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FLUORIDE TOXICITY ON HUMAN HEALTH FROM WATER RESOURCES AVAILABLE AT GRANITE MINE IN BAGALKOT DISTRICT, KARNATAKA, INDIA.

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ABSTRACT

Physico-Chemical analysis of ground water samples was carried out from 30 locations of Bagalkot district such as Hungund, Badami, Ron, Kustagi and Bagalkot taluks. The analysis of different parameters such as pH, EC, TDS, Cl, SO_4, NO_3 and Fluoride were carried out as per the standard methods. All the parameters studied were within the permissible limit except Fluoride content in few locations. The analyzed results indicate the Fluoride concentration in some sampling spots namely Herur, Kesarabhavi, Benekanadoni, Balakundi, and Husur of Hunagund Taluk. Maradi village, Budanagad locations of Badami Taluk. Hanumasagar, Hanumanal villages of Kustagi Taluk. Tulasigeri, Simikeri (Govt. Primary School Campus) of Bagalkot Taluk, were found above standards (WHO- 1.0 ppm to 1.5 ppm) probably due to seasonal variations and salt water contamination. Fluoride ion in water sources is known for both beneficial and detrimental effects on live stock. The higher concentration of Fluoride in ground water causes a disease called "Fluorosis". It is a slow, progressive, crippling malady, which affects every organ, tissue and cells in the body system and results in health complaints having overlapping manifestations with several other diseases like chronic dental and skeletal Fluorosis.

Keywords: fluoride toxicity, human health, granite mining, fluorosis effect on body organ, genetic material.

INTRODUCTION

Fluoride occurs in combined state, it is present naturally in almost all foods and beverages including water, but levels of which can vary widely. Fluoride in drinking water to adjust concentrations in between 0.8 ppm to 1.0 ppm for the beneficial effect of teeth decay prevention. The Fluoride accumulation of ground water varies according to the source of water, area with semi-arid, climate, crystalline rock and alkaline soils of the area. The types of rocks composition of the host rock that water flows through and amount of rain fall are mainly affected[1]. Fluoride is a geochemical contaminant and natural sources account for most of the Fluoride in surface and ground water[2]. Its concentration is dependent on solubility of Fluoride containing rocks.

Fluoride ion in drinking water is known for both beneficial and detrimental effects on health. World Health Organization and Indian council of Medical Research described the drinking water quality guidelines values for Fluoride is 1.5 ppm (Guidelines for drinking water quality International Standards for drinking water[3,4]. Low content ratio of Fluoride provides protection against dental caries, especially in children. In India around 60 million people including children were severely affected by Fluorosis because of high consumption of Fluoride content[5]. Longer exposure to Fluoride leads to certain types of bone diseases, mottling of teeth-enamel, nervous and skeletal disorder[6]. It also adversely affects the foetal cerebral function and neurotransmitters[7].

The number of people getting affected, meanwhile villages, blocks, districts and states endemic for Fluorosis have been steadily increasing ever since the disease was discovered in India during 1930s. The reason for the increase in the disease incidence and the sizeable number of locations being identified as endemic zones for Fluorosis is due to overgrowth of population, necessitating more and more water,

resorting to the use of hand pump water, unawareness regarding the importance of checking water quality especially for Fluoride content and due to water shortage. The agencies responsible for water supply (Municipal authorities) resort to pumping water from open wells bore wells to overhead tanks or direct supply to residents, and invariably such water sources are not tested for Fluoride[8].

Keeping in view of the above, the present investigation under taken to assess fluoride concentrations in water resources available around granite mining and various adverse effects on human health by estimating fluoride level in drinking water, identification of exact geographical locations which are having high concentration of fluoride in water, toxicity of fluoride due to the consumption of drinking water in the area of Bagalkot district of Karnataka state in India, especially in Hunagund, Ilakal, Badami and Bagalkot Taluk.

The main objectives of this research work was to investigate the various aspects of fluoride and its importance in human life, as well as fluorosis effect on young and old men and women alike. This investigation may help in bringing awareness about fluorosis diseases to the public residing in that affected area.

EXPERIMENTAL

Material and Methods

Water samples were collected from 30 locations from various villages in and around Bagalkot district. All the samples were stored at 25^{o}C and analyzed by using a fluoride selective electrode (Thermo Scientific Arian, Combination Fluoride Electrode No. 9609 BNWP) as per the prescribed standard methods[9,10]. All the Physico-chemical parameters were measured in accordance with standard methods[11,12]. While collection of water samples, the temperature was recorded by 110th thermometer. All the Chemicals and reagents such as sodium fluoride, zyrconyl chloride, 3-alizerin sulphuric acid, ammonium acetate and other compounds used were of analytical grade. Double distilled water was used for preparing the required reagents and solutions.

Nitrate present in the water resources was measured by ion selective electrode method using digital ion-pH meter (Elico equipments pvt. Ltd., India) by taking known volume (25 ml) of water sample in 100 ml beaker and equal volume of buffer solution for total ionic strength adjustment was added and stirred for 1 minute. The electrode was immersed, recorded the readings when stable. pH, EC, TDS and other chemical parameters of water samples were also measured by electrode method. The chloride, alkalinity, total hardness, calcium, magnesium and sulphur in the form of sulphate were determined by titrimetric methods and turbidity methods[13].

All the parameter values were recorded in Tables-1 to 5, in different three seasons–during 2014–2015. These values were compared with the drinking water standards (table 6) of Bureau of Indian standards and World Health Organization for evaluation of Physico-chemical parameters, Nitrate ions and fluoride concentration in the water samples of the different locations were measured.

RESULTS AND DISCUSSION

It was observed that the water table depth found approximately in between 8 – 10 meters (in the selected locations based on the enquiry from the local people). All the 30 water samples being using for domestic purposes by the public were analyzed their quality parameters such as pH, EC, TDS, Cl, SO_4, nitrate and fluoride concentrations of the selected villages such as Belakundi of Hunagund Taluk, where the drinking water is supplying by the municipal board or by punchayat committee, through the water storage tanks. In addition to this the public of this area is also depended upon bore wells. But, in all locations, the water resources contaminated with the maximum fluoride concentration was noticed throughout the monitoring periods.

Temperature

The temperature of water is an important parameter because it effects bio-chemical reactions in aquatic organisms; rise in temperature reduces the solubility and amplifies the tests and odors. Hence, during summer days, DO values of water slightly decreases, the temperature of water and DO values are quite related. If the temperature of water reaches to 28^{o}C to 29^{o}C, the CO_2 gas begins to dissolve in water.

Hence, water turns to acidic and forms carbonic acid, as a result the pH of water changes. The alteration in pH of water is accompanied by change in other physicochemical aspects of the medium.
The study area of Hunagund and Ilakal is covered by granite. The area is semi-arid with subtropics climate conditions. The temperature varies in these locations 27.5°C to 29.8°C. The temperature of water samples were collected from the residential colonies situated in Bagalkot, Badami, Kustagi, Koppal and Ron in all three seasons were ranges in between 27°C to 29.0°C.

pH (Power of Hydrogen)
The pH is an important index of hydrogen ion activity and is resulting value of acid-base interaction of number of mineral and organic components in water. The pH is an important ecological factor used universally to express the intensity of acid and alkaline condition of the water samples. Most of the water samples in the present investigation were slightly alkaline in nature (pH 7.2 to 7.8) due to the presence of carbonates [CO_3] and bicarbonates [HCO_3]. Thus the pH values determine the equilibrium between free CO_2, CO_3 and HCO_3.
In the study locations like Cholachagudda village of Badami, Hanumanal and Hanumsagar villages of Kustagi, Kalliganur of Ron, the pH values of water samples ranges in between 6.8 to 7.1. Whereas the water samples collected from Belakundi, Herur and Benakanadoni of Hunagund, the pH values were found to be 8.1, 7.8 and 7.8 respectively. Hence, the water is alkaline in nature due to the presence of CO_3 and HCO_3. The pH values more than 7.0 in water samples reflect contamination of bases like sodium hydroxide and calcium hydroxide[14,15]. Nevertheless, no acidic water found around the granite mining.

Electrical Conductivity (EC)
It is an important parameter for determining the water quality for drinking and agricultural purposes. Many dissolved substances may produce an esthetically displeasing color, taste, odor and salinity conditions in water samples. It signifies the amount of total dissolved solids. The higher EC values in water samples indicate the presence of high amount of total inorganic substances in ionized state. EC value is always correlated with TDS found in water and EC is an indicator of degree of mineralization of water. In the present investigation the EC values ranged in between 0.746 m mhos/cm to 2.961 m mhos/cm in Hunagund locations of Bagalkot district, 1.460 m mhos/cm to 1.882 m mhos/cm in Kustagi Taluk of Koppal district, 0.486 m mhos/cm to 1.240 m mhos/cm found in the locations of Ron Taluk of Gadag district and EC values found in between 1.419 m mhos/cm to 1.747 m mhos/cm in Badami Taluk of Bagalkot district. Except Ron locations the EC values of all locations of water samples found slightly higher than the permissible limit (1.4 m mhos/cm) indicates the presence of maximum total dissolved solids in water samples of Hunagund, Kustagi and Badami taluks. Whereas the EC values of Ron taluk found within the legal limit prescribed by the international standards.

Total Dissolved Solids (TDS)
Total dissolved solids are one of the desirable parameters of water for drinking purpose. The TDS values of water samples were measured by using Elico TDS meter. TDS indicates the salinity behavior of ground water. Water containing more than 500 ppm of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 ppm is also allowed. In the present investigation the TDS values of Hunagund locations ranged in between 354 ppm to 1524 ppm the minimum TDS values found in the ground water of Hosur village, where as the maximum TDS values found in Herur village of the same Taluk. The TDS values 1127 ppm, 1071 ppm, 1081 ppm and 1217 ppm found in the bore well water samples of Chinnapur, Kesarabhavi, Mahanthpur and Tumba villages of Hunagund Taluk respectively, the water will give threat on the health of human and other beings. in case of Ron Taluk (Kuntoji, Gajendragad and Kalliganur villages) the TDS values of ground water samples found below the prescribed limits recommended by the WHO and ISI standards. TDS values in case Kustagi and Badami locations found slightly more than 500 ppm. People of this area are asked to use the water for drinking purposes after RO purifications.

Chloride (Cl)

Chloride serves as an indicator of pollution by sewage and industrial effluents. Chloride occurs in all ground waters, but in widely varying concentrations. Excessive chloride in potable water is not particularly harmful; however, chloride in excess (more than 250 ppm) imparts a salty taste to water. People accustomed to higher chloride in water are subjected to laxative effects. In the present investigation the chloride values ranged from 28.5 ppm to 37.8 ppm in the case of Kustagi Taluk of Koppal district. 26.6 ppm to 35.6 ppm found in Ron Taluk of Gadag district, and 27.6 ppm to 36.9 ppm from the water resources available in Badami Taluk of Bagalkot district. The maximum chloride concentration found in between 31.8 ppm to 54.5 ppm this is because of granite mines available around Hunagund Taluk of Bagalkot district.

Sulphate (SO_4)

Sulphate in the water samples is depending upon the nature of the soils. Each and every water resources consist with sulphate in varying ranges. It is known that the sulphate concentration in water samples around 1000 ppm has Laxative effect and causes gastrointestinal irritation. Excess sodium sulphate in water causes Cathartic action. The high concentration of Na and $MgSO_4$ is associated with respiratory illness. In the present investigation sulphate concentration in Hunagund locations found in between 28.6 ppm 63.5 ppm where as in Badami locations the sulphate concentration ranged in between 25.2 ppm to 56.3 ppm. The higher concentration of sulphate in Hunagund area due to granite rocks, iron and manganese ores. The sulphate concentration in the study area of Kustagi, Ron and Badami found less than the prescribed legal limits (WHO: 150 ppm to 250 ppm).

Nitrate (NO_3)

The water samples having Nitrate concentration below 22.5 ppm is said to be safe for agriculture uses, but higher than 22.5 ppm showed increasing problems on food products and vegetations. Thus, water from various locations whose Nitrate concentrations more than 22.5 ppm will be appeared to have gone in the increasing problem zone for agricultural purposes with regard to Nitrate concentrations. This is possibly due to unrestricted use of nitrogenous fertilizers in agricultural practices in the areas.

The analysis report reveals the Nitrate concentration is water samples collected from the locations of Hunagund of Bagalkot district found in between 14 ppm to 21.3 ppm. Where as in the locations of Badami and Ron range in between 11 ppm to 20.3 ppm and 12.3 ppm to 19.8 ppm respectively. Kustagi Taluk of Koppal district found Nitrate ion concentration 102 ppm to 18.9 ppm, all the vales were found within the prescribed legal limits.

Fluoride (F)

The major sources of Fluoride in ground water are fluoride bearing rocks such as fluorspar, Cryolite, Fluorspatite, granite rocks and hydroxyl apatite. Fluoride has widely been in the focus of public and scientific interest because of their important physiological role in the health of a man[16]. It is high time that an affordable solution should be found to minimize the fluoride contamination for maintaining the good health of the large population of the Hunagund, Ilakal, Bagalkot region of study area there is urgent need to carry out studies on hydro-chemical and hydro-geological aspect of occurrence of fluoride which can be useful to mitigate Fluorosis in the study area. Defluoridation tanks should also be installed in the villages which having high exposure of fluoride concentration in ground water resources where using for drinking purposes.

In the present investigation of water samples of Hunagund, Badami, Ilakal of Bagalkot district, Kustagi and Ron taluks in and around Bagalkot district out of 30 water samples 8 samples contained more Fluoride concentrations (above 2.4 ppm), the 7 water samples contained Fluoride concentration within the range of 1.5 ppm, and 4 water samples of study area consists with Fluoride concentration less than prescribed standard limit. The Fluoride concentration in the water samples of the villages such as Herur, Kesarabhavi, Benakanadoni Hosur and Balakundi of Hunagund taluk of Bagalkot district found in between 1.523 ppm to 2.433 ppm (Figures-1 and 3). Fluoride concentration in the ground water resources

of Hanumasagar, Hanamanal villages of Kustagi Taluk found in between 1.524 ppm to 1.451 ppm (Figure-4). The least Fluoride concentration fond in the ground water resources of Jalihal, Belur and Cholachagudda villages of Badami Taluk in the Bagalkot district (Figure-2).

Picture-1: Dental Fluorosis caused by the uses of fluorinated bore water resources from Benakanadoni, Balakundi villages of Hunagund and Budangud village of Badami taluk.

Picture-2: Skeletal Fluorosis affected every organ of the body system (tissue, mental and nerves system) which results in health complaints (Locations: Hosur, Yerigonal & Kesarabhavi villages in and around Hunagund region).

Picture-3: Maximum Fluoride concentrations found in water resources of Hunagund, Ilakal and Badami taluks (Bagalkot District)

Higher concentration of Fluoride which is characterized by molting of teeth enamel, nervous and skeletal disorder (Picture-1 and 2). Ground water with high Fluoride content are generally Bicarbonates, sodium mixed water, particularly poor in Calcium content. Rocks which are rich in Fluoride mineral contributed enriched Fluoride contents of ground water. In the area of Bagalkot district the high levels of Fluoride are due to geogenic sources.

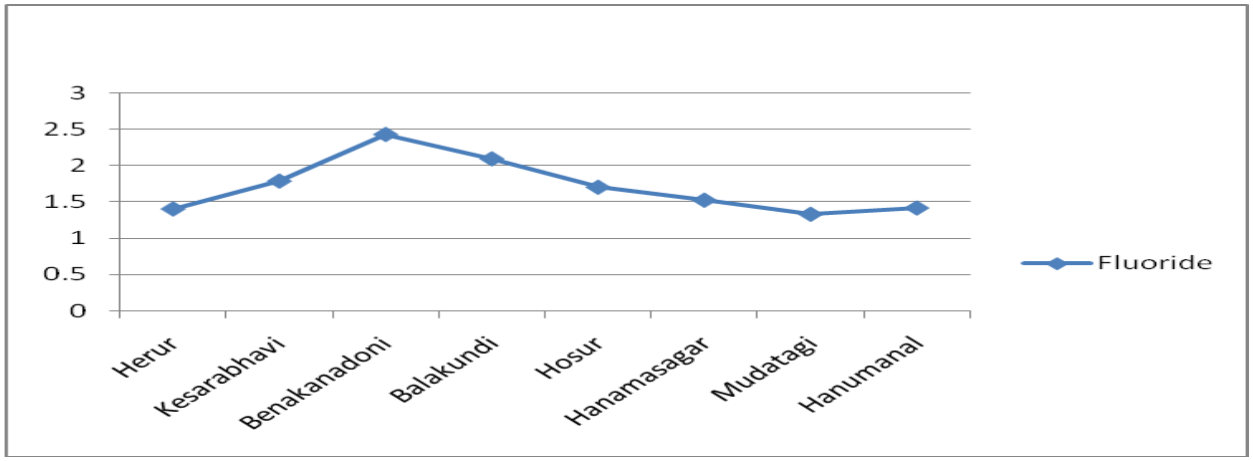

Fig.-1: Maximum fluoride content in Benakanadoni and Balakundi villages of Hunagund.

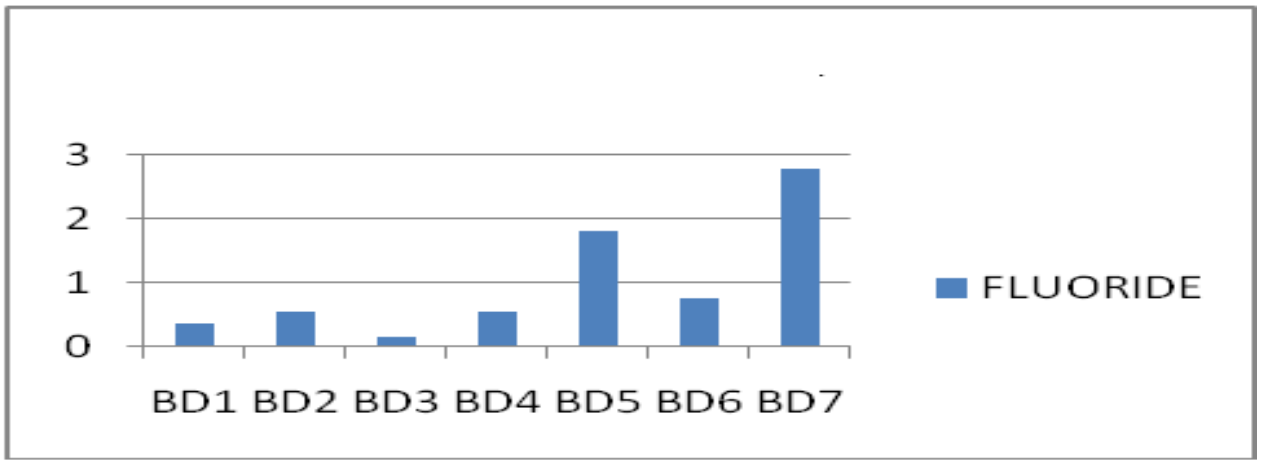

Fig.-2: Maximum fluoride content in Budangud village of Badami taluk. (Locations BD1 to BD7)

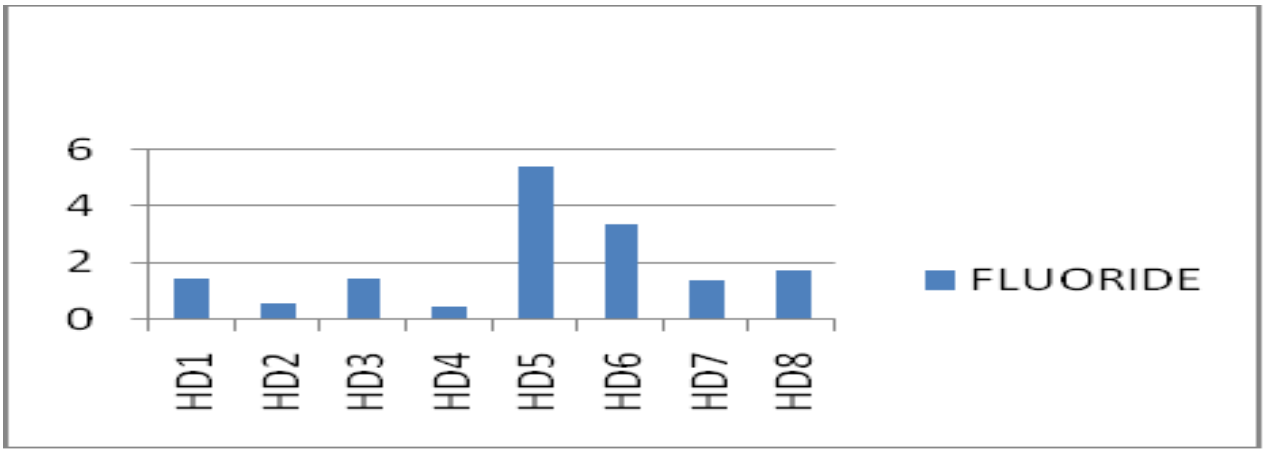

Fig.-3: Maximum fluoride content found in Yerigonal village in Hunagund region. (Locations HD1 to HD8)

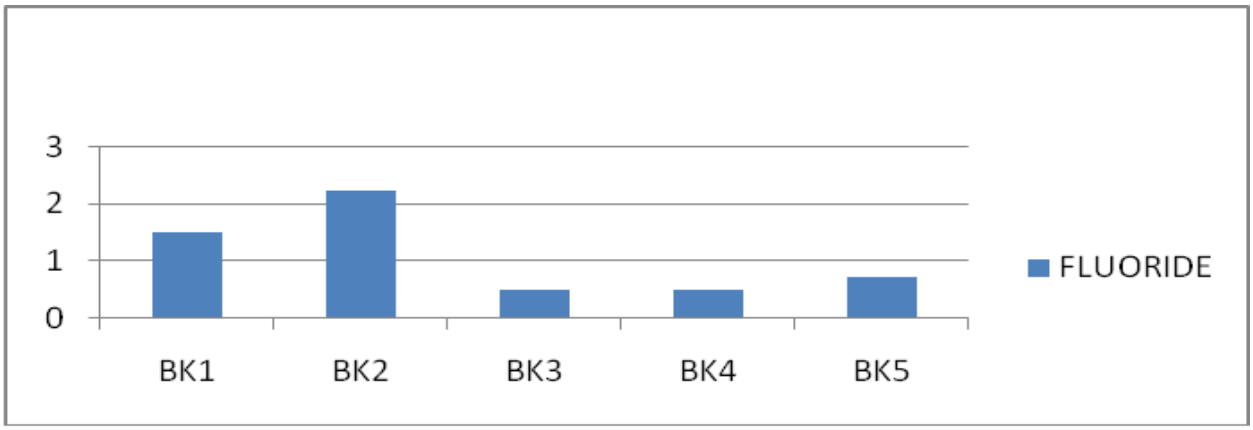

Fig.-4: Maximum Fluoride content found in ground water in Semikeri Village of Bagalkot District. (Locations BK1 to BK5).

Regular intake of Fluoride enriched waters seems to be the main cause for Fluorosis in the study area (Picture-3). These will be helpful to prepare Fluorosis plan for the affected population of the study area. It should be better to Monitoring systems is to be established to periodically evaluate the prevalence of fluorosis and dental carries in the affected areas. Documents of water fluoride concentration may be kept in municipalities/punchayat for the benefit of public health providers, health professionals and the public with regard to fluoride consuming from drinking water.

Defluoridation tanks should also be installed in the villages like Kesabhavi (pH 1.784), Benakadoni (pH 2.433), Balakundi (pH 2.096) Hosur (pH 1.703) of Hunagund Taluk and Jalihal H.K. village (pH 1.572), and Belur (pH 1.504) of Badami taluk. Around Bagalkot district some villages of Kustagi and Ron taluks are also affected by the kinds Fluorosis diseases, in these villages also having high exposure of Fluoride concentration in drinking water.

Table-1: Chemical parameters of water samples collected in and around Bagalkot district from the locations of Hunagund taluk during winter, summer and monsoon seasons of 2014-15

S.No.	Village & Taluk	Seasons	pH	EC m mhos/cm	TDS ppm	Cl ppm	SO_4 ppm	NO_3 ppm	Fluoride ppm
1	Herur of Hunagund	Winter	7.5	2.782	1296	30.2	27.8	17.3	1.503
		Summer	7.8	2.961	1396	31.8	28.6	18.6	1.523
		Monsoon	7.4	0.746	1125	30.1	26..8	17.8	1.421
2	Herur of Hunagund	Winter	7.2	2.864	1453	31.6	28.9	18.3	1.296
		Summer	7.2	2.961	1524	32.5	29.6	19.2	1.337
		Monsoon	7.1	1.956	1123	32.0	27.6	19.0	1.293
3	Chinnapur Hunagund	Winter	7.1	2.143	1056	42.3	30.5	19.6	1.301
		Summer	7.3	2.244	1127	44.1	31.2	20.1	1.367
		Monsoon	7.2	1.859	1005	41.3	31.0	18.9	1.323
4	Keasarabhavi Hunagund	Winter	7.6	2.048	1015	42.1	36.9	19.8	1.695
		Summer	7.8	2.150	1071	43.2	38.9	21.3	1.784
		Monsoon	7.7	1.986	989	40.6	35.4	19.3	1.761
5	Mahantapur Hunagund	Winter	7.4	2.017	987	32.	40.2	20.1	1.202
		Summer	7.5	2.149	1081	33.8	41.3	21.0	1.227
		Monsoon	7.3	1.968	995	31.6	40.9	19.4	1.201
	Tumba of Hunagund	Winter	7.2	2.147	1189	43.2	50.1	18.9	1.263
		Summer	7.3	2.396	1217	45.3	51.3	21.2	1.341
		Monsoon	7.1	2.004	1025	44.3	50.6	19.3	1.306
6	Benakanadoni Hunagund	Winter	7.8	0.811	325	52.9	61.2	19.5	0.896
		Summer	8.1	0.812	394	54.5	63.5	21.3	0.923

		Monsoon	7.6	0.789	301	52.6	62.6	20.3	0.854
7	Benakanadoni Hunagund	Winter	7.1	1.986	897	50.1	59.9	18.6	2.436
		Summer	7.8	2.028	996	53.2	62.5	19.2	2.443
		Monsoon	7.5	1.895	852	51.2	61.5	17.8	2.430
8	Balakundi Hunagund	Winter	7.9	0.857	412	50.1	27.9	16.7	1.986
		Summer	8.1	0.874	418	52.6	29.1	18.8	2.096
		Monsoon	8.0	0.789	396	51.6	28.9	15.8	1.963
9	Husur of Hunagund	Winter	7.5	0.698	325	43.2	29.5	16.5	1.639
		Summer	7.6	0.746	354	45.6	30.1	19.2	1.703
		Monsoon	7.4	0.668	301	41.5	28.9	17.3	1.693

Table-2: Chemical parameters of water samples collected in and around Bagalkot district from the locations of Badami taluk during winter, summer and monsoon seasons of 2014-15.

S.No.	Village & Taluk	Seasons	pH	EC m mhos/cm	TDS ppm	Cl ppm	SO_4 ppm	NO_3 ppm	Fluoride ppm
1	Jalihal H.K. Badami	Winter	7.5	1.321	789	25.6	24.6	10.6	1.153
		Summer	7.6	1.419	873	27.6	25.2	11.1	1.172
		Monsoon	7.4	1.228	812	26.8	25.0	10.8	1.135
2	Belur of Badami	Winter	7.2	1.536	698	33.2	45.3	14.6	1.210
		Summer	7.3	1.652	717	34.2	46.8	15.9	1.304
		Monsoon	7.2	1.455	696	33.9	45.9	14.6	1.223
3	Cholachagudda Badami	Winter	6.8	1.698	658	35.6	49.6	18.9	1.001
		Summer	6.8	1.747	700	36.5	56.3	20.3	1.109
		Monsoon	6.7	1.692	698	36.1	48.7	19.2	1.086
4	Maradi Badami	Winter	6.8	1.680	898	43	50	24	2.010
		Summer	7.6	1.461	925	67	32	26	2.800
		Monsoon	7.4	1.563	924	59	45	31	2.014
5	Budangad Badami	Winter	7.3	1.620	900	98	68	15	2.29
		Summer	7.5	1.610	900	95	54	18	2.80
		Monsoon	7.4	1.598	895	92	42	16	2.65
	Budangad Badami	Winter	7.5	1.660	912	72	48	11	3.34
		Summer	7.1	1.581	898	89	71	12	3.68
		Monsoon		1.485	852	78	56	12	3.58
6	Budangad Badami	Winter	7.2	1.640	918	88	38	27	3.55
		Summer	7.4	1.722	791	62	52	26	3.21
		Monsoon	7.1	1.652	786	75	48	23	3.25
7	Agasanakoppa Badami	Winter	7.1	1.510	778	28	25	21	0.34
		Summer	7.2	1.520	820	38	33	23	0.48
		Monsoon	7.3	1.598	789	35	35	22	0.52
8	Kerur of Badami	Winter	7.1	1.98	842	101	78	27	0.72
		Summer	7.0	1.95	821	82	62	23	0.53
		Monsoon	7.2	1.85	824	95	80	25	0.65
9	Guledagudda Badami	Winter	6.5	1.720	790	52	48	25	0.75
		Summer	6.9	1.642	798	110	40	22	0.82
		Monsoon	6.8	1.689	769	85	51	20	0.85

Table-3: Chemical parameters of water samples collected in and around Bagalkot district from the locations of Ron taluk during winter, summer and monsoon seasons of 2014-15.

S.No.	Village & Taluk	Seasons	pH	EC m mhos/cm	TDS ppm	Cl ppm	SO_4 ppm	NO_3 ppm	Fluoride ppm
1	Kuntoji of Ron	Winter	7.3	0.412	212	26.3	44.5	11.2	1.336
		Summer	7.4	0.486	228	26.6	45.6	12.0	1.377

		Monsoon	7.2	0.458	213	25.6	43.2	11.6	1.320
2	Gajendragad Ron	Winter	7.3	1.012	265	30.2	65.2	12.6	1.303
		Summer	7.4	1.120	273	32.5	66.2	14.3	1.306
		Monsoon	7.3	1.009	263	31.2	64.3	13.2	1.300
3	Kalliganur Ron	Winter	6.9	1.158	501	34.2	73.2	19.5	1.396
		Summer	7.0	1.240	598	35.6	72.6	20.1	1.422
		Monsoon	6.8	1.198	512	33.6	71.5	18.6	1.402

Table-4: Chemical parameters of water samples collected in and around Bagalkot district from the locations of Kustagi taluk during winter, summer and monsoon seasons of 2014-15.

S.No.	Village & Taluk	Seasons	pH	EC m mhos/cm	TDS ppm	Cl ppm	SO_4 ppm	NO_3 ppm	Fluoride ppm
1	Mudatagi Kustagi	Winter	7.4	1..352	659	27.8	59.6	19.9	1.320
		Summer	7.5	1.460	716	28.5	60.2	21.2	1.329
		Monsoon	7.3	1.356	649	27.6	56.8	18.6	1.301
2	Hanamasagar Kustagi	Winter	6.9	1.742	8.95	29.6	69.7	18.4	1.522
		Summer	6.8	1.882	9.38	30.2	71.3	20.5	1.524
		Monsoon	6.9	1.721	9.02	28.4	70.1	19.3	1.520
3	Hanamanal Kustagi	Winter	7.0	1.569	698	30.2	75.6	19.3	1.400
		Summer	7.1	1.622	797	34.5	82.3	22.0	1.416
		Monsoon	7.0	1.581	712	31.2	79.2	20.4	1.410
4	Hanamanal Kustagi	Winter	7.3	1.269	612	36.4	88.6	15.6	1.449
		Summer	7.4	1.385	677	37.8	91.5	19.5	1.451
		Monsoon	7.3	1.233	623	35.9	85.1	16.2	1.450

Table-5: Chemical parameters of water samples collected in and around Bagalkot district from the locations of Bagalkot taluk during winter, summer and monsoon seasons of 2014-15.

S. No.	Village & Taluk	Seasons	pH	EC m mhos/cm	TDS ppm	Cl ppm	SO_4 ppm	NO_3 ppm	Fluoride ppm
1	Tulasigeri Bagalkot	Winter	6.6	1.480	821	38	36	22	1.61
		Summer	6.7	1.510	790	21	28	13	1.50
		Monsoon	6.8	1.501	802	28	32	20	1.52
2	Semikeri Bagalkot	Winter	6.7	1.518	792	69	43	36	2.32
		Summer	6.6	1.683	786	52	36	21	2.23
		Monsoon	6.8	1.568	768	47	50	29	2.30
3	Muchandi Bagalkot	Winter	6.8	1.689	712	55	78	25	0.51
		Summer	6.8	1.360	634	48	62	20	0.47
		Monsoon	6.9	1.425	658	54	59	21	0.52
4	Sirur of Bagalkot	Winter	6.9	1.368	798	54	38	21	0.49
		Summer	6.7	1.570	723	36	42	18	0.48
		Monsoon	6.9	1.512	734	42	39	16	0.50
5	Mannikeri Bagalkot	Winter	6.7	1.720	698	78	71	24	0.78
		Summer	6.9	1.710	634	61	61	19	0.72
		Monsoon	6.8	1.698	686	72	70	22	0.80

Table-6: Prescribed legal limits and guidelines

Parameter	WHO	ISI	ICMR
pH	7.0 – 8.5	6.5-8.5	6.5-9.2
EC	1.4 ds/m	1400µs/cm	250
TDS	500	500	1500-3000
BOD	5.0	5.0	---
COD	10.0	10.0	---

DO	5.0	5.0	5.0
Cl’	250	250	1000
Calcium	75-100	45-75	200
Magnesium	30-150	30	50
Sodium	200	200	---
Potassium	1.4	1.4	---
Sulphate	150-250	150-200	400
TH	300	300	600
TA	120	200-600	200-600
Zinc	0.75	---	---
Copper	0.60	---	---
Iron	<1	0.3	---
Manganese	2.0	0.3	---
Nitrate	40-100	40-100	40-100
Fluoride	1.0-1.5	1.0-1.5	1.0-1.5
Color	5 HU	5 HU	5 HU
Odor	Unobjectionable	Unobjectionable	Unobjectionable
Turbidity	5 NTU	5 NTU	5 NTU

CONCLUSION

The present study attempted to identify the areas affected by fluoride contamination in ground water resources of Bagalkot, Badami, Hungund and Ilakal taluks and around Bagalkot. The taluks like Kustagi of Koppal and Ron of Gadag districts were also affected by the fluoride contaminated ground water resources. The study has focused more on both urban and rural areas of Bagalkot district in order to supplement the data base in this direction. The following conclusions, recommendations and suggestions are made based on the investigation:

1. De-fluoridation tanks should be installed in such area having high concentration of fluoride in ground water resources.
2. Fluoride concentrations can be diluted by inducing ground water recharge techniques, i.e., construction of percolation tanks, flooding of ground water by mixing surface water by promoting rain water harvesting.
3. The financial support by the Government is made to install water purification units in the fluorosis affected area.
4. The possibilities of bringing safe water from nearby villages can also be planned by the municipal and punchayat authorities.

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