www.cafetinnova.org

Indexed in
Scopus Compendex and Geobase Elsevier,
Geo-Ref Information Services-USA, List B of Scientific Journals, Poland, Directory of Research Journals

ISSN 0974-5904, Volume 09, No. 04

International Journal of Earth Sciences and Engineering

August 2016, P.P.1434-1440

Ground Water Quality in the Western Part of Sandur Schist Belt, Karnataka, India

G V GAONKAR[1], J T GUDAGUR[1] AND T K LAKKUNDI[2]
[1]*Department of Geology, Karnatak Science College, Dharwad, Karnataka, India*
[2]*Department of Studies in Geology, Karnatak University, Dharwad, Karnataka, India*
Email: *gaonkargv@gmail.com, jagadishgeo@gmail.com, tejaswi_sh@yahoo.co.uk*

Abstract: Close monitoring of human health reveals prevalence of different forms of fluorosis amongst the inhabitants of a section of western part of the mining-intensive Sandur Schist Belt which can be attributed to consumption of groundwater characterized by excessive concentration of the fluoride ion. Partial physico-chemical analyses of a total of 65 representative water samples collected from the study area has proved the existence of excessive fluoride ranging from 0.10 mg/L to 1.40 mg/L in surface water and from 0.30 mg/L to 3.2 mg/L in groundwater. More than 46% of the samples report fluoride concentration to be in excess of the Global Maximum Permissible Limit (1.5 mg/L) for drinking water. This excessive fluoride concentration, especially in the groundwater, is primarily derived from geogenic sources and can also be partly attributed to deterioration of water quality due to its overexploitation. A clear relation between geology and water quality has been established as indicated by the fact that fluoride concentration in groundwater from granitoid aquifers is higher than in groundwater from other aquifers. Since the area is characterized by recurrence of chronic drought episodes, scant precipitation since decades, near total dependence on groundwater for drinking, excessive concentration of fluoride in groundwater, health problems of dental- and skeletal-fluorosis and associated complexities amongst others are on the rise across age groups of the population. Aforesaid challenges faced by the masses need to be addressed on urgency by adopting measures such as supply of drinking water from the nearby Tungabhadra reservoir as a long-term solution.

Keywords: *Sandur schist belt, Groundwater Quality, Fluoride, Mining, Environment*

1. Introduction

Water is the most abundant material on the earth whereas potable water is not. Greediness as well as carelessness of human nature is costing their forthcoming generation's health, ultimately the life. Over exploitation coupled with reduced recharge has resulted in scarcity of readily usable potable water, thereby spoiling the precious gift of nature.

Quality of groundwater depends on the soluble elements in the water bearing rocks/aquifer, also percolating media [1]. Deterioration of quality of groundwater may be either natural or man-made or a combination of both. The natural factors are geogenic whereas man-made factors include discharging pollutants to water sources, over exploitation, land-use practices etc. Certain elements are very essential for the plants and animals especially for human beings, few of which we procure through water consumption. However, excess concentration of the same might be dangerous to human health.

Fluoride is one such element which is a very essential component for normal growth of bone and teeth [2]. Fluoride exists abundantly in the earth crust [3] and also found in water. However, surface water contains less fluoride compared to groundwater in general. In fact, the concentration of fluoride depends primarily on characteristics of the aquifer and depth. As per WHO Standard for drinking water, fluoride shall be between 1.0mg/L and 1.50mg/L. Less than 0.6 mg/L promotes tooth decay [4]. Concentration of fluoride between 1.5 mg/L to 2.0 mg/L leads to white patches on the teeth or mottled enamel and leads to dental fluorosis [5], concentration between 2 mg/L to 6 mg/L leads to skeletal fluorosis and 6 mg/L to 10 mg/L or more result in crippling fluorosis [6].

Enrichment of fluoride and problems related to fluoride are noticed in the western part of Sandur Schist Belt. This paper deals with the preliminary investigation of water quality of the study area with emphasis on occurrence of excessive fluoride and its impact on the human health.

2. Study Area

The study area is located in parts of western region of Sandur Schist Belt, Bellary District, Karnataka State between latitudes N 14º 58' 35" to N 15º 13' 45" and longitudes E 76º 15' 00" to E 76º 30' 00" [Survey of India toposheets numbered 57 A/8 (D43E8) and 57 B/5 (D43K5)] (Fig. 1). Mariyammanahalli is the only town and 46 villages are located within the study area, and all the villages are well connected by all-weather roads.

The lithological units include granitic gneiss, younger granite, quartzite, migmatites and metavolcanics. Eastern segment of the study area includes part of

Sandur Schist Belt having several mining leases for Iron Ore and western segment is plateau with granitic terrain.

Study area experiences a semi-arid type climate with dry and hot summer. The maximum temperature is experienced during May and the minimum during December month in general. Temperature varies between 22°C and 43°C and the relative humidity of the region varies from 38% to 95%. The climate is influenced by South-West and North-East monsoons. The average annual rainfall of the study area is 870.7mm. It receives about 60.22% of the annual rainfall during South-West monsoon (June-September), 22.21% during North-East monsoon (October-November) and balance 17.57% of rainfall occurs as sporadic in other months of the year [7].

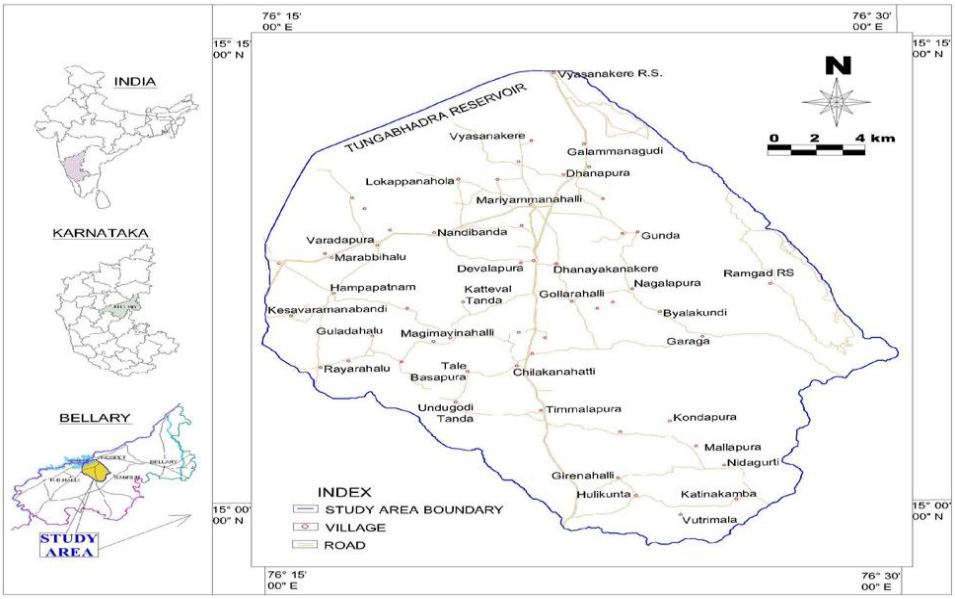

***Fig. 1**: Location Plan*

3. Materials and Methods

Surface water samples from 12 locations and groundwater samples from 53 locations, a total of 65 water samples (Fig. 2) were collected during pre-monsoon 2012 from the study area spread over 455 sq km covering parts of Hospet, Hagaribommanahalli and Sandur Taluks.

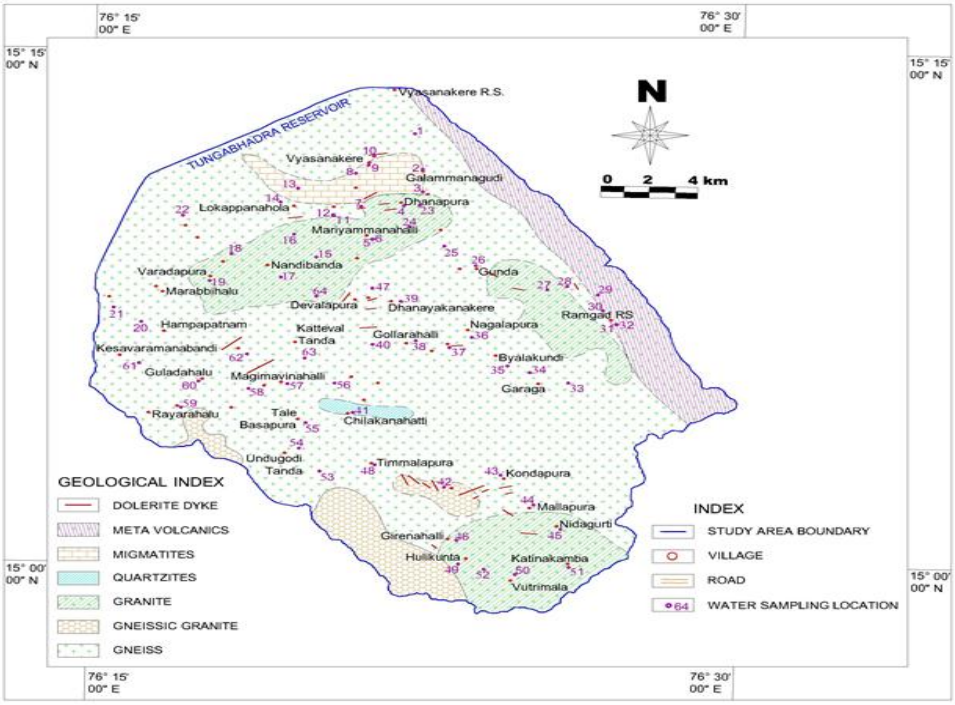

***Fig. 2**: Geological map and location plan of water samples*

Partial physico-chemical analyses were carried-out as per the standard methods of APHA [8, 9] and IS 3025. The physical parameters analyzed on site with mobile kits were Temperature, pH and Electrical Conductivity (EC) while the chemical parameters Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Carbonate (CO_3^{-}), Bicarbonate (HCO_3^{-}), Chloride(Cl^{-}), Nitrate (NO_3^{-}), Sulphate (SO_4^{2-}), Iron (Fe), Manganese (Mn), Fluoride (F^{-}) and Total Hardness (TH) were analyzed in the laboratory.

4. Results and Discussions

The partial physico-chemical analyses results of 65 representative water samples from the study area are presented in Table 1.

***Table 1**: Partial physico-chemical analyses of water samples (Pre Monsoon-2012)*

Sl. No.	Location	Type	PARAMETERS														
			EC	pH	TH	Ca	Mg	Na	K	F	Fe	Mn	CO_3	HCO_3	SO_4	Cl	NO_3
1	Gunda Nursery	BW	1830	7.7	490	56	105	84	0.5	1.8	BDL	BDL	14	326	29	302	BDL
2	Galemmanagudi	BW	2300	7.7	580	44	130	92	4.9	2.1	BDL	BDL	30	410	71	427	2.4
3	Hanumanahalli	BW	2000	7.9	476	26	109	97	1.2	2.0	BDL	BDL	24	426	73	319	7.0
4	Danapura	BW	3000	7.2	820	112	172	96	3.2	1.1	BDL	BDL	BDL	394	130	499	13.2
5	Mariyammanahalli	BW	2900	7.4	568	88	117	104	3.3	1.9	BDL	BDL	BDL	420	93	634	14.3
6	Mariyammanahalli	S	1800	7.8	312	67	60	94	13.3	1.4	BDL	BDL	12	332	1	210	13.7
7	Iyanahalli Cross	BW	470	8.0	100	26	18	48	0.2	1.7	BDL	BDL	10	164	100	17	3.3
8	Venkatapuram Colony	BW	1390	7.6	244	58	45	90	1.2	1.3	BDL	BDL	BDL	330	55	133	12.8
9	TBDam-backwater	BW	870	8.3	244	40	50	56	1.9	1.5	BDL	BDL	18	248	48	58	5.7
10	Vyasanakeri	BW	1130	8.0	332	24	75	65	1.7	1.1	BDL	BDL	18	310	48	58	5.7
11	Ayinahalli-Pond	S	610	8.7	60	16	11	72	6.5	1.0	BDL	BDL	10	128	10	85	0.1
12	Ayinahalli-Tank	BW	710	8.0	180	32	36	55	0.4	1.1	BDL	BDL	6	238	7	61	1.1
13	SLR Quarters	BW	950	7.8	236	48	46	76	0.9	1.4	BDL	BDL	4	296	36	61	7.4
14	Lokappanahola	BW	590	7.8	152	29	30	52	BDL	1.0	BDL	BDL	4	184	23	32	10.2
15	Mariyammanahalli Tanda	BW	2000	7.4	412	106	74	96	0.5	1.0	BDL	BDL	BDL	374	83	271	13.5
16	VSL Agrotech	BW	1540	7.9	232	15	53	94	0.5	1.4	BDL	BDL	12	452	40	133	6.8
17	Nandibanda	BW	980	7.5	244	56	46	78	0.5	1.1	BDL	BDL	BDL	352	26	49	6.6
18	Kenchanahalli	BW	700	7.9	232	51	44	29	0.7	0.8	BDL	BDL	8	156	29	54	13.8
19	Varadapura	BW	960	7.6	300	56	59	57	1.2	1.1	BDL	BDL	4	236	29	80	12.6
20	Hampapatnam	BW	2900	7.2	700	144	135	102	5.4	1.3	BDL	BDL	4	466	53	413	15.6
21	Upanayakanahalli	BW	2000	7.9	452	64	94	99	2.7	1.4	BDL	BDL	20	488	62	278	13.9
22	Ladkanabavi	BW	1030	7.4	240	32	51	87	0.8	1.7	BDL	BDL	10	310	43	84	2.6
23	Danapur-BMM Ispat	S	310	7.3	80	16	16	65	3.3	0.6	0.2	BDL	12	44	46	31	4.3
24	BMM Ispat	BW	570	7.9	224	48	43	51	1.0	1.5	BDL	BDL	20	130	26	66	0.7
25	Gunda Road Junction	S	164	7.0	68	19	12	33	2.3	0.4	0.1	BDL	4	24	44	22	3.7
26	Gunda Village	BW	1270	8.3	212	24	46	87	5.0	1.6	BDL	BDL	12	318	36	156	3.5
27	Gunda Village	BW	1650	8.1	340	112	55	86	2.3	1.8	BDL	BDL	22	282	38	239	3.6
28	Ramgad Railway Station	S	163	7.1	52	14	9	61	1.9	0.1	0.2	BDL	4	36	29	29	12.7
29	Ramgad Railway Station	S	90	6.0	40	10	7	8.6	5.8	0.1	0.3	BDL	4	30	29	29	BDL
30	Ramgad Railway Station	S	162	6.6	76	16	15	57	6.2	0.2	0.2	BDL	8	16	27	17	5.2
31	Ramgad Railway Siding	S	100	6.2	52	10	10	26	4.2	0.3	0.2	BDL	4	18	31	8	2.6
32	Ramgad Railway Siding	S	164	6.6	60	14	11	6.8	8.7	0.1	0.2	BDL	10	40	33	13	1.0
33	Ramgad Railway Siding	BW	260	7.9	76	18	14	20	2.8	1.1	BDL	BDL	4	116	4	17	BDL
34	Garag	BW	920	7.7	320	54	65	54	2.8	0.5	BDL	BDL	12	248	30.5	85	3.9
35	Garag	S	930	7.5	196	48	36	66	0.6	0.7	BDL	BDL	BDL	100	5	172	1.0
36	Bayalakundi	BW	860	8.0	244	66	43	64	28.0	2.4	BDL	BDL	20	280	43	66	0.1
37	Nagalapura	BW	710	7.8	144	26	29	61	2.2	0.8	0.1	BDL	16	238	20	46	0.4
38	NagalapuraTanda	BW	1460	7.8	300	92	51	86	0.4	1.6	BDL	BDL	4	258	87	152	13.9
39	Gollarahalli	BW	1160	7.7	240	70	41	86	3.0	1.4	BDL	BDL	28	314	58	94	17.1
40	Danayakanakere	S	450	7.8	100	24	18	40	0.3	0.6	BDL	BDL	20	130	20	37	1.2
41	Daba-Gollarahalli Cross	BW	1410	7.6	320	76	59	85	6.2	0.5	BDL	BDL	10	270	72	181	6.6
42	Chilakanakatti	BW	540	8.4	180	44	33	25	0.5	0.3	BDL	BDL	14	186	11	37	5.0
43	Potalakatte	BW	1900	8.2	136	16	29	103	0.8	1.7	BDL	BDL	34	636	45	191	8.5
44	Kondapura	BW	1490	7.9	360	90	66	87	0.5	1.6	BDL	BDL	30	320	79	152	19.1
45	K.Mallapura	BW	930	7.6	240	72	41	87	0.5	2.8	BDL	BDL	30	190	79	90	21.0
46	Nidagurti	BW	850	7.9	226	64	39	58	2.0	1.8	BDL	BDL	20	208	44	80	9.5

47	Girenahalli	BW	1630	8.0	184	34	36	99	2.3	3.1	BDL	BDL	24	386	44	104	11.7
48	Devalapura Cross	BW	1400	7.7	260	43	53	89	0.4	2.9	BDL	BDL	24	296	26	75	9.7
49	Timmalapura	BW	2800	7.3	396	43	86	116	0.9	2.4	0.2	BDL	24	542	37	210	20.7
50	Hulikunta	BW	1630	7.8	208	30	43	94	4.2	3.2	BDL	BDL	28	444	28	94	1.4
51	Vutrimala	BW	1110	8.0	128	32	23	93	1.0	2.5	BDL	BDL	24	320	27	172	3.0
52	Kattinakamba	BW	1150	7.2	272	71	49	92	0.9	2.7	BDL	BDL	16	244	57	209	13.0
53	Vutrimala	S	700	7.6	100	32	17	83	4.2	1.2	0.2	BDL	12	160	33	152	1.3
54	TalebasapuraTanda	BW	1560	7.7	112	22	22	99	3.0	3.1	BDL	BDL	26	418	42	162	11.3
55	UndugodiTanda	BW	860	7.7	200	43	38	73	1.3	1.0	BDL	BDL	20	284	25	21	8.6
56	Talebasapura	BW	2000	7.8	428	56	90	99	1.2	1.2	BDL	BDL	28	352	34	94	9.7
57	Pampapatna	BW	1280	7.8	148	16	32	96	0.2	1.9	BDL	BDL	24	332	34	94	9.7
58	Magimavinahalli	BW	760	8.1	100	16	20	88	0.3	1.7	BDL	BDL	16	264	16	42	14.2
59	Halagapura	BW	1150	8.3	280	40	58	35	0.6	1.5	BDL	BDL	22	268	18	127	5.8
60	RayarahaluTanda	BW	2200	7.3	488	72	101	97	0.6	1.3	0.1	BDL	16	372	25	349	14.7
61	Guledahalu	BW	1110	7.8	240	24	52	93	3.4	2.8	0.1	BDL	32	386	20	56	11.4
62	Kesavaramanabandi	BW	910	7.5	200	45	38	66	1.0	0.7	BDL	BDL	18	228	25	75	3.8
63	YesapuraTanda	BW	1020	8.3	160	22	34	93	0.6	2.0	BDL	BDL	46	342	27	56	1.6
64	Katteval Tanda	BW	1920	8.0	280	32	60	87	3.0	1.9	BDL	BDL	18	352	38	268	0.1
65	Devalapura	BW	850	7.5	80	32	12	87	0.3	2.1	BDL	BDL	12	278	19	46	BDL

BW=Borewell Water, S=Surface Water, EC=Electric Conductivity (µm hos/cm), TH=Total Hardness as $CaCO_3$, Ca=Calcium as Ca (mg/L), Mg=Magnesium as Mg (mg/L), Na=Sodium as Na (mg/L), K=Potassium as K (mg/L), F=Fluoride as F (mg/L), Fe=Iron as Fe (mg/L), Mn=Manganese as Mn (mg/L), CO_3=Carbonates as CO_3 (mg/L), HCO_3=Bi-carbonates as HCO_3 (mg/L), SO_4=Sulphates as SO_4 (mg/L), Cl=Chlorides as Cl (mg/L), NO_3=Nitrates as NO_3 (mg/L), BDL=Below Detectable Limit (Na=1.0 mg/L, K=1.0 mg/L, F=0.1 mg/L, Fe=0.1 mg/L, Mn=0.02 mg/L, NO_3=0.1 mg/L).

Comparisons of the results with WHO Standards [10], IS:10500 Standards [11, 12] and CPCB Standards for drinking water are presented in Tables 2, 3 and 4 respectively.

Table 2: *Comparison of results of partial physico chemical analyses with WHO Standards:*

Sl. No.	Parameter	Concentrations of ions (mg/L)			WHO Standards (2004) (mg/L)		Percentage of samples exceeding permissible limit
		Min.	Max.	Average	Desirable limit	Permissible limit	
1	EC	90	3000	1187.89	-	-	-
2	pH	6.0	8.7	7.68	6.5	8.5	1.54
3	TH	40	820	248.55	100	500	6.15
4	F	0.1	3.2	1.45	-	1.5	46.15
5	Fe	BDL	0.30	-	-	0.1	12.31
6	Mn	BDL	BDL	-	-	-	-
7	Ca	10	144	45.2	75	200	-
8	Mg	7	172	49.42	50	150	1.54
9	Na	6.80	115.6	73.86	-	200	-
10	K	BDL	28	2.69	-	-	-
11	Cl	8	634	133.45	200	600	1.54
12	SO_4	1	130	40	200	400	-
13	NO_3	BDL	21	7.85	45	-	-
14	CO_3	BDL	46	16.61	-	-	-
15	HCO_3	16	636	272.9	-	-	-

Table 3: *Comparison of results of partial physico chemical analyses with IS 10500 Standards*

Sl. No.	Parameter	Concentrations of ions (mg/L)			IS 10500 Standards (1991) (mg/L)		Percentage of samples exceeding permissible limit
		Min.	Max.	Average	Desirable limit	Permissible limit	
1	EC	90	3000	1187.89	-	-	-
2	pH	6.0	8.7	7.68	6.5	8.5	1.54
3	TH	40	820	248.55	300	600	3.08
4	F	0.1	3.2	1.45	1.0	1.5	46.15
5	Fe	BDL	0.30	-	0.3	1.0	-
6	Mn	BDL	BDL	-	-	-	-

7	Ca	10	144	45.2	75	200	-
8	Mg	7	172	49.42	30	100	10.77
9	Na	6.80	115.6	73.86	-	-	-
10	K	BDL	28	2.69	-	-	-
11	Cl	8	634	133.45	250	1000	-
12	SO_4	1	130	40	200	400	-
13	NO_3	BDL	21	7.85	45	45	-
14	CO_3	BDL	46	16.61	-	-	-
15	HCO_3	16	636	272.9	-	-	-

Table 4: *Comparison of results of partial physico chemical analysis with CPCB[#] Standards*

Sl. No.	Parameter	Concentrations of ions (mg/L)			CPCB Standards (mg/L)	Percentage of samples exceeding standard limit
		Min.	Max.	Average		
1	EC	90	3000	1187.89	2000	9.23
2	pH	6.0	8.7	7.68	6.5-8.5	1.54
3	TH	40	820	248.55	600	3.08
4	F	0.1	3.2	1.45	1.5	46.15
5	Fe	BDL	0.30	-	1.0	-
6	Mn	BDL	BDL	-	-	-
7	Ca	10	144	45.2	200	-
8	Mg	7	172	49.42	100	10.77
9	Na	6.80	115.60	73.86	-	-
10	K	BDL	28	2.69	-	-
11	Cl	8	634	133.45	1000	-
12	SO_4	1	130	40	400	-
13	NO_3	BDL	21	7.85	100	-
14	CO_3	BDL	46	16.61	-	-
15	HCO_3	16	636	272.9	-	-

[#] Central Pollution Control Board

EC=Electric Conductivity (µm hos/cm), TH=Total Hardness as $CaCO_3$, Ca=Calcium as Ca (mg/L), Mg=Magnesium as Mg (mg/L), Na=Sodium as Na (mg/L), K=Potassium as K (mg/L), F=Fluoride as F (mg/L), Fe=Iron as Fe (mg/L), Mn=Manganese as Mn (mg/L), CO_3=Carbonates as CO_3 (mg/L), HCO_3=Bi-carbonates as HCO_3 (mg/L), SO_4=Sulphates as SO_4 (mg/L), Cl=Chlorides as Cl (mg/L), NO_3=Nitrates as NO_3 (mg/L), BDL=Below Detectable Limit (Na=1.0 mg/L, K=1.0 mg/L, F=0.1 mg/L, Fe=0.1 mg/L, Mn=0.02 mg/L, NO_3=0.1 mg/L).

The standard of EC prescribed for drinking water is 2000 µmhos/cm as per CPCB guidelines. EC of the water samples from the study area varies from 90 to 3000 µmhos/ cm with an average value of 1187.89 µmhos/cm and out of which 6 samples exceed the prescribed limit.

The pH value of the water samples in the study area varies from 6.0 to 8.7 and the average is 7.68 which indicate that the water in the study area is slightly acidic to alkaline. The slight acidic nature may be attributed to the anthropogenic activities like sewage disposal and use of fertilizers. The pH limit for drinking water is specified from 6.5 to 8.5 whereas out of 65 samples 2 samples fall below the prescribed limit, one sample falls above the prescribed limit and rest all are within the prescribed limit. In general, pH of groundwater of the study area is within the specified limits of WHO, IS 10500 and CPCB.

Desirable limit of Total Hardness is 100mg/L and maximum permissible limit is 500mg/L as per WHO standards. The Total Hardness of water samples from the study area ranges between 40 and 820 mg/L with an average of 248.55 mg/L and 4 water samples exceeds the maximum permissible limit.

Calcium concentration in the water samples of study area ranges between 10 and 144 mg/L with an average of 45.2 mg/L. All the water samples are well within the permissible limit of Calcium (WHO 2004). Similarly, the Magnesium concentration ranges between 7.29 mg/L and 172.04 mg/L with an average of 49.42 mg/L. The highest desirable limit as per WHO 2004 is 150mg/L and only one sample exceeds this limit.

The Sodium concentration in water samples varies between 6.80 and 115.60 mg/L and all are in prescribed safe limit of 200 mg/L for drinking water (WHO 2004).

According to WHO standards, the maximum permissible limit of Potassium in drinking water is 12 mg/L. Concentration of K ranges from below detectable level to 28 mg/L and only 2 samples show higher concentration.

The desirable limit of Sulphate is 400mg/L (WHO 2004) and all the samples collected fall under the desirable limit. Sulphate concentration varies from 1 mg/L to 130 mg/L and an average of 40 mg/L. The concentration of Nitrate varies from BDL to 21 mg/L whereas the WHO and BIS acceptable limit is 45 mg/L. Hence all the samples are within the permissible limit.

The Chloride concentration in water samples ranges between 8 and 634 mg/L with an average of 133.45 mg/L. Acceptable limit of the chloride in drinking water as per IS standard is 250mg/L and 10 samples are exceeding this limit.

Iron and Manganese concentrations are below detectable level in most of the water samples. Few surface water samples and bore well water samples show concentration between 0.1 mg/L to 0.3 mg/L which is also within the permissible limits of IS 10500 and CPCB. However, as per the WHO standards only 12.31% of the water samples exceed the permissible limit of iron.

The Fluoride concentration varies from 0.1 to 3.2 mg/L with an average of 1.45 mg/L. The safe limit is 1.5 mg/L and 30 samples exceed this limit. Towards southern part of the study area viz., Hulikunta, Girenahalli, Katinankamba villages shows highest concentration where the granitic terrain is observed. It is also important to note that, pH value is also more than 7.2 where the fluoride exceeds 1.5 mg/L. It was noticed during the survey that health problems of dental- and skeletal-fluorosis and associated complexities amongst others are on the rise across age groups of the population. Incidences of mottled enamel/dental fluorosis are quite common and many cases of bone deformations in the form of knock-knee syndrome were observed (Fig. 3).

Fig. 3*: Effect of excess Fluoride on human health*

5. Conclusions

The partial physico-chemical analysis of representative water samples from the study area reveals that, other than TH, Fe and F all other parameters are within the permissible limits as per WHO standards in most of the samples. However, 46.15% of water samples show higher concentration of Fluoride, 12.31% of water samples show higher concentration of Fe, 6.15% of water samples show higher concentration of TH and 1.54% of water samples show higher concentration of Mg, Cl & pH.

As per IS 10500 standards for drinking water, 46.15% of water samples show higher concentration of Fluoride, 10.77% of water samples show higher concentration of Mg, 3.08% of water samples show higher concentration of TH and 1.51% of water samples exceeds pH limit.

As per CPCB standards for drinking water, 46.15% of water samples show higher concentration of Fluoride, 10.77% of water samples show higher concentration of Mg, 9.23% of water samples exceeds the standard limit of EC, 3.08% of water samples show higher concentration of TH and 1.51% of water samples exceeds pH limit.

The excessive fluoride concentration, especially in the groundwater, is primarily derived from geogenic sources and can also be partly attributed to deterioration of water quality due to its overexploitation. Possible fluoride bearing minerals in the granitic aquifers of the study area are like fluorite, apatite, and mica amongst others.

A clear relation between geology and water quality has been established as indicated by the fact that fluoride concentration in groundwater from granitic aquifers is higher than in groundwater from other aquifers (ref. Fig.2 and Table 1).

Near total depend on groundwater for drinking as the area is characterized by recurrence of chronic drought episodes, scant precipitation since decades. Excessive concentration of fluoride in groundwater and accumulation of trace elements like Fe and Mn as a result of intense mining, health problems of dental- and skeletal-fluorosis and associated complexities amongst others are on the rise across age groups of the population.

6. Recommendations

Aforesaid challenges faced by the masses needs to be addressed on urgency by adopting measures such as;

1) Alternate water sources: Supply of drinking water from the nearby Tungabhadra reservoir as a long-term solution,
2) Defluoridation: Water purification technologies for removal of excess fluoride based on the principles of adsorption, ion exchange, precipitation etc,
3) Treatment of water with Tamarind pulp, Lime/Calcium Carbonate, Tulsi etc will help to reduce the concentration of fluoride.
4) Rain water harvesting will also reduce the concentration of fluoride in ground water,
5) Vitamin C and Calcium intake is directly associated with reduced risk of fluorosis.

In addition to the above, awareness about quality of water, its effect of pollution on human health and responsibility of public to safeguard the sources of water is very much essential.

References

[1] S.Z.Jadhav and S.Bogawar – Fluoride in Environmental Compartments – International Journal of Advanced Research (2014), Volume 2, Issue 3, 629-636.

[2] Bell MC and TG Ludwig (1970) The supply of fluoride to man; ingestion from water, fluorides and human health, WHO Monograph series 59, World Health Organization, Geneva.

[3] Kumar A and Kumar V – Fluoride contamination in drinking water and its impact on Human Health of Krishnganj, Bihar, India – Research Journal of Chemical Sciences, Vol.5(2), 76-84, February 2015.

[4] WHO, 2004, Guidelines for drinking water quality, Third Edition, World Health Organization, Geneva.

[5] Apambire WB, Boyle DR and Michel FA, Environmental Geology, 33 (1997) 13.

[6] WHO, Fluorides and human health, Monograph series, (1970), WHO, Geneva.

[7] Macro-level environmental Impact Assessment Study Report of Bellary District, Karnataka – Indian Council of Forestry Research and Education, Dehradun.

[8] APHA 1985, Standard Methods for Examination of waters and waste waters. 19thEdn, Washington, D.C.

[9] 20th ed. New York: American Public Health Association; 1998. APHA. Standard methods for the examination of water and waste water.

[10] WHO. (2004-2012) Guidelines for Drinking water Quality. World Health Organisation, Genewa.

[11] BIS1991.Indian Standard Drinking water Specifications (IS 10500-1991).

[12] Drinking Water – specification (second revision - IS 10500:2012), Bureau of Indian Standards.

[13] Groundwater information booklet – Bellary District, Karnataka State. CGWB, Govt. of India Ministry of Water Resources.

[14] B.P. Radhakrishna, (2006) Ground Water in Karnataka, Geological Society of India, Bangalore.

[15] Jagadeesh T. Gudagur (2002) - Hydrogeological studies with special reference to fluoride incidence and its environmental impact analysis of Doddahalla watershed, Gadag District, Karnataka State, India.

[16] Lavanya G. Hegde (2004) - Studies on the surface and sub-surface water pollution and its environmental impact in parts of Sandur-Hospet Mining Sector, Bellary District, Karnataka, India.

[17] C. Singaraja et.al., (2014) – Geochemical evaluation of fluoride contamination of groundwater in the Thoothukudi District of Tamilnadu, India.

[18] AV Ganesha et.al., (2013) – Fluoride content in groundwater of Pandavapura Taluk, Mandya District, Karnataka.