2.5 mg/l at Phubala and the minimum value was 1.9 mg/l recorded at Ningthoukhong. The maximum value of BOD for March was 2.5 mg/l at Komlakhong whereas the minimum value was 2.1 mg/l recorded at Ningthoukhong. The maximum value of BOD for April was 2.6 mg/l at Phubala and whereas the minimum value was 2.0 mg/l recorded at Ningthoukhong. The maximum value of BOD for May was 2.5 mg/l at Sendra whereas the minimum value was 2.0 mg/l recorded at Komlakhong. The maximum value of BOD for June was 2.3 mg/l at Sendra whereas the minimum value was 2.0 mg/l recorded at Phubala. The presence of BOD in natural surface of the water bodies of Loktak Lake may be polluted from the rivers mainly from the Nambul river and also from the domestic waste from local area including from several huts lying inside the lake on the phumdis [4].

The maximum value of Total Hardness for January was 50 mg/l at Komlakhong whereas the minimum value was 36 mg/l recorded at Phubala. The maximum value of Total Hardness for February was 48 mg/l at Komlakhong and the minimum value was 38 mg/l recorded at Phubala. The maximum value of Total Hardness for March was 49 mg/l at Komlakhong whereas the minimum value was 38 mg/l recorded at Phubala. The maximum value of Total Hardness for April was 44 mg/l at Mayang Imphal whereas the minimum value was 36 mg/l recorded at Phubala. The maximum value of Total Hardness for May was 44 mg/l at Ningthoukhong and Komlakhong whereas the minimum value was 36 recorded at Sendra. The maximum value of Total Hardness for June was 46 at Komlakhong whereas the minimum value was 37 mg/l recorded at Sendra. Ritabrata et at., [7] reported Total Hardness tended to increase in winter and decrease in monsoon.

The maximum value of Total Alkalinity for January was 73 mg/l at Komlakhong whereas the minimum value was 51 mg/l recorded at Phubala. The maximum value of Total Alkalinity for February was 78 mg/l at Komlakhong and the minimum value was 50 mg/l recorded at Phubala. The maximum value of Total Alkalinity for March was 75 mg/l at Komlakhong whereas the minimum value was 54 mg/l recorded at Phubala. The maximum value of Total Alkalinity for April was 75 mg/l at Mayang Imphal and whereas the minimum value was 58 mg/l recorded at Phubala. The maximum value of Total Alkalinity for May was 75 mg/l at Komlakhong whereas the minimum value was 53 mg/l recorded at Phubala. The maximum value of Total Alkalinity for June was 71 mg/l at Komlakhong whereas the minimum value was 63 mg/l recorded at Sendra. Higher Alkalinity was possible due to greater human activities including washing and bathing [8].

The maximum value of Acidity for January was 19 mg/l at Mayang Imphal and Komlakhong whereas the minimum value was 15 mg/l recorded at Phubala. The maximum value of Acidity for February was 20 mg/l at Komlakhong and the minimum value was 12.5 mg/l recorded at Phubala. The maximum value of Acidity for March was 20 mg/l at Sendra whereas the minimum value was 15 mg/l recorded at Phubala and Mayang Imphal. The maximum value of Acidity for April was 19.1 at Ningthoukhong and Komlakhong and whereas the minimum value was 13.3 mg/l recorded at Phubala. The

maximum value of Acidity for May was 19 mg/l at Sendra whereas the minimum value was 16.6 mg/l recorded at Phubala. The maximum value of Acidity for June was 19.9 mg/l at Mayang Imphal whereas the minimum value was 14 mg/l recorded at Phubala. Acidity may be contained the lake is due to carry on different rivers to pass the city of Manipur and joint the lake at the end.

The maximum value of Chloride for January was 10.80 mg/l at Sendra whereas the minimum value was 6.10 mg/l recorded at Phubala. The maximum value of Chloride for February was 11.36 mg/l at Sendra and the minimum value was 7.10 mg/l recorded at Phubala. The maximum value of Chloride for March was 9.93 mg/l at Sendra whereas the minimum value was 6.10 mg/l recorded at Phubala and Mayang Imphal. The maximum value of Chloride for April was 10.80 mg/l at Sendra whereas the minimum value was 8.10 mg/l recorded at Phubala. The maximum value of Chloride for May was 18.88 mg/l at Sendra whereas the minimum value was 7.10 mg/l recorded at Phubala. The maximum value of Chloride for June was 9.94 mg/l at Ningthoukhong whereas the minimum value was 7.10 mg/l recorded at Mayang Imphal. High chloride content may indicate pollution by sewage or industrial wastes [9].

Table 2. Physicochemical Parameters of different sites of Loktak Lake

Sl. No	Parameter	Months	Ningthoukhong (S1)	Phubala (S2)	Sendra (S3)	Mayang Imphal (S4)	Komlakhong (S5)
1.	pH	January	7.36	**7.10***	7.45	7.33	7.49
		February	7.45	7.37	7.43	7.39	7.48
		March	7.33	7.27	7.32	7.28	7.35
		April	7.36	7.25	7.38	7.46	7.37
		May	7.37	7.25	**7.58****	7.38	7.43
		June	7.34	7.27	7.48	7.26	7.47
2.	EC	January	156	**93***	136	143	**173****
		February	146	90	140	130	160
		March	160	90	143	130	156
		April	130	110	140	160	160
		May	130	100	136	160	150
		June	156	106	146	146	156
3	DO	January	7.8	7.6	**7.9****	7.4	6.3
		February	7.4	7.7	7.5	6.9	7.9
		March	7.3	7.4	7.3	7.2	7.5
		April	7.6	7.2	6.7	7.6	7.7
		May	7.7	7.5	7.8	6.7	7.9
		June	7.8	7.9	**6.2***	7.5	7.6
4	BOD	January	2.5	2.4	2.2	2.3	1.9
		February	**1.9***	2.5	2.3	2	2.4
		March	2.1	2.3	2.4	2.4	2.5
		April	2	2.6	2.1	2.5	2.3
		May	2.3	2.2	2.5	2.1	2
		June	2.2	2	2.3	2.2	**2.7****
5	Total hardness	January	41	36	40	38	**50***
		February	40	38	42	40	48
		March	42	38	43	41	49
		April	38	36	38	44	42
		May	44	37	36	39	44
		June	39	40	37	43	46
6	Alkalinity	January	68	51	65	71	73
		February	71	**50***	71	68	**78****
		March	72	54	70	73	75
		April	70	58	72	75	70
		May	70	53	61	72	75
		June	68	66	63	70	71
7	Acidity	January	18.0	15.0	18.0	19.0	19.0

Sl. No	Parameter	Months	Ningthoukhong (S1)	Phubala (S2)	Sendra (S3)	Mayang Imphal (S4)	Komlakhong (S5)
		February	20.0	**12.5***	19.1	18.3	**20.1****
		March	17.5	15.0	20.0	15.0	17.5
		April	19.1	13.3	16.6	17.5	19.1
		May	18.0	16.6	19.0	18.9	18.0
		June	16.6	14.0	17.5	19.9	18.0
8	Chloride	January	7.60	6.10	10.80	7.60	8.10
		February	8.52	7.10	**11.36****	8.85	10.80
		March	7.50	**6.10***	9.93	7.50	7.50
		April	9.40	8.10	10.80	10.4	8.52
		May	8.52	7.10	10.88	8.52	7.57
		June	9.94	8.52	9.46	7.10	7.57
9	TDS	January	60	34	55	58	64
		February	63	**33***	56	57	65
		March	59	35	55	59	65
		April	57	44	57	66	64
		May	61	41	53	**68****	62
		June	61	40	51	65	63
10	Sulphate	January	27	23	28	24	25
		February	24	**18***	27	23	25
		March	27	23	28	24	24
		April	26	25	26	27	26
		May	28	22	27	25	28
		June	25	19	24	23	26
11	COD	January	16	13	24	**26****	9
		February	21	16	21	16	8
		March	16	18	22	18	8
		April	**7***	16	24	24	16
		May	8	17	13	7	24
		June	20	16	23	8	13

The maximum value of TDS for January was 64 mg/l at Komlakhong whereas the minimum value was 34 mg/l recorded at Phubala. The maximum value of TDS for February was 65 mg/l at Komlakhong and the minimum value was 33 mg/l recorded at Phubala. The maximum value of TDS for March was 65 mg/l at Komlakhong whereas the minimum value was 35 mg/l recorded at Phubala. The maximum value of TDS for April was 66 mg/l at Mayang Imphal whereas the minimum value was 44 mg/l recorded at Phubala. The maximum value of TDS for May was 68 mg/l at Mayang Imphal whereas the minimum value was 41 mg/l recorded at Phubala. The maximum value of TDS for June was 65 mg/l at Mayang Imphal whereas the minimum value was 40 mg/l recorded at Phubala. Among the different site the highest value was at Ningthoukhong and Mayang Imphal [7]. Reported TDS increase in summer and winter and decreased in spring and post-monsoon. In summer and winter, water level drops due to increased evaporation and decreased inflow. In decreased water volume the solutes get concentrated, so TDS increased.

The maximum value of Sulphate for January was 28 mg/l at Sendra whereas the minimum value was 23 mg/l recorded at Phubala. The maximum value of Sulphate for February was 27 mg/l at Sendra and the minimum value was 18 mg/l recorded at Phubala. The maximum value of Sulphate for March was 28 mg/l at Sendra whereas the minimum value was 23 mg/l recorded at Phubala. The maximum value of Sulphate for April was 27 mg/l at Mayang Imphal and whereas the minimum value was 23 mg/l recorded at Phubala. The maximum value of Sulphate for May was 28 mg/l at Ningthoukhong and Komlakhong whereas the minimum value was 22 mg/l recorded at Phubala. The maximum value of Sulphate for June was 26 mg/l at Komlakhong whereas the minimum value was 19 recorded at Phubala. [2] found concentration of sulphate were low during monsoon and higher during pre monsoon.

The maximum value of COD for January was 26 mg/l at Mayang Imphal whereas the minimum value was 9 mg/l recorded at Komlakhong. The maximum value of COD for February was 21

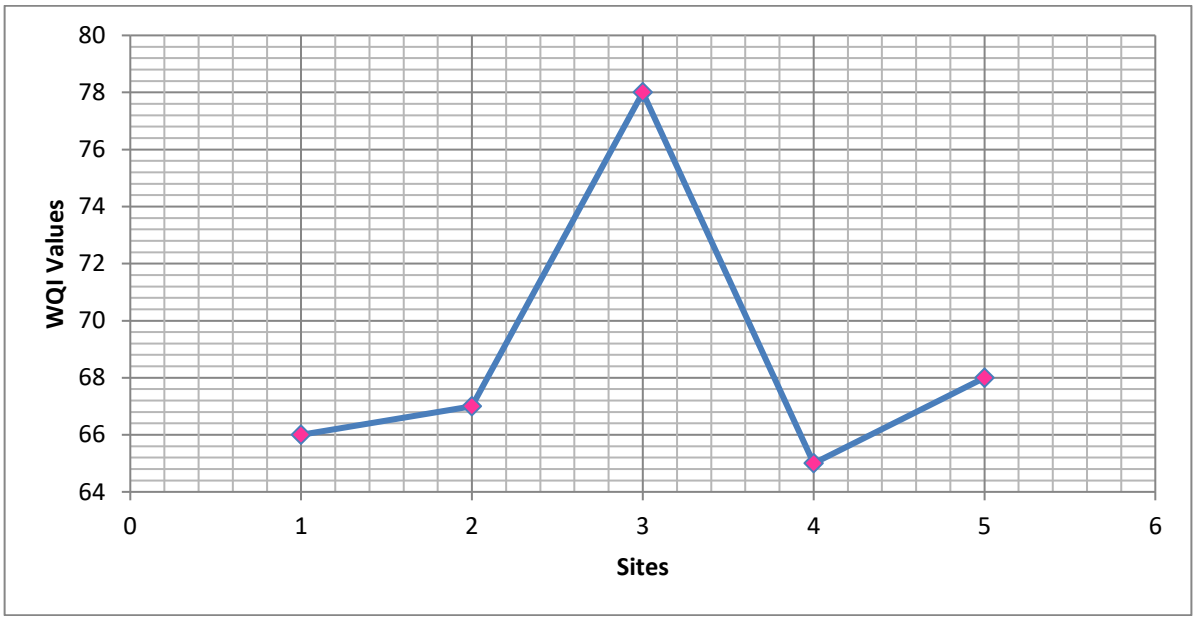

Fig. 2. Graphical representation of WQI of different sites of Loktak Lake

mg/l at Ningthoukhong and Sendra and the minimum value was 8 recorded at Komlakhong. The maximum value of COD for March was 22 mg/l at Sendra whereas the minimum value was 8 mg/l recorded at Komlakhong. The maximum value of COD for April was 24 mg/l at Sendra and Mayang Imphal, the minimum value was 7 mg/l recorded at Ningthoukhong. The maximum value of COD for May was 24 mg/l at Komlakhong whereas the minimum value was 7 mg/l recorded at Mayang Imphal. The maximum value of COD for June was 23 mg/l at Sendra whereas the minimum value was 8 mg/l recorded at Mayang Imphal. The value of water quality index were good as per the National Sanitation Foundation Water Quality Index. The maximum value of WQI was 78 at Sendra and the minimum value was 65 at Mayang Imphal. According to NSFWQI these values gives good and medium water quality status.

4. CONCLUSION

Loktak lake acts as a natural reservoir for rivers and streams of the valleys and hills of Manipur. The analysis of the different parameters of loktak lake revealed that most of the values are within the permissible limit when compared with BIS/WHO/ICMR except for DO and COD where the values are slightly higher than the permissible limit. The higher values of DO is not a case of concern since it indicates a high amount of oxygen content in the water which is the most important requirement of the aquatic organisms, therefore higher the DO better is the water quality but high COD on the other hand is a case of concern since there will be greater oxygen demand. The results obtained from WQI of the different sites indicate that the water at most of the sites comes in medium category which is not much polluted. It is also the largest freshwater inland natural reservoir in the eastern region of the country and has been identified as a major Indian Wetland by the World Conservation Union (IUCN) therefore proper monitoring is necessary for proper maintenance of its natural quality and beauty as the lake becomes more polluted day by day with the increase in population, increase in pollution from various industries, urbanization, industrial effluent, domestic sewage and municipal waste thrown into the lake.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare 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 manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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