IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 9, September 2020

DOI 10.17148/IARJSET.2020.7914

Water Quality Assessment of Hebbal Lake Using Canadian Council of Ministers of the Environment (CCME) Model

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Abstract: Lakes are important feature of the Earth's landscape which are not only the source of precious water, but provide valuable habitats to plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape and extend many recreational opportunities to mankind. The release of domestic wastewater, agricultural runoff water & industrial effluents promote excessive growth of algae in water bodies, which results in their eutrophication. In the present study, Mysore's one of the major lake is considered for the study. Hebbal lake is Situated at latitude 12°21'31" N and departure 76°36'40" E and is at an elevation of +751.220m. It is spread over an area of 17.44hectares. The physical, chemical, biological characteristics of Hebbal Lake were evaluated to estimate the quality of lake water. In this work, 12 grab samples were collected out of which 10 sampling stations from 5m shoreline and one station at centre and another one sample is collected where drainage water joins the lake. The pH value ranges from 7.09 to 9.07. The minimum value of 7.09 was recorded in S_{12} and maximum of 9.07 in S_1. Total dissolved solids observed in the lake ranges from 870 mg/L to 1970 mg/L. Minimum value of 870 mg/L was recorded in S_6 and maximum of 1970 mg/L in S_{12}. Turbidity ranges from 26.35 NTU to 84.6 NTU. The minimum value of 26.35 NTU was observed in S_{10} and maximum of 84.6 NTU in S_{12}. The minimum value of 3.94 mg/L was recorded in S_{12}, in the month of March and May and maximum value of 9.815 mg/L in S_8. COD values ranges from 24 mg/L to 174 mg/L. BOD values ranges from 140 mg/L to 455 mg/L. A minimum value of 140 mg/L was observed in S_4 and maximum of 455 mg/L in S_8. . Iron ranges from 0.33 mg/L to 0.56 mg/L. A minimum of 0.33 mg/L was observed in S_1 and maximum of 0.56 mg/L in S_{11}. Certain parameters analysed like BOD, turbidity and hardness exceeds the maximum limits of the drinking water standards. The water quality index evaluated using CCME is 48, which =indicates the lake water as marginal.

Keywords: Water quality; Turbidity; Total dissolved solids; BOD and CCME model.

I. INTRODUCTION

Water is one of the main important abiotic components of the environment. Approximately, 97% of the total water is found in oceans, which is not appropriate for drinking, and only 3% is considered as fresh water, out of which 2.97% is found as glaciers and ice caps. Only the remaining little portion, 0.03%, is obtainable as surface and ground water for human use. Harmless drinking water is a basic need for good health and it is a rudimentary right of humans. In addition, it is impossible to imagine clean and sanitary environment without water. Knowing the importance of water for sustenance of life, the need for conservation of water bodies especially the fresh water bodies is being realized everywhere in the world. The global water scenario is very much alarming. It is predicted that if at all a third world war takes place; the reason for it will be water. The World Health Organization (2006) reports mentioned that approximately 36% of urban and 65% of rural Indian's were without access to safe drinking water. Fresh Water is essential to existence of life. Lakes are important feature of the Earth's landscape which are not only the source of precious water, but provide valuable habitats to plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape and extend many recreational opportunities to mankind. Age-old customs and habits of community, cattle bathing and washing in rivers are responsible for rampant pollution of river water. The release of domestic wastewater, agricultural runoff water & industrial effluents promote excessive growth of algae in water bodies, which results in their eutrophication. Several states in the country are facing problems due to over exploitation of ground water resources and pollution of surface water. Its manifestations are declining per capita water availability, falling water tables and deterioration of water quality. Accurate information on the condition and trends of water resources quantity and quality is required as a basis for economic and social development and for the development and maintenance of environmental quality. In this scenario we assess the water quality index of the lake.

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Objective: The main goal of this research work is to evaluate the water quality index (WQI) of Hebbal Lake.

Specific Objectives

- To determine the physico-chemical and biological characteristics of lake water
- To determine the physico-chemical and biological characteristics of wastewater being disposed to lake
- To assess the Eutrophication Index and WQI using Canadian Council of Ministers of the Environment (CCME)

II. MATERIALS AND METHODOLOGY

2.1 Study Area

This section clearly narrates about the study area and the methodology adopted to achieve the objectives of this research work. Mysore houses six major lakes out of which hebbal lake is one of them. Heabbal lake is Situated at latitude 12°21'31" N and departure 76°36'40" E and is at a elevation of +751.220m. It is spread over an area of 17.44hectares. Figure 1 shows the location of Hebbal lake. The lake is surrounded by Industries, hospitals and few recreation places. It is located about 6 km away from Mysore city. The Shape of the lake is irregular. Anthropogenic activities are found and large numbers of industries are situated around the lake. Macrophytes are less abundant. Construction and demolition wastes and industrial wastes are dumped into the lake. High organic matter is present in lake and suspended matter and high algal growth exist at the sides of lake.

2.2 Sampling

Surface water samples were collected for 2 cycles at 20 days interval. Figure 2 shows the location of sampling stations. The physical, chemical, biological characteristics of Hebbal Lake were evaluated to estimate the quality of lake water. In this study 12 grab samples were collected out of which 10 sampling stations from 5m shoreline and one station at centre and one sample is collected where drainage water joins the lake and marked it as S_{12}. Table 1 shows the details of sampling stations. A sample is a part or piece taken from a larger entity and presented as being representative of the whole. The sampling methods are chosen keeping in mind the following-

- Parameters to be sampled
- Identification of proper equipment and procedures for safe, accurate and effective Sampling
- Identification of representative sampling sites
- To collect adequate volumes for the required analyses
- To preserve samples to maintain integrity
- Sample transport procedures
- Procedures to ensure that holding times are not exceeded

The water chemistry variables analyzed are pH, water temperature, Electrical conductivity, total dissolved salts, Total acidity, turbidity, Dissolved Oxygen, Total hardness, Chloride, Total alkalinity, Chemical Oxygen Demand, Nitrate, Phosphate and Biochemical Oxygen Demand, Chlorophyll a, MPN, Sulphates.

Figure 1 Map Of Study Area

Figure 2 Location Of Sampling Stations

Table 1 Details of Sampling Stations

SAMPLING POINTS	LATITUDE	LONGITUDE
Sampling station (S_1)	12º21’33”N	76º36’47”E
Sampling station (S_2)	12º21’36”N	76º36’44” E
Sampling station (S_3)	12º21’34”N	76º36’41” E
Sampling station (S_4)	12º21’37”N	76º36’38” E
Sampling station (S_5)	12º21’31”N	76º36’39” E

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Sampling station (S_6)	12º21'34"N	76º36'48" E
Sampling station (S_7)	12º21'32"N	76º36'41" E
Sampling station (S_8)	12º21'36"N	76º36'00" E
Sampling station (S_9)	12º21'33"N	76º36'46" E
Sampling station (S_{10})	12º21'33"N	76º36'47" E
Sampling station (S_{11})	12º21'29"N	76º36'36" E
Sampling station (S_{12})	12º21'31"N	76º36'43" E

2.2.1 Sample Collection

To collect the samples use a cleaned sample container of 5 liters capacity. Firstly open the cap on the top end of the sampler bottle and field rinse by submerging it three times in the lake and draining. Slowly lower the sampler bottle into the lake as vertically as possible using 2.5m rod. Water sample is collected below the water surface (subsurface) and the DO is fixed on site. Sample is brought to laboratory for further analysis as mentioned in Table 2 and labelled sample are stored in a dark cool place.

Table 2 Concerned Parameters Analytical Techniques

PARAMETERS	ANALYTICAL METHOD	INSTRUMENTS USED
Turbidity mg/L as $CaCO_3$	Nephelometric method	Nephelo- turbiditymeter
pH	Electrode method	pH meter
Acidity, mg/L as $CaCO_3$	Titrimetric Method	-
Nitrate, mg/L	Spectrophotometric method	Spectrophotometer
Sulphate, mg/L	Turbidimetric method	Spectrophotometer
Alkalinity mg/L as $CaCO_3$	Titrimetric Method	-
Electrical conductivity	Electrode method	Conductivity meter
Chloride , mg/L	Argentometric method	-
Hardness, mg/L	Titrimetric Method	-
Total solids mg/L	Gravimetric Method	Hot air oven
Phosphate, mg/L	Spectrophotometric method	Spectrophotometer
Iron	Phenanthroline method	Spectrophotometer
Fluoride , mg/L	Alizarin visual method	-
COD, mg/L	Refluxing Method	COD Digester
BOD_5 , mg/L	Dilution method	BOD Incubator
DO, mg/L	Winklers or Iodometric method	-

2.3 Water Quality Index

Water Quality Index (WQI) may be defined as the rating that reflects the composite influence of a number of water quality factors on the overall quality of water. It reduces the large amount of water quality data to a single numerical value. It is one of the most effective ways to communicate information on water quality trends to policy makers, to shape sound public policy and implement the water quality improvement programmes efficiently. It integrates the data pool generated after collecting due weights to the different parameters. The advantages of an index include its ability to represent measurements of a variety of variables in a single number, its ability to combine various measurements in a variety of different measurement units in a single metric and its effectiveness as a communication tool. WQI is to give a single value to water quality of a source along with reducing higher number of parameters into a simple expression resulting into easy interpretation of water quality monitoring data. In the present work, the water quality index is assessed using Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)

2.3.1 Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)

The Canadian Council of Ministers of the Environment (CCME) was designed to evaluate surface water quality for the purpose of protecting aquatic life aided with specific guidelines. The number of parameters to be measured can be determined by the water quality monitoring agency. The sampling protocol requires at least four parameters sampled at least four times. The finding must reflect the water quality in a given water area as accurately as possible. Characterization of water quality index is as shown in table 3. Water quality guidelines are numerical values that define physical, chemical or biological characteristics of the water that cannot be exceeded without causing harmful effect (CEQG, 1999). The indices are among the most effective ways to communicate the information on water quality trends to the general public and in water quality management. The present work was focused on this model.

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This index uses a combination of three factors, the number of variables whose objectives are not met, (**Scope)**, the frequency with which the objectives are not met, (**Frequency) and t**he amount by which the objectives are not met, (**Amplitude)**

Table 3 Characterization of Water Quality Index

RATING	CCME-WQI
Excellent	95-100
Good	80-94
Fair	65-79
Marginal	44-64
Poor	0-44

$$F_1 = \frac{\text{(Number of failed variables)}}{\text{(Total number of variables)}} * 100 \quad \text{………………(1)}$$

$$F_2 = \frac{\text{(Number of failed tests)}}{\text{(Total number of tests)}} * 100 \quad \text{………………(2)}$$

Test value not exceeding test objective,

$$\text{Excursion}_i = \frac{\text{(failed test value}_j)}{(\text{Objective}_j)} - 1 \quad \text{………………(3)}$$

Test value not falling below objective,

$$\text{Excursion}_i = \frac{(\text{Objective}_j)}{\text{(failed test value}_i)} - 1 \quad \text{………………(4)}$$

$$\text{nse}= \{\textstyle\sum_{i=1}^{n}(Excursion)i\} / \text{ No. of tests} \quad \text{………......(5)}$$

$$F_3 = \left(\frac{\text{nse}}{(0.01\text{nse} + 0.01)}\right) * 100 \quad \text{………………(6)}$$

$$\text{CCME WQI} = 100 - \frac{(F_1^2 + F_2^2 + F_3^2)^{½}}{1.732} \quad \text{………………(7)}$$

Eutrophication index

$$EI = \frac{COD * DIP * DIN}{4500} * 10^6 \quad \text{………………(8)}$$

- **Eutrophication (>1)**
- **No Eutrophication (<1)**

III. RESULTS AND DISCUSSION

3.1 Physico- chemical parameters

The water was analysed for its physical and chemical properties and the results have been discussed and presented in the following sections.

3.1.1 Temperature: It is one of the critical physical parameter which controls most the biological activities in the aquatic environment. The water temperature of lake during study period ranges from 25°C to 30°C.

3.1.2 Electrical conductivity: Electric conductivity is a parameter used to ascertain the purity of water and is the measure of capability of water to transmit electric current. The Electric conductance ranges from 2.8m mho/cm to 4.65m mho/cm. A minimum value of 2.8m mho/cm was recorded in S_{10} and maximum of 4.65m mho/cm in S_{11}. Figure 3 shows that values obtained in all sampling stations. It has been mentioned that increase in EC is due to dissolved salts content.

3.1.3 pH: pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The pH value ranges from 7.09 to 9.07. The minimum value of 7.09 was recorded in S_{12} and maximum of 9.07 in S_1. It has been mentioned that the increase in pH value appears to be associated with increased use of alkaline detergents in residential areas & alkaline material from wastewater is from industrial areas. Fig 4 shows that value obtained in all sample stations.

3.1.4 Total dissolved solids: Total dissolved solids represent the amount of soluble inorganic substance in water. Total dissolved solids observed in the lake ranges from 870 mg/L to 1970 mg/L. Minimum value of 870 mg/L was recorded in S_6 and maximum of 1970 mg/L in S_{12}. The entry of sewage, urban runoff, industrial wastewater influence the increase in the concentration of Total dissolved solids. Figure 5 shows that values obtained in all sampling stations.

3.1.5 Turbidity: Turbidity is the measure of suspended matter in water. Suspended matter often includes mud, clay and silt. Turbidity ranges from 26.35 NTU to 84.6 NTU. The minimum value of 26.35 NTU was observed in S_{10} and

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maximum of 84.6 NTU in S_{12}. The entry of wastewater from industries influences the increase in concentration of turbidity. Figure 6 shows that values obtained in all sampling stations.

3.1.6 Dissolved oxygen: Dissolved oxygen values ranges from 0 mg/L to 9.815 mg/L. The minimum value of 3.94 mg/L was recorded in S_{12}, March and May and maximum value of 9.815 mg/L in S_8. The increase in DO is influenced by the moderate temperature. Lower DO indicates the pollution of the lake by algae are unwanted things in lake. Figure 7 shows that values obtained in all sampling stations.

3.1.7 Hardness: The regular addition of large quantities of sewage and detergent into the lake from nearby residential localities is responsible for higher level of hardness. Hardness ranges from 625 mg/L as $CaCO_3$ to 920 mg/l as $CaCO_3$. The minimum of 625 mg/L as $CaCO_3$ was recorded in S_4 and S_6 and maximum of 920 mg/l as $CaCO_3$ in S_{12}. The harness will be more where the concentration of calcium and magnesium is more. Figure 8 shows that values obtained in all sampling stations.

3.1.8 Chloride: Chloride is not utilized directly or indirectly for aquatic plant growth and hence its existence in the aquatic system is regarded as pollution. Chloride ranges from 448.5 mg/L to 569.4 mg/L in the lake. A Minimum of 448.5 mg/L was observed in S_1 and S_4 and maximum value of 569.4 mg/L in S_{12}. High chloride concentration in the lake water may be due to high rate of evaporation or due to organic waste of animal origin. Figure 9 shows that values obtained in all sampling stations.

3.1.9 Total alkalinity: Total alkalinity is due to the presence of carbonates and bicarbonates of calcium and magnesium discharged from Kitchen waste water. Amount of total alkalinity in the lake ranges from 204.5 mg/L as $CaCO_3$ to 225 mg/L as $CaCO_3$. A Minimum concentration of 204.5 mg/L as $CaCO_3$ was observed in S_{11} and maximum of 225 mg/L as $CaCO_3$ in S_{12}. The high value of total alkalinity in the lake may be due to cattle bathing and laundering of clothes. Figure 10 shows that values obtained in all sampling stations.

3.1.10 Chemical oxygen demand (COD): Chemical oxygen demand (COD) is commonly used to indirectly measure the amount of organic compounds in water. This makes COD as a useful indicator of organic pollution in surface water. COD values ranges from 24 mg/L to 174 mg/L. A minimum of 24 mg/L was observed in S_2 and maximum of 174 mg/L in S_4. Higher value of COD pointing to deterioration of water quality was likely caused by the discharge of municipal waste water. Figure 11 shows that values obtained in all sampling stations.

3.1.11 Biochemical oxygen demand (BOD): Biochemical oxygen demand (BOD) refers to the oxygen used by the micro-organisms in aerobic oxidation of organic matter, therefore with the increase in the amount of organic matter in the water BOD increases. BOD values ranges from 140 mg/L to 455 mg/L. A minimum value of 140 mg/L was observed in S_4 and maximum of 455 mg/L in S_8. Higher contents of organic load as well as high proliferation of microorganism are the causative factors for maximum BOD levels. Figure 12 shows that values obtained in all sampling stations.

3.1.12 Nitrate: Nitrate value ranges from 1.25 mg/L to 2.31 mg/L. A minimum of 1.25 mg/L was observed in S_5 and maximum of 2.31 mg/L in S_1. Nitrate concentration was mainly due to anthropogenic activities such as runoff water from agricultural lands, discharge of household and municipal sewage. Figure 13 shows that values obtained in all sampling stations.

3.1.13 Iron: When there is no oxygen in the water then the iron is present in a reduced, dissolved form (Fe^{2+}), which is frequently present in well water. This form of iron is dissolved and has no colour. Iron ranges from 0.33 mg/L to 0.56 mg/L. A minimum of 0.33 mg/L was observed in S_1 and maximum of 0.56 mg/L in S_{11}. Figure 14 shows that values obtained in all sampling stations.

3.1.14 Sulphate: Drinking water with excess sulphate concentrations often has a bitter taste and a strong „rotten-egg" odor. Sulphate can also interfere with disinfection efficiency by scavenging residual chlorine in distribution systems. Sulphate ranges from 8.2 mg/L to 44.2 mg/L. A minimum of 8.2 mg/L was observed in S_{12} and maximum of 44.2 mg/L in S_7. Sulphate content is more due to mix of the drainage water. Figure 15 shows that values obtained in all sampling stations.

3.1.15 Fluoride: Fluoride is essential for human beings to fight against dental caries. The desirable concentration is 1 mg/L, if it is more than this it proves to be harmful. Actually the higher concentration of fluoride leads to the discoloration of teeth known as dental fluorosis. The more dangerous is the deformation of the Skelton. Fluoride value is 0.4 mg/L in S_1 and S_2 and 0.3 mg/L in all other stations. Figure 16 shows that values obtained in all sampling stations.

3.1.16 Phosphate: The occurrence of Phosphate in surface water may be due to addition of domestic sewage, detergents and agricultural effluents with fertilizers. Phosphate values ranges from 0.3705 mg/L to 0708 mg/L. A minimum of 0.3705 mg/L was observed in S_5 and maximum of 0.708 mg/L in S_2. Due to growth of plant and algae the phosphates will be more in those regions. Figure 17 shows that values obtained in all sampling stations.

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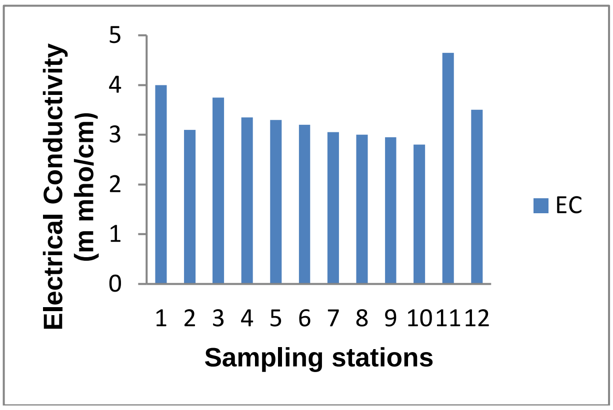

Figure 3 Electrical conductivity

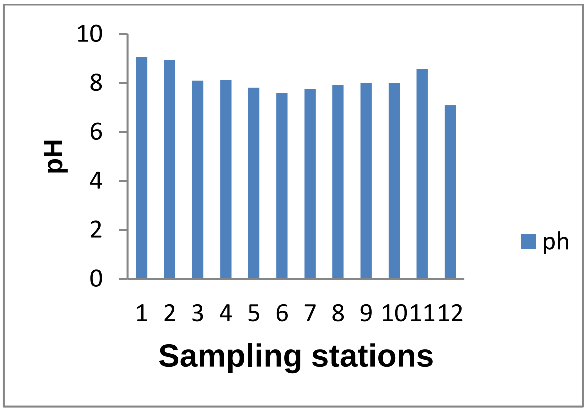

Figure 4 pH

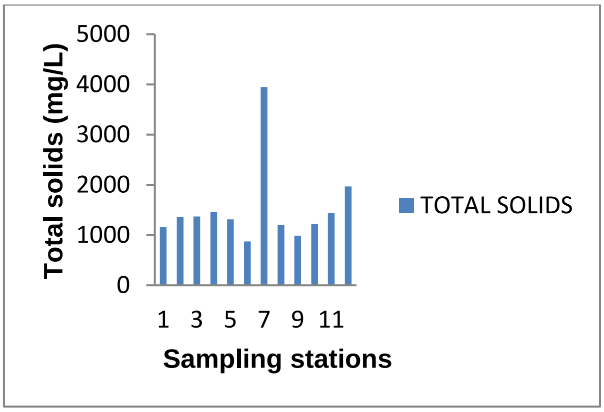

Figure 5 Total solids

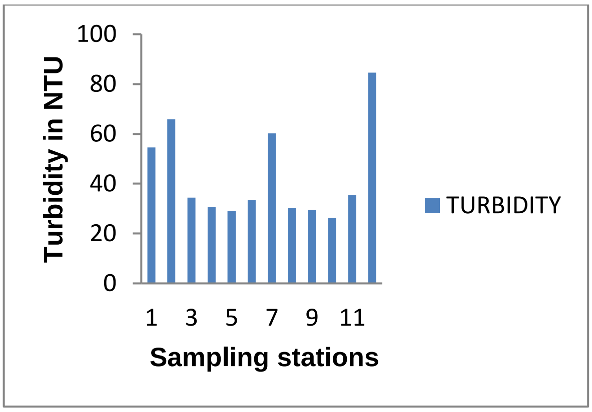

Figure 6 Turbidity

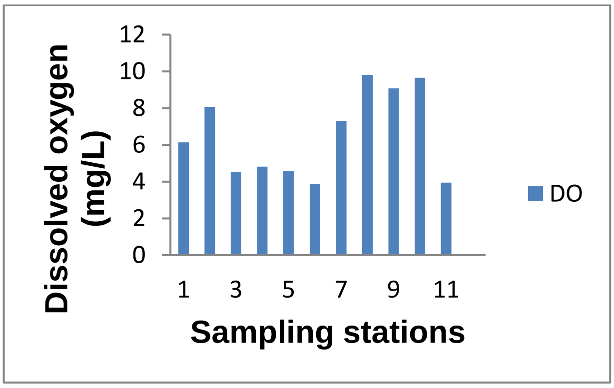

Figure 7 Dissolved oxygen

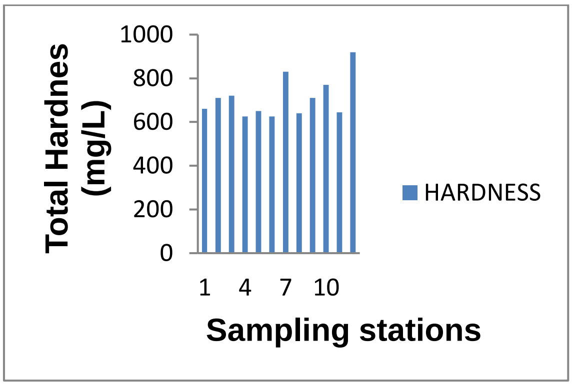

Figure 8 Total hardness

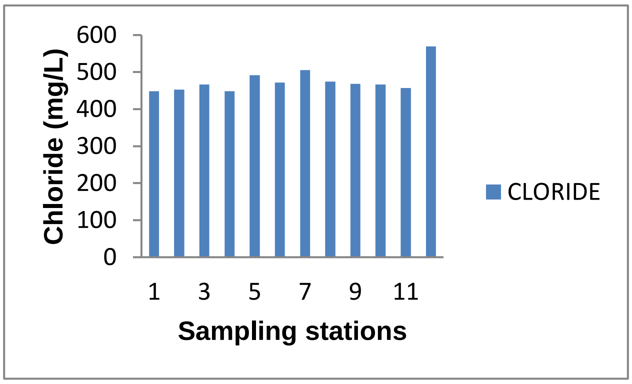

Figure 9 Chloride concentration

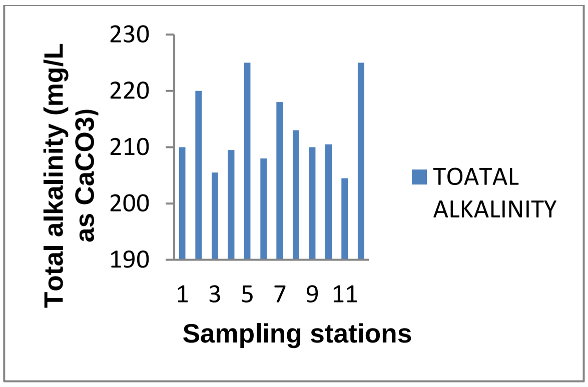

Figure 10 Total Alkalinity

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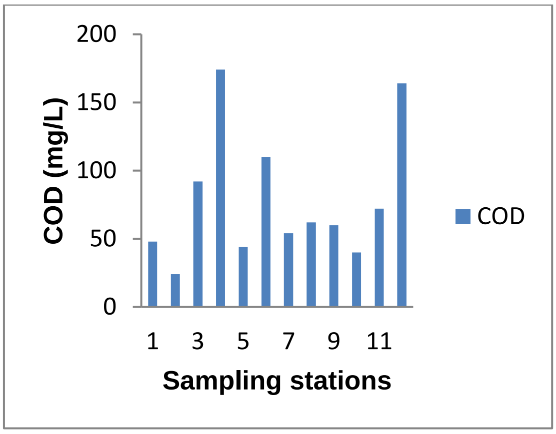

Figure 11 Chemical oxygen demand

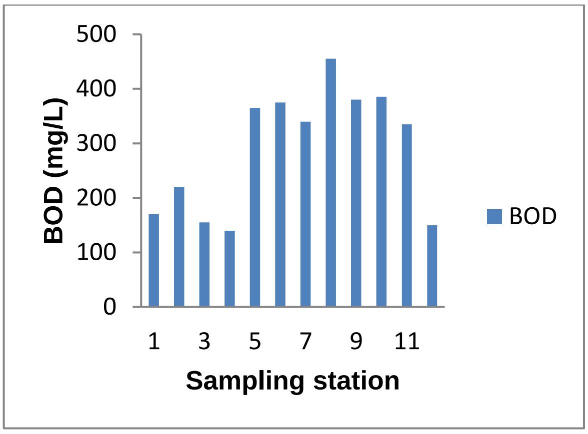

Figure 12 Biochemical oxygen demand

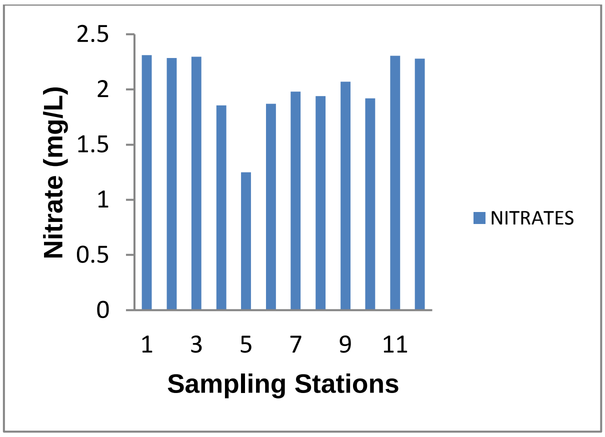

Figure 13 Nitrate concentration

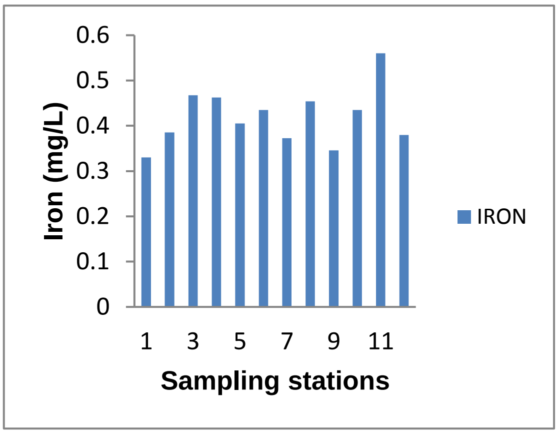

Figure 14 Iron concentration

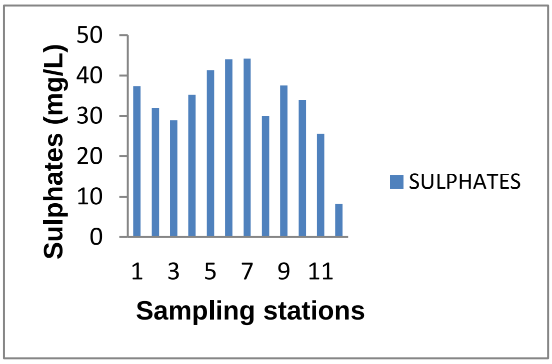

Figure 15 Sulphate concentration

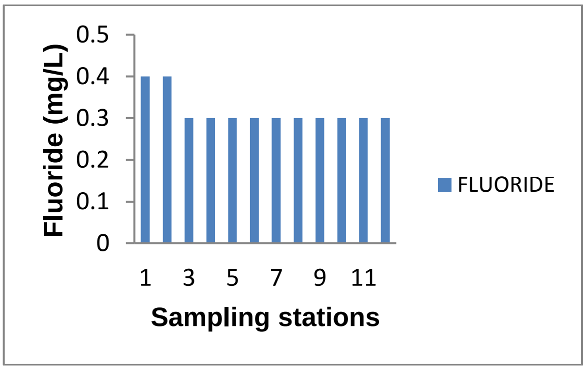

Figure 16 Fluoride concentration

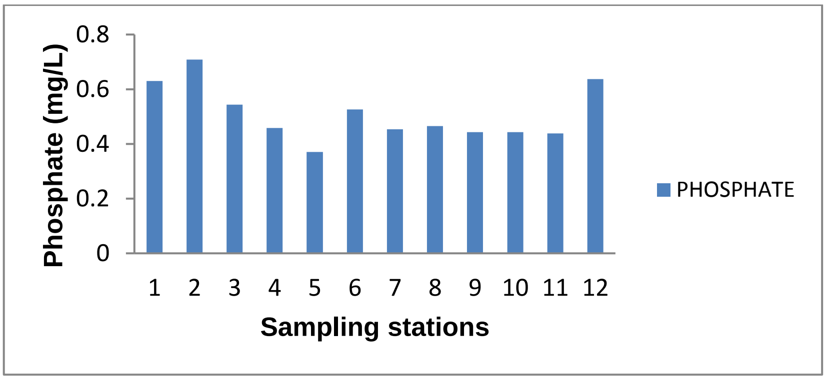

Figure 17 Phosphate concentration

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 9, September 2020

DOI 10.17148/IARJSET.2020.7914

IV. CONCLUSION

From this work, conclusions can be drawn as,

- Most of the physico-chemical parameters such as alkalinity, chlorides, iron and phosphates are within the limits
- Certain parameters analysed like BOD, turbidity and hardness exceeds the maximum limits of the drinking water standards
- The water quality index evaluated using CCME is 48, which indicates the lake water as marginal

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