CORRELATION OF FLUORIDE WITH FEW OTHER PHYSICOCHEMICAL PARAMETERS OF GROUNDWATER IN GULBARGA TALUK, KARNATAKA, INDIA

Mohammed Aleem Pasha

Department of Geology

Central University of Karnataka

Kalaburgi 585367, Karnataka, India

Abstract

Groundwater pollution is one of the major concerns as it is directly related to human health. Gulbarga is one among the districts where the fluoride concentration is very high. The present study shows the fluoride concentration in Gulbarga taluk ranged between 1.61 and 5.17 mg/l. A simple correlation study is carried out to understand the relationship among the few available physicochemical parameters. The observed correlation relationship indicates that there is a strong interdependence among fluoride, pH, TH, TDS and elevation in the present study area. The study revealed that the entire taluk of Gulbarga is having fluoride concentration higher than the permissible limits. The authors are of the opinion that there is an urgent need of testing the water quality of all the drinking water wells in the taluk as a public health concern and identify safe drinking water sources in the taluk.

Key words: *Fluoride, Gulbarga, Correlation, Groundwater*

INTRODUCTION

Groundwater is over exploited for multi purposes all over the world. Groundwater is an important source of drinking water for about 70% of Indian population [1]. Groundwater is consumed directly without purification as it is considered clean. But even the groundwater may get polluted due to either natural or anthropogenic causes. One of the important natural pollutants of groundwater is fluoride (F^-) that may originate either from anthropogenic or natural causes. Fluoride has an ability to enhance the

remineralisation of hard tissues like bones and teeth in human body [2]. Fluoride concentration between 0.8 - 1.0 mg/lt is beneficial for healthy teeth. The world health organization (WHO) recommends a maximum allowable concentration of 1.5 mg/l of fluoride in drinking water. It has been established that the excess of fluoride (> 1.5 mg/l) causes dental caries and skeletal fluorosis. As per the recent reports concentration of fluoride in groundwater of eastern, north eastern and south eastern parts of Karnataka range between 0.5 and 7.4 mg/l. Gulbarga is one among the districts where the fluoride concentration is as high as 7.40 mg/l which is one of the highest in Karnataka [2, 3].

The correlation and regression coefficients of the water quality parameters give a good idea about the overall water quality. The correlation coefficient measures the degree of association of two variables where one of the variables is taken as dependent variable. The correlation study provides an excellent tool for the prediction of parametric values within a reasonable degree of accuracy. Literature shows that few studies related to groundwater quality are available for Gulbarga district and Gulbarga city as well but there is no data available regarding the fluoride and its correlation with other parameters for Gulbarga Taluk as such. This prompted us to take up the present study. The main objective of the present study is to understand the occurrence of fluoride in Gulbarga Taluk and its correlation with other available physicochemical parameters.

STUDY AREA

Gulbarga is one of the fast developing districts in the Hyderabad Karnataka. Gulbarga taluk is extended between the latitudes $17^O2'30"$ and $17^O41'43"$ and longitudes $76^O36'10"$ and $77^O9'52"$ comprising a geographical area of 1741 sq km. Map 1, shows the location of the study area. As per the 2011 census of India the total population of Gulbarga taluk is 829830. Annual temperature range for Gulbarga taluk is 19^OC during winter and 46^OC during summer. Annual average rainfall is about 750mm and most of it precipitates during monsoon season. Gulbarga is situated in the semi arid region of peninsular India and declared as one of the chronic drought affected areas of Karnataka state. The mean elevation of the study area is about 450m above MSL.
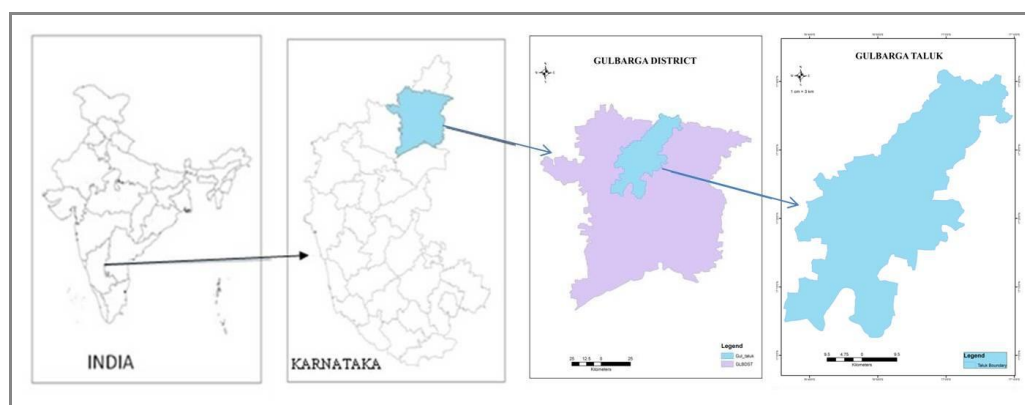
*Map 1. Location of the study area; Gulbarga Taluk.*

GEOLOGY OF THE STUDY AREA

The Gulbarga District is covered by the rock types ranging from Archean to Recent. The entire area of the Gulbarga taluk is predominant by basaltic lava flows except a small area in the south where limestone are deposited. Basaltic lava flows belong to the Deccan traps of Deccan volcanic province and limestone belongs to the Bhima group of rocks. The major rock types of sedimentary formations of Bhima group are conglomerate, sandstones, shales and limestone. Limestone are fractured and sheared due to tectonic disturbances are exposed subhorizontally with a local northward dip of less than 5° overlying the Archean basement rocks and are traversed by pegmatite veins filled with fluorite associated minerals [3, 4]. A part of the present study area at the southern portion is covered by these limestones which are inter-bedded with shales. Map 2, shows the geology of the Gulbarga district.
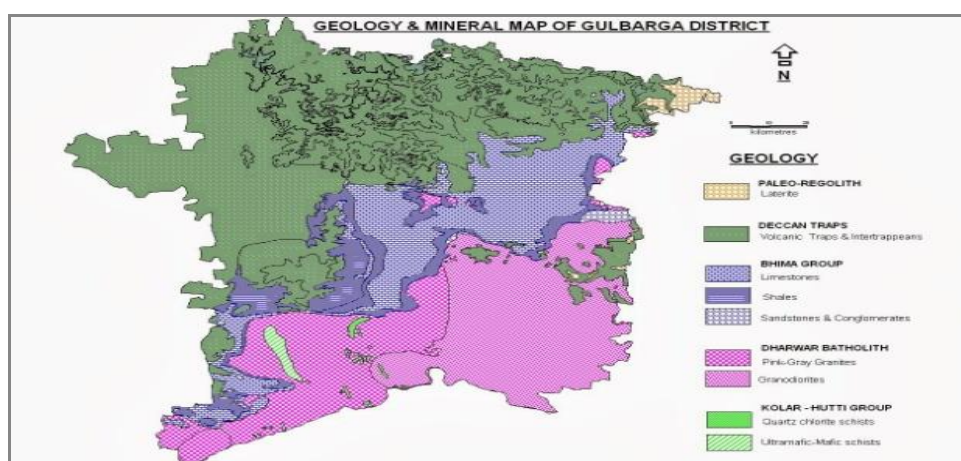
Map 2. Geology of Gulbarga District

METHODOLOGY

Groundwater occurs in the weathered zones, fractures and vesicular basalts and limestone's of Deccan Basalts and Bhima group of rocks. A total of 46 samples are collected from both bore wells as well as dug wells from different villages. Standard procedures of the sample collection are followed for the collection of groundwater samples. Samples are collected in 1 litre PVC cans. The cans are thoroughly washed and rinsed twice with the water of sample collecting wells before filling to the brim. Care has been taken to avoid presence of any air gap in the sample cans. Sample cans are properly sealed first with airtight cork and then closed with a cap. Samples are properly labelled and date and location are mentioned on it for future reference. Such collected water samples are sent to the laboratory for the groundwater quality analysis immediately and are analysed within 24 hours. Samples are analysed for fluoride content through SPADNS method following the standard procedures. Map 3, shows the locations of the groundwater sample collecting points in the Gulbarga Taluk.
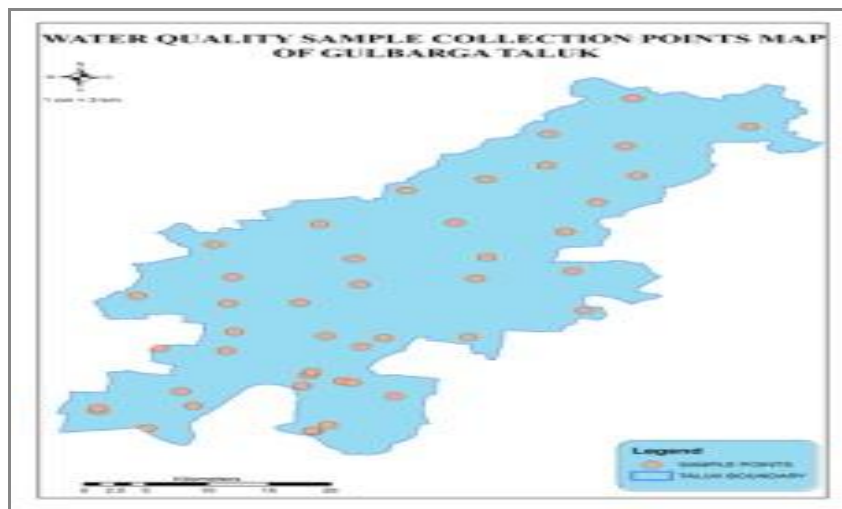
Map 3. Location of the groundwater sample collecting points.

Correlation study for various physicochemical parameters is conducted employing Microsoft Office Excel. Correlation coefficient determines the relationship between two parameters. The formula used for the calculation of the correlation coefficient using Microsoft Excel is as follows;

Correlation $(X, Y) = \sum(X-X')(Y-Y')/\sqrt{\sum(X-X')^2\sum(Y-Y')^2}$ where X and Y are the sample means average.

The correlation coefficient is a measure of the extent to which two measurement variables vary together. The value of any correlation coefficient must be between -1 and +1 inclusive. Large values of one variable tend to be associated with large values of the other producing a positive correlation, whereas small values of one variable tend to be associated with large values of the other producing a negative correlation. If the resultant value is zero (0), it implies that both the variables are unrelated. The linear Regression analysis is done using the "least squares" method to fit a line through a set of observations using Microsoft Excel. It shows how a single dependent variable is affected by the values of one or more independent variables. Linear fit plots are generated which gives the relation between the predicted values versus observed values.

RESULTS AND DISCUSSION

The major source for occurrence of fluoride in the study area may be natural sources. Regional and local geological settings and hydrogeological conditions influence the occurrence of F in groundwater. The study area consists of basalts and limestones interbedded with shales. The source of the F content in the basaltic area may be the OH^- bearing Hornblende, Biotite and Fluorapatite minerals [5]. The other source of F in the study area could be the clay minerals present in the shales of the Bhima group. The process of weathering of soil or rocks and breakdown of above mentioned minerals present in the study area may contribute for the fluoride in groundwater. Table 1, shows the sampling locations along with some of the groundwater quality parameters of the study area with its acceptable and permissible limits. Table 2, shows some of the statistical parameters for the entire study area.

Table 1. Sampling locations along with some of the groundwater quality parameters of the study area with its acceptable and permissible limits.

Acceptable limit			6.5 to 8.5	1 mg/l		500 mg/l	200 mg/l
Permissible limit			6.5 to 8.5	0.5 to 1.5 mg/l		2000 mg/l	600 mg/l
Sample No		Elevation	pH	F		TDS	TH
1	Khanadal	426.1104	7.29	2.35	111	550	

2	Itaga	405.0792	7.55	2.33	563	316
3	Farhatabad	381.3048	7.61	5.17	153	234
4	Farhatabad	384.9624	7.36	4.90	960	256
5	H Saradagi	382.8288	7.35	5.08	577	316
6	H Saradagi	383.4384	7.55	5.17	585	304
7	Tilgul	397.1544	7.6	3.83	777	160
8	Tilgul	401.1168	7.82	4.45	541	250
9	H Kirangi	420.9288	7.48	3.03	656	210
10	Firozabad	379.476	7.42	2.6	120	386
11	Firozabad	386.4864	7.33	2.17	123	370
12	Firozabad	396.8496	7.43	1.69	130	280
13	Sarana Saradgi	433.7304	7.1	2.11	291	1350
14	H Haroti	419.4048	7.17	2.085	854	694
15	Kadani	418.1856	7.14	2	180	676
16	Minajagi	406.2984	7.32	2.05	596	298
17	Garur	403.2504	7.28	2.11	122	452
18	Bidanur	390.144	7.44	2.002	548	330
19	Kavalagi cross	414.2232	7.47	1.96	391	230
20	Jogur	389.2296	7.13	2.15	564	304
21	Jogur	409.0416	7	2.19	120	460
22	Herur	398.3736	7.2	2.255	695	320
23	Basavapattana	388.62	7.33	2.16	465	170
24	Panigaon	418.1856	7.36	2.195	557	322
25	Sultanpur	473.964	7.41	2.198	719	308
26	Jambaga	504.7488	7.45	2.164	123	650
27	Babalad	473.3544	7.84	2.071	444	120
28	Mahagaon	432.2064	7.84	2.164	108	190
29	Navadagi	466.9536	8.3	1.76	111	92
30	Okali	470.3064	8.62	1.7	333	24
31	Dongargaon	573.024	7.65	2.22	405	166
32	Sauntha	537.0576	7.81	2.185	803	330
33	Antapnala	484.9368	8.11	2.075	428	100
34	Jeevanagi	431.9016	7.59	2.2	104	626
35	Nagur	437.6928	7.73	2.075	634	204
36	Pattana	517.5504	7.58	2.191	552	414
37	Melakunda	455.676	7.64	2.18	404	162
38	Savalagi	457.5048	8.49	1.61	475	58
39	Aurad	452.3232	7.65	2.168	856	576
40	Harasur	460.8576	7.44	2.28	125	724

41	Bhopal Tegnur	406.6032	7.21	2.23	151	776
42	Khaja Kotnur	428.5488	7.48	2.12	731	436
43	Hagaraga	458.4192	8.22	1.88	446	52
44	Sannur	439.8264	7.63	2.18	716	550
45	Nandur B	438.912	8.05	1.78	596	80
46	Gulbarga City	464.5152	7.63	1.69	102	350

Table 2. Statistical parameters of physicochemical parameters of groundwater in Gulbarga Taluk.

For 46 samples	Elevation	pH	F	TDS	TH
Total	19901.3064	348.1	113.1816	20045	16226
Average	432.6370957	7.567391304	2.46047	435.7609	352.7391
Median	423.5196	7.48	2.173833	455.5	312
Max	573.024	8.62	5.17	960	1350
Min	379.476	7	1.61	102	24
StDev	43.62267084	0.356398247	0.950176	255.805	244.18

A simple correlation study is carried out to understand the relationship among the physicochemical parameters. A systematic calculation of correlation coefficient between water quality variables and regression analysis provides an indirect means of rapid monitoring of water quality [6]. Table 3, shows the correlation matrix for the available physicochemical parameters of the study area. Table 4, shows the regression analysis values for the same physicochemical parameters.

Table 3. Correlation matrix of physicochemical parameters of groundwater in Gulbarga Taluk.

	Elevation	pH	F	TDS	TH
Elevation	1				
pH	0.44507719	1			
F	-0.418206292	-0.149142869	1		
TDS	0.009733407	0.023029729	0.238847864	1	
TH	-0.074603581	-0.613796057	-0.080765731	-0.192828288	1

Table 4. Regression analysis values of physicochemical parameters of groundwater in Gulbarga Taluk.

Regression	Elevation/F	pH/F	F/TDS	*F/TH*	*Elevation/pH*
r value	0.418206292	0.149142869	0.238847864	0.080765731	0.44507719
P value	0.003825563	0.322543254	0.109910202	0.593633779	0.001939557
Regression	Elevation/TH	pH/TH	*TDS/TH*	Elevation/TDS	pH/TDS
r value	0.074603581	0.613796057	0.192828288	0.009733407	0.023029729
P value	0.622190153	5.72661E-06	0.199169254	0.948811079	0.879252643

FLUORIDE

Figure 1, shows the concentration of fluoride in groundwater in different sampling locations of Gulbarga Taluk. The present study shows the fluoride concentration in Gulbarga Taluk ranged between 1.61 and 5.17 mg/l with a mean value of 2.46 mg/l.
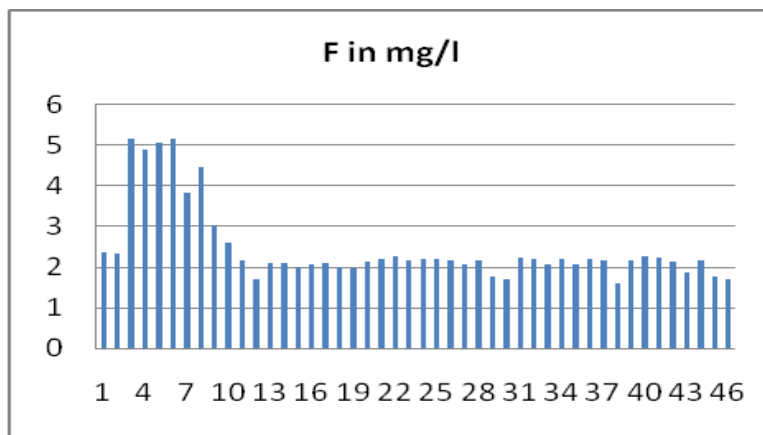
Figure 1. Concentration of Fluoride in groundwater in Gulbarga Taluk.

The highest concentration of fluoride is 5.17 mg/l and the lowest concentration is 1.61 mg/lt. The fluoride in the study area showed a positive correlation with TDS with r = 0.238847864 and P = 0.109910202 and negative correlation with TH, pH with r - 0.080765731, -0.149142869 and P values of 0.593633779, 0.322543254 respectively. Figure 2, 3 and 4 shows the linear correlation graph for the fluoride with TDS, TH and pH respectively.
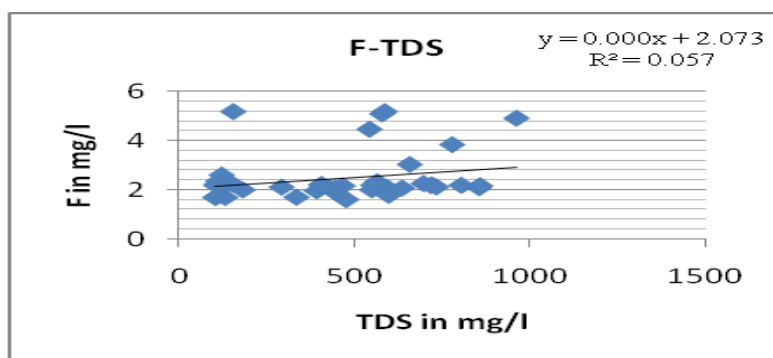
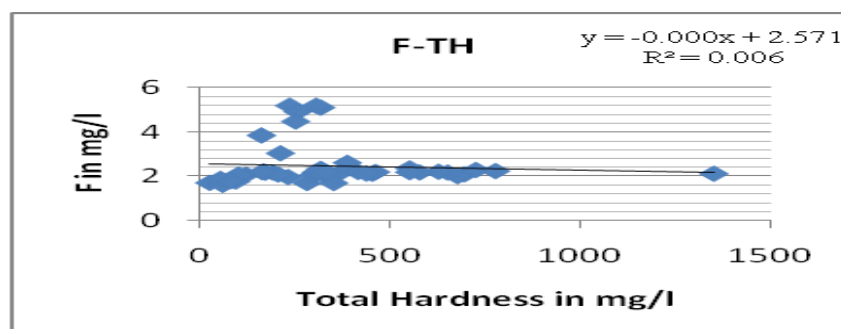*Figure 2. Scatter plot shows the correlation between F and TDS.*

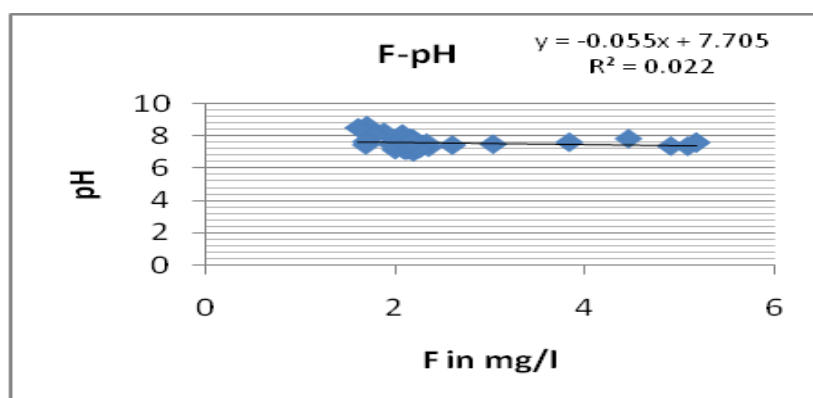*Figure 3. Scatter plot shows the correlation between F and TH.*

Figure 4. Scatter plot shows the linear correlation graph for pH and Fluoride.

pH

The pH is a measure of hydrogen ion concentration, (H+) ranging from 0 to 14 pH. In the study area the pH of the groundwater varies from 7 to 8.62 which are falling well within the permissible limit except one sample which is showing the highest value collected at Okali. The correlation between fluoride and pH shows the values r = -0.149 and P = 0.322 indicate a strong linear correlation between them. A negative correlation is noticed between fluoride and pH for the entire taluk. In an earlier study the authors have reported a positive correlation in the limestone terrain [7]. The pH shows a strong

negative correlation with Total Hardness (TH) having the values r = -0.613and P = 5.72661E-06. It also shows a strong positive correlation with Total Dissolved Salts (TDS) having the values r = 0.023 and P = 0.879 and elevation with values r = 0.445 and P = 0.0019.
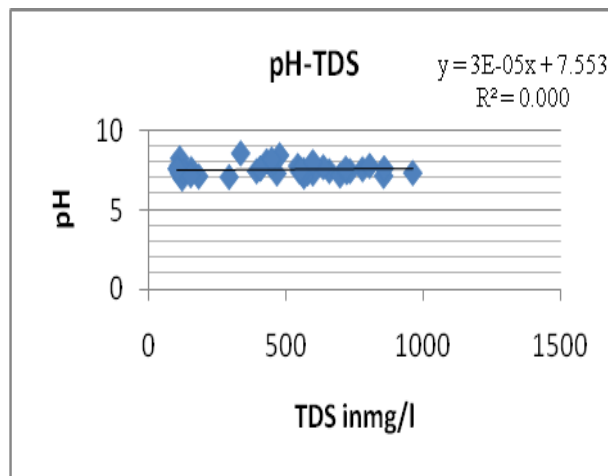

Figure 5. Scatter plot shows the correlation between pH and TDS.

TOTAL HARDNESS (TH)

Hardness in water is caused by dissolving alkaline earth elements like calcium and magnesium. It is usually expressed as the equivalent quantity of carbonate and bicarbonates. Carbonate related hardness is temporary and bicarbonate related hardness is a permanent hardness. Total hardness is the sum of temporary and permanent hardness. Hardness of water prevents lather formation with soap and increases the boiling point of the water. The high hardness may cause precipitation of calcium carbonate and encrustation on water supply distribution systems [8]. In the present study the TH range between 24 mg/l and 1350 mg/l for Gulbarga Taluk. Previous reports show the TH range between 611 to 930 mg/l in Gulbarga District and 52 to 1184 mg/l in Gulbarga city [1,9]. The correlation reports show a negative correlation with all the listed parameters with r values of -0.074603581, -0.613796057, -0.080765731 and -0.192828288; P values of 0.622190153, 5.72661E-06, 0.593633779 and 0.199169254 for elevation, pH, F and TDS respectively. Figure 6, shows the linear correlation graph of pH with TH.

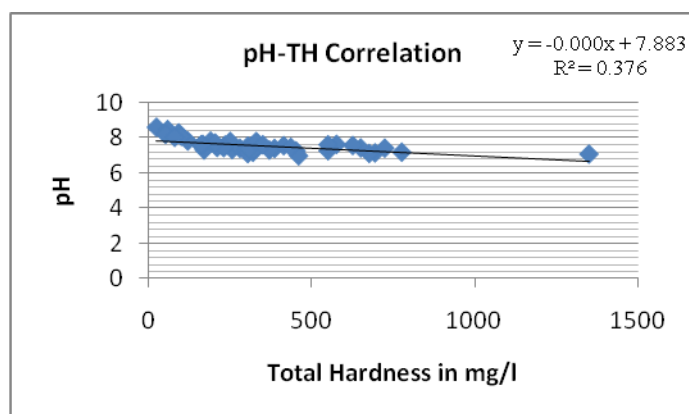*Figure 6, Scatter plot shows the linear correlation graph of pH with TH.*

TOTAL DISSOLVED SOLIDS (TDS)

The mineral constituents dissolved in water contribute for the total dissolved solids in groundwater. TDS imparts peculiar taste to water and reduce its potability. Total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of Calcium, Magnesium, Sodium, Potassium, Manganese, organic matter salt and other particles [10]. In the present study, TDS range between 102 to 960 mg/l. All the samples show the value within the permissible limit in the study area. The correlation study showed a positive correlation with pH and F with r values of 0.023029729, 0.238847864 and P = 0.879252643, 0.109910202 respectively and negative correlation with TH with r = -0.192828288 and P = 0.199169254. Figure 7, shows the linear regression line graph for TDS with TH.
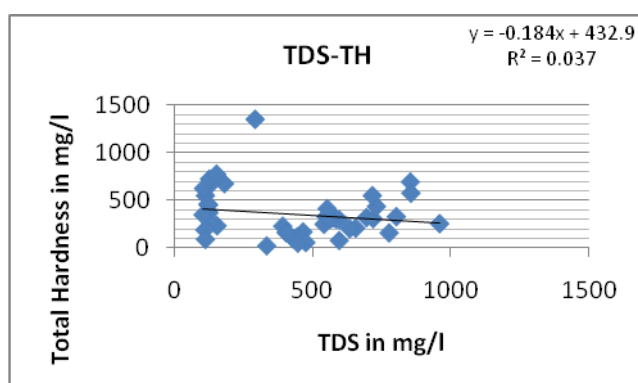

Figure 7, Scatter plot shows the linear regression line graph for TDS with TH.

ELEVATION

The authors reported the relation between the elevation and fluoride in their previous study that lower concentration of fluoride is noticed at the higher elevated areas in

pockets compare to the other areas in the basaltic terrain [7]. The correlation studies showed that positive correlation between elevation with pH and TDS with r = 0.44507719, 0.009733407, P = 0.001939557, 0.948811079 respectively whereas a negative correlation is noticed with fluoride and TH with r = -0.418206292, -0.074603581 and P = 0.003825563, 0.622190153 respectively.
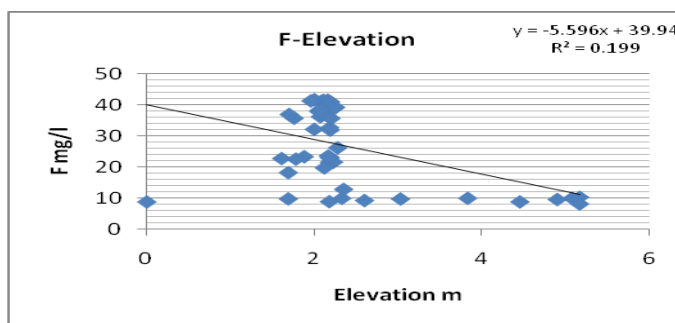

Figure 8, Scatter shows the linear regression graph for fluoride and elevation.

CONCLUSION

The study demonstrated that correlation study helps to identify the interdependence of the physicochemical parameters in the study area. The correlation study of different physicochemical parameters of groundwater such as fluoride, pH, TDS and TH revealed their interdependence. A positive correlation is observed for fluoride with TDS and negative correlations are observed with pH and TH. Similarly, a positive correlation is observed between pH, TDS and elevation. The observed correlation relationship indicates that there is a strong interdependence among fluoride, pH, TH, TDS and elevation in the present study area.

The present study shows the fluoride concentration in Gulbarga taluk is ranged between 1.61 and 5.17 mg/l with a mean value of 2.46 mg/l. A recent report indicated occurrence of dental fluorosis among 98% of the children living in the northern districts of Karnataka which includes Gulbarga [2]. People reported the higher incidence of fluorosis in the southern parts of the Gulbarga taluk to the oral enquiries made during the sample collections. The study also revealed that the entire taluk of Gulbarga is having fluoride concentration higher than the permissible limits. The authors are of the opinion

that there is an urgent need of testing the water quality of all the drinking water wells in the taluk as a public health concern and identify safe drinking water sources in the taluk.

ACKNOWLEDGEMENT

REFERENCES

[1] Shashikanth Majagi & K. Vijaykumar & M. Rajshekhar & B. Vasanthkumar, "Chemistry of groundwater in Gulbarga district, Karnataka, India", Environmental Monitoring and Assessment, 136, 347-354, 2008.

[2] Chitta R Chowdhury, Khijmatgar Shahnawaz, Divya Kumari, Avidyuti Chowdhury, Raman Bedi, Edward Lynch, Stewart Harding, Martin Grootveld, "Spatial distribution mapping of drinking water fluoride levels in Karnataka, India:fluoride-related health effects", Perspectives in Public Health, Vol XX No X, P 1-8, 2016.

[3] S. Sumalatha, S R Ambika and S J Prasad, "Fluoride contamination status of groundwater in Karnataka", current scince, vol 76, no 6, p 730 – 734, 1999.

[4] Vivek S Kale, A V Mudholkar, V G Phansalkar, and V V Peshwa, "Staratigraphy of the Bhima group", Journal of the Paleontological society of India, Vol 35, p91-1031990.

[5] Pandith Madhnure, D. Y. Sirsikar,A. N. Tiwari, B. Ranjan and D. B. Malpe, "Occurrence of fluoride in the groundwaters of Pandharkawada area, Yavatmal district, Maharashtra, India" CURRENT SCIENCE, VOL. 92, NO. 5, 675-679, 10 MARCH 2007.

[6] Srinivas Kushtagi, Padaki Srinivas and S.G.Patil, Regression Analysis of Ground Water of Afzalpur and Jewargi Talukas of Gulbarga District, Karnataka(India), International Journal of Chemical, Environmental and Pharmaceutical Research, Vol. 3, No.1, 35-41, 2012.

[7] Mohammed Aleem Pasha, Bharat Kumar L and Babu Nallusamy, Spatial distribution study of fluoride in groundwater of Gulbarga Taluk, Karnataka, Proceedings:National conference on recent trends in geo sciences, material science and civil engineering (RTGMCE 2017), ISBN: 978-93-86256-67-6, 169-174, 2017.

[8] D. K. Verma, Gouri Sankar Bhunia, Pravat Kumar Shit, S. Kumar, Jajati Mandal, Rajeev Padbhushan, Spatial variability of groundwater quality of Sabour block, Bhagalpur district (Bihar, India), Appl Water Sci, 7:1997–2008, 2017, DOI 10.1007/s13201-016-0380-9.

[9] P. Balakrishnan, Abdul Saleem and N. D. Mallikarjun, "Groundwater quality mapping using geographic information system (GIS): A case study of Gulbarga City, Karnataka, India", African Journal of Environmental Science and Technology, Vol. 5(12), pp. 1069-1084, December 2011.

[10] S Siebert, J Burke, J M Faures, K Frenken, J Hoogeveen, P Doll and F T Portmann, Groundwater use for irrigation-a global inventory, Hydrology and Earth System Sciences, 14, 1863-1880,2010.