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Determination of Groundwater Quality Index in Vidyanagar, Davanagere City, Karnataka State, India

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Abstract*— Groundwater is natural resource for drinking water. Due to human and industrial activities the ground water is contaminated. This is the serious problem now a day. Thus the analysis of the water quality is very important to preserve and prefect the natural eco system. The present work is aimed at assessing the water quality index for the groundwater samples of Vidyanagar, Davanagere city. The groundwater samples of about 40 samples were collected and subjected for a comprehensive physicochemical analysis during the study period April 2014. The purposes of this investigation are to provide an overview of present groundwater quality for the following 12 parameters such as P^H, Total hardness, Calcium, Magnesium, Chloride, Nitrate, Sulphate, Total dissolved solids, Iron, Fluoride, Alkalinity and Electrical conductivity are to be considered for calculating the WQI. The obtained results are compared with Indian Standard Drinking Water specification IS: 10500-2012.The results are analyzed by WQI method for predicting water quality. Water Quality Index (WQI) is a very useful and effective way for assessing the quality of water. WQI is a very useful tool for communicating the information on overall quality of groundwater.

Keywords: **Groundwater, Vidyanagar, Water quality characteristics, Water quality standards, Water quality index**

I. INTRODUCTION

Water is a precious and most commonly used resource. It is one of the basic requirements of human beings. Groundwater is an important source of water supply throughout the world. The groundwater quality is normally characterized by different physico-chemical characteristics. These parameters change widely due to the various types of pollution, seasonal fluctuation, groundwater extraction, etc. Hence a continuous monitoring on groundwater becomes mandatory in order to minimize the groundwater pollution and have control on the pollution-caused agents. The quantity and the suitability of groundwater for human consumption and for irrigation are determined by its physical, chemical and bacteriological properties[1]. Groundwater is used for domestic, industrial, water supply and irrigation all over the world. Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas[6]. According to WHO organization, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored back easily and to device ways and means to protect it[3]. Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of groundwater. WQI is defined as a rating, reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of groundwater for human consumption. The objective of the present work is to discuss the suitability of groundwater for human consumption based on computed, groundwater characteristics, quality assessment and water quality index values.

II. MATERIALS AND METHODS

A. Study area

The current study area is Vidyanagar City, is located at Davanagere district of Karnataka State, India. Lying in western South India and lies in the Maidan region on the Deccan Plateau. The administrative headquarters of Davangere District, which lies at the centre of the state of Karnataka (Figure no 1). The city is located on National Highway 4 (India), at a distance of about 265 kilometers (165 mi) from the state capital, Bangalore. It is the 6th-largest city in Karnataka. And the study area Vidyanagar is located at almost outskirt of the Davanagere city.

B. Geomorphology & Soil Types

The major soil types are Red sandy soil and Black soil and Predominant geological formations are Granites, Gneiss & Schist. In Davangere taluk fractured granitic-gneisses,

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gneisses and hornblendeschists are the main water bearing formations. Groundwater occurs within the weathered and fractured rocks under water-table conditions and semi-confined conditions. Groundwater exploration reveals that aquifers are encountered between the depths of 8.46 and 32 mbgl.

C. Population

As of the 2011 census, city has a population of 4,35,125. Males constitute 52% of the population,(2,26,265) and females 48%(2,08,860). Davangere has an average literacy rate of 85%, higher than the national average of 59.5%: male literacy is 74% and, female literacy is 64%.

D. Physico-Chemical analysis of groundwater samples

All the reagents used were of analytical grade and solutions were made of distilled water. Various water quality parameters such as alkalinity, hardness, chlorides etc., were determined using standard analytical methods and procedures .The instruments used were calibrated before use for observing readings. The repeated measurements were made to ensure precision and accuracy of results. Methods Used for Groundwater analysis is shown in table 1

Table 1: Methods Used for Groundwater analysis (Laboratory analytical methods) [5]

Parameters	Method adopted
P^H	Digital P^H meter
Conductivity	Conductivity meter
Total Dissolved Solids	Digital TDS meter
Total Hardness	EDTA titration
Calcium	EDTA titration
Magnesium	EDTA titration
Alkalinity	Titration(neutralizing with standard HCL)
Chloride	Argentometric titration
Fluoride	Spectrophotometer
Iron	Spectrophotometer
Nitrate	Spectrophotometer
Sulphate	Spectrophotometer

E. Environmental profile: Topography/ Location

Davanagere can be located at 14°28' north latitude and 75°59' east longitude and its elevation is about 602.5 m above the mean sea level. Davangere is surrounded from Chithradurga, Bellary, Shimoga, Chikmagalur and Haveri districts. and it has 6 taluks Harihar, Davangere, Honnali, Channagiri,Jagalur and Harpanahalli.

F. Sample collection

Groundwater samples from all the selected 40 sampling stations were collected as per standard procedural method for the physicochemical analysis of 12 parameters3; it has been revealed that all the parameters studied under the area are within the prescribed limits4-5. Careful planning and preparation of a groundwater sampling was made. Correct sampling procedure begins with thorough preparation in the laboratory before sample collection. The sample containers are rinsed several times with deionised water. Grab sampling has been adopted to collect groundwater samples. Groundwater samples were collected in polythene containers of 2 liters capacity for chemical analysis. The samples thus collected were transported to the laboratory condition. . Sampling location of the study area is shown in the Fig. 1.

G. Estimation of Water Quality Index (WQI)

For computing WQI three steps are followed. In the first step, each of the all parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes (Table-6). The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Magnesium which is given the minimum weight of 1 as magnesium by itself may not be harmful. In the second step, the relative weight (Wi) is computed from the following equation.

$$W_i = w_i / \sum w_i \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

Where, Wi is the relative weight, wi is the weightage of each parameter and $\sum w_i$ is the sum of weightage assigned to the parameters. Calculated relative weight (Wi) values of each parameter are also given in table-7

In the third step, a quality rating scale (qi) for each parameter is assigned by dividing its concentration of each water sample by its respective standard according to the guideline laid down in the BIS 10500 and the result is multiplied by 100.

$$q_i = (C_i / S_i) * 100 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (2)$$

Where, qi is the quality rating, Ci is the concentration of each chemical parameter of each water sample in mg/l, Si is the standard value for each chemical parameter, mg/l according to the guidelines of BIS (BIS 10500-2012).

For computing the WQI, the sub index SI is first determined for each chemical parameter, which is then used to determine the WQI using the following equation

$$SI_i = W_i * q_i \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (3)$$

$$WQI = \sum SI_i \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (4)$$

Where, SI_i is the sub index of Ith parameter, q_i is the rating based on concentration of ith parameter The computed WQI values are classified into five types and are as shown in Table no 7

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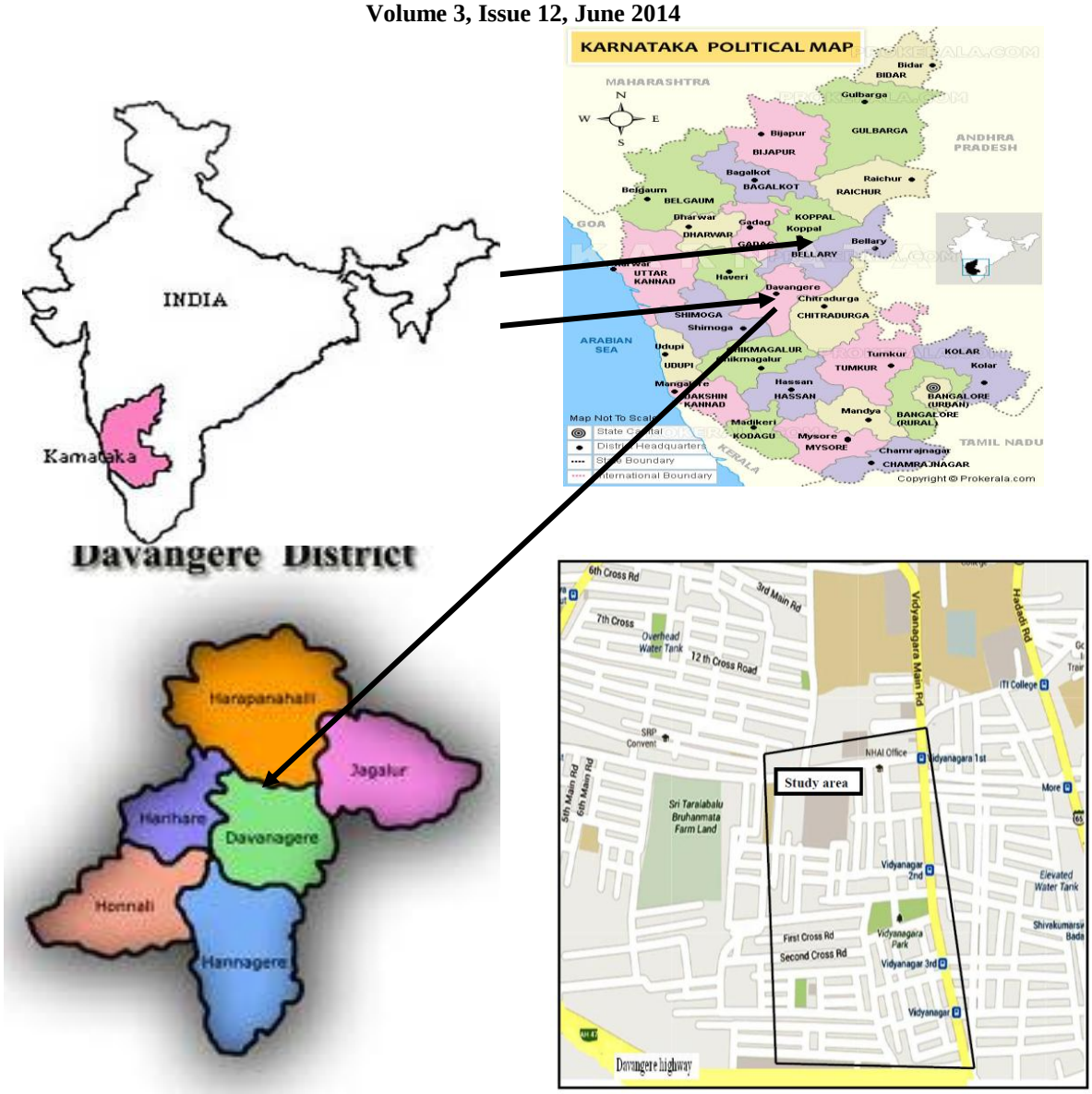

Fig. 1: Location of the study area Vidyanagar, Davanagere City, Karnataka

Table 2: Bureau of Indian Standards (BIS) for drinking water (IS 10500: 2012) [5]

Sl. No.	Characteristics	Desirable limit	Permissible limit
1	Colour, (Hazen units)	5	25
2	Odour	Unobjectionable	Unobjectionable
3	Taste	Agreeable	Agreeable
4	pH value	6.5-8.5	No relaxation
5	Total hardness (mg/l as $CaCO_3$)	300	600
6	Iron (Fe), mg/l	0.3	1.0
7	Chloride, mg/l	250	1000
8	Total dissolved solids, mg/l	500	2000
9	Calcium, mg/l	100	200
10	Sulphate, mg/l	200	400
11	Nitrate, mg/l	45	100
12	Fluoride, mg/l	-	1.5
13	Alkalinity, mg/l	200	600

III. RESULTS AND DISCUSSIONS

In this Section, analysis of groundwater for study area Vidyanagar, Davanagere city is carried out during the study period of Five months from January 2014 to May 2014. During the study period of Five months 200 groundwater

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samples (40*5=200, 40 groundwater samples from same sampling location for the period of 5 month) are collected and are analyzed to know the monthly variation of groundwater characteristics and WQI and it is observed that in the study period of April 2014 is of having comparatively low concentration of groundwater parameters found in study area, hence for the analysis 40 groundwater samples are taken from study area to establish WQI during study period of April 2014 by determining the physical and chemical characteristics as per standard methods[4]. They have been listed systematically and represented in Table 1.

A. P^H

P^H is a measure of the hydrogen ion concentration of water. P^H of the groundwater samples in the study area ranges from 7.25 to 8.06. And the Minimum concentration of P^H is found in groundwater sample B7 having P^H value 7.25 and Maximum concentration of P^H is found in groundwater sample B5 having P^H value 8.06, which are within the permissible limits 6.5- 8.5 given by Indian Standards, also complies with standard 0f 7.0-8.0 given by WHO[6]. One of the main objectives in controlling p^H is to produce water that minimizes corrosion or incrustation. These processes, which can cause considerable damage to the water supply systems, result from complex interactions between pH and other parameters pH of groundwater samples in study area during the study period April 2014 having almost positive correlation with groundwater parameter except with Total hardness, Ca, Mg, F, NO_3, SO_4 and The variation of pH in the study period April 2014 is shown Fig. 2.

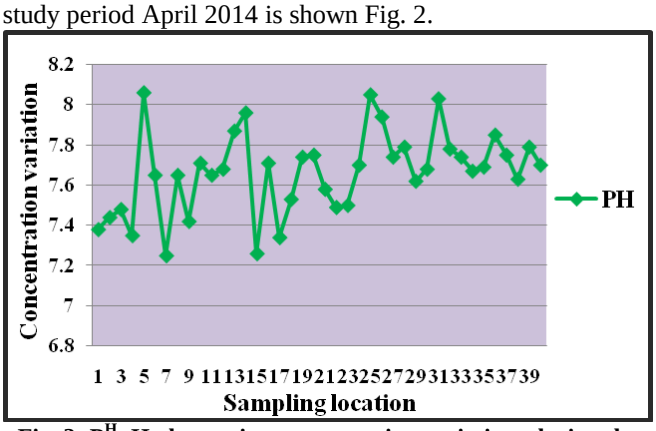

Fig. 2: P^H- Hydrogen ion concentration variations during the study period

B. Electrical conductivity

Electrical conductivity is the numerical expression of the ability of water to conduct electric current. Electrical conductivity of the groundwater in Vidyanagar, Davanagere city ranges from 613.8-1245µs/cm. Maximum concentration of EC is found in groundwater sample B22 having EC value 1245 µs/cm. and Minimum concentration of EC is found in groundwater sample B12 having EC value 613.8 µs/cm, which are within the permissible limits. It can serve as an indicator of other water quality problems. Water with high mineral content tends to have higher conductivity, which is a general indication of high dissolved solid concentration of the water[10].And from the correlation analysis EC is almost positively correlated with groundwater parameters except Iron. The variation of EC in the study period April 2014 is shown Fig. 3.

C. Total dissolved solids

Total dissolved solids comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in water. Total dissolved solids level in ground water is 347.8-682.0 mg/L which exceeds the permissible limit of 500 mg/L as per Indian standards and 1000 mg/L as per WHO Standards. And the Maximum concentration of TDS is found in groundwater sample collected from B22 is 682.0 and Minimum concentration of TDS is found in groundwater sample collected from B12 is 347.8 mg/L. And from the correlation analysis TDS is almost positively correlated with groundwater parameters except Iron .The variation of TDS in the study period April 2014 is shown Fig. 3.

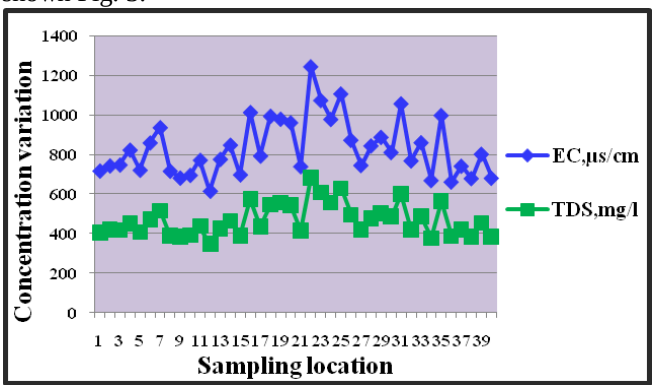

Fig. 3: EC- Electrical conductivity, TDS- Total dissolved solids concentration variations during the study period

D. Total Alkalinity

Alkalinity is introduced into the water by dissolving carbonate-containing minerals. Alkalinity control is important in boiler feed water, cooling tower water, and in the beverage industry. Total Alkalinity of the samples are in the range of 268-404 mg/L. Minimum concentration is found in ground water sample collected from B12 is 268 mg/L. Maximum concentration is 404 mg/L found in water sample of B4. The total alkalinity levels of all the water samples are high thus, resisting acidification of the groundwater samples. Total Alkalinity is almost positively correlated with groundwater parameters except Total hardness, Magnesium and Iron. The variation of total alkalinity and total hardness in the study period during the study period April 2014 is shown Fig. 4.

E. Total Hardness

Hardness is predominantly caused by divalent cations such as calcium, magnesium, alkaline earth metals such as iron, manganese, etc. Total Hardness in the study area ranges from 188-460 mg/L as $CaCO_3$. According to BIS desirable limit is 300mg/L and permissible limit is 600mg/L. Maximum concentration of TH is found in groundwater sample B22 having TH value 460 mg/L. and Minimum concentration of

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TH is found in groundwater sample B5 having TH value 188 mg/L. Hardness is caused by polyvalent metallic ions dissolved in water, which in natural water are principally magnesium and calcium. Total Hardness is almost positively correlated with groundwater parameters except with TA, Iron and Nitrate. According to Sawyer and McCarthy classification the hardness values for the study area are found to be hard for almost all locations and According to WHO specification and Indian standards it is determined to fall higher edge of the desirable limit.

Table 3: Classification of water based on hardness by Sawyer and McCarthy [10]

Hardness as $CaCO_3$ (mg/L)	Water quality	Percent
0-75	Soft	10.26
75-150	Moderately hard	33.33
150-300	Hard	28.21
Above 300	Very hard	28.21

According to Sawyer and McCarty's classification for hardness, water samples collected from study area are falls under the hard class 28.21%. The variation of total alkalinity and total hardness in the study period April 2014 is shown Fig. 4.

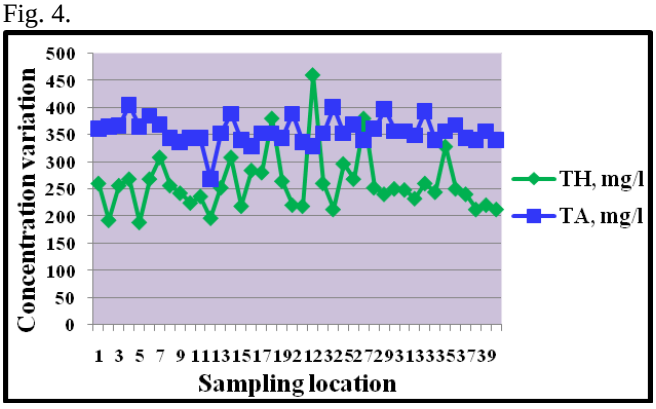

Fig. 4: TH- Total Hardness, TA- Total Alkalinity variations during the study period

F. Calcium

Calcium presence in water results from its passage through the deposits of limestone, dolomite, gypsum and other calcium bearing rocks. In the present study area, the groundwater samples have calcium concentration varying from 40-86.4 mg/l. And the Maximum calcium concentration is found in ground water sample collected from B35 is 86.4 mg/L. Minimum calcium concentration is 40 mg/L found in water sample collected from B12. Calcium is negatively correlated with total alkalinity, iron and fluoride. But increased concentration of calcium precipitates on heating to form harmful scales in boilers, pipes and utensils. As per BIS and WHO standards, the permissible limit for calcium is 200 mg/l. Calcium is almost positively correlated with groundwater parameters except with P^H. The variation of calcium concentration in the study area during the study period April 2014 is shown in the Fig. 5.

G. Magnesium

Magnesium is one of the abundant elements in the earth's crust, It is found in all natural waters and its source lies in rocks. Magnesium concentration in the study area ranges from 17.28-70.08 mg/l. In the present study, the groundwater samples have And the Maximum magnesium concentration is found in ground water sample collected from B22 is 70.08 mg/L. Minimum magnesium concentration is 17.28 mg/L found in water sample collected from B39. As per IS: 10500-2012, the desirable limit of magnesium is 30 mg/l and permissible limit is 100 mg/l. High concentrations of magnesium reduce utility of water for domestic use, while a concentration above 500mg/l imparts an unpleasant taste to water and renders it unfit for drinking. Magnesium is almost positively correlated with groundwater parameters except with Total Alkalinity, Iron and PH. Variations of Magnesium in the study area during study period April 2014 is shown in the Fig. 5.

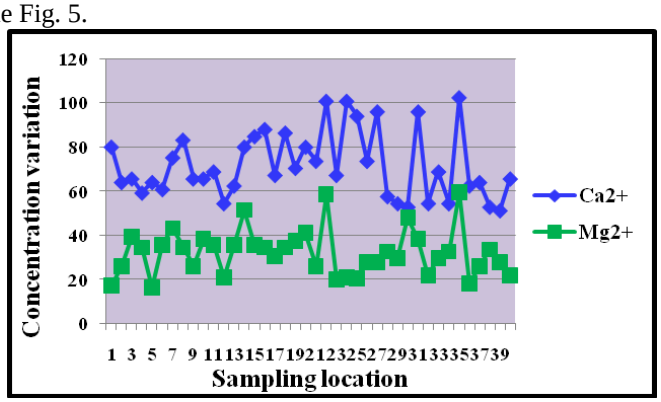

Fig. 5: Ca- Calcium, Mg- Magnesium concentration variations during the study period

H. Chloride

Chlorides are widely distributed in nature as salts of sodium, potassium and calcium. Chlorides are leached from various rocks into soil and water by weathering. Chloride present in ground water samples are in the range of 87.82-195.6 mg/L, which exceeds the permissible limit of 250 mg/L as per Indian standards as well as WHO Standards and this obviously affects the taste of the water. Maximum chloride concentration is found in groundwater sample collected from B25 is 195.6 mg/L. Minimum chloride concentration is found in groundwater sample B40 is 87.82 mg/L. and in the study area chloride content is beyond the permissible limit. High Chloride content can corrode metals and affect the taste of food products. Chloride is almost positively correlated with groundwater parameters except with Iron and Sulphate. The variation of Chlorides in the study period April 2014 is shown Fig. 6.

I. Sulphate

Sulphate concentration in collected groundwater samples is ranges from 65.14-90.6 mg/l as in the permissible limit of 200mg/l as per Indian standards and 250mg/L as per WHO Standards. And the Maximum sulphate concentration is found in ground water sample collected from B3 is 90.6 mg/L. Minimum sulphate concentration is 65.14 mg/L found in water sample collected from B40. Health concerns regarding sulphate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water

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containing high levels of sulphate. Sulphate is almost positively correlated with groundwater parameters except with Total Alkalinity, chloride, P^H,F and Fe. The variation of Sulphate in the study period April 2014 is shown Fig. 6

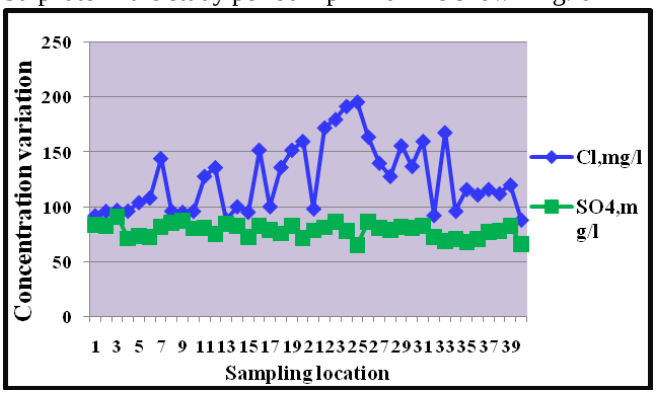

Fig. 6: Cl- Chloride, SO_4- Sulphate concentration variations during the study period.

J. Nitrate

Nitrate is produced from chemical and fertilizer factories, matters of animals, decline vegetables, domestic and industrial discharge[16]. Nitrate is a naturally occurring form of nitrogen found in soil. Nitrate concentration in the study area is varies from 4.3-8.6 mg/L which complies with the permissible limit of 45 mg/L as per Indian standards and 50 mg/L as per WHO Standards. And the Maximum nitrate concentration is found in ground water sample collected from B15 is 8.6 mg/L. Minimum nitrate concentration is 4.3 mg/L found in water sample collected from B3. Nitrate levels above 45 mg/l NO_3 may cause methemoglobinemia in infants .Sources of nitrate contamination in Vidyanagar, Davanagere city may include septic tanks and municipal sewage treatment systems. The ability of nitrate to enter well water depends on the type of soil and bedrock present, and on the depth and construction of the well. Nitrate is almost negatively correlated with remaining groundwater parameters except P^H and Iron .The variation of Nitrate in the study period April 2014 is shown Fig. 7.

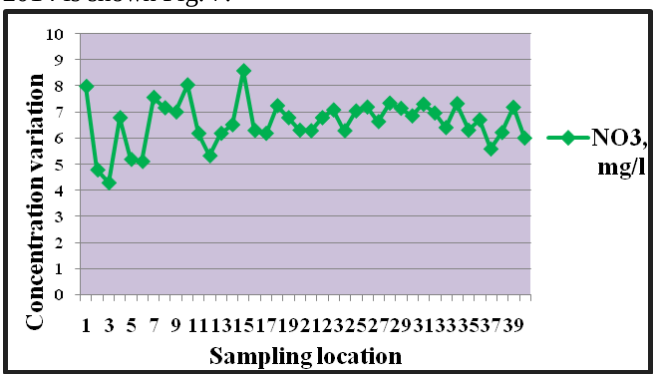

Fig. 7:NO_3- Nitrate concentration variations during the study period

K. Flouride

Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite crystals etc, in nature. among factors which control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock minerals assemblage through which the ground water is circulating[11]. Flouride concentration in the study area ranges from 0.30-0.65 mg/L which are within the permissible limit of 1 mg/L as per Indian standards as well as WHO Standards. And the Maximum fluoride concentration is found in ground water sample collected from B22 is 0.65 mg/L. Minimum fluoride concentration is 0.30 mg/L found in water sample collected from B1. It is negatively correlated with all parameters expect P^H. Fluoride is almost positively correlated with groundwater parameters except with Sulphate. The variation of Fluoride in the study period April 2014 is shown Fig. 8.

L. Iron

Iron concentration of groundwater samples in the study area are varies from 0.2 to 0.46 mg/L and the Maximum iron concentration is found in ground water sample collected from B4 is 0.46 mg/L. Minimum iron concentration is 0.2 mg/L found in water sample collected from B8. And BIS has recommended 0.3 mg/L as the desirable limit and 1.0 mg/L as the maximum permissible limit for iron in drinking water (BIS, 2012). Hence it is within the permissible limit. Iron is positively correlated with groundwater parameters except with PH, Electrical conductivity, TDS and Total hardness. The variation of Iron in the study period of April 2014 is shown Fig. 8.

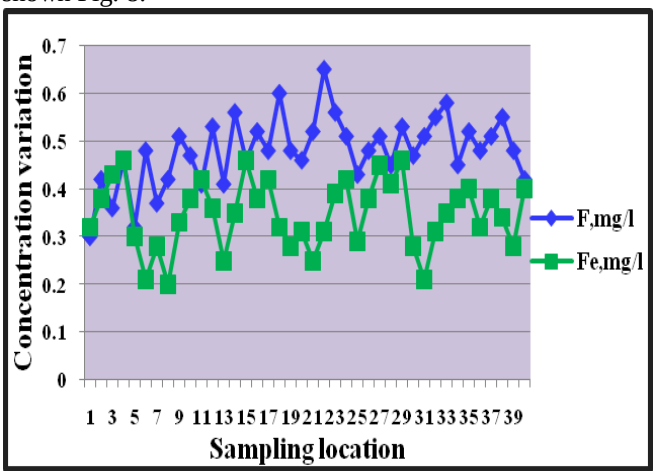

Fig. 8: F- Fluoride, Fe- Iron variations during study period

Table 4: Comparison of groundwater quality with drinking water standards, Indian and WHO[6]

Parameters	Indian Standard	Percentage compliance	WHO Standard
pH	6.5-8.5	100	7.0-8.0
TH, mg/L	300	100	100
Ca^{2+},mg/L	75	0	75
Mg^{2+},mg/L	30	100	30
Cl^-, mg/L	250	100	250
TDS, ppm	500	100	1000
Fe, mg/L	0.3	83	0.1
F, mg/L	1.0	100	1.0
NO_3^2,mg/L	45	100	50
SO_4^2,mg/L	200	100	250
TA, mg/L	200	100	-

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Table 5: Groundwater physico-chemical characteristics of Vidyanagar, Davanagere city during study period April 2014

Sample no	pH	EC µs/cm	TDS ppm	TH mg/l	Ca^{2+}	Mg^{2+}	Cl mg/L	TA mg/L	F mg/L	Fe mg/L	NO_3^{2-} mg/L	SO_4^{2-} mg/L
B1	7.38	716.2	405.0	260	56	28.8	91.81	360	0.30	0.32	8.0	83
B2	7.44	742.2	420.6	192	44.8	19.2	95.80	364	0.42	0.38	4.8	82.2
B3	7.48	746.7	418.2	256	54.4	28.8	96.72	366	0.36	0.43	4.3	90.6
B4	7.35	822.2	450.6	268	56	30.72	96.0	404	0.46	0.46	6.8	71.08
B5	8.06	720.2	407.5	188	44.8	18.24	103.7	364	0.32	0.30	5.2	73.23
B6	7.65	858.7	471.4	268	60.8	27.84	108.0	384	0.48	0.21	5.12	72.6
B7	7.25	936	515.2	308	59.2	38.4	144	368	0.37	0.28	7.58	81.2
B8	7.65	715.3	391.0	256	48	32.64	96.0	344	0.42	0.2	7.18	85.0
B9	7.42	680.5	383.5	242	47.2	29.76	94.8	336	0.51	0.33	7.02	86.8
B10	7.71	694.2	392.1	224	46.4	25.92	95.80	344	0.47	0.38	8.06	80.1
B11	7.65	770.7	437.5	236	48	27.84	127.7	344	0.41	0.42	6.2	80.63
B12	7.68	613.8	347.8	196	40	23.04	135.7	268	0.53	0.36	5.34	75.05
B13	7.87	775.4	425.1	252	49.6	30.72	88.0	352	0.41	0.25	6.2	84.01
B14	7.96	847.4	463.9	308	57.6	39.36	100	388	0.56	0.35	6.53	82.12
B15	7.26	696.7	390.2	218	44	25.92	95	340	0.46	0.46	8.6	72.4
B16	7.71	1013	575.1	284	67.2	27.84	151.6	328	0.52	0.38	6.31	82.7
B17	7.34	792.2	434.7	280	51.2	36.48	100.0	352	0.48	0.42	6.2	78.6
B18	7.53	994	545.3	380	72	48	136.0	352	0.60	0.32	7.26	75.6
B19	7.74	979	555.4	264	64	24.96	151.6	344	0.48	0.28	6.8	82.1
B20	7.75	961	543.9	220	44.8	18.24	159.6	388	0.46	0.31	6.32	71.4
B21	7.58	738.6	415.8	218	42.4	26.88	98	336	0.52	0.25	6.3	78.3
B22	7.49	1245	682.0	460	67.2	70.08	172.0	328	0.65	0.31	6.8	81.08
B23	7.50	1074	607.1	260	68.8	21.12	179.6	352	0.56	0.39	7.1	85.9
B24	7.70	978	556.4	212	51.2	20.16	191.6	400	0.51	0.42	6.3	78.02
B25	8.05	1107	628.2	296	51.2	40.32	195.6	352	0.43	0.29	7.06	65.14
B26	7.94	872.3	494.7	268	41.6	39.36	163.6	368	0.48	0.38	7.21	86.25
B27	7.74	744.4	421.1	380	67.2	50.88	139.7	340	0.51	0.45	6.65	80.63
B28	7.79	843.5	476.9	252	67.2	20.16	127.7	360	0.45	0.41	7.36	78.81
B29	7.62	887	502.2	240	51.2	26.88	155.6	396	0.53	0.46	7.16	81.69
B30	7.68	810.3	486.5	250	44	33.6	136.8	356	0.47	0.28	6.87	80.23
B31	8.03	1057	598.0	248	59.2	24	159.6	356	0.51	0.21	7.32	82.14
B32	7.78	767.6	419.8	232	40.0	31.68	92.0	348	0.55	0.31	6.98	72.31
B33	7.74	859.8	486.6	260	64.0	24	167.6	392	0.58	0.35	6.42	68.61
B34	7.67	667.8	377.6	244	46.4	30.72	95.80	340	0.45	0.38	7.34	71.02
B35	7.69	998	564.9	328	86.4	26.88	115.7	356	0.52	0.40	6.32	68.08
B36	7.85	660.2	386.5	250	40.4	35.76	110.8	367	0.48	0.32	6.72	70.7
B37	7.75	740.6	419.2	240	49.6	29.76	115.7	344	0.51	0.38	5.60	76.6
B38	7.63	677.9	383.5	212	46.4	23.04	111.7	340	0.55	0.34	6.23	78.23
B39	7.79	801.2	453.4	220	59.2	17.28	119.7	356	0.48	0.28	7.2	82.10
B40	7.70	679.6	383.4	212	51.2	20.16	87.82	340	0.42	0.40	6.02	65.74
Min	7.25	613.8	347.8	188	40	17.28	87.82	268	0.3	0.2	4.3	65.14
Max	8.06	1245	682	460	86.4	70.08	195.6	404	0.65	0.46	8.6	90.6
mean	7.66	832.1	467.9	259.5	53.7	29.88	125.1	355.4	0.479	0.346	6.619	78.05
SD	0.203	145.3	80.93	53.7	10.5	10.14	31.52	24.22	0.071	0.071	0.879	6.138

Table 6: Results of groundwater quality Index analysis during the study period April 2014

Sl. No	Parameters	Indian Standards	Mean value	Min value	Max value	Weightage (w_i)	Relative Weight (W_i)	Quantity Rating (q_i)	Sub Index (SI_i)
1	pH	6.5-8.5	7.665	7.25	8.06	4	0.0952	90.17	8.584
2	EC, µS/cm	500-2000	832.13	613.8	1245	4	0.0952	41.6065	3.96
3	TDS, ppm	500-2000	467.94	347.8	682	4	0.0952	23.397	2.227
4	TH, mg/L	300-600	259.55	188	460	3	0.071	43.25	3.07
5	Ca^{2+}, mg/L	75-200	53.77	40	86.4	2	0.0476	26.885	1.2703
6	Mg^{2+}, mg/L	30-100	29.886	17.28	70.08	2	0.0476	29.886	1.4225

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7	Fe, mg/L	0.3-1.0	0.346	0.2	0.46	4	0.0952	34.6	3.2939
8	TA, mg/L	200-600	335.42	268	404	3	0.071	55.90416	3.96919
9	Cl^-, mg/L	250-1000	125.13	87.82	195.60	3	0.071	12.5137	0.888
10	F, mg/L	1-1.5	0.479	0.3	0.65	4	0.0952	31.933	3.0400
11	NO_3^{2-},mg/L	45-100	6.619	4.3	8.6	5	0.119	6.619	0.7876
12	SO_4^{2-}, mg/L	200-400	78.05	65.14	90.6	4	0.0952	19.5125	1.8575
						w_i=42	W_i=0.998	q_i=416.27	SI_i=34.3

Hence, WQI for the groundwater samples in the study area during study period April 2014 is 34.3699, hence from the Table 7, WQI for the study area is less than 50, from the WQI assessment it is considered as **Excellent** water.

Table 7: Water quality classification based on WQI value [3]

WQI Value	Water Quality
<50	Excellent
50-100	Good
100-200	Poor
200-300	Very poor
>300	Water Unsuitable for drinking

Table 8: Correlation analysis for the study area parameters during the study period April 2014

	PH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Cl	TA	F	Fe	NO_3^{2-}	SO_4^{2-}
PH	1											
EC	0.112	1										
TDS	0.145	0.994	1									
TH	-0.119	0.588	0.550	1								
Ca^{2+}	-0.078	0.611	0.594	0.651	1							
Mg^{2+}	-0.108	0.346	0.307	0.877	0.220	1						
Cl	0.252	0.760	0.795	0.305	0.308	0.173	1					
TA	0.049	0.228	0.226	-0.021	0.120	-0.130	0.1324	1				
F	0.050	0.395	0.383	0.414	0.298	0.348	0.3785	-0.122	1			
Fe	-0.315	-0.147	-0.138	-0.010	0.080	-0.051	-0.0030	0.096	0.052	1		
NO_3^{2-}	-0.129	0.145	0.146	0.192	0.080	0.195	0.1242	0.006	0.096	-0.017	1	
SO_4^{2-}	-0.184	0.028	0.022	0.070	0.022	0.095	-0.0002	-0.079	-0.071	-0.060	0.014	1

Table 9: Regression analysis of Calcium and Chloride

Regression Statistics	
Multiple R	0.433718
R Square	0.188111
Adjusted R Square	0.166746
Standard Error	28.77571
Observations	40

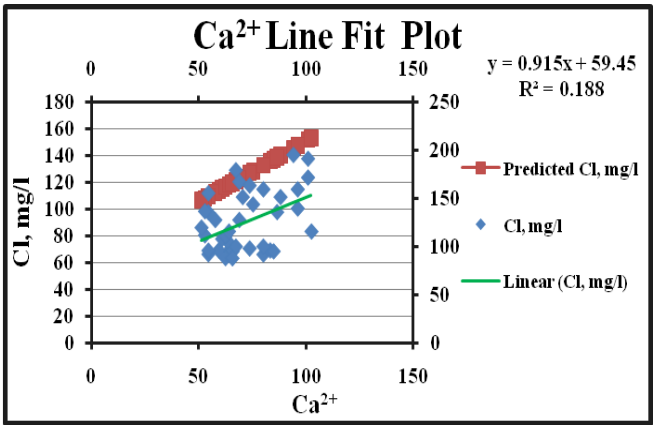

Fig. 9: Regression of Calcium and Chloride

Table 10: Regression analysis of Total dissolved solids and Electrical conductivity

Regression Statistics	
Multiple R	0.994112
R Square	0.988258
Adjusted R Square	0.987949
Standard Error	15.95619
Observations	40

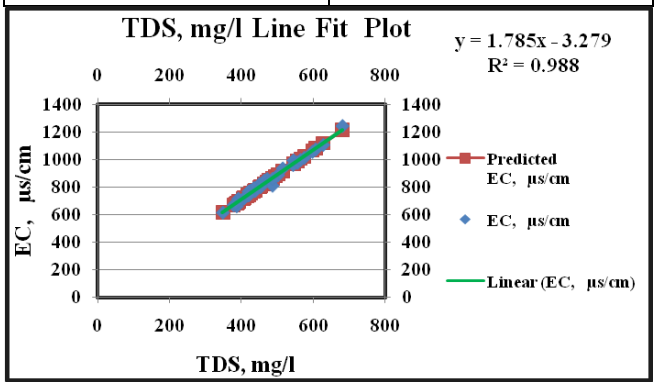

Fig. 11: Regression of Total dissolved solids and Electrical conductivity

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Table 11: Regression analysis of Sulphate and magnesium

Regression Statistics	
Multiple R	0.095682
R Square	0.009155
Adjusted R Square	-0.01692
Standard Error	10.2328
Observations	40

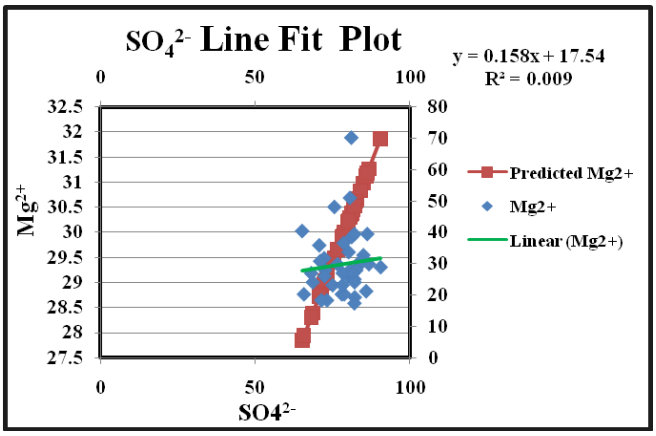

Fig 11: Regression of Sulphate and magnesium

Table 12: Regression analysis of Iron and Fluoride

Regression Statistics	
Multiple R	0.052768
R Square	0.002784
Adjusted R Square	-0.02346
Standard Error	0.072626
Observations	40

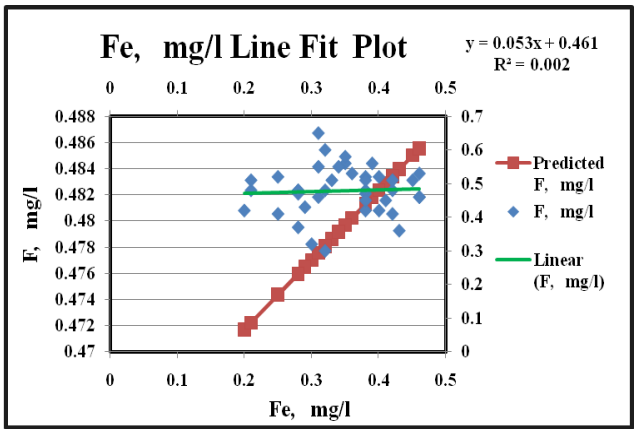

Fig. 12: Regression of Iron and Fluoride

Table 13: Regression equations for the study area groundwater parameters.

Sl. No	Parameters	R^2 value	Regression Equation
1	Ca & Cl	0.188	Y=0.915x+59.45
2	TDS & EC	0.988	Y=1.785x-3.279
3	Mg & SO_4	0.009	Y=0.158x+17.54
4	Fe & F	0.002	Y=0.053x+0.461

IV. CONCLUSIONS

In the current investigation, physicochemical parameters are studied in the groundwater samples of various Sampling locations in Vidyanagar, Davanagere city. After the careful study of analysis, interpretation and discussions of the numerical data following conclusions have been drawn for the ground water of Vidyanagar, Davanagere city. The investigation revealed that all most all the physical and chemical parameters are within the permissible limits of standards, except at Anjaneya temple B22 and Eshwara Parvathi temple B18. Most of the bore wells yield potable water with moderate mineral or dissolved salts. Water is soft in almost all the sampling points. But in some sampling location such as Anjaneya temple, Eshwara Parvathi temple is of highly hard and highly turbid water. As there is no considerable increase in sulphate, it shows that there is no possible contamination of groundwater due to percolation of polluted surface water. The concentration of nitrate and fluoride in the entire Vidyanagar, Davanagere city is well within the permissible limit. From the regression analysis of groundwater parameters in study area yielding almost positive regression equations and having positive R^2 values and are shown in Figure 9 to 12 and also from Table 9 to 13. From the correlation analysis of groundwater parameters in study area is also most positively correlated with each other which are shown in Table 8. It has been revealed by the analysis that due to rapid urbanization effects have negative effects on the quality of ground water of Vidyanagar, Davanagere City. The water quality index (WQI) of the study area during the study period of April month falls in the Excellent Range as shown in Table 6-7 and hence the groundwater of Vidyanagar, Davanagere city is as considered as **Excellent**. Hence the groundwater of study area is as considered as fit for domestic and drinking purpose. The analysis reveals that the groundwater of the area, needs certain degree of treatment before consumption (at least disinfection), and it also needs to be protected from the possible sources of contamination.

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REFERENCES

[1]. Mangukiya R., Bhattacharya T., and Chakraborty S (2012),"Quality Characterization of Groundwater using Water Quality Index in Surat city, Gujarat, India", International Research Journal of Environment Sciences, 1(4): 14-23

[2]. Nagarajappa D P., Rajappa B., Manjappa s., and Puttaiah E T., (2011), "Physico chemical analysis of underground water of Harihara taluk of Davanagere district, Karnataka, India", Advances in applied science research, 2(5): 143-150

[3]. Shivasharanappa., Srinivas P., and Mallikarjun Huggi S (2011), "Assessment of ground water quality characteristics and Water Quality Index (WQI) of Bidar city and its industrial area, Karnataka State, India", International journal of environmental sciences, 2(2): 965-976

[4]. APHA, American Public Health Association (2012), standard method for examination of water & wastewater specifications, Washington DC, 6, 22nd Edition.

[5]. Bureau of Indian Standards, 1993, (IS 10500:1991), Edition 2.1., (IS 10500:2012),

[6]. WHO (World Health Organization) Guidelines for drinking water quality (1993), second edition, Vol. 1, 188.

[7]. Shivasharanappa., Srinivas P., and Mallikarjun Huggi S (2011), "Study on physic-chemical characterictics of groundwater of Bidar city and its Industrial area", International journal of applied biology and pharmaceutical technology, 3(1): 359-367

[8]. Nirdosh P, Ahmed A, Sureshbabu H, Kottureshwar N M, Jayashree M., and Nijalingappa J. (2010), "Study on the Physico-Chemical characteristics of ground water of Gulbarga City (Karnataka)" International Journal of Applied Biology & Pharmaceutical Technology, 1(2): 519

[9]. Grewal B S (2003), "Higher engineering mathematics ", Khanna publication, 37th edition,755-759

[10]. Sawyer G.N., Carthy Mc D.L (1967) ., Chemistry of sanitary Engineers, 2ndEd., McGraw Hill, New York, 1(2):518

[11]. Devendra Dohare., Shriram Deshpande and Atul Kotiya3 (2014) "Analysis of Ground Water Quality Parameters: A Review", International research journal of engineering sciences,3(5):26-31.