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Assessment of groundwater quality in nine villages of Mundaragi Taluka in Gadag District of Karnataka

M.N.Hiremath[1], C.B.Shivayogimath[2] and S.N.Shivalingappa[3]

[1]Department of Civil Engineering, Anjuman Institute of Technology & Management, Bhatkal, Karnataka.

[2]Department of Civil Engineering, B.E.C.Bagalkot, Karnataka.

[3]STJIT, Ranebennur, Karnataka.

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ABSTRACT

In this present study groundwater quality analysis, of nine fluoride affected villages in and around Mundaragi taluka of Gadag district in Karnataka, has been carried out in pre-monsoon season. The samples were collected in the month of February 2012, all the reagents used were of AR grade and standard methods were followed. The study revealed that all the nine villages have fluoride ion concentration above permissible limits. Higher fluoride concentration of 6.9 mg/L was observed in Mevundi village and lower concentration of 2.3 mg/L was observed in Hirewaddatti village.

Introduction

Water is the most abundant molecule of earth's surface constituting about 70% of planet's surface. But water is necessary for most life on earth. Humans can survive for several weeks without food, but can hardly survive only for a few days without water. The exact amount of water a human need is highly individual, as it depends on the condition of the subject, the amount of physical exercise, and on the environmental temperature and humidity. Water is a ubiquitous chemical substance that is composed of hydrogen and oxygen and is vital for all known forms of life. In nature it exists in liquid, solid, and gaseous states. All these three forms of water are extremely useful to man, providing him the luxuries and comforts, in addition to fulfilling his basic necessities of life. Every one of us knows how important and precious the water is? At room temperature, it is nearly colorless with a hint of blue, tasteless and odorless liquid. Many substances dissolve in water and it is commonly referred to as the universal solvent. Water usually makes up 55 % to 78 % of the human body.

Fluoride is a salt of the element fluorine; fluorine is the most highly reactive element of halogen family. Fluoride is the one of the very few chemicals that has been shown to cause significant effects in people through drinking water. High concentrations of fluoride cause mottling of teeth initially and dental fluorosis diseases to crippling skeletal fluorosis with continued use of fluoride rich waters. Fluoride is attracted by positively charged calcium in teeth and bones due to its electro-negetivity, which results in dental, skeletal, non skeletal forms of fluorosis in children as well as adults [1, 2].

Fluorine is highly reactive and is found naturally as CaF_2. It is an essential constituent in minerals like topaz, fluorite, fluropatite, cryolite, phosphorite, theorapatite, etc., [3]. The Fluoride is found in the atmosphere, soil and water. It enters the soil through the weathering action of rocks, precipitation or water runoff. It has been observed that low calcium and high bicarbonate alkalinity favour high fluoride content in ground water [4, 5], other sources of fluoride poisoning include food, industrial exposure, drugs, cosmetics, etc. [6].

Ground water in many parts of India is found to contain very high concentrations of fluorides. A total of 17 states are reported to have endemic flurosis in India. [7], it was estimated that 62 million people including six million children, suffering from fluorosis [8]. The states which are affected by high fluoride levels in drinking water include Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Kerala, Madhypradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh and West Bengal. These have been progressively identified since the first report by Short.*et.al* 1937 [9].

In Karnataka Dharwad, Gadag, Bellary, Belgaum, Raichur, Bijapur, Gulbarga, Chitradurga, Tumkur, Chikmagalur, Mandya, Bangalore and Mysore districts are identified to be endemic for Fluoride [10], and the range of fluoride concentration varies from 0.2 to 18.0mg/L in these districts. As per Central Ground Water Boards report (2009), a Government of India organization under the Ministry of Water Resources, the ground water in major parts of Gadag, Ron and south central parts of Mundaragi taluka have been found to contain high fluoride levels. Therefore nine villages in Mundaragi taluka of Gadag district [11] were selected for the investigation of fluoride ion concentration in the present study.

Chemistry of Fluoride

Fluoride is a salt of the element fluorine. Fluorine is highly reactive element of halogen family. Fluorine is ninth element in the periodic table belonging to the group VII A with atomic weight 18.9984. It is a chemically reactive pale yellow green irritating gas with a sharp odour, which rarely occurs naturally in

Tele:

E-mail addresses: mnhiremath007@rediffmail.com

elemental state as it combines with every other element except inert gases forming strong electromagnetic bonds. It is widely dispersed in the environment accounting for 0.38g/kg of the earth's crust. Most fluoride associated with monovalent cat ions such as NaF and KF is water soluble, while the one formed with divalent cat ions such as CaF_2 and PbF_2 are generally soluble.

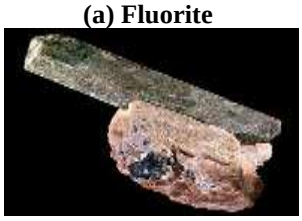
Fluoride in Environment

Fluorides like other minerals are originated in the earth's crust due to volcanic and plutonic activities. They exist in many forms viz., fluorspar or calcium fluoride (CaF_2), apatite or rock phosphate [$Ca_5F(PO_4)_3$], cryolite of sodium aluminum fluoride (Na_3AlF_6), topaz ($Al_2SiO_4(OH,F)_2$), sellaite (MgF_2), villianmite(NaF), fluorine hydro silicates, etc. The minerals containing fluoride are given in Table 1.As fluorspar is found in sedimentary rocks and as cryolite in igneous rocks, these fluoride minerals are nearly insoluble in water. The fluoride content in soil normally ranges from 200 to 300ppm. It is observed that fluoride content in soil in crease with depth, and only 5 to 10% of the total fluoride in soil is water soluble[12, 13, 14]. Application of fertilizer for irrigation results in the presence of Cl^-, SO_4^- and F^- in groundwater.

Fluoride human food and beverage chain in increasing amounts through consumption of tea, wheat, spinach, cabbage, carrots etc, [15]. It has been observed that as fluoride problem is acute in Andhra Pradesh; many agricultural products from Andhra Pradesh in India were containing fluoride ranging from 0.20-11.00mg/kg [16]. The fluoride content of tea leaves is about 1000 times the soluble fluoride content of soil and 2 to 7 times the fluoride in soil [17].

The sources of fluoride in the environment also include industrial plants manufacturing hydrofluoric acid, phosphate fertilizers, glass, brick and tile works, textile dyeing, plastic factories and industries consuming high sulphor, non – coking coal like thermal power plants, and cigarettes with an average 236ppm fluoride contributing significantly to fluoride intake by humans [18, 19]. Fluoride in water may initiate leaching of aluminum form cooking utensils and copper from pipe works at normal and high concentrations respectively (MRC 2002). Fluoride is also present inSeaWater (0.5-1.4ppm), in mica and in many drinking water supplies [1]

(a) Fluorite



(b) Cryolite

(c) Fluorapatite

Fig.1. various forms of fluoride minerals

Study Area

In this part the study area with reference to its location, geographical features, and hydro geological features are discussed.

About Mundaragi

Mundargi is a panchayat town in Gadag district in the Indian state of Karnataka. Mundargi is very near to two district head quarters (Gadag and Koppal); it is 36 km from Gadag and 50km from Koppal. Mundargi-this name came from hill station Mrudagiri. This is combination of two words mruda (means Shiva) giri (means hill) later it became Mundargi .one can see a single stone big hill attached to this place (around 7km).

As per Central Ground Water Board report (2009), a central government organization under the Ministry of Water Resources, the ground water in major parts of Gadag,Ron and south central parts of Mundaragi taluka have been found to contain high fluoride levels. Therefore the area of Mundaragi taluk of Gadag district [11] is selected for the investigation in the present study.

Geography of the Study Area

Mundargi is located at 15.22 degree N 75.9 degree E, it has an average elevation of 528 mts(1732ft) surrounded by Kappadgiri range of hills, Mundargi is primarily a drought hit area.

Hydrogeology of Study Area

The district is underlain by hard rock formations like granites, gneisses, and schists. These rocks have no primary porosity or permeability. Ground water occurs under phreatic conditions in weathered zone of these formations. At higher depths ground water occurs under confined to semi confined conditions in fractures and joints as well as formation contacts, its movement is controlled by the inter connectivity and geometry of the structurally week zones called lineaments.[11].

Rainfall and Climate

The district falls under semi arid region of the state and it is categorized as draught prone, the normal rainfall is 613 mm. The North-East monsoon contributes nearly 24.8% and prevails from October to early December. And about 54.7% precipitation takes place during South–West monsoon period from June to September, and remaining 20.5% takes place during rest of the year. In the district, from December to February month is winter season, During April to May temperature reaches up to 42°C and December and January temperature will go down up to 16°C. The standard deviation of rainfall in the district varies from 1.3 to 263.5mm from west to east. The average standard deviation for the district is about 146 mm. South West monsoon is dominant followed by north east monsoon. [11]

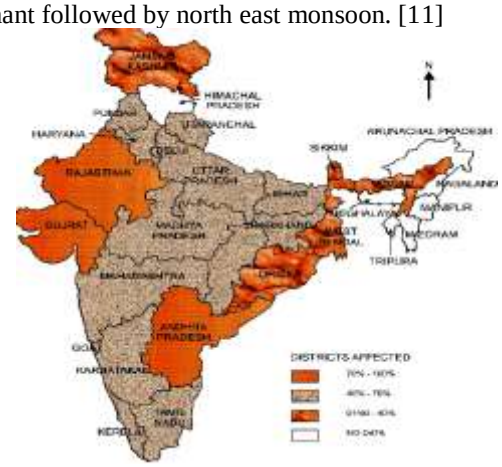


Fig.2 Fluoride map of India

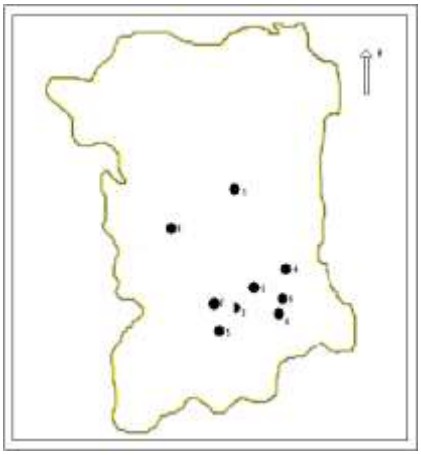


Fig.3. Location map of study area (Mundaragi Taluka)

Materials and Methods

For the present study, nine bore well water samples from Mevundi, Kalakeri, Budhihal, Mundaragi, Virupapur, Muktampur, Mushtikoppa, Bennihalli, and Hirewaddatti villages of Mundaragi taluka were collected in pre monsoon season i.e. in the month of February 2012.The depths of all these bore wells studied were ranged between 150 to 250 feet as per the local people of the concerned villages. For collecting water samples double sterilized 2000 ml capacity plastic cans were used, and collected water can were brought to the laboratory immediately and preserved in the refrigerator. Important water quality parameters viz, pH, electric conductivity, total hardness, alkalinity, acidity, chloride, and fluoride were investigated. For investigation of various water quality parameters all the reagents used were of AR grade and standard methods were followed.

Results and Discussion

The results of the present investigation revealed that all the nine samples have excess fluoride concentration above prescribed limits by various standards, higher fluoride concentration of 6.9 mg/L was observed in Mevundi village and lower concentration of 2.3 mg/L was observed in Hirewaddatti village. From the investigation it was also observed that TDS is 2747 mg/L and 2471 mg/L which are above permissible limit in Kalakeri and Mushtikoppa villages respectively. And higher alkalinity values of 1264, 690 and 1065 mg/L were found in Kalakeri, Muktampur and Mushtikoppa villages respectively, from the study it was also revealed that total hardness of 688 and 832 mg/L were found in Mundaragi and Muktampur villages respectively. All other parameters like calcium, magnesium, chloride, and electrical conductivity were found well within the permissible limits prescribed by IS 10500 standards, and pH values of Mevundi, Mushtikoppa and Bennihalli villages were also found slightly higher than BIS standard values.

Conclusions

From the investigation it was revealed that fluoride concentration is dominant in all the bore well samples of nine villages, and which ranges from 6.9 to 2.3 mg/L.These values are above limits prescribed by various standards, obviously prolonged consumption of drinking water from these villages leads to various health problems of fluoride origin. Therefore villages affected by fluoride problems are supplied with safe water by changing the source of supply or by supplying the water after adopting suitable defluoridation technique.

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Table .1: Fluoride bearing minerals

Minerals	Chemical Formula	% of fluorine
Sellatite	MgF_2	61
Villianmite	NaF	55
Fluorite	CaF_2	49
Cryolite	Na_3AlF_6	45
Bastnaesite	$(Ce, La)(CO_3)F$	9
Fluorapatite	$Ca_3(PO_4)_3F$	13

Table .2 Drinking water standards for fluoride ion prescribed by various authorities

Sl.No	Authority	Permissible limit, mg/L
1.	WHO (Indian context)	1.5
2.	WHO (International standard)	0.50
3.	BIS (IS-10500)	1.0-1.5
4.	ICMR	1.0-2.0
5.	CPHEEO	1.0-1.5
6.	US Public Health	0.7-1.2

Table.3. Result analysis of the study area

Stations	pH -----	TDS Mg/L	EC µΩ/cm	TH Mg/L	Alkalinity Mg/L	Ca Mg/L	Mg Mg/L	Cl Mg/L	F Mg/L
Mevundi 1	7.68	458	758	232	141	51.6	21.48	88.3	6.9
Kalakeri 2	7.13	2749	4579	992	1264	220.4	91.85	640	6.2
Budihal 3	7.40	1362	2271	376	543	178.2	34.81	288	4.1
Mundaragi 4	7.48	1287	2145	688	504	152.2	63.7	280	4.6
Virupapur 5	7.5	800	1325	240	98	46.4	20.2	34	3.2
Muktampur 6	7.11	1902	3169	832	690	184.8	77.03	480	3.9
Mushtikoppa7	7.79	2471	4119	400	1065	88.8	37.07	496	5.1
Bennihalli 8	7.8	468	779	240	325	53.4	22.22	56	3.6
Hirewaddatti 9	7.4	800	1322	400	92	73.3	28.6	112	2.3