Studies on Fluoride and Other Trace Elements Content in Domestic Water Sources of Chandidongri Fluoride Mine Area of District Rajnandgaon of Chhattisgarh (India)

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The present study was undertaken to find out fluorides and other associated elements in different domestic water sources from hand-pumps, ponds and open wells of village Chandidongri fluoride mine area. Twenty water samples were collected from the mineralized area and three samples were collected from the non-mineralized area as control. The primary aim of this study was to find out the concentration of fluoride in the samples of drinking water. These studies revealed that all the water samples had chemical parameters within the range recommended by ISI and WHO except in a few samples in which iron and fluoride were found to be above the permissible limits. These water sources are not safe from human/animal consumption with respect to these elements. Dental and skeletal fluorosis was observed in some humans and cattle of Chandidongri mine area.

Key Words: Fluoride, Domestic water, Chandidongri District Rajnandgaon.

INTRODUCTION

The area Chandidongri is withi then Chhuria tahsil of district Rajnandgaon in Chhattisgarh state which falls in the tropical region and National Highway No. 6 passes through the Chandidongri village. The area is about 6 km west of Chichola and 46 km away from Rajnandgaon. Geographically it is bounded by latitudes 21°00′ and 21°13′ and longitudes 80°36′ and 80°40′ and at about 365 metres height above the mean sea level. The climate of the area is of extreme continental type, hot and dry in summer, annual average rainfall 121.01 cm. Relative humidity approaches to 90% in the peak rainy months of August, while the temperature during summer shoots up to 48°C. In this area the basic population consists of tribes and backward classes. Geologically the area falls within the western part of the Chhattisgarh super-group, deposited in an inter craton over the Dongargarh super-group[1, 2]. This area belongs to the Precambrian formation. Dongargarh super-group consists of three groups of rock formations, namely (1) Amgaon group, (2) Nandgaon group, (3) Khairagarh group. The volcanic phase is followed

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by the emplacement of porphyritic micro-granites, grano phyre and coarse granite, popularly known as "Dongargarh granite"[3]. In Chandidongri the host rock is pale greenish, coarse to porphyritic hornblende granite. The mineral constituents are pink phenocryst microline, plagioclase with lamellar twinning, quartz and hornblende, with a few grains of zircon and iron ores as accessory minerals.

Water is a natural solvent and has a property of dissolving and carrying solutes in solution. The chemical composition of natural water is derived from different sources of solutes, including gases and aerosols from atmosphere, weathering and erosion of rocks and soils, solution and precipitation reactions occurring below the land surface and from cultural effects resulting from human activities[4]. In this process it gets contaminated. Problems posed by elevated concentration of toxic metals in aquatic environment are hazardous to human health as well as to plants and animals. The significant drop in milk production and bone-weakening of dairy cattle, due to consuming water and fluoride accumulator plants[5]. Thus, the term quality encompasses physical, chemical and biological characteristics of water[6]. The main sources of fluorite, fluorapatite, cryolite as well as micas and horn blend in which fluoride ion replaces hydroxyl group reported that the main sources of fluoride in ordinary soil consist of clay minerals. The quality of fluoride dissolved or precipitated is dependent on the presence of other electrolytes in aqueous solution, which are partially ionized. But most of the soluble fluorides are leached out from the soil and lost by getting co- precipitated with calcium carbonate, while part of the fluoride enters the clay minerals which are removed as fine suspended particles in water and only a very small portion of fluoride occurs in the form of soluble fluoride in natural water.

Fluoride is a normal constituent of all diets and is considered as an essential element. It is found in the enamel of teeth, bones and in minute quantities in other tissues of the body. Maximum permissible limit of 1.0 mg/L in drinking water supplies may prevent dental carries in children, probably by reducing the rate of conversion of sugars to acids in oral cavities during the period when their tooth enamel formation takes place[7,8]. Higher levels of fluoride in water may lead to adverse health effects, such as mottling of teeth (2.0 mg/L fluoride) particularly on young children during the period of tooth calcification (dental fluorosis) leading to a dark discolouration of permanent teeth. Skeletal fluorosis causing bone deformity (3–6 mg/L), crippling fluorosis (20 mg/L per day for a period of more than 20 years). The Bureau of Indian Standards[9], in view of the health problems, has laid down the Indian standard 1.00 ppm as the maximum permissible limit for drinking water, although Rajiv Gandhi National Drinking Water Mission[10] is still working with 1.5 ppm as the upper limit of fluoride. This means that the body may tolerate fluoride up to 1.0 or 1.5 ppm, depending upon the hot climatic conditions, nutritional standards and body physiology.

EXPERIMENTAL

Sample Collection: Water samples were collected for two seasons, *i.e.*, summer and winter. Samples within the mineralized area were collected from 20 points. Sampling points were located depending on the availability of water sources, but were located within a radius of about 5 km from Chandidongri. Water samples from non-mineralized area (within the municipal boundary of Rajnandgaon city) were collected from 3 points. Water samples from both the mineralized as well as non-mineralized areas were collected in polythene bottles for analysis.

Chemical analysis: Analysis of physico-chemical parameters was done following mainly the standard methods[11, 12], such as chloride content was determined by the argenometric method, iron was determined by the phenanthroline method, sodium and potassium were estimated with the help of a flame photometer: microprocessor based Chemita-102 model at 589 nm for Na and at 766.5 nm for K. Pb, Zn, Mn, Cu, Co, Cr and Ni were estimated with the help of atomic absorption spectrophotometer, Varian-Techtron model AA-575. Elements were analyzed by different selective wavelengths for different elements such as Pb at 217.0 nm, Zn at 215.9 nm, Mn at 279.5 nm, Cu at 324.7 nm, Co at 240 nm, Cr at 357.9 nm and Ni at 232 nm. Fluoride was estimated with the help of Orion ion selective electrode meter model 901, using a fluoride electrode.

RESULTS AND DISCUSSION

The chemical data of the different sources of water samples collected for two seasons are shown in Table-1. The results of the samples may vary with different nature of soil contamination. The pH values in summer season were in the range 6.30 to 7.50 in mineralized area; on the other hand, in the non-mineralized area pH was found to be more than 7.0, going up to as high as 9.0. Fluoride was present in all the water samples of the mineralized area. Its concentration ranged from 0.3 ppm to 8.0 ppm. In the winter season the minimum value of 0.1 ppm was recorded for sample no. 2 while the maximum value of 5.6 ppm was recorded for sample no. 1. In the summer season the minimum value of 0.3 was recorded for sample no. 2 while the maximum value 8.0 ppm was recorded for sample no. 1. Thus, both the minimum and maximum values in both the seasons of analysis were recorded for the same sites. Water samples from the three sites from the non-mineralized area had fluoride concentration ranging from 0.1 to 0.3 ppm. Manganese was also detected in water samples from the mineralized area in only ten of the twenty sites. Maximum values, both for summer (0.06 ppm) and for winter (0.52 ppm) were obtained for water sample no. 9. Manganese was absent in water samples from the non-mineralized area. Iron concentration in the majority of samples is lower than the permissible limit (less than 0.3 ppm) but in sample no. 5 of the factory open well the content is the highest, 3.23 ppm. In sample no. 17, 1.20 ppm, in sample no. 9, 0.94 ppm and in sample no. 18, 0.70 ppm, higher than the permissible limits, have been noticed; so the water can be regarded toxic for human consumption with respect to iron. In the non-mineralized area, iron was in non-detectable concentration in all the three water samples. Chloride ion, in the water samples from the mined area, ranged from 0.3 ppm to 168 ppm. On the other hand, in the non-mineralized area, it ranged from 124 to 185 ppm. It reveals that in the non-mineralized (city) areas water contains higher chloride content. Cobalt, in the water samples from the mineralized area, was

TABLE-1

CHEMICAL CHARACTERS OF WATER FROM MINERALIZED AND NON-MINERALIZED AREAS

Sample No. and Site	F		Mn		Fe		Cl		Co		Ni		Pb		Zn		Cr		Na_2O		K_2O	
	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
1. Chandidongri, mine pond (I)	8.00	5.60	0.04	0.00	0.08	0.06	0.5	0.4	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.0	1.7	3.0	2.5
2. Chandidongri, Ranitalab Dam	0.30	0.10	0.10	0.00	0.08	0.55	10.0	0.8	0.09	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.0	34.0	0.0	0.0
3. Chandidongri, mine pond (II)	6.90	4.70	0.00	0.00	0.75	0.62	18.0	16.0	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.0	16.0	2.1	1.8
4. Chandidongri, Ranitalab	5.70	4.70	0.00	0.00	0.00	0.00	12.0	10.0	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.5	9.3	13.5	10.3
5. Chandidongri, open well of factory	0.50	0.30	0.00	0.00	3.23	2.80	43.0	39.0	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.3	63.1	0.1	0.0
6. Chandidongri, open well of Sarpanch	1.20	0.90	0.00	0.00	0.20	0.13	25.0	23.0	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.8	38.4	3.8	2.7
7. Chandidongri, open well of Babakutia	1.00	0.80	0.00	0.00	0.04	0.02	25.0	21.0	0.01	0.00	0.00	0.00	0.11	0.05	0.10	0.06	0.07	0.03	73.6	65.3	0.0	0.0
8. Birutola, talab	1.60	1.20	0.20	0.16	0.00	0.00	60.0	58.0	0.06	0.04	0.00	0.00	0.00	0.00	0.10	0.08	0.09	0.07	54.0	48.0	46.2	41.3
9. Birutola, handpump in front of Vishnudas' house	0.80	0.70	0.60	0.52	0.36	0.24	65.0	61.0	0.06	0.03	0.11	0.09	0.00	0.00	1.30	0.21	0.00	0.00	49.6	43.2	0.0	0.0
10. Birutola, government open well	0.20	0.20	0.00	0.00	0.46	0.39	168.0	163.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	62.1	54.6	0.0	0.0
11. Birutola, handpump	1.40	1.20	0.50	0.46	0.94	0.83	120.0	116.0	0.08	0.06	0.02	0.00	0.00	0.00	0.15	0.12	0.00	0.00	29.5	23.2	0.0	0.0
12. Birutola, open well of Lekhram	0.30	0.20	0.00	0.00	0.20	0.16	33.0	31.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	88.7	72.9	0.8	0.6

Sample No. and Site	F		Mn		Fe		Cl		Co		Ni		Pb		Zn		Cr		Na_2O		K_2O	
	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
13. Kubradihi, handpump	0.80	0.60	0.40	0.35	0.10	0.06	30.0	26.0	0.00	0.00	0.00	0.00	0.00	0.00	4.70	3.09	0.00	0.00	35.4	31.2	0.00	0.00
14. Kubradihi, open well of Budhram	0.30	0.20	0.00	0.00	0.00	0.00	75.0	71.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.0	58.1	4.20	3.80
15. Sadak Banjari, handpump of Thakur Ram	0.60	0.40	0.40	0.34	0.25	0.21	30.0	27.0	0.00	0.00	0.00	0.00	0.00	0.00	1.30	1.12	0.00	0.00	32.0	28.3	0.00	0.00
16. Sadak Banjari, government open well	0.20	0.10	0.00	0.00	0.20	0.16	35.0	32.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.1	13.7	0.00	0.00
17. Sadak Banjari, handpump near Dhaba	1.40	1.10	0.20	0.13	1.20	1.12	33.0	31.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.6	29.2	0.00	0.00
18. Patekohra, handpump	0.30	0.20	0.10	0.07	0.70	0.63	10.0	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.08	0.00	0.00	25.7	23.2	0.00	0.00
19. Chandidongri, handpump Sarpanch	1.60	1.30	0.10	0.06	0.25	0.21	1.0	0.7	0.08	0.06	0.00	0.00	0.00	0.00	6.30	5.22	0.00	0.00	35.7	31.4	0.00	0.00
20. Chandidongri, open well Jogindar	1.10	0.90	0.00	0.00	0.25	0.21	11.0	0.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.8	41.2	0.00	0.00
21. Rajnandgaon, handpump V. Nagar	0.30	0.10	0.00	0.00	0.00	0.00	175.0	168.0	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.069	0.00	0.00	132.2	126.3	0.00	0.00
22. Rajnandgaon, open well Jain School	0.30	0.20	0.00	0.00	0.00	0.00	130.0	124.0	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.08	0.00	0.00	142.0	136.3	0.00	0.00
23. Rajnandgaon, Ranisagar Talab	0.20	0.00	0.00	0.00	0.00	0.00	185.0	162.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	160.6	151.3	0.00	0.00

S = Summer, W = Winter.

absent in 50% of the samples. Maximum values of 0.07 and 0.09 ppm for winter and summer season, respectively, were recorded for sample no. 2. In the non-mineralized area, cobalt was absent in the samples from all the three sites. *Nickel in the* water samples from the mineralized area was detected only in two of the samples, 0.11 and 0.09 ppm, while the other sites, at which nickel was detected, had only 0.02 and 0.01 ppm respectively. In the non-mineralized area, nickel was recorded to be nil in all the water samples collected from the three sites. Lead concentrations, in all the water samples, both from the mineralized and the non-mineralized areas, were recorded to be nil, except for the open well (sample no. 7) water sample from the mineralized area. Water samples from this site had concentrations of 0.11 and 0.5 ppm in summer and winter seasons respectively. Zinc was recorded to be present at only eight of the twenty sites from the mineralized area. Maximum values for summer and winter were recorded to be 6.30 and 5.22 ppm respectively for the same site (sample no. 19). In the non-mineralized area, in summer season, maximum concentration was recorded 0.07 ppm for a hand pump while in winter season, maximum concentration was recorded 0.08 ppm for an open well water sample. Chromium was found to be present in only three sites out of the twenty sites from the mineralized and three sites from the non-mineralized areas (sample nos.7, 8, 10). A maximum of 0.09 ppm was obtained for sample no. 8 for summer. In non-mineralized area in all the water samples chromium was totally absent. Sodium, estimated as di-sodium-oxide (Na_2O), was present in all the water samples, both from the mineralized and the non-mineralized areas within a range of 1.7–88.7 ppm. The non-mineralized water sample had a minimum value of 126.3 ppm recorded for a hand pump while maximum value of 151.3 ppm was recorded for a pond water. Water samples from the non-mineralized area had values always higher than the maximum value recorded for any of the water samples from the mineralized area. Potassium was also estimated as di-potassium-oxide. It was detected in only eight of the sites, all of them located in the mineralized area. Maximum values for both the seasons, summer (46.2 ppm) and winter (41.3 ppm), were obtained for water samples from sample no. 8. Non-mineralized area exhibited absence of potassium in all the water samples, in both the seasons, from all the three sites. It is clear from the above results that most of the variations are found in the summer season and most of the parameters such as the elements Na, K, Mn, Co, Zn and fluoride probably increased abruptly in hot climatic conditions.

Conclusion and Recommendations

The assessment of water samples from different sources (pond, hand pump and open well) by various methods shows that majority of the water samples are good both for drinking as well as for domestic purposes. However, in the study area a few water samples are undesirable for drinking based on Fe and F content above the permissible limits. The deterioration of ground water quality can be checked by careful excavation, extraction and transportation of ores and proper drainage system at mine areas as well as at the neighboring villages. In the case of water having higher fluoride content, a change of water source is not feasible. Instead, water should be defluoridated by adopting the Nalgoda adsorption technique[8–13]. Villagers should be advised by the concerned government machinery at the Panchyat level to create an awareness regarding fluorosis and its prevention. Villagers should also be advised to consume fluoride-free water, vitamin-C-rich vegetables, fruits and to have an adequate calcium-rich diet. In this area lesser milk production from cattle was also observed, therefore people should also be advised to provide fluoride-free water and calcium-rich fodder to cattle which may help increase milk production. Continuous monitoring is required for safe drinking water purposes.

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