GROUNDWATER QUALITY ANALYSIS IN AND AROUND BIDADI INDUSTRIAL AREA, RAMANAGAR DISTRICT, KARNATAKA

M. Inayathulla[1], R. Madhusudhan[2]

[1]*Associate Professor, Department of Civil Engineering, UVCE, Bangalore, India*
[2]*Associate Professor, Department of Civil Engineering, Dr AIT, Bangalore, India*

Abstract

The water quality index (WQI) is a single number that expresses the quality of water by integrating the water quality variables. The purpose is to provide a simple and concise method for expressing the water quality for different usage. The present work deals with the monitoring of variation of seasonal ground water quality index of ground water for Bidadi industrial area in Bangalore, Karnataka state of India. For calculating the WQI the following 12 physico-chemical parameters such as pH, Total Dissolved Solids, Total Alkalinity, Chlorides, Total Hardness, Turbidity, Fluoride, Iron, Calcium, Sodium, Sulphate and Nitrates have been considered. The water quality index value of ground water was 51.176. In the present investigation the quality of water was found to be good in and around Bidadi industrial area.

Keywords: *Ground Water, Physico-Chemical Parameters, Water Quality Index, Water Quality Standards*

----------***----------

1. INTRODUCTION

The fresh water is of vital concern for mankind since it is directly linked to human welfare. Ground water is an important natural source of water supply all over the world. Its use in irrigation, industrial and domestic usage continues to increase where perennial surface water source are absent. The modern civilization, over exploitation, rapid industrialization and increased population has lead to fast degradation of our environment. The quality of ground water may depend on geology of particular area and also vary with depth of water table and seasonal changes and is governed by the extent and composition of the dissolved salts depending upon source of the salt and soil-surface environment.

Water quality index provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is understandable and usable for common man. A single number is not enough to describe the water quality: there are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water body with number (Yogendra et al., 2007).

2. OBJECTIVE OF PRESENT WORK

The objective of the present research is to provide information on the physico-chemical characteristics of ground water in order to discuss it's suitability for human consumption based on computed water quality index values.

3. PARAMETERS OF WATER QUALITY ANALYSED

For the assessment of water pollution status of the groundwater, the following water quality parameters were analyzed: (1) pH, (2) Total Dissolved Solids, (3) Total hardness, (4) Calcium, (5) Sodium, (6) Sulphates, (7) Total alkalinity, (8) Chlorides, (9) Iron (10) Fluorides, (11) Nitrates and (12) Turbidity.

4. STUDY AREA

For the present study Bidadi Industrial Area was selected. Bidadi Industrial Area is 2km away from SH-17. It is located at $N12^{0}47'$and $E77^{0}23'$ and in the north-eastern part of the Ramanagara Taluk, Ramanagara District. A number of villages surrounding the Industrial Area are Anchipura, Abbanakuppe, Bannigere, Maregowdana Doddi, Byramangala, Shanamangala, Parasanapalya, Thimmegowdana Doddi and Vrishbavathipura. Industrial area covers 852 acres. Ramanagara Taluk covers 62,930 hectares of geographical area and consists of 4 Hoblies namely Bidadi, Kasaba, Kailancha and Kootgal. The taluk had 126 villages, 23 Gram Panchayats and Municipal Council. According to the 2011 census, total population is approximately 3.5lakhs.Detailed survey was conducted to identify the number of existing bore wells. The survey was conducted by visiting each industrial plot and surrounding the industries by identifying the existing of bore wells and open wells.

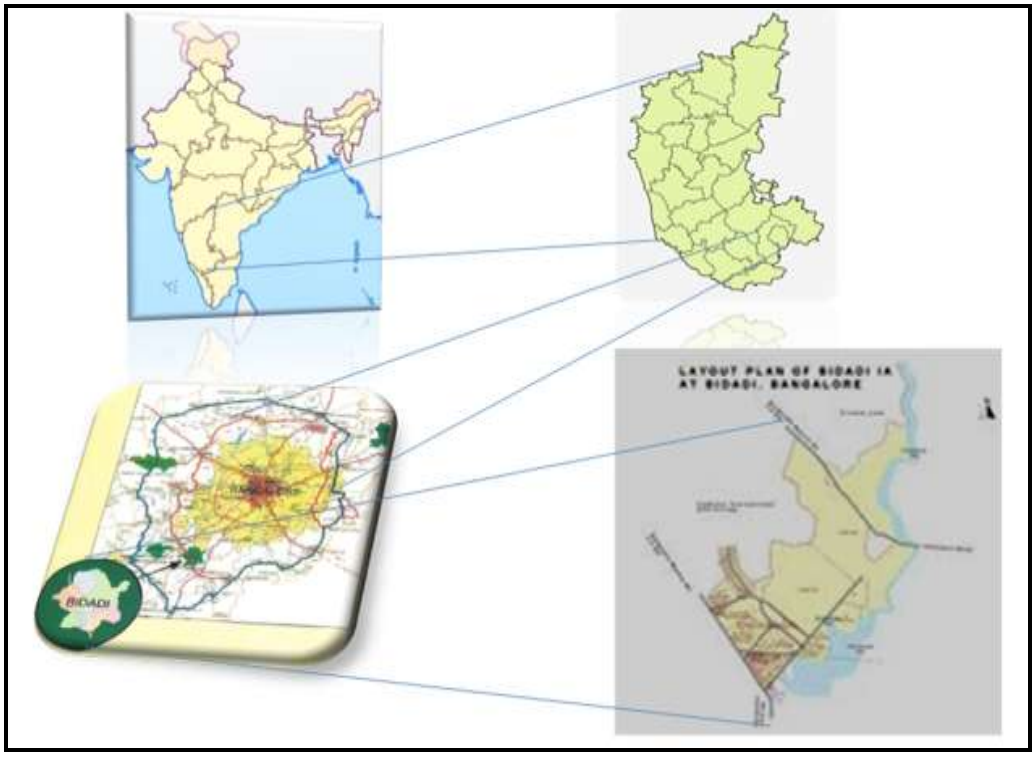


Fig 1: Key map of the study area

5. MATERIALS AND METHODS

The water samples from nine open wells and three bore wells were collected and analysed for 13 physico-chemical parameters by following the established procedures. The parameters pH, electrical conductivity and dissolved oxygen were monitored at the sampling site and other parameters were analysed in the laboratory as per the standard procedure of APHA (1995)

The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organisation (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). The calculation of WQI was made using a weighted arithmetic index method given below (Brown et al., 1972) in the following steps.

5.1 Calculation of Sub Index of Quality Rating (q_n)

Let there be *n* water quality parameters where the quality rating or sub index (q_n) corresponding to the n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The value of q_n is calculated using the following expression:

$$q_n = 100[(V_n-V_{io})/(S_n-V_{io})] \quad (1)$$

Where,

q_n = quality rating for the n^{th} water quality parameter.

V_n = observed value of the n^{th} parameter.

S_n = standard permissible value of n^{th} parameter.

V_{io} = ideal value of n^{th} parameter in pure water.

All the ideal values (V_{io}) are taken as zero for drinking water except for pH=7.0 and Fluoride = 1 mg/L.

5.2 Calculation of Quality Rating for pH

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

q_{pH} = $100[(V_{pH}-7.0)/(8.5-7.0)]$

Where,

V_{pH} = observed value of pH during the study period.

5.3 Calculation of Quality Rating for Fluoride

The ideal value (V_{io}) for fluoride is 1 mg/L and standard permitted value for drinking water is 1.5 mg/L. Therefore, quality rating is calculated from following relation:

Q_F = $100[(V_F - 1)/(1.5 - 1)]$

where,

V_F = observed value of fluoride.

5.4 Calculation of Unit Weight (W_n)

Calculation of unit weight (W_n) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Wn = K/S_n

Where,

W_n = unit weight of n^{th} parameters

S_n = standard value for n^{th} parameters

K = constant for proportionality and is given as (Kalavathy et al., 2011):

$K=1/[1/V_{S1}+1/V_{S2}+\ldots\ldots+1/V_{sn}]$

5.5 Calculation of WQI

WQI is calculated from the following equation

$$WQI = \sum_{i=1}^{n} q_n W_n / \sum_{i=1}^{n} W_n$$

Table 1 shows the classification of water quality status based on Water Quality index (Ramakrishnaiah et al. 2009, Bhaven et al. 2011 and Srinivasa Kushtagi et. al. 2012,).

Table 1: Water Quality Classification Based on WQI Value

Class	WQI value	Water Quality Status
I	<50	Excellent
II	50-100	Good Water
III	100-200	Poor water
IV	200-300	Very poor water
V	>300	Water unsuitable for drinking

Table 2: Drinking Water Standards, Recommending Agencies and Unit

SL NO	Parameters	Permissible Value (Sn)	Recommended Agency	1/Sn	Unit Weight
1	PH	8.5	ICMR/BIS	8.5	0.028
2	Ec (µ-s/cm)	300	ICMR	300	0.0007
3	TDS (mg/Lt)	500	ICMR/BIS	500	0.0004
4	Total Alkalinity (mg/ Lt)	200	ICMR	200	0.001
5	Chlorides (mg/Lt)	250	ICMR	250	0.0009
6	Total Hardness (mg/Lt)	300	ICMR/BIS	300	0.0007
7	Ca (mg/Lt)	75	ICMR/BIS	75	0.003
8	Mg (mg/Lt)	30	ICMR/BIS	30	0.007
9	Fluorides (mg/Lt)	1.5	BIS	1.5	0.16
10	Sulphate (mg/Lt)	200	ICMR/BIS	200	0.001
11	Iron (mg/Lt)	0.3	BIS	0.3	0.79
12	Sodium (mg/Lt)	200	BIS	200	0.001
13	Nitrate (mg/Lt)	45	ICMR/BIS	45	0.005

6. RESULTS OF WATER QUALITY ANALYSED

The individual data acquired for each element are shown in Table.3. The statistical analysis results are summarized as minimum, average, median and standard deviation of pH, Total Dissolved Solids (TDS), Total Hardness, Calcium (Ca), Sodium (Na), Sulphates (SO_4), Total Alkalinity (TA),Chlorides (Cl), Iron (Fe), Fluorides (F), Nitrates (NO_3) ,Turbidity (Table 4).

Table 3: Physico-chemical characteristics of ground water (mg/L)

SLNO	pH	TDS	TH	Ca	Na	SO_4	TA	Cl	Fe	F	NO_3	TURBIDITY
1	7.35	1120	600	144	60	140	371	354.5	0.13	0.09	13.85	0
2	6.95	1180	680	160	80	155	318	368	0.1	0.12	15.6	0
3	7.05	1140	640	148	70	148	330	357	0.12	0.1	14	0
4	7.45	1280	690	180	90	160	375	380	0.1	0.08	15.8	0
5	7.8	1320	760	210	120	240	406	425	0.18	0.13	18	0
6	7.95	1270	650	150	85	155	418	370	0.13	0.11	16.5	0
7	7.6	1040	560	132	60	116	365	285	0.1	0.09	14	0
8	7.55	360	180	40	15	18	153	99.85	0.06	0.08	8	0
9	7.85	340	600	140	70	120	388	340	0.13	0.12	17	0
10	7.75	380	200	45	20	25	155	380	0.05	0.07	9	0
11	8.05	430	230	58	25	38	158	122	0.08	0.09	9.5	0
12	6.7	300	160	35	10	5	145.15	77.9	0.04	0.07	7	0

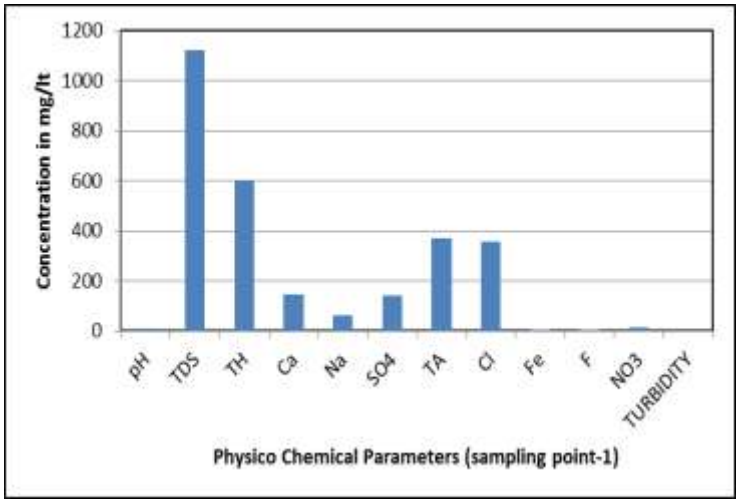
Table 4: Summary of concentration in ground water (mg/L)

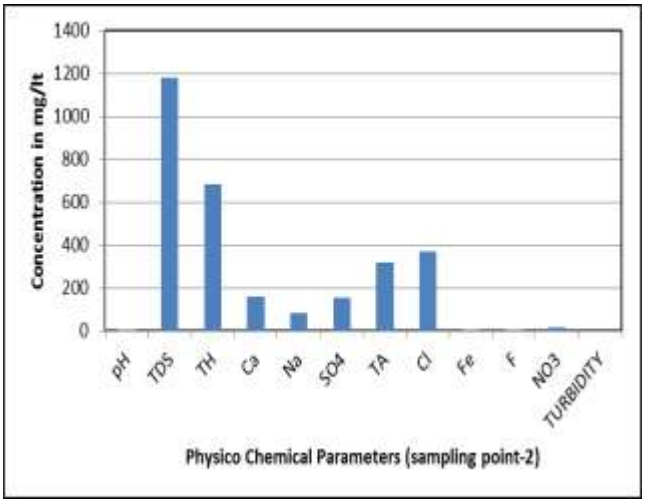
	pH	TDS	TH	Ca	Na	SO_4	TA	Cl	Fe	F	NO_3	TURBIDITY
Maximum	8.05	1320	690	210	120	240	418	425	0.18	0.13	17	0
Minimum	6.7	300	180	35	10	5	145.15	99.85	0.04	0.07	07	0
Average	7.32	715.22	417.06	55.47	89.77	54.72	374.3	161.6	0.61	0.54	2.56	0
Median	7.29	765.56	412	48	85.2	40.39	396	174.55	0.55	0.52	2.45	0
Std. dev	0.14	179.3	106.7	21.28	31.86	37.71	81.3	54.27	0.53	0.31	1.76	0
Std. Value	8.5	500	300	75	200	200	200	250	0.3	1.5	45	0

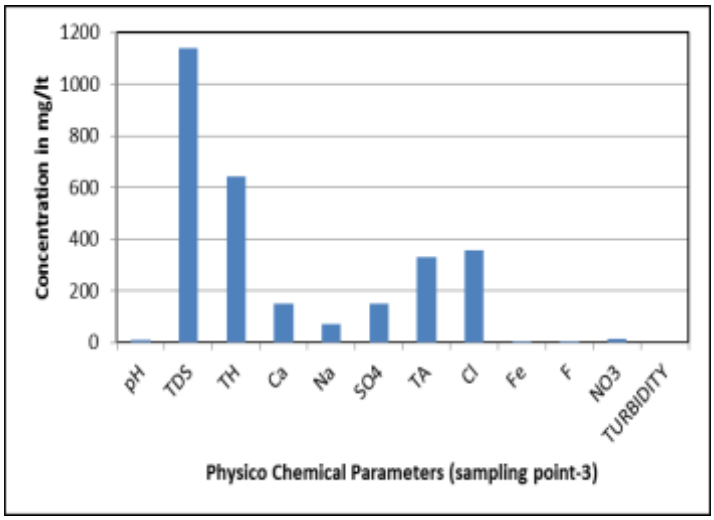
Table 5: Calculations of Water Quality Index

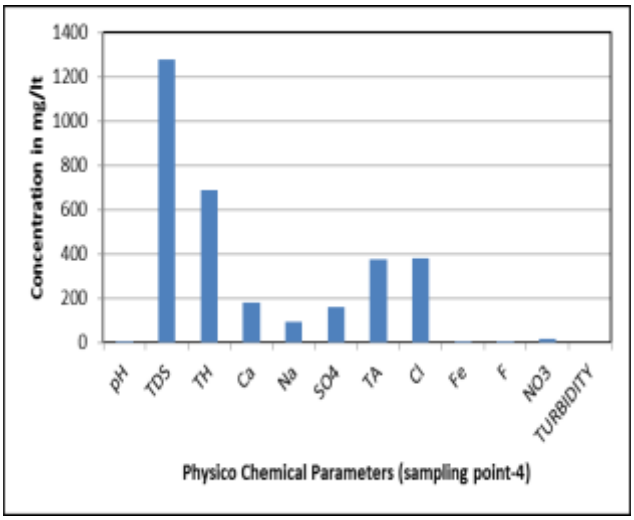
SL NO	PARAMETERS	STANDARD PERMISSIBLE VALUE (S_n)	$1/S_n$	UNIT WEIGHT (W_n)	OBSERVED VALUE	QUALITY RATING (Q_n)	WEIGHTED W_nQ_n
1	Sodium(Na)	200	0.005	0.00116	60	30	0.0348
2	Potassium (K)	200	0.005	0.00116	6	3	0.00348
3	P^H	8.5	0.1176	0.0274	7.35	23.33	0.639
4	Total hardness ($CaCO_3$)	300	0.0033	0.00077	600	200	0.154
5	Calcium (Ca	75	0.0133	0.00315	144	192	0.604
6	Iron (Fe)	0.3	3.333	0.7886	0.13	43.33	34.172
7	Chloride (Cl)	250	0.004	0.000946	354.5	141.8	0.134
8	Total Dissolved Solids (TDS)	500	0.002	0.000473	1120	224	0.105
9	Sulphate (SO_4)	200	0.005	0.00116	140	70	0.081
10	Nitrate (NO_3)	45	0.0222	0.00519	13.85	30.77	0.159
11	Fluoride (F)	1.5	0.6666	0.1557	0.09	-91	14.168
12	Total Alkalinity ($CaCO_3$)	200	0.1176	0.00116	371	185.5	0.215
			4.2805	$\sum W_n$=0.986			$\sum$WnQn =50.46

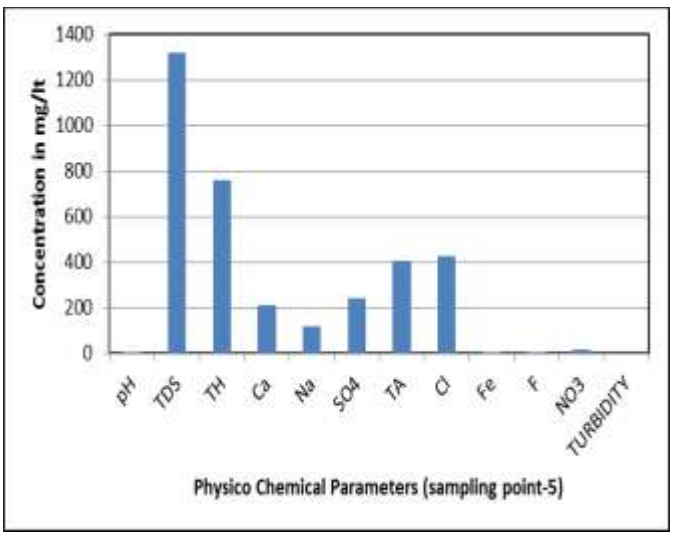
Water Quality Index obtained is 51.176

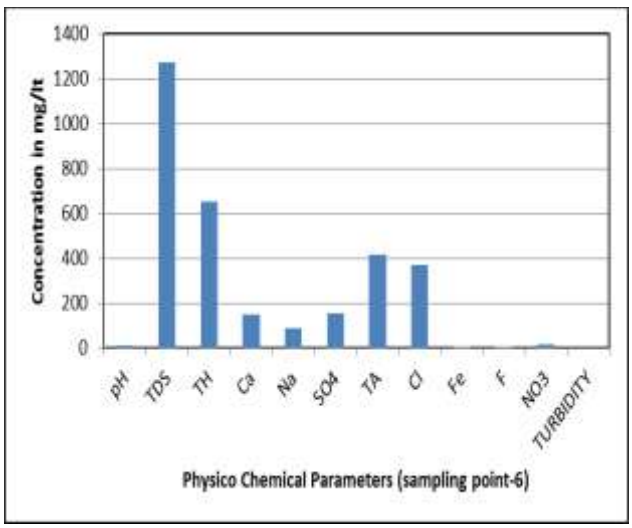

Concentration in mg/lt
1200
1000
800
600
400
200
0
pH
TDS
TH
Ca
Na
SO4
TA
Cl
Fe
F
NO3
TURBIDITY
Physico Chemical Parameters (sampling point-1)

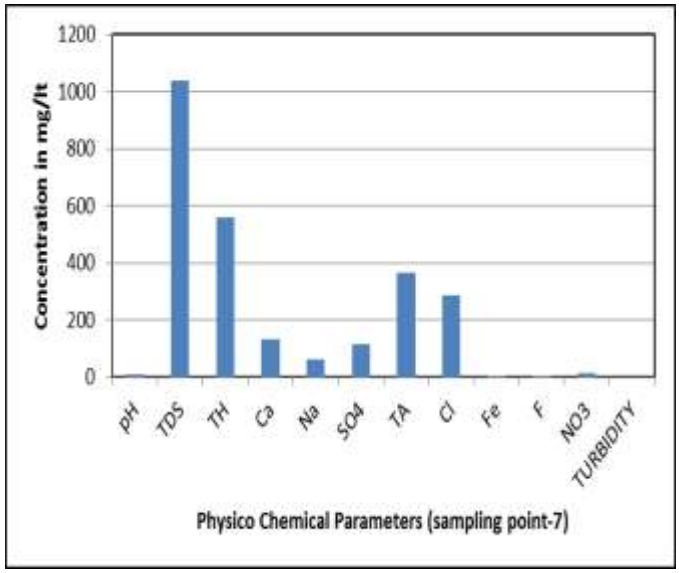

Concentration in mg/lt
1400
1200
1000
800
600
400
200
0
pH
TDS
TH
Ca
Na
SO4
TA
Cl
Fe
F
NO3
TURBIDITY
Physico Chemical Parameters (sampling point-2)

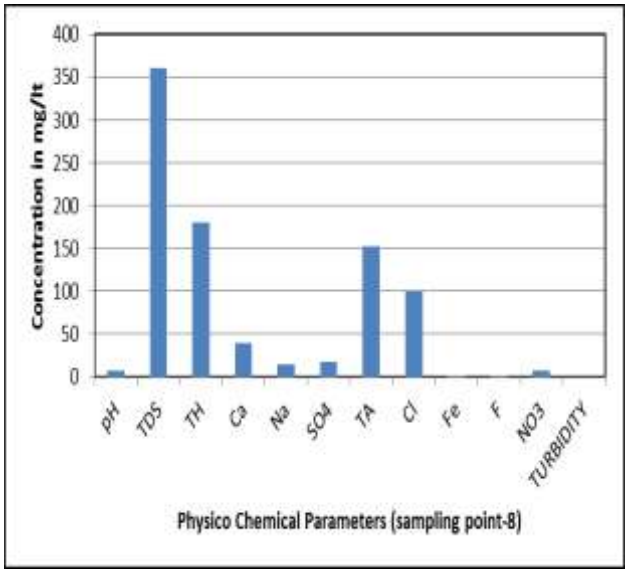

Concentration in mg/lt
1200
1000
800
600
400
200
0
pH
TDS
TH
Ca
Na
SO4
TA
Cl
Fe
F
NO3
TURBIDITY
Physico Chemical Parameters (sampling point-3)

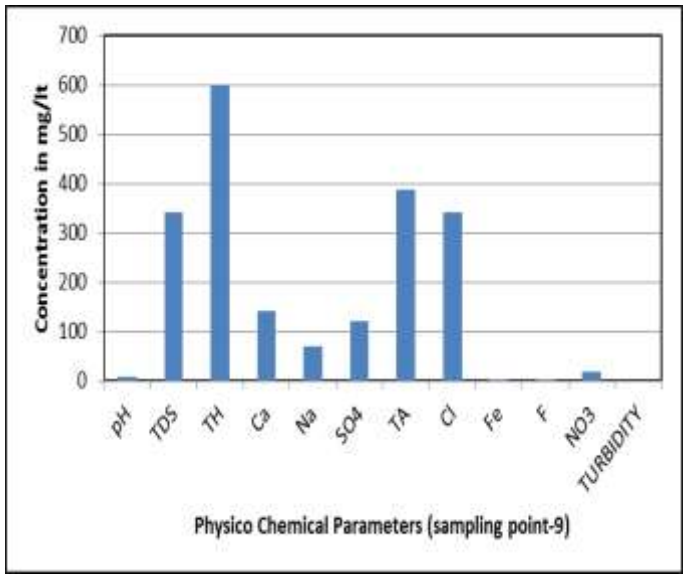

Concentration in mg/lt
1400
1200
1000
800
600
400
200
0
pH
TDS
TH
Ca
Na
SO4
TA
Cl
Fe
F
NO3
TURBIDITY
Physico Chemical Parameters (sampling point-4)

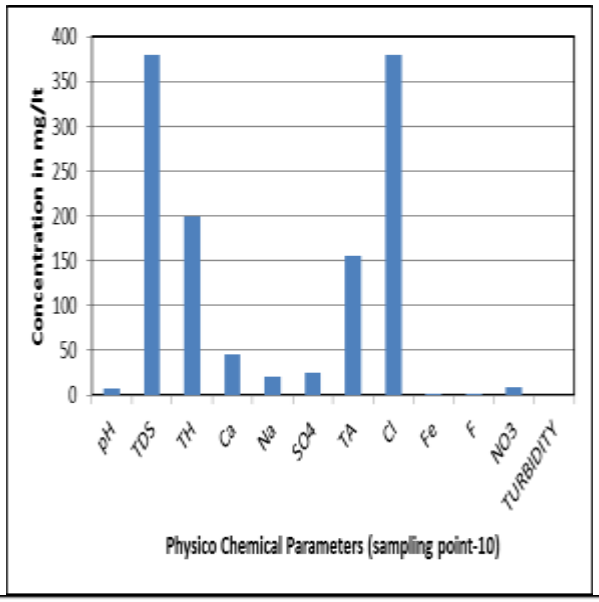

Concentration in mg/lt
1400
1200
1000
800
600
400
200
0
pH
TDS
TH
Ca
Na
SO4
TA
Cl
Fe
F
NO3
TURBIDITY
Physico Chemical Parameters (sampling point-5)

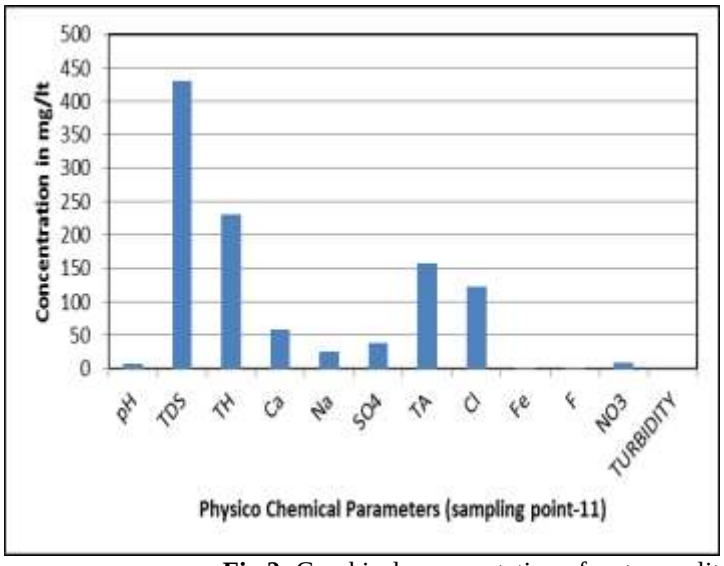

Concentration in mg/lt
1400
1200
1000
800
600
400
200
0
pH
TDS
TH
Ca
Na
SO4
TA
Cl
Fe
F
NO3
TURBIDITY
Physico Chemical Parameters (sampling point-6)











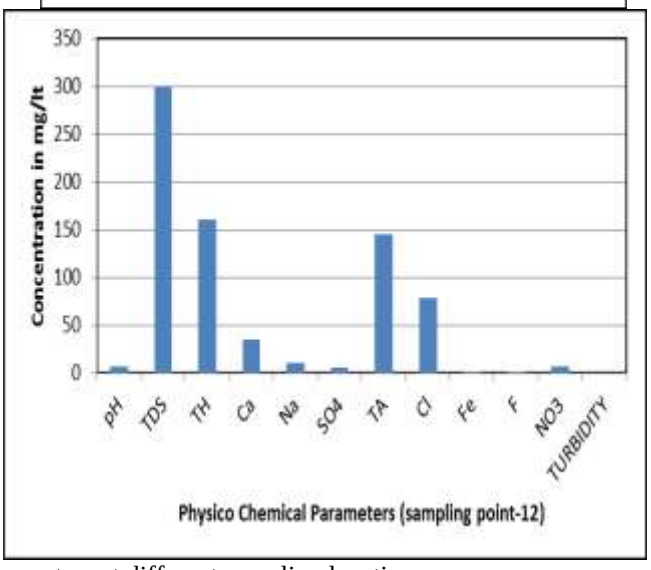


Fig 2: Graphical representation of water quality parameters at different sampling locations

7. RESULTS AND DISCUSSIONS

Application of WQI in this study has been found using in assessing the overall quality of water. It is helpful for public to understand the quality management. Analysis of ground water samples from 12 sampling points in the surrounding of an Industrial Area showed the significant spatial variation in the parameters analysed (pH, TDS, Total Hardness, Ca, Na, SO_4, Alkalinity, Cl, Fe, F and NO_3). The analysis shows that the value of Total Hardness, Fe, Total alkalinity, Total Dissolved Solids exceeds the permissible limits. Water quality index computed for study area is tabulated in Table 5. The computed WQI for the study area was found to be 51.176 and it reveals that overall WQI values computed in post monsoon season under class II of Table1, indicates that the water quality is good for drinking and other domestic purposes after certain degree of treatments.

8. CONCLUSION

The method employed in the study is found to be suitable to study the water quality analysis around an industrial area. The analysis showed the significant variation of the parameters analysed and it also shows that the influence of the parameter like Total Hardness, Fe, Mg, Ca, Total alkalinity, Total Dissolved Solids with exceedance in permissible limits. From this it can be concluded that the overall WQI values computed in post monsoon season under Class II of Table 1, indicates that the water is good for drinking and domestic purposes after implementing certain degree of treatments.

REFERENCES

[1] APHA (1995). Standard Methods (18 Ed.) for the examination of water and waste water, APHA, AWWA, WPCE, Washington DC.

[2] Bhaven N. Tandel, JEM Macwan and Chirag K. Soni (2011). Assessment of Water Quality Index of small lake in south Gujarath region, India, Proceedings of ISEM-2011, Thailand.

[3] BIS 10500, (1991), Specifications for drinking water, Indian Standard Institutions (Bureau of Indian Standards), New Delhi.

[4] Brown R.M, N.J. Mccleiland, R.A. Deiniger, M.F.A. Oconnor (1972). Water quality index – crossing the physical barrier, Proc. Int. Conf. on water pollution research, Jerusalem, 6, 787-797.

[5] ICMR Manual of standards of quality for drinking water supplies (1975). ICMR, New Delhi.

[6] Inayathulla. M and Jai M. Paul (2013), "Water Quality Index Assessment of Ground Water in Jakkur Sub Watershed of Bangalore, Karnataka, India", International Journal of Civil, Structural, and infrastructure Engineering Research and Development (IJCSEIERD), Transstellar Journal Publications, Vol. 3, P. 99-108, ISSN 2249-6866

[7] Kalavathy S., T. Rakesh Sharma and P. Sureshkumar (2011), Water uality Index River Cauvery in Tiruchirappalli district, Tamilnadu, Arch. Environ. Sci., 5, 55-61.

[8] Ramakrishnaiah C.R, C. Sadashivaiah and G. Ranganna (2009). Assessment of Water Quality Index for theGroundwater in Tumkur Taluk, Karnataka State, India; E-Journal of Chemistry, 6(2), 523-530.

[9] Srinivasa Kushtagi and Padaki Srinivas (2012). Studies on chemistry and Water Quality Index of ground water in Chincholi Taluk, Gulbarga district, Karnataka India, International Journal of Environmental Science, 2, 1154-1160.

[10] WHO (1992). International Standards for Drinking Water. World Health Organization, Geneva, Switzerland

[11] Yogendra K. and E.T. Puttaiah (2008). Determination of water quality index and Suitability of an Urban Waterbody, Shimoga Town, Karnataka, Proceedings of 12th world Lake Conference 342-346.