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

- 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.

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

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

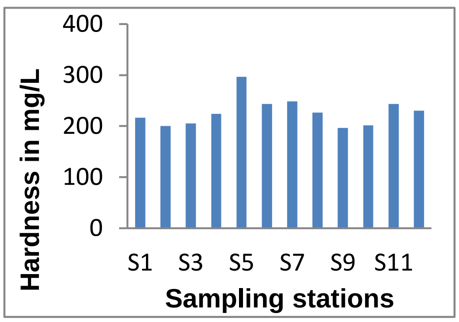
This section presents the physico-chemical characteristics of groundwater and water quality index.Fig. 2 shows the variation of all concerned physico-chemical characteristics at various sampling stations.

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

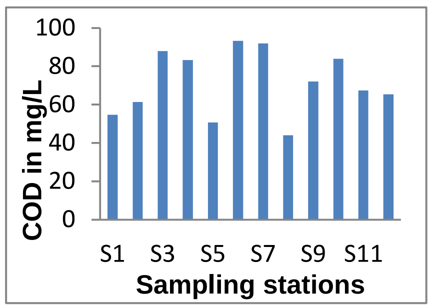
0.08 mg/L was observed at $S_2$and maximum of 0.12 mg/L at S_1. A minimum sulphateof 100 mg/L was observed at S_7 and maximum of 130 mg/L at S_6. Sulphate content at S_6 is more due to disposal of wastes on ground.EC minimum value of5.6 mmho/cm was recorded at $S_2$and maximum of 6.6mmho/cm at S_5. Water 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)



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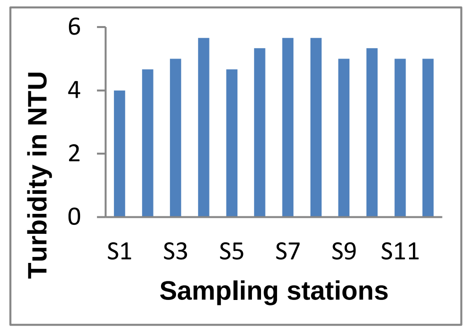

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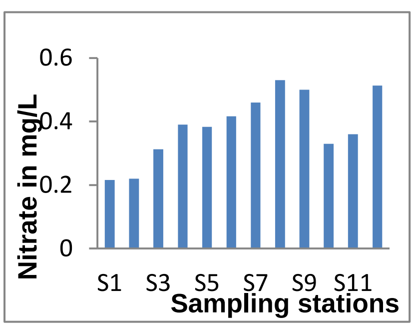

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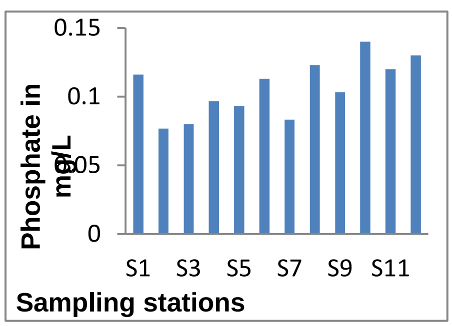
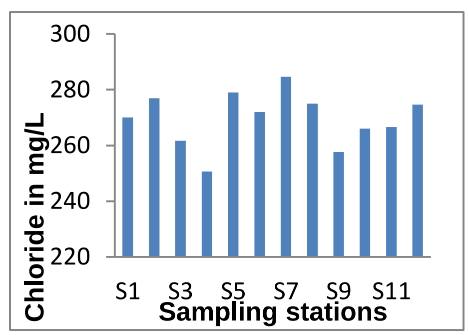
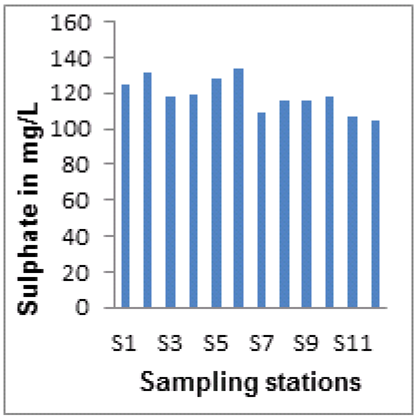


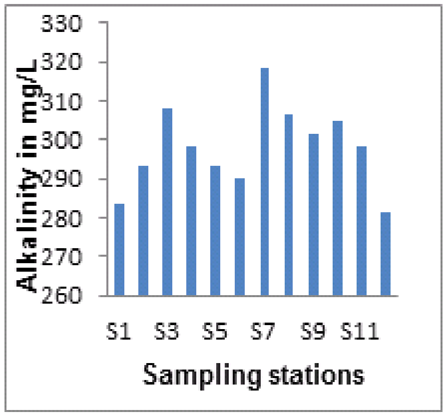
(e)



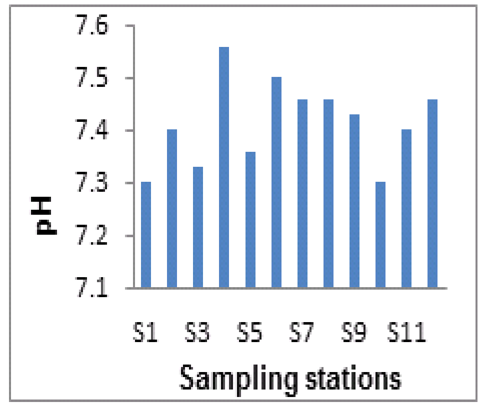
(f)



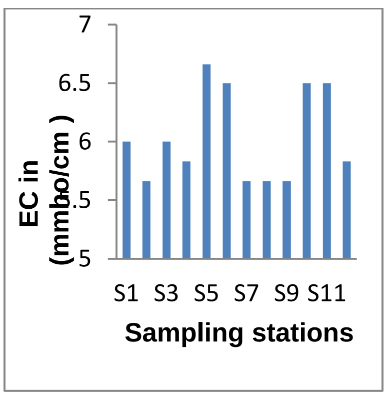
(g)



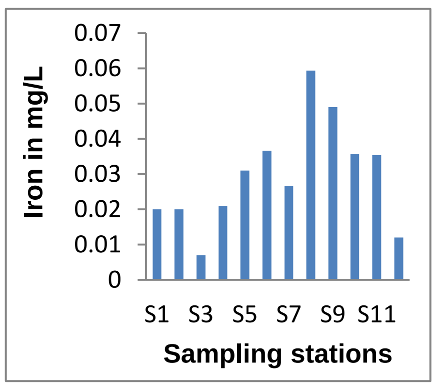
(h)



(i)



(j)



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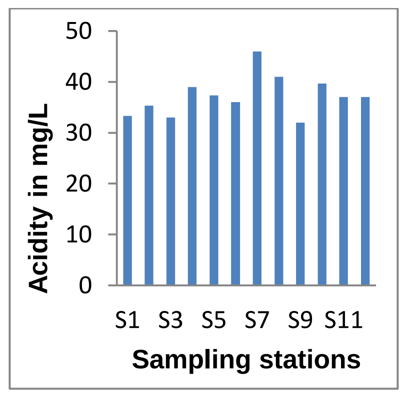

(l)

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

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.

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