Groundwater Quality Assessment Around the Hebbal Lake by Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI)

SHILPA B S[1*], GIRISH P[2], SANJAY H G[3], DISHA J[3]

[1]*Associate Professor, [2]Assistant Professor, [3]UG Students*
Department of Civil Engineering, Vidyavardhaka College of Engineering, Gokulam III stage, Mysuru, India

---***---

Abstract: The groundwater quality in an industrial area is one of the most important criterion to ascertain its suitability for human consumption and other purposes. In this work, an attempt has been made to assess the groundwater quality index around Hebbal lake, Hebbal industrial area, Mysore. The methodology adopted to assess WQI is Canadian Council of Ministers of the Environment (CCME). The twelve samples were collected for physico-chemical characteristics such as pH, Electrical conductivity, Turbidity, Alkalinity, Nitrate(NO_3), Chloride (Cl^-), Sulphates (SO_4^{2-}), phosphate (PO_4^{3-}), Iron(Fe), Hardness, Fluoride, COD. The obtained results were compared with Bureau of Indian Standard (BIS) limits. The results reveal that, parameters such as COD, turbidity and hardness were high concentration of 90mg/L, 7 NTU and 300mg/L as $CaCO_3$.According to CCME, the lake water WQI for all stations varied between 49-56. Which characterizes the groundwater as marginal around Hebbal lake. The overall quality of the groundwater is fit for drinking purposes with primary treatment. An effective groundwater management plan of artificial recharge is necessary to conserve valuable groundwater resources around Hebbal Lake.

Keywords: Groundwater, Hebbal Lake, WQI and CCME

1. INTRODUCTION

Groundwater is one of the most useful water sources. Water is second to oxygen as being essential for life. People can survive days, weeks, or even longer without food, but only about four days without water. Contamination of such water sources is a big problem creating health hazard. Water is very important life supporting material and required for all biotic communities. Normally water in nature is never pure in chemical sense. Groundwater contamination portfolio is an indispensable part of any comprehensive groundwater protection strategy. The level of groundwater contamination and its sources must be identified, assessed and its impacts on groundwater quality must be determined, before appropriate protection measures designed and implemented,. An account of the number, type, and intensity of potentially contaminating activities and of the extent of existing contamination of groundwater can serves a two-fold purpose for groundwater protection. Firstly, the potential of groundwater contamination needed for successful management programs. Secondly, it provides basic data that can be used for the design of the type and location of various strategies of the monitoring programs. Results of a comprehensive, detailed inventory allow water managers to prioritize contamination sources according to intended purpose and to develop differential management strategies, thereby safeguarding public health and protecting groundwater.

In this scenario, an attempt has been made to assess the groundwater quality assessment using CCME WQI around the Hebbal Lake.

2. Materials and Methodology

2.1 Study Area

Mysore houses six major lakes out of which Hebbal Lake is one of them. Hebbal lake is situated at latitude 12°21'31" N and logitude 76°36'40" E and is at an elevation of +751.220m. It is spread over an area of 17.44hectares (174419.5m²). Fig.1 shows the location of Hebbal Lake and sampling station. 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 Sample Collection and Analysis of Groundwater

Twelve groundwater sampling stations (Table 1) were randomly selected within 1km radius from the Hebballake as shown in Fig.1. The samples were collected in the months of March & April with all precautions measures. While sampling, bore wells, pumps were allowed to flow for more than 10 min and then required quantity of water was collected in pre-cleaned polythene containers (5L) as shown in Plate 1. Samples were immediately brought to laboratory for further analysis. The samples were analyzed for physical and chemical parameters. These include pH, turbidity, electrical conductivity, chloride, hardness, nitrates, sulphates, phosphates, iron, COD, hardness fluoride. The analyses of water samples was done using standard procedure and all analysis was done in triplicate.
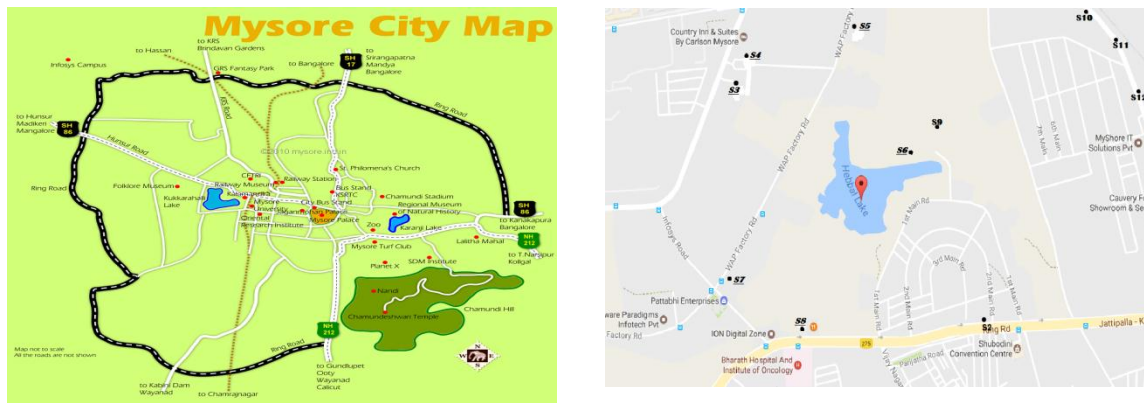

Fig.1 Map of Study Area and Sampling Station

(Source:http://www.veethi.com/images/maps/districts/karnataka/mysore_district_map.png)

Table 1 Details of Sampling Stations

SAMPLING POINTS	LATITUDE	LONGITUDE
Sampling station (S_1)	12º21'39"N	76º36'47"E
Sampling station (S_2)	12º21'35"N	76º36'44" E
Sampling station (S_3)	12º21'34"N	76º36'41" E
Sampling station (S_4)	12º21'36"N	76º36'42" E
Sampling station (S_5)	12º21'31"N	76º36'39" E
Sampling station (S_6)	12º21'34"N	76º36'49" E
Sampling station (S_7)	12º21'38"N	76º36'48" E
Sampling station (S_8)	12º21'36"N	76º36'38" E
Sampling station (S_9)	12º21'38"N	76º36'46" E
Sampling station (S_{10})	12º21'39"N	76º36'47" E
Sampling station (S_{11})	12º21'30"N	76º36'39" E

Sampling station (S_{12})	12º21'31"N	76º36'40" E

Plate 1 Collection of Samples at various stations

2.3 Water Quality Index (WQI)

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 huge water quality data to a single numerical value. It is one of the ways to assess the water quality trends by policy makers, to shape sound public policy and implement the water quality improvement programs effectively. A water quality index is a means to summarize huge water quality data into simple terms for reporting to management and the public in a consistent manner. Water quality index (WQI), integrates the data pool generated after collecting data and giving 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. Water quality index (WQI) is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers as it is an important parameter for the assessment and management of surface/groundwater.

2.3.1 Methods of Assessing WQI

The water quality index can assessed using various methods such as,

- National Sanitation Foundation Water Quality Index (NSFWQI)
- Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)
- Oregon Water Quality Index (OWQI)
- Weighted Arithmetic Water Quality Index Method

2.3.1.1 Canadian Council Of Ministers Of The Environment Water Quality Index (CCME WQI)

The purpose of this section is to provide information related to the quality of "treated" or "finished" drinking water to the users of Canadian Environmental Quality Guidelines. Water may be drawn from surface waters or groundwater for domestic use by individuals or by communities. Surface waters are almost always treated; groundwater may be used without treatment, as is generally the case with individual wells. Provincial and territorial regulations concerning water treatment vary. Characterization of water quality index is as shown in Table 2. 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 index is based on a combination of three factors:
- The number of variables whose objectives are not met, (**Scope) – F1**
- The frequency with which the objectives are not met, (**Frequency) – F2**
- The amount by which the objectives are not met, (**Amplitude) – F3**

The CCME WQI provides a mathematical framework for assessing ambient groundwater quality conditions relative to groundwater quality objectives. It is flexible with respect to the type and number of groundwater quality variables to be tested, the period of application, and the type of water body (stream, river reach, lake, *etc.*) tested. These decisions are left to the user. Therefore, before the index is calculated, the water body, time period, variables, and appropriate objectives need to be defined. The body of water to which the index will apply can be defined by one station (*e.g.,* a monitoring site on a particular river reach) or by a number of different stations (*e.g.,* sites throughout a lake). Individual stations work well, but only if there are enough data available for them.

Calculation of CCME index

After the body of water, the period of time, and the variables and objectives have been defined, each of the three factors that make up the index has to be calculated. The calculation of F1 and F2 is relatively simple where calculation of F3 is complex.

I.   **F1**(**Scope**) represents the percentage of variables that do not meet their objectives at least once during the time period under consideration ("failed variables"), relative the total number of variables measured:

$$F1 = \frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100$$

II.   **F2**(**Frequency**) represents the percentage of individual tests that do not meet objectives ("failed tests"):

$$F2 = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100$$

III.   F3 (**Amplitude**) represents the amount by which failed test values do not meet their objectives. F3 is calculated in three steps.
- The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an "excursion" and is expressed as follows.

Test value not exceeding test objective,

$$\text{Excursion} = \frac{\text{Failed test value}}{\text{objective}} - 1$$

Test value not falling below objective,

$$\text{Excursion} = \frac{\text{objective}}{\text{failed test value}} - 1$$

- The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursions, or nse, is calculated as:

INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET)   E-ISSN: 2395-0056

VOLUME: 07, SPECIAL ISSUE | JUNE 2020   **WWW.IRJET.NET**   P-ISSN: 2395-0072

International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
Organised by: ATME College of Engineering, Mysuru, INDIA

$$nse = \frac{\sum_{i=1}^{n} excursion\ i}{\#\ of\ tests}$$

- F3 is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (nse) to yield a range between 0 and 100.

$$F3 = \frac{(nse)}{(0.01nse + 0.01)} X100$$

Table 2 Characterization of Water Quality Index

RATING	CCME-WQI	CHARACTERIZATION OF THE WATER
Excellent	95-100	Water quality intact, conditions close to natural level
Good	80-94	Water quality is protected with only a minor degree of threat, conditions rarely depart from natural desirable levels
Fair	65-79	Water quality usually intact, but occasionally endangered, conditions often deviate from natural levels
Marginal	44-64	Water quality frequently endangered, conditions very often deviate from natural levels
Poor	0-44	Water quality almost endangered, conditions regularly deviate from natural levels

(Source: CCME manual, 2001)

3. Results And Discussion

3.1 Physico-Chemical Parameters of Groundwater

This section presents the physico-chemical characteristics of groundwater and water quality index.Fig. 2 shows the variation of all concerned physico-chemical characteristics at various sampling stations.

The pH minimum value of 7.3 was recorded at S_1 and S_9 maximum of 7.6 at S_4. One of the main objectives in controlling pH is to produce water that minimizes corrosion or incrustation. The minimum turbidityvalue of 4 NTU was observed at $S_1$and maximum of 5.5 NTU at S_4 and S_7. Due to the presence of algal blooms, high turbidity was observed at S_2 and the industrial wastewater disposal contributed high turbidity at S_7. The turbidity is the haziness of a fluid caused by the suspended solids that are usually invisible to the naked eye. The minimum Total alkalinity concentration of 282 mg/L as $CaCO_3$ was observed at S_1 and S_{12} maximum of 315 mg/L as $CaCO_3$ in S_7. The alkalinity levels of all the water samples are high thus, resisting acidification of the groundwater samples. A Minimum chloride of 250 mg/L was observed at S_4 and maximum value of 282 mg/L at S_7.. This occurs may be due to saline water intrusion. A minimum COD value of 40 mg/L was observed at S_8 and maximum of 90 mg/L at S_6. Chemical oxygen demand (COD) is commonly used to indirectly measure the amount of organic compounds in water. Higher value of COD pointing to deterioration of water quality was likely caused by the discharge of municipal waste water. The total hardness of 200 mg/L as $CaCO_3$ was recorded at S_2as minimum and S_9 and maximum of 290 mg/L as $CaCO_3$ in S_5. Hardness is caused by polyvalent metallic ions dissolved in water, which in natural water are principally magnesium and calcium. A minimum iron of 0.01 mg/L was observed at S_3 and maximum of 0.06 mg/L at S_8. Concentration of iron is may contributed by industrial estate located at the sampling site, Iron is an essential element in human nutrition. Nitrate (Minimum) of 0.2 mg/L was observed at S_1 and S_2maximum of 2.31 mg/L at S_8 and S_{12}. Nitrate concentration was mainly due to runoff water from agricultural lands, discharge of domestic wastewater. Nitrogen essential component of amino acids, and therefore all proteins and nucleic acids, and therefore needed for all cell division and reproduction. Fluoride is essential for human beings to fight against dental caries. All samples are within the desirable limits. A minimum phosphate of

INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET)   **E-ISSN: 2395-0056**

VOLUME: 07, SPECIAL ISSUE | JUNE 2020   **WWW.IRJET.NET**   **P-ISSN: 2395-0072**

International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
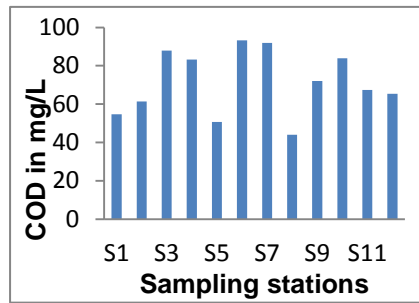**Organised by: ATME College of Engineering, Mysuru, INDIA**

0.08 mg/L was observed at S_2 and maximum of 0.12 mg/L at S_1. A minimum sulphate of 100 mg/L was observed at S_7 and maximum of 130 mg/L at S_6. Sulphate content at S_6 is more due to disposal of wastes on ground. EC minimum value of 5.6 mmho/cm was recorded at S_2 and maximum of 6.6 mmho/cm at S_5. Water with high mineral content tends to have higher conductivity, which is a general indication of high dissolved solid concentration of the water due to pollution.

3.2 CCME WATER QUALITY INDEX

With the BIS drinking water standards (IS 10500: 2012) as objective, the value obtained for F1, F2, F3 are presented in the Table 3. Station S1 has 7.7, 7.7, and 80.5, Station S2 has 7.7, 7.7, and 82.3, Station S3 has 15.4, 10.3, and 75.8, Station S4 has 15.3, 10.3, and 86.4, Station S5 has 23, 12.8, and 79.3, Station S6 has 23.1, 10.3, and 87.6, Station S7 has 15.4, 10.3, and 87.5, Station S8 has 15.4, 10.3, and 76.8, Station S9 has 15.4, 12.8, and 84.5, StationS10 has 15.3, 10.3, and 86.5, Station S11 has 15.3, 10.3, and 83.6, Station S12 has 7.7, 7.7, and 93.2 The CCME WQI value for all stations ranged between 49-56, which categorize the water quality as marginal.
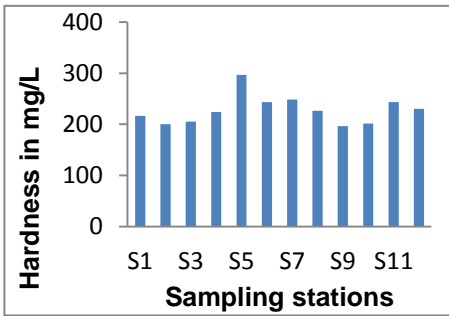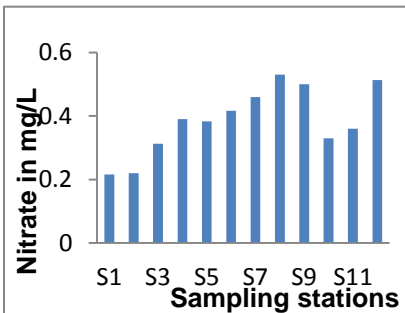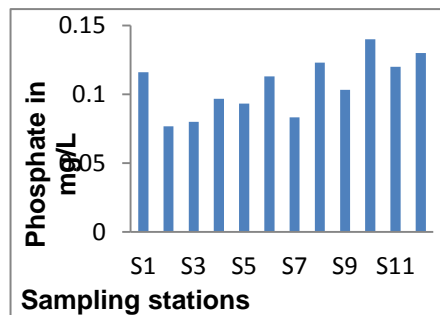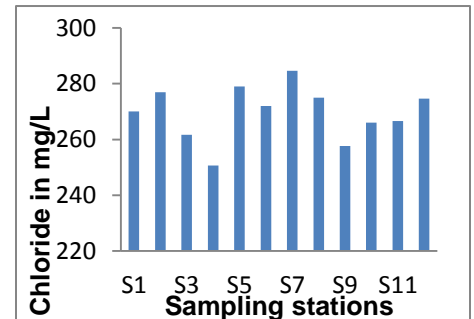

(a)

(b)
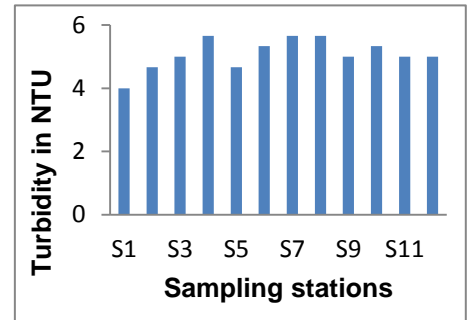
(c)

(d)

(e)

(f)

International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
Organised by: ATME College of Engineering, Mysuru, INDIA

(g)   (h)   (i)

(j)   (k)   (l)
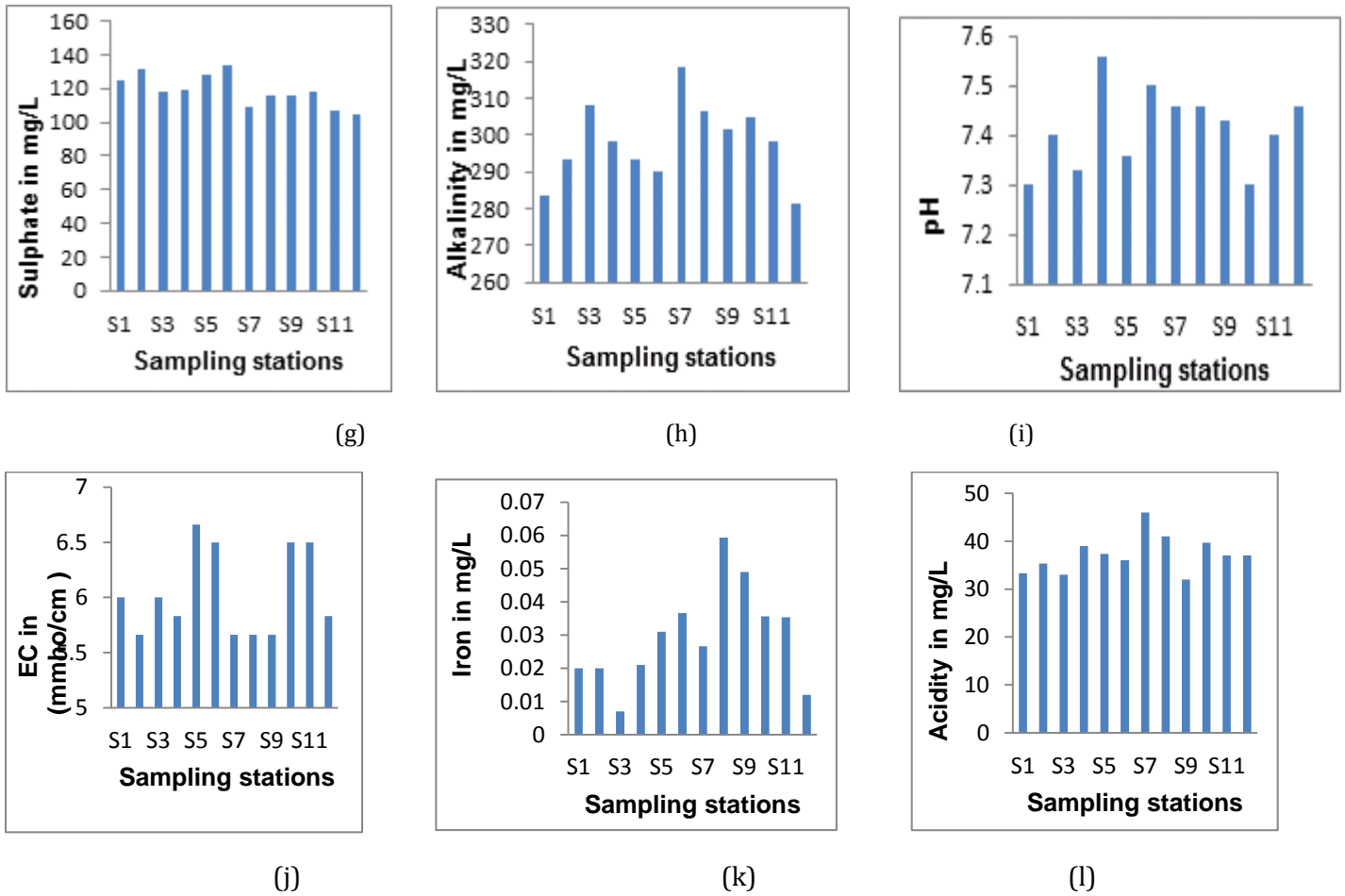
Fig. 2 (a-l) Variation of concerned Physico-Chemical Characteristics of groundwater

Table 3 CCME WQI values

Sample stations / CCME Components	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
F1	7.7	7.7	15.4	15.3	23.1	23.1	15.4	15.4	15.4	15.3	15.3	7.7
F2	7.7	7.7	10.3	10.3	12.8	10.3	10.3	10.3	12.8	10.3	10.3	7.7
F3	80.5	82.3	75.8	86.4	79.3	87.6	87.5	76.8	84.5	86.5	83.6	93.2
CCMEWQI	53	52	56	50	54	49	49	55	51	50	52	52
RATING	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal	Marginal

INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET)   **E-ISSN: 2395-0056**

VOLUME: 07, SPECIAL ISSUE | JUNE 2020   WWW.IRJET.NET   **P-ISSN: 2395-0072**

International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
**Organised by: ATME College of Engineering, Mysuru, INDIA**

Table 4 Drinking Water Standards of concerned parameter (IS 10500 : 2012)

Parameters	Permissible Limit	Maximum Limit
pH	6.5 -8.5	No relaxation
Turbidity (NTU)	5	10
Alkalinity (mg/L as $CaCO_3$)	200	600
Nitrate(mg/L as CaCO3)	45	No relaxation
Chloride (mg/L)	250	1000
Sulfate(mg/L)	200	400
Iron(mg/L)	0.3	No relaxation
Hardness(mg/L as CaCO3)	200	600
Fluoride(mg/L)	1	1.5

4. Conclusions

From the literature citations and the results of this work, the conclusion are drawn as,

- The physico-chemical parameters such as alkalinity(310mg/L), chlorides(280mg/L), iron(0.06)and phosphates(0.13 mg/L) are within the limits
- The turbidity exceeds the permissible limits of the drinking water standards of values 50 NTU in all stations, except Stations S1, S2, S11, and S12
- The COD (55mg/L-90mg/L) concentration found to be higher range indicating the contamination of groundwater
- The water quality index evaluated using CCME for station was found to be in range 49-56, which characterizes the groundwater as marginal around Hebbal lake
- The overall quality of the groundwater is fit for drinking purposes with primary treatment.

REFERENCES

1. DamiA ,Ayuba H. K. andAmukali O,"Groundwater pollution in Okpai and Beneku, Ndokwa-east local government area, delta state, Nigeria", Journal of Environmental Research and Management, Vol. 4(1). pp. 0171-0179, (2013).
2. Ramesh A., Nagendra B.S.,Prakash,Sivapullaiaih P.V.,Sadhashivaiah A.S.,"Assessment of Groundwater Quality in Designated Peenya Industrial Area and Estate, Bangalore, India",Journal of Environmental Protection, Vol 2, pp 20-25, (2012).
3. Shaji C., Nimi1 H. andBinduL., "Water quality assessment of open wells in and around Chavara industrial area, Quilon, Kerala", Journal of Environmental Biology,Vol 30(5),pp 701-704, (2009).
4. DipuSukumaran, Rita Saha, Rakesh Chandra Saxena, "Groundwater Quality Index of Patna, the Capital City of Bihar, India", Journal of Water Resources, Vol. 3, pp 17-21, (2015).
5. Nagarnaik P. B., Pankaj N. Patil,"Analysis of Groundwater of Rural Areas of Wardha-City Using Physico – Chemical and Biological parameters" , Journal of Engineering Research and Applications, Vol 2, pp 803-807, (2012).
6. Malik D. S., Pawan Kumar,UmeshBharti, "A study on groundwater quality of industrial area at Gajraula (U.P.), India" ,Journal on Applied andNatural Science, Vol 2 ,pp 275-27, (2009).
7. Mohammed Sadeque, Abdul Majeed, "Assessment of Groundwater Quality around Industrial Area in Aurangabad, Maharashtra", Journal on Environmental science, Vol 9 ,pp 2319-2399, (2015).
8. Govindarajan M. and Senthilnathan T., "Groundwater quality and its health impact analysis in an industrial area", Journal on Current Microbiology and Applied sciences ,Vol 3 ,pp 1028-1034,(2014).
9. Nagaraja Gupta M.S. andSadashivaiah C.,"Assessment of water quality in Peenya Industrial area, Bangalore", Journal of Research in Engineering and Technology, Vol 3 ,pp 2319-232, (2014).
10. NavdeepDhindsaRandev, Sunil Puri, Sujata Bhattacharya, ArtiJamwal and Shikha Sharma, "Evaluation of Water Quality Index for the Groundwater in region around Buddha Nallah, Punjab, India", Journal of Advanced Research, Vol 4 ,pp 1411-1414, (2016).

International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
Organised by: ATME College of Engineering, Mysuru, INDIA

11. Nassir El-Jabi, Daniel Caissie, NoyanTurkkan, "Water Quality Index Assessment under Climate Change", Journal of Water Resource and Protection, Vol6 ,pp 533-542, (2014),.

12. Robert Damo, PirroIcka, "Evaluation of Water Quality Index for Drinking Water", Journal on Environmental studies, Vol 22, pp 1045-1051, (2013).

13. Shivasharanappa and PadakiSrinivas"Assessment of Groundwater Quality of Bidar City and its Industrial Areafor Drinking and Irrigation Purpose: A Geo-chemical Analysis", Journal of Chemical, Environmental and Pharmaceutical Research, Vol 2, pp 121-130(2011),.

14. Shivaprasad, Nagarajappa D.P., Ravichandra , Prasanna Kumar , KedarrayaMallanna, SavitaKubakaddi "An Assessment of Groundwater Quality Index in Bommasandra Area, Bengaluru city, Karnataka State, India" , Journal of Engineering Research and Applications, Vol 5,pp 90-96, (2015).

15. Venkatramanan S., Chunga S.Y., Ramkumar T., Rajesh R.&Gnanachandrasamy G. , "Assessment of groundwater quality using GIS and CCME WQI techniques: a case study of Thiruthuraipoondi city in Cauvery deltaic region, Tamil Nadu, India", Journal on water treatment, pp 3986-3994 , (2015).

16. VenkataRaoGummadi and KalpanaPolipalli, "Assessment of Groundwater Quality in and around Pydibhimavaram Industrial Area, AP, India", Journal of Environmental Science and Development, Vol. 7,pp 405-408, (2016).

17. Karpagam V. & Ramesh K., "Assessment of Groundwater Quality of Chrompet Industrial Area by Water Quality Index Method", Journal of Engineering Technology, Management and Applied Sciences, Vol 3 ,pp 2349-4476, (2015),