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Survey and characterization of fluoride in drinking waters in Jhabua district of Madhya Pradesh

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ABSTRACT- Water is an invaluable basic natural resource for human beings. Without water there is no life. Water is being used for several purposes viz. drinking, irrigation, hydro-electric production, industries, transport, sanitation, recreation etc. However, a major part of water is used for drinking and livelihood as well as irrigation of farm lands. Therefore, fresh water good of quality is extremely important and valuable to life. A part of rain water percolates in the ground through soil pores, joints and cracks in the rocks and is known as ground water. Ground water is a major source of drinking and domestic uses and irrigation of about 60% farm lands in the country (FAI 2011).

Water is an integral part of the life on the planet. It is an odorless and tasteless substance that covers more than three fourths of the earth's surface. Only 2.5% of the Earth's water is fresh water and 98.8% of that water is in ice and ground water. Groundwater is the major source of fresh water on the earth for drinking and agriculture. Some ground water contains dissolved ions beyond the permissible limit is harmful and is not suitable for domestic use. Groundwater has several cations like sodium, potassium, calcium and magnesium and that of anions like carbonate and bicarbonate, chloride, sulphate etc. Besides these ions, water contains some specific anions like lithium, fluoride, nitrate, selenium, arsenic etc in small amounts. Excess of each specific ion causes health hazards through their deficiency or toxicity to the soil, plants, human and animals. The concentrations of these specific ion influences the quality of water and its suitability for drinking purpose or irrigation of the crops. Water is a good source for supplementation of small amount of micronutrients to human and animals. Specific ions like fluoride, selenium that are present in drinking water, long term supplementation of these micronutrients is found beneficial for the normal health. Since, fluoride has been reported an essential element indispensable for the normal growth of animal and human beings. Low quantity of fluoride supplemented through water is reported well for normal health in several parts of the country. However, little excess of fluoride adversely affects the quality of drinking water for human consumption and its excess cause's fluorosis disease and other health problems in children. Plants and vegetation does not need fluoride for completing their life cycles.

Keywords: Groundwater, Fluoride, Fluorosis, Defluorination.

I. INTRODUCTION

India is one of the 25 nations in the world where fluoride problem is persisting due to long term consumption of excessive fluoride bearing drinking water. Recent findings indicate that more than 60 Million people including children in India are suffering with dental, skeletal and non skeletal forms of fluorosis and other associated health problems. In affected areas fluoride concentration in ground water is found to be more than tolerable limits. According to the survey made by Rajiv Gandhi National Drinking Water Mission, New Delhi many districts (in 16 out of 32 states) in India are affected due to endemic fluorosis problem till 1992. The total numbers of affected district and states in India might have been increased further more by now. The approximate percentage of affected districts in each state is presented in pie chart. It can be seen that 30% districts are affected in Punjab, Haryana, Madhya Pradesh, Maharashtra, and Bihar whereas population in 50% districts in Uttar Pradesh, Rajasthan, Gujarat, Andhra Pradesh and Tamil Nadu due effected by fluorosis. The percentage of affected districts is comparatively less in Delhi and Kerala states. Dental fluorosis is endemic in 14 states and 1,50,000 villages in India with the problem most pronounced in the states of Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh (Pillai and Stanley2002). In case of Madhya Pradesh (M.P.) and Chhattisgarh, approximately 170 villages were identified as fluoride toxicity affected villages in six districts.

Among them nearly 50% of the villages are affected alone in Jhabua district. Jhabua district is situated in the south-western corner of Madhya Pradesh. Jhabua is home to the Bheel Tribes or indigenous people with the various sub tribes like Bheel, Bhilala, Patelia and Manka together constituting 86.8% of the total population (Census, 2001). The district forms an unique climatic zone called the Jhabua hills in the southern part of Madhya Pradesh where it is part of the Vindya hill ranges which drains rail water enough into river from shallow tube wells or bore well, and ponds is the main source for drinking water . These tribes are poor, less educated and depends upon rural livelihood with low income. So several tribes children are suffering with fluorosis and other health problems in this area due to poor quality of drinking water particularly of high fluoride concentration. The high contamination of fluoride in drinking waters appears due to its contamination from rock phosphate mining and processing for phosphatic fertilizer production. Jhabua has large deposits of rock phosphate ores. It exists in the form of fluoraspar, cryolite and fluorapatite. The rock phosphate ores is used in manufacture of superphosphate for fertilization of agricultural crops. The native rock phosphate contaminates ground water with fluoride ion through slow to dissolution or processing of rock phosphate in mining area into phosphatic fertilizers which leads to release of higher concentration of fluoride in both surface and ground waters. Survey studies showed that this may be one of possible reasons for contamination of ground water source in Jhabua district with fluoride. In Madhya Pradesh the fluoride toxicity in the ground water has been studied in Shivpuri, Jhabua, Mandla, Mandsaur, Hoshangabad, Bhind, Morena, Guna over the period. Chakma *et al.* (1997) observed that the fluoride content of the deep bore wells in Mandla district of Madhya Pradesh ranged from 9.22 to 10.83 ppm. The depth of deep bore wells ranged from 37 meters to 43 meters, as per the recorded of public health engineering department, Mandla district. Earlier reports indicated that fluoride content in groundwater exceed 1.0 mg/L (permissible limit) in some isolated patches of Hoshangabad, Bhind, Morena and, Guna and even 4.5 mg L^{-1} fluoride was observed in some villages of Bhind district (Minhas and Samra, 2003). Fluoride adsorption was mainly affected by pH and ESP. For knowing the quality of ground water it is necessary to generate systematic database instead of random information. Earlier studies in Jhabua under Rajeev Gandhi National Drinking Water Mission (1992) have indicated elevated concentration of fluoride in ground water but no latest survey has been made on characterization of fluoride status in drinking water of Jhabua district. As per PHE Department (latter No. 4750), Jhabua, the fluoride affected drinking waters were observed 518 villages in Jhabua district. There number in different talukas were like Petlawad – 79 villages, Thandla – 88 villages, Meghnagar – 84 villages, Jhabua – 90 villages, Rama – 98 villages, Ranapur – 76 villages. Defluoridation, the process by which excess fluoride are removed or fluoridation the process by which small amounts of fluoride is added in drinking water, are becoming a serious challenge in remote areas particularly in these tribes areas of Jhabua district. Excess fluoride in drinking water is causing wide spread "fluorosis" among the people. Considering the fluoride supplementation as an important public health issue in tribes population of Jhabua and lack of systematic latest information on fluoride status of drinking water in Jhabua, present study has been proposed to "survey and characterization of drinking water sources of Jhabua districts of Madhya Pradesh in India".

II. MATERIALS AND METHODS

A. Location and extent

The Jhabua district is located on south west part of Madhya Pradesh state. It is one of the important tribal district of Jhabua hill Zone of Madhya Pradesh. The district is bounded by Dhar, Ratlam, Alirajpur districts of Madhya Pradesh and in south western Rajasthan border, respectively. The district area extends between the parallels of latitude $21^0$20' and $23^0$40' N and between the meridians of longitude $74^0$30' and 75^0 16' E of India. The mean altitude ranges from 450 to 700 m above sea level. The total geographical area of the district is 5,517 Sq. Km. Among 11 climatic zone, district Jhabua is situated in the Jhabua Hill climatic zone (XI zone) of Madhya Pradesh. It is situated in south-western corner of Madhya Pradesh which is home to the Bhil Adivasi or indigenous people with the various sub tribes like Bhil, Bhilala, Patelia and Manka together constituting 86.8% of the total population. The total population of Jhabua is 1,024,091. The climate of the area is arid to sub humid with annual precipitation of 600-800 mm. The rainfall is erratic and annual variations are constant. Mean maximum and minimum temperature ranged 10 ºC and 51ºC, respectively in summer. The area is characterized by hot summer and mild winter. South west monsoon is mainly responsible for major part of annual rainfall which is received during June to September months.

B. *Collection of Drinking Water Samples*

The total 208 water samples from different sources like hand pump, tube well and wells of the different villages of Jhabua district were collected and analyzed for different parameters for judging water quality parameters and specific ions like fluoride and nitrate content. Details of water samples site characterization are given in table 3.1 and each village location and other important information are given in appendix-I. District Jhabua is predominantly a hard rock terrain, comprises of granites of Archaeans age. Gnesise, Granite, Lameta, Bagh Formations are Fluoride bearing rocks. These rocks impart dissolved Fluoride in ground and surface water. Fluoride concentration in ground water is predominant in area covered with granitic rocks.

Fig.1. Jhabua had six tehsil (Talukas).

Granite contains alkaline igneous intrusions which are also responsible for fluoride enrichment in drinking water. Jhabua had six tehsil (Talukas) as shown in Fig.1.

III. RESULTS

A. Depth of drinking water Sources

Details of depth of tube well and hand pumps sources were enquired from nearby residents during the current survey.

Accordingly, ground water samples of Jhabua district were classified based on the depth of wells and tube wells (Table 1). The depth of wells/tubewells of Jhabua, Ranapur, Rama, Meghnagar, Petlawad and Thandla blocks is less than 45 m represented more than of 65% of the total hand pump.

Jhabua district as a whole had 65% hand pump in the range less than 45 meters. Also 11.5, 21.6, 15.4, 15.2, 11.2 and 32.2 % of hand pump of the Jhabua, Ranapur, Rama, Meghnagar, Thandla, Petlawad blocks have more than 45 m depth, respectively.

Table 1: Distribution of ground water samples according to hand pump depth in Jhabua.

S.N.	Hand pump / bore well depth (m)	Percentage of water samples in various Blocks of Jhabua					
		Ranapur	Rama	Jhabua	Megh-nagar	Thandla	Petlawad
1	< 45	88.5	78.4	84.6	74.8	78.8	67.8
2	>45	11.5	21.6	15.4	15.2	11.2	32.2

B. Block Wise Drinking Water Quality for Six Blocks in Jhabua District

The average drinking water quality parameters with respect to range and mean of alkalinity (pH), salinity (EC) and fluoride (F^-) concentration for different water samples for different blocks for post monsoon (October 2011) seasons are presented in Table 2.

C. Water reaction (pH)

Average pH value of drinking water collected in October 2011 for 208 samples is given in Table 4.3. The pH of water samples ranged from 7.05 to 7.33 with mean value of pH 7.13. Most of the water samples were categorized to be normal in reaction.

D. Electrical Conductivity (EC)

Data given in Table 4.3 revealed that average EC values of drinking waters collected during post monsoon season ranged between 0.83 to 1.67 dSm^{-1} with a mean of 1.26 dSm^{-1}. The lowest salt concentration (EC 0.83 dSm^{-1}) in water samples was observed in Block Meghnagar and the highest EC value of 1.67 dSm^{-1} was recorded in Ranapur block.

Table 2: Fluoride concentration and other water quality parameters of drinking water in different blocks of Jhabua district during October 2011.

S.N.	Name of block	No. of water samples	pH	EC, dsm^{-1}	Fluoride conc. mg/L	Nitrate conc. mg/L
1	**Ranapur**	40	7.33	1.67	1.320	2.174
2	**Rama**	43	7.05	1.15	2.477	1.334
3	**Jhabua**	27	7.12	1.51	0.810	1.948
4	**Meghnagar**	28	7.07	0.83	0.913	1.467
5	**Thandla**	37	7.20	1.11	2.188	1.375
6	**Petlawad**	33	7.00	1.21	1.196	1.509
All	**Mean**	**208**	**7.13**	**1.26**	**1.573**	**1.628**

E. Fluoride concentration in drinking waters

Data given in Table 2 representing October 2011 sampling indicated that the F concentration in hand pump waters ranged from 0.810 to 2.477 mg F/ L with a mean of 1.573 mg/L. The maximum F concentration in drinking water sources was found in Rama block followed by Thandla whereas the minimum F concentration was recorded in Jhabua and Meghnagar blocks being an average value of 0.810 and 0.910 mg/L, respectively.

F. Block Wise Drinking Water Quality for Six Blocks in Jhabua District

The average drinking water quality parameters with respect to range and mean of alkalinity (pH), salinity (EC) and fluoride (F^-) concentration for different water samples for different blocks for presummer (March 2012) seasons are presented in Table 3.

Table 3 Fluoride concentration and other water quality parameters of drinking water in different blocks of Jhabua district during March 2012.

S.N.	Name of block	No. of water samples	pH	EC, dsm^{-1}	Fluoride conc. mg/L	Nitrate conc. mg/L
1	**Ranapur**	40	7.76	1.27	1.769	16.090
2	**Rama**	43	8.17	0.95	2.486	11.058
3	**Jhabua**	26	8.35	1.01	0.897	7.225
4	**Meghnagar**	29	7.89	0.62	1.423	4.827
5	**Thandla**	38	8.04	0.97	1.295	4.842
6	**Petlawad**	29	8.06	1.03	0.767	6.177
All	**Mean**	**205**	**8.03**	**0.99**	**1.530**	**8.830**

G. Water reaction (pH)

The pH of 205 drinking water samples in pre summer season ranged from 7.76 to 8.35 with a mean of pH 8.03 (Table 4.5). This suggests that the pH (alkalinity) of water samples was lower after monsoon season than pre summer season.

H. Electrical Conductivity (EC)

Data given in Table 3 indicated that on an average salinity of drinking water for presummer season ranged between 0.95 to 1.27 dSm^{-1} with a mean of 0.99 dSm^{-1}.

Average salinity of water samples for presummer season was found to be low than post monsoon season. Seasonal variations in fluoride concentration in drinking waters of Jhabua district.

Data shown in Fig.2 and 3 clearly revealed a wide variations in F concentration in drinking water samples collected from various blocks of Jhabua during October 2011 and March 2012. However the overall mean of about 205 water samples remained similar viz. 1.570 mg F/L for post monsoon (October 2011) and 1.530 mg F/L for presummer seasons (March 2012).

This indicated that drinking water samples in both the seasons had F concentration just near to the critical limit of fluoride in drinking water 1.5 mg F/L recommended by World Health Organization (2002) safe for drinking purposes world over. It may be relevent to mention that average F concentrations of drinking water sources ranged between 0.810 to 2.477 mg F/L and the F concentration in drinking water was found in the order of maximum in Rama > Thandla > Ranapur > Petlawad > Meghnagar > Jhabua.

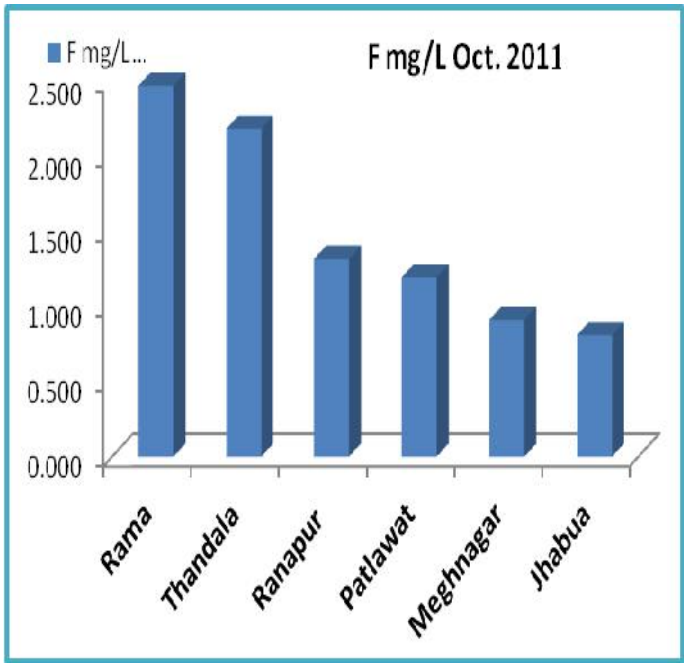

Fig. 2. Block wise fluoride distribution in drinking water samples collected in Oct. 2011.

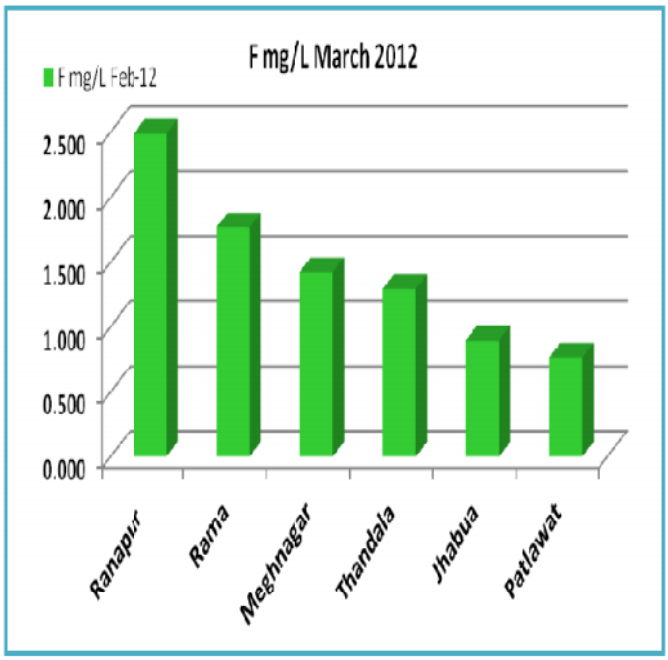

Fig. 3. Block wise fluoride distribution in drinking water samples in Feb-March 2012.

IV. CONCLUSIONS

Systematic information on fluoride content of ground water of Jhabua is very much lacking, therefore the research topic chosen is of topical interest with following research objectives to survey of fluoride status in drinking water being consumed in Jhabua district, study the impact of fluoride contaminant water on general health, to find out limits of fluoride content in drinking water sources and interaction with other ions present in drinking water to assess water safe for human consumption. Therefore, systematic survey of ground water resources was carried out in Oct-Nov. 2011 and Feb-March 2012 covering 6 blocks, 68 villages and 413 samples from 208 hand pumps in Jhabua district of Madhya Pradesh.Results showed that these water samples had pH 6.65 to 7.58, electrical conductivity 0.47 to 4.22 dS/m, sulphate concentration 0.5 to 11.6 mg/L. The carbonate and bicarbonate concentration ranged from traces to 0.6 and bicarbonate 2.2 to 5.8 me/L. The cations like Ca and Mg content ranged from 1.8 to 14.8 me/L whereas Na concentration varied widely in these waters. The fluoride content of drinking waters ranged from 0.43 to 4.51 mg/L which varied widely among these water sources, within villages, blocks in this district. Average F concentration in October 2011 and March 2012 was 1.53 and 1.57 mg F/L above the critical levels of 1.50 mg F/L. Overall these waters are moderately unsafe for drinking and may cause fluorosis in people of Jhabua. Block wise critical analysis reveled that drinking water quality of majority of hand pumps during October 2012 in Jhabua and Meghnagar blocks was good with respect to pH, salinity, fluoride and other parameters whereas drinking water samples obtained from Rama and Thandla and Ranapur blocks had high fluoride concentration and moderately unsafe for drinking purposes. In March 2012, Megh nagar and Thandala blocks hand pumps had good quality water with respect to pH, salinity, fluoride and other parameters whereas drinking water samples obtained from Rama and Thandla blocks had high fluoride concentration and unsafe for drinking purposes. The water of Jhabua and Petlawad blocks showed moderate water quality.

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