Assessment of Fluoride Distribution And Ionic Balance in Ground Water of Siruguppa Taluk, Ballari District, Karnataka, India – A Case Study

N. M. Kottureshwara[1], M. Jayashree[2], Dinesh N D[3], S. Manjappa[4]
[1, 2, 3, 4]Dept of Chemistry
[1, 2]Bahadur Y Mahabaleswarappa Engineering College, Bellary – 583 104, Karnataka, India
[3]AIT, Chikkamangaluru - 577102, Karnataka, India
[4]University BDT College of Engineering, Davangere – 577005, Karnataka, India

***Abstract*-** *A total, 44 different ground-water samples collected in Siruguppai taluk in of Ballari district, Karnataka, India to appraise the distribution of Fluoride. pH of collected groundwater are shown alkaline in nature and ranged between 7.4 and 8.5 with a mean value of 8.0. Fluoride content ranged between 0.16 to 2.76 mg/L in ground water samples, with minimum value 0.16 mg/L (SWG38) and maximum value 2.76 mg/L (SWG17). 64% of samples indicated fluoride content below 1.0 mg/ L and 20% samples indicated fluoride content in between 1.0 and 2.0 mg/L. Followed by 16% of the samples showed fluoride content ranges above 2.0 mg/L. The public from villagers have been used high fluoride-bearing groundwater for drinking prolonged period and suffering from fluorosis. Analytical values also predict that, occurrence of minerals like apatite, fluorspar, topaz and mica get processed naturally and releases fluoride into the lithosphere and percolates into ground water. The present study also helps find out a suitable adsorbent for removal of Fluoride in ground water. However, with respect to chemistry of water, the cation and anion balance of all the 44 groundwater samples were inside the recognized limit of ± 10%. The fluoride content is maximum in Na+– HCO3−- type and low in Ca2+–HCO3−. type groundwater in the Siruguppa Taluk. Furthermore, F− shown a significant positive correlation with pH, EC, TDS, Ca2+, HCO3- and negative correlation with Mg2+ and NO3−, which shows that the alkaline condition of water is the key role for leachate forming of fluoride-bearing minerals. Gibbs chart shows all groundwater values are fall under dominance of rock weathering group with a tendency towards the evaporation dominance class. Hence, interaction of rock–water is the pioneer cause of raised fluoride in the groundwater of the study area. Furthermore, the study showed no such substantial relation present between F− and NO3− these variables are further process to groundwater from different sources, F− from geological minerals and NO3− from manmade activities.*

***Keywords*-** Fluoride, cation, anion behaviour, Siruguppa, Karnataka, India

I. INTRODUCTION

Reasonable to maximum fluoride level in groundwater is published as one of the chief ecological issue in some of the countries (Buddharatna, et al., 2014) and also aggressive an estimated 0.2 billion people (Mishra, et al., 2010). Roughly, in India, the extreme fluoride content in groundwater is reported in different districts covering Karnataka states in India, affecting 61 million individuals, along with 5.9 million children (Adimalla and Venkatayogi, 2018). In general, fluoride is mixing in groundwater from fluorine enclosing minerals like fluorite, biotite, apatite, muscovite, hornblende, topaz, microlite, fluormica, amphibole, some micas and sedimentary rocks, particularly shale (Islam and Patel, 2011; Ayoob and Gupta 2006 and Kanthe VN, 2014).

Apart from natural process, fluoride content may be distributed due to manmade activities like burning of coal, production industries like aluminium, steel, bricks, phosphate fertilizers comprise fluoride as an impurity and are entering as leachate down in to the ground water (Nath and Dutta 2010). The related human health hazards due to fluoride will roughly classified as: dental, renal, reproductive, skeletal, neurological, developmental, endocrine and carcinogenic effects. Continuously drinking of fluoride contaminated water affects modest level inhibits dental caries. Thus, the best pioneer step to control fluorosis is to confirm allowable fluoride content in drinking water. The WHO has suggested 1.5 mg/L as the maximum allowable limit of water (Kanthe, 2014 and WHO, 2006). A survey report indicated that no appraisal have been conducted in the Siruguppa Taluk with respect to fluoride and fluorosis issues. Hence, chief objective of this work is to apprise the quality of ground water with special conditions to fluoride content.

II. MATERIALS AND METHODS

Study area

Siruguppa is a city and headquarters of the Siruguppa taluk and second largest city in Ballari district after Hospete carved out of Ballari district of Indian state of Karnataka. The study region Siruguppa taluk is situated at 15.6175° N, 76.9006° E. It belongs to the dry inland region of Karnataka with an annual rainfall of 645 mm.

Water sampling

A total of 44 ground water samples collected in scientifically using clear acid rinsed polythene canes of one litre capacity from various bore wells at different sampling sites of Siruguppa Taluk. The ground water sampling was during the post monsoon session (October 2020 to January 2021).

Analysis

Fluoride content was measured in ground water samples by adopting technique (APHA, 1998), Ion Selective Electrode method (Hatch, 101 with Orion electrode). Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were analysed titrimetric method using EDTA, Sodium (Na^{+}) and potassium (K^{+}) contents by Flame photometer (Systronics, 148). Chloride (Cl^{-}) was analysed by standard $AgNO_3$ titration method. Bicarbonate (HCO_3^{-}) and carbonate (CO_3^{2-}) determined by titration with HCl. Sulfate (SO_4^{2-}) and nitrate (NO_3^{-}) by using UV–visible spectrophotometer (Shemadzhu 7000). Eventually, the value all chemical analyses results were calculated using formula (cations−anions)/(cations+anions) × 100 ion-charge balance with cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) and anions (HCO_3^{-}, Cl^{-} , SO_4^{2-}, NO_3^{-}, and F^{-}). All the 25 groundwater samples are showed well within the accepted limit of ± 10% given by Domenico and Schwartz, 1990.

III. RESULTS AND DISCUSSIONS

Ground water samples from Siruguppa Taluk were clear no visible color, odour and turbidity during the study period. The fluoride content in ground water showed significantly in sampling locations of study areas. The fluoride content in ground water is given in Table 1.

The fluoride content in the ground water samples indicated a define trends with respect to sampling locations of Siruguppa Taluk. Fluoride content ranged between 0.16 to 2.76 mg/L in ground water samples, with minimum value 0.16 mg/L (SWG38) and maximum value 2.76 mg/L (SWG17). 64% of samples indicated fluoride content below 1.0 mg/ L and 20% samples indicated fluoride content in between 1.0 and 2.0 mg/L. Followed by 16% of the samples showed fluoride content ranges above 2.0 mg/L (>1.5 mg/L, WHO) for drinking (Table 3).

As per the BIS, 2012 standard, the allowable and maximum permissible level of fluoride in drinking water is ranged between 0.6 and 1.2 mg/L. If fluoride content less than 0.6 mg/L affect dental caries, while more than 1.2 mg/L cause fluorosis. It is reported that the fluoride content of groundwater during the study period is 2.76 is more than 1.2 mg/L.

Association of fluoride with other variables

To know the correlation with fluoride and chemical variables, correlation graphs gives important correlation and also support to understand the monitoring factors and its activity with fluoride content in the groundwater (Wang, et al., 2004). A moderate positive correlation is noticed fluoride with pH (Fig. 1a) which predicts that the maximum alkaline condition of water increases the enhancement of fluoride content and normally affects the content of fluoride in the groundwater (Tasawar Ali Chandio, et al., 2015). A significant positive relationship is identified fluoride with bicarbonate (Fig. 1b) and also with sodium (Fig. 1c), which predicts that the alkaline ecological condition supports and controls chemical process to mix with fluoride and bleached with the fluoride containing minerals in the groundwater in the study area (Tasawar Ali Chandio, et al., 2015; Li et al. 2014a; Rao, et al. 2017). Moreover, as predicted in Fig. 1d, the correlation fluoride with calcium, the values are clearly shows that the occurrence of maximum content of calcium will support less in fluoride content in the groundwater. It is indicated that the chief role of surface runoff is a main process for enrichment of fluoride in groundwater (Tasawar Ali Chandio, et al., 2015; Narsimha and Sudarshan, 2018; Li et al. 2014a).

A number of research works have reported that the positive relationships between fluoride with Na^{+}, pH and bicarbonate and normally enhances the fluoride content in groundwater but vice versa with Ca^{2+}, which predicts the content in fluorite soaked groundwater (Yumin Wang, et al., 2019; Adimalla et al. 2018). However, Fig. 1e depicts that the maximum content of EC and TDS is also connected with more fluoride content and the related publications done at various locations and regions (Saxena and Ahmed, 2001; Jabeen, et al., 2016; Adimalla et al. 2018; Subbarao, et al. 2015; Sami, et al., 2016; Yumin Wang, et al., 2019; Anim-Gyampo et al. 2018; Narsimha and Sudarshan 2013). Furthermore, EC and TDS relationship with fluoride is not that much effect as high as other variables during the study period, which reveals that a maximum attraction of fluoride with pH and bicarbonate compared with EC and TDS. The present study reveals that, no significant correlation was found between fluoride and SO_4^{2-}, Cl^-, and K+ but negative correlation with Mg^{2+}. The analytical values shows that the ionic composition added into groundwater is not key sources. Furthermore, it is showed that no noticeable relation exists F^- with NO_3^- (Fig. 1f) as these variables are mix with groundwater from different sources, F^- from geological minerals and NO_3^- from manmade activities.

Phenomenon of rock dominance

Gibbs diagram (Fig. 2) shows that the selected groundwater samples are fall under the rock dominance, which normally generates from the weathering rocks present in beds and also chief process to enhance the fluoride content in groundwater (Sami, et al., 2016; Adimalla and Wu 2019). Analytical results of the groundwater samples also indicates water chemistry and end with evaporation process and none of the sampling location present in the rainfall dominance (Fig. 2). Results indicates, fluoride content enters through leachate with typically comes from rocks like igneous and sedimentary at different layers of the lithosphere also presence of fluoride behaviour minerals. (Kumar et al. 2014; Narsimha and Sudarshan 2013, Jabeen, et al., 2016).

Similar observations found using the Gibbs chart by Gibbs RJ (1970) and other at coastal region of Andhra Pradesh, India (Rao et al. 2017); Worldwide contamination of water by fluoride (Ali et al. 2016); groundwater and associated risk in Vaniyar River basin, Dharmapuri district, Tamil Nadu, India (Jagadeshan et al. 2015); groundwater in parts of eastern India (Patel et al. 2014) and Chimakurthy pluton, Prakasam District, Andhra Pradesh (Reddy et al. 2016) also agreement with to the present study found that fluoride content is related rock dominance plots in Gibbs chart. Similarly, it is also appreciated by the researchers is negative correlation between fluoride and nitrate also predicts fluoride from interaction of rocks not by the manmade activities. Hence, present study reveals that, in the some of the locations requires some treatment for fluoride. The 'Nalgonda' and 'activated alumina' techniques are the most commonly used defluoridation methods of drinking water. But, a suitable, effective, eco-friendly and cost effective, an awareness are given in people regarding fluorosis. The present study also helps find out suitable adsorbent for removal of Fluoride in ground water.

IV. CONCLUSIONS

Assessment of Fluoride distribution and controlling factors Ionic Balance in Ground water of Siruguppa Taluk, Ballari District, and Karnataka, India are reported the conclusions. The fluoride contents ranges between 0.16 to 2.76 mg/L in ground water samples, with minimum value 0.16 mg/L (SWG38) and maximum value 2.76 mg/L (SWG17). 64% of samples indicated fluoride content below 1.0 mg/ L and 20% samples indicated fluoride content in between 1.0 and 2.0 mg/L. Followed by 16% of the samples showed fluoride content ranges above 2.0 mg/L are crossed the suggested maximum limit by WHO and by BIS. Rock–water interaction, leachate formation in the underground and freeing up of ionic minerals have affected the ionic condition of the water. Hence, the chief cause for maximum fluoride in the study area and during the study period is may be due to reaction between rock and water, deficiency of calcium, and alkaline condition of water. The excess of fluoride is occurs in water, then water to be treated with de-fluoridation technique. The technology that is adopted for treatment of fluoride depends on the presence of fluoride content in water and the amount of fluoride to be removed.

V. ACKNOWLEDGEMENTS:

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Table 1 Fluoride content and Ionic balance in sampling locations of Siruguppa Taluk

Sl. No	Sampling Locations	Code	Fluoride (mg/L)
1	Haaglur	SWG-1	1.10
2	Hosahalli	SWG-2	0.61
3	Thallur	SWG-3	0.81
4	Thanavasapura	SWG-4	0.87
5	Konchigeri	SWG-5	0.49
6	Dharur	SWG-6	2.51
7	Karur	SWG-7	2.30

8	Hulluru	SWG-8	2.38
9	Gopula	SWG-9	1.07
10	Byrapura	SWG-10	1.16
11	Sirigeri	SWG-11	0.77
12	Havinahalu	SWG-12	0.93
13	Muddhattanur	SWG-13	0.78
14	Mannur	SWG-14	1.95
15	Mannursugur	SWG-15	2.06
16	Nadahalli	SWG-16	0.97
17	Hungulam	SWG-17	2.76
18	Tekklakote	SWG-18	2.04
19	Nittur	SWG-19	0.80
20	Kenchanagudda	SWG-20	0.97
21	Devasugur	SWG-21	0.66
22	Bagewadi	SWG-22	1.28
23	Huttanur	SWG-23	0.89
24	Budaguppa	SWG-24	0.74
25	K. Belagallu	SWG-25	0.77
26	Byrapur	SWG-26	2.10
27	Upparhosalli	SWG-27	0.62
28	Halekote	SWG-28	0.91
29	Haraganur	SWG-29	0.86
30	Devalapura	SWG-30	0.59
31	Karai	SWG-31	1.10
32	Narangi	SWG-32	0.20
33	Karjiganur	SWG-33	0.45
34	Kuruvalli	SWG-34	1.43
35	Nagalapura	SWG-35	1.91
36	Sridaragadda	SWG-36	0.67
37	Volaballary	SWG-37	1.09
38	Naganahalli	SWG-38	1.18
39	Hagasanur	SWG-39	0.16
40	Kottalakunte	SWG-40	0.85
41	Biranahalli	SWG-41	0.74
42	Chellekuthalur	SWG-42	0.79
43	Siruguppa	SWG-43	0.69
44	Heccholli	SWG-44	1.61
		Minimum	0.2
		Maximum	2.8

Table 2 Ionic Balance, Cation and Anion data from different villages a Siruguppa Taluk

Sl. No	Sampling Locations	Code	Anion				Cation				Ionic Balance		
			Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NO_3	HCO_3	Na^+	K^+	Cation	Anion	Differences ±10%
1	Haaglur	SWG-1	55.0	26.0	191.0	180.0	16.0	201	79.0	3.9	17.90	17.29	1.73
2	Hosahalli	SWG-2	150.0	38.0	226.0	20.0	19.0	236	92.0	1.3	12.98	13.97	-3.67
3	Thallur	SWG-3	80.2	40.0	141.0	7.5	9.0	248	77.0	1.1	17.32	16.01	3.93
4	Thanavasapura	SWG-4	89.0	16.2	104.0	10.0	23.0	196	68.0	0.0	15.92	14.46	4.81
5	Konchigeri	SWG-5	120.4	8.0	189.0	80.0	44.5	242	45.0	14.0	15.43	17.56	-6.46
6	Dharur	SWG-6	28.5	9.4	153.0	100.0	18.0	256	36.0	4.8	14.40	13.45	3.41
7	Karur	SWG-7	32.1	10.2	117.0	210.0	27.0	250	46.0	4.1	15.45	14.83	2.05
8	Hulluru	SWG-8	47.0	17.0	268.0	400.0	59.0	242	81.0	3.4	13.79	12.81	3.68
9	Gopula	SWG-9	67.2	12.1	192.0	306.0	30.0	284	76.0	0.4	14.90	16.38	-4.73
10	Byrapura	SWG-10	34.1	18.0	91.0	235.0	35.0	260	54.0	1.8	16.87	17.00	-0.38
11	Sirigeri	SWG-11	70.5	10.7	36.0	210.0	27.0	164	70.0	1.8	16.75	17.5	-2.19
12	Havinahalu	SWG-12	44.1	39.8	83.0	52.5	19.0	226	79.0	2.4	16.66	15.06	5.04
13	Muddhattanur	SWG-13	136.0	6.9	62.5	10.0	48.0	232	48.0	0.4	18.18	16.66	4.36
14	Mannur	SWG-14	27.3	5.8	36.5	52.5	24.0	186	36.0	2.8	16.82	15.43	4.31
15	Mannursugur	SWG-15	20.4	10.2	90.0	60.0	10.0	216	69.0	9.4	16.06	15.00	3.41
16	Nadahalli	SWG-16	57.3	6.4	180.5	148.0	17.0	235	38.0	9.2	15.07	15.12	-0.17
17	Hungulam	SWG-17	39.6	5.1	117.0	130.0	61.0	282	44.0	2.4	14.71	15.24	-1.77
18	Tekklakote	SWG-18	41.2	5.8	121.0	325.0	42.0	256	34.0	2.0	15.6	17.05	-4.44
19	Nittur	SWG-19	69.3	6.4	147.0	45.0	49.0	302	38.0	3.0	16.17	17.75	-4.66
20	Kenchanagudda	SWG-20	60.1	10.3	129.0	110.0	71.0	294	48.0	2.2	18.10	16.55	4.47
21	Devasugur	SWG-21	40.1	9.4	116.0	92.0	30.0	270	38.0	1.1	22.49	24.95	-5.19
22	Bagewadi	SWG-22	29.6	6.4	123.0	40.0	2.7	288	34.0	0.8	15.27	14.03	4.23
23	Huttanur	SWG-23	32.5	7.2	180.0	150.0	21.0	252	66.0	1.8	13.96	13.83	0.47
24	Budaguppa	SWG-24	42.9	8.4	131.0	270.0	56.0	196	72.0	1.8	17.9	17.29	1.73
25	K. Belagallu	SWG-25	32.1	7.5	39.0	84.0	13.0	302	38.0	10.8	12.98	13.97	-3.67
26	Byrapur	SWG-26	20.0	63.0	100.0	290.0	23.0	246	86.0	1.9	17.90	17.29	1.73
27	Upparhosalli	SWG-27	84.0	41.0	83.0	450.0	24.0	262	98.0	6.0	12.98	13.97	-3.67
28	Halekote	SWG-28	60.0	26.0	129.0	140.0	54.0	284	56.0	1.4	17.32	16.01	3.93
29	Haraganur	SWG-29	40.0	6.2	89.5	41.0	14.0	394	52.0	3.6	15.92	14.46	4.81
30	Devalapura	SWG-30	113.0	42.0	65.0	260.0	21.0	204	40.0	3.4	15.43	17.56	-6.46
31	Karai	SWG-31	70.2	38.0	85.0	210.0	25.0	230	38.0	68.0	14.40	13.45	3.41
32	Narangi	SWG-32	35.3	6.1	137.0	151.6	19.0	318	6.1	36.0	15.45	14.83	2.05
34	Karjiganur	SWG-33	76.2	7.2	110.0	160.0	44.0	260	7.2	84.0	13.79	12.81	3.68
35	Kuruvalli	SWG-34	40.1	4.2	96.0	140.0	36.0	284	4.2	48.0	14.90	16.38	-4.73

36	Nagalapura	SWG-35	176.0	17.2	40.0	12.0	16.0	268	17.2	84.0	16.87	17.00	-0.38
37	Sridaragadda	SWG-36	42.1	4.6	64.5	130.0	41.0	248	4.6	36.0	16.75	17.5	-2.19
38	Volaballary	SWG-37	79.4	7.2	30.0	5.0	44.0	246	7.2	48.0	16.66	15.06	5.04
39	Naganahalli	SWG-38	199.0	41.0	112.0	20.0	41.0	264	41.0	116.0	18.18	16.66	4.36
40	Hagasanur	SWG-39	124.0	36.0	108.0	190.0	52.0	138	36.0	128.0	16.82	15.43	4.31
41	Kottalakunte	SWG-40	120.2	47.0	115.0	100.0	23.0	278	47.0	86.0	16.06	15.00	3.41
42	Biranahalli	SWG-41	79.7	35.4	83.0	65.0	22.0	226	35.4	96.0	15.07	15.12	-0.17
43	Chellekuthalur	SWG-42	94.9	9.6	41.0	19.0	11.0	294	9.6	84.0	14.71	15.24	-1.77
44	Siruguppa	SWG-43	41.7	4.2	46.0	30.0	12.0	284	4.2	68.0	15.6	17.05	-4.44
		Minimum	20.0	4.2	22.0	5.0	2.7	138.0	4.2	34.0	22.49	24.95	5.04
		Maximum	199.0	63.0	268.0	450.0	71.0	394.0	63.0	128.0	12.98	12.81	-6.46

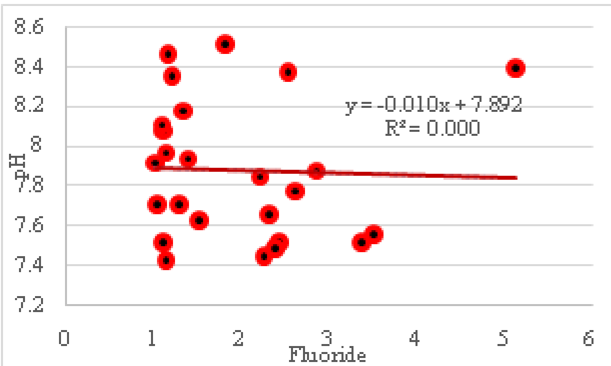

Fig. 1a Correlation between a fluoride and pH

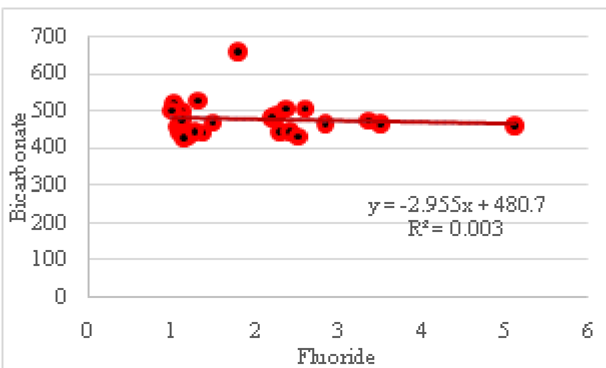

Fig. 1b Correlation between a fluoride and HCO_3

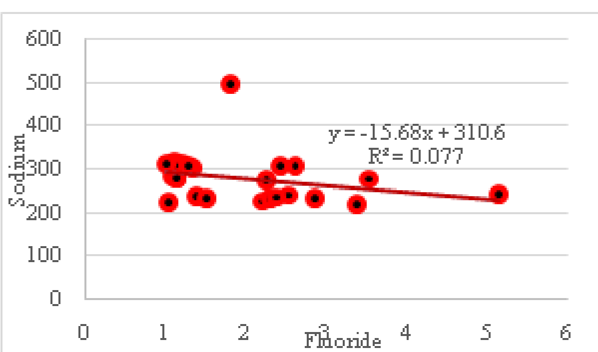

Fig. 1c Correlation between a fluoride and Na^+

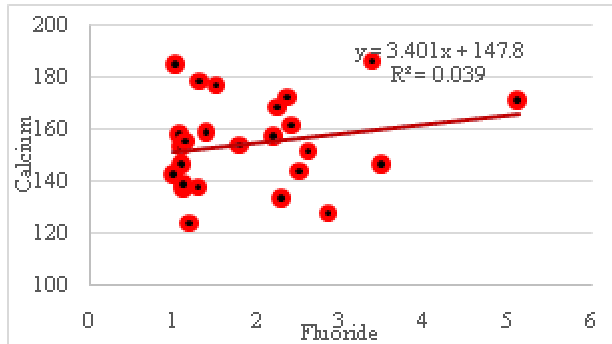

Fig. 1d Correlation between a fluoride and Ca^{2+}

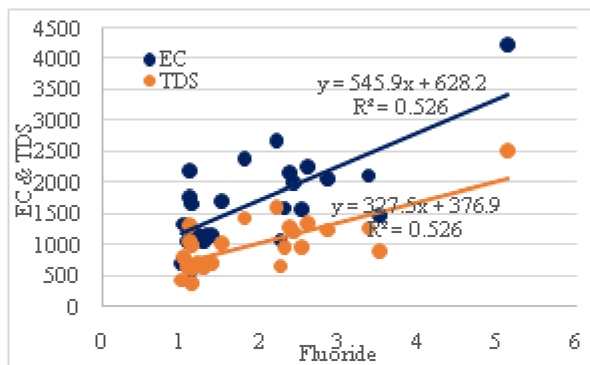

Fig. 1e Correlation between a fluoride and EC&TDS

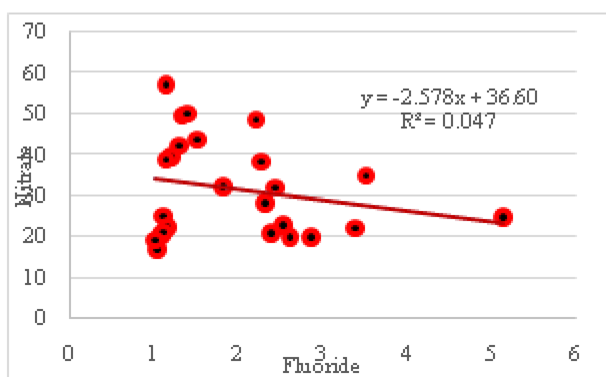

Fig. 1f Correlation between a fluoride and NO_3^-

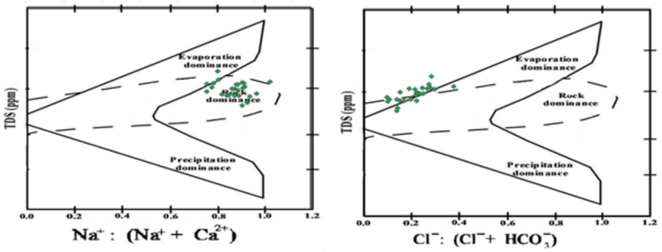

Fig. 2 Gibbs diagram, chemistry of groundwater samples from Siruguppa (Bellary, Karnataka, India

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