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SUITABILITY ASSESSMENT OF DRINKING WATER WITH SPECIAL ATTENTION TOWARDS FLUORIDE OF FIVE BKOCKS OF DISTRICT FATEHABAD, HARYANA, INDIA

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ABSTRACT

Fluoride acts as a two way sword. It has been reported in earlier studies that both lower and higher dose of fluoride pose harmful effects on human population, plants as well as on animals. Fluoride can enter inside the body through water, food, cosmetics and drugs. Drinking water is the main source of fluoride which contributes 75 % of fluoride to the body. Therefore, this study was under taken to analyze fluoride in drinking water to know the current scenario. To conduct the study, total 150 samples have been collected from five blocks i.e. Bhuna, Bhattu, Ratia, Fatehabad and Tohana of district Fatehabad of Haryana, India. Samples were collected in high density polythene bottles during three different seasons: post monsoon 2013, pre monsoon 2014 and monsoon 2014 and analyzed for fluoride by using SPADNS method. Wide variation occurs among all the samples from different locations and in three different seasons. Results revealed that minimum value 0.03 ppm recorded from Bhattu block in monsoon season and highest value 1.9 ppm was recorded at block Fatehabad in post monsoon season. All the values were compared with standard values prescribed by WHO & BIS. Mean values of fluoride of all blocks except Bhattu were decreased during pre monsoon season as compare to post monsoon season. Mean values in monsoon season remains similar for Tohana and Bhuna blocks, decreased in Ratia and Bhattu blocks but increase in fluoride level was recorded during monsoon season in block Fatehabad.

Keywords: Fluoride, drinking water, Fatehabad, Bhuna, Bhattu, Ratia, Tohana, Seasons

1.0 INTRODUCTION

200 million people of 25 different nations from all over the world are in the clutch of fluorosis (Garg *et al*., 2008). Around 65% disease named endemic fluorosis is due to fluoride contamination in water and more than 62 million people including children in India are affected by fluorosis (Bishnoi & Arora, 2005). It not only affects teeth but also other cells and tissues in the body (Gopalakrishnan *et al*., 2012). Many researchers reported regarding fluoride affects biotic components that is humans, plants and animals (Bishnoi & Arora, 2005, Ramanaiah *et al*., 2006) as discussed in Table 1. Excess fluoride in Groundwater was firstly reported in

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Nellore district of Andhra Pradesh (state) in India (Bishnoi & Arora, 2005, Babu *et al.,* 2006, Singaraja *et al.,* 2014).

Fluoride is reported to be present naturally at handful concentrations in natural waters, soil, plants and animals (Singh *et al.,* 2013). It is present in almost both shallow and deep water zone. Concentration of fluoride is found to be high at lower depth (Fawell *et al.,* 2006). Its amount may vary from low to high i.e. 0.1 to 8.7 ppm in groundwater depending upon type of rocks and minerals present underneath (Yu *et al.,* 2011). Its presence in water is due to weathering of fluoride containing rocks (Alabdulaaly *et al*., 2013). Minerals including rock phosphate, hornblende, cryolite, mica, fluorapatite, fluorspar, hydroxylapatite and others comprise remarkable extent of Flouride (Fawell *et al.,* 2006, Ramanaiah *et al.,* 2006, Babu *et al.,* 2006, Raju *et al.,* 2009, Singh *et al*., 2013, Singaraja *et al.,* 2014). In minerals, fluoride ion is able to replace hydroxide ion due to almost same radius and charge which may also be a cause for higher values of it (Gupta *et al.,* 2012, Fawell *et al.,* 2006).

In India, Granites and gneisses rocks (metamorphic and igneous) are endowed to be associated with rich concentrations of fluoride in groundwater especially in arid & semi arid regions (Gupta *et al*., 2012). Due to highest electronegativity (Bishnoi & Arora, 2005, Pazand, 2016) of Fluorine among all chemical elements of halogen group, it is always found in combinations with other electropositive elements to form compounds of fluorides (Fawell *et al*., 2006, Gupta *et al.,* 2012). Fluoride in nature is generally found in sedimentary and igneous rocks as CaF2 commonly known as Fluorite (Chae *et al.,* 2005, Fawell *et al.,* 2006). Approximate concentration of fluoride on earth crust is 0.06-0.09 per cent by weight (Fawell *et al.,* 2006, Yu *et al.,* 2011).
It is an indispensable element for the formation of teeth enamel & bone mineralization in humans. 0.5 ppm fluoride is daily required dose for human being (Singh *et al.,* 2013). Out of all the chemical components present in drinking water, fluoride poses noteworthy influence on people. Among all chemical substances present in water, both minimum and maximum values have been set for fluoride (Raju *et al.,* 2009). Dose less than 0.6 mg/l of fluoride in water cause decaying of teeth or dental carries (Babu *et al.,* 2006), above 1.5 mg/l may cause dental fluorosis (Chae *et al.,* 2005) and values even more than 3 mg/l is the major cause of skeletal fluorosis (Raju *et al.,* 2009, Alabdulaaly *et al.,* 2013, Singaraja *et al.,* 2014). Exposure to excessive dose of fluoride for long duration of time may result into retarded growth, alteration in DNA, low IQ in children & death at high doses (Pazand, 2016, Brima, 2014) also discussed in table 1.0. Some other heath related issues other than fluorosis were also associated such as Down syndrome, hematopoiesis, modifications of proteins, carbohydrates, lipids in living cells, alterations in blood biochemistry etc. (Garg *et al.,* 2008).

Out of all states, 22 states have been reported for endemic fluorosis in human population (Gopalakrishnan *et al.,* 2012, Singaraja *et al.,* 2014). According to CGWB & BIS, Out of 20 states and territories, Haryana state is one of the severely affected areas (Rout & Sharma, 2011). 48 mg/l F^- ion was observed in groundwater samples of Rewari district of Haryana which is the highest value found among all the other districts till now (Fawell *et al.,* 2006). In the recent past studies, Garg *et al.,* 2008 have recorded maximum 86 mg/l Fluoride in Motipura village of Bhiwani district. Concerning about the results, research on fluoride in drinking water in different parts of districts Hisar (Garg *et al.,* 1998 b, Kaushik *et al.,* 2002, Ravindra & Garg, 2006), Panipat (Kaushik *et al.,* 2002) Jind (Garg *et al.,* 1998 a, Mor *et al.,* 2003, Meenakshi *et al.,* 2004, Singh *et al.,* 2011), Faridabad (Kaushik *et al.,* 2004), Rohtak (Kaushik *et al.,* 2004, Bishnoi & Arora 2005), Jajjhar (Yadav & Lata, 2003), Gurgaon (Singh *et al.,* 2008), Bhiwani (Garg *et al.,* 2008) & Ambala (Rout & Sharma, 2011) of Haryana state of India has already been done by various researchers (Gupta *et al.,* 2012). Fatehabad is one of the districts in Haryana also reported to have fluoride values beyond BIS and WHO norms. In the present

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study, Bhuna, Bhattu, Ratia, Fatehabad and Tohana blocks of district Fatehabad have been selected for estimation of fluoride in drinking water.

Table 1.0: Effects of excess fluoride on living organism

Living organism	Effects	References
On plants	Inhibition of plant metabolism which may cause tip burn diseases, needle scratch and necrosis .	Ramanaiah *et al.,* 2006
	Reduction in root length, germination rate, vigour, catalase activity, protein content, induction of stress etc.	Datta *et al.,* 2012
	Alteration in chlorophyll synthesis	Joshi and Bhardwaj, 2012, Ram *et al.,* 2014
	Decrease in leaf expansion, plant biomass photosynthetic CO2 assimilation, stomatal conductance harvest index etc.	Singh and Verma, 2013
On domestic animals	weak bones, dental and skeletal fluorosis	Ramanaiah *et al.,* 2006, Kumar *et al.,* 2015
	reduction in milk production	Ulemale *et al.,* 2010
	reduction in plasma concentrationofCa, Mg, Cu and Zn, Hypocalcaemia	Chhabra *et al.,* 2012
On humans	Excess dose of fluoride affects metabolism of protein, carbohydrates, enzymes, Lipids, minerals and vitamins.	Ramanaiah *et al.,* 2006
	lower dose of fluoride cause dental carries	Garg *et al.,* 2008
	retarded growth, alteration in DNA	Brima, 2014
	Down syndrome	Pizzo *et al.,* 2007
	Hematopoiesis	Machaliński *et al.,* 2000
	low IQ in children	Tang *et al.,* 2008, Pazand, 2016
	alteration in blood biochemistry, Cancer	Ostovar *et al.,* 2013
	hip fractures, Hypertension	Li *et al.,* 2001

2.0 MATERIALS AND METHODS

2.1 SELECTED AREA FOR STUDY

Samples were collected from different blocks such as Bhuna, Bhattu, Ratia, Fatehabad and Tohana of district Fatehabad of Haryana (India).District Fatehabad covers only 5.69 % area of the state (CGWB, 2013). It is bounded by 29° 31' N latitude and 75° 27' E Longitude and is bound by Jind district in East, Sirsa district and Rajasthan in the West, Punjab in North and Hisar district in south. Locations of blocks and district are shown in figure 1 (a) & (b).

2.2 SAMPLE COLLECTION

Total 150 samples have been collected from blocks Bhuna, Bhattu, Ratia, Fatehabad and Tohana in three different seasons such as post monsoon in the month of December 2013, pre monsoonin in June 2014 and monsoon season in September 2014. All the samples were collected from different services of groundwater i.e. hand pumps, submersibles, tube wells and waterworks taps. The main source of all water samples were groundwater and the residents were using the water source directly for their domestic use. Samples were collected directly from the source in high density polythene bottles (HDPE) with two liters

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capacity (Babu *et al.,*2006, Roy and Thakuria, 2007, Ramadevi *et al.,* 2009, Rout and Sharma, 2011, Amoako *et al.,* 2011, Alabdulaaly *et al.,* 2013). Bottles were cleaned earlier & rinsed with distilled water and with the sample three times before filling of the bottle. (Babu *et al.,* 2006, Amoako *et al.,* 2011, Pazand and Hezarkhani, 2012). To collect representative sample taps were flushed for 5-10 minutes (Amoako *et al.,* 2011, Rout and Sharma, 2011, Pazand and Hezarkhani, 2012, Singaraja *et al.,* 2014).

Map 1(a). **(b).**

1. (a) Location map of Fatehabad in Haryana (India),

1. (b) Location map of all blocks in Fatehabad (Haryana), India.

2.3 STORAGE AND PRESERVATION OF SAMPLES

Collected Samples were stored at 4° C temperature in order to avoid any alteration in quality of samples as the method described by APHA (Babu *et al.,* 2006, Roy and Thakuria, 2007, Amoako *et al.,* 2011, Dhale and Pachkore, 2012, Singaraja *et al.,* 2014).

2.4 METHOD ADOPTED FOR ANALYSIS OF FLUORIDE

Spectrophotometric determination of fluoride in water samples was performed by following the SPADNS colorimeter method as described by APHA. (APHA 2000, Das *et al.,* 2003, Bishnoi & Arora, 2005, Gupta *et al.,* 2006, Matini *et al.,* 2012, Singh *et al.,*. 2012, Vincent & Balakumar, 2014, Babu *et al.,* 2016) by using Shimadzu UV-VIS-1800 spectrophotometer.

2.5 CHEMICALS USED FOR ANALYSIS

Anhydrous Sodium fluoride (NaF), SPADNS dye {sodium 2-(parasulfophenylazo)-1,8-dihydroxy-3,6-naphthalene disulfonate}, also called {4,5-dihydroxy-3-(parasulfophenylazo)-2,7-naphthalenedisulfonic acid trisodium salt}, zirconyl chloride octahydrate, ($ZrOCl_2 \cdot 8H_2O$) & Sodium arsenite ($NaAsO_2$) were used. All the chemicals were of AR grade (Thermo fisher scientific). Stock solution and dilutions were prepared by using double distilled water (APHA, 2000, Das *et al.,* 2003).

3.0 RESULT AND DISCUSSION

In the studied area, it was found that values of fluoride at all the locations were distributed unevenly possibly due to presence of uneven distribution of fluoride bearing minerals in rocks (Khaiwal & Garg, 2006). Obtained fluoride values were beyond the WHO & BIS limit during all the three seasons. The available results were statistically analyzed by using SPSS 16 software to calculate minimum, maximum, mean and standard deviation values. Mean values with standard deviation and the range of values are shown in table 1. Results indicated that minimum value 0.03 ppm observed from Bhattu block in monsoon season and highest value 1.9 ppm was found to be at block Fatehabad in post monsoon season. Maximum number of samples during post monsoon season were having fluoride values beyond the standard value i.e. 1 mg/l as recommended by WHO. Similar trend of mean values of fluoride were recorded in all blocks except Bhattu where values decreased in pre monsoon season as compared to post monsoon season as the similar results were observed by Gupta &

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Roy, 2012. The probable reason for trend may be due to rock water interaction timing, rainfall, soil temperature, oxidation reduction processes and the amount of total fluoride from parental rocks that can be soluble and insoluble (Gupta & Roy, 2012). Increase during monsoon season might be due to precipitation and dilution of groundwater as discussed by (Shailaja & Johnson, 2007). Mean values in monsoon season remains same for Tohana and Bhuna blocks, decreased in Ratia and Bhattu blocks and increase in Fatehabad block when compared with pre monsoon values. Earliar Saxena *et al.,* 2014 observed similar results that overall values in post monsoon season were higher than both pre monsoon and monsoon season.

Among all the samples only 5-6 samples were recorded to be in permissible limit while remaining samples resulted into higher or lower value than permissible limit. 28 % samples each from Fatehabad & Bhattu blocks which the highest percent was observed among all the other blocks followed by Ratia (22 %), Bhuna & Tohana (11 %) each throughout the year were found to have values below 0.6 mg/l which can cause dental carries (Babu *et al.,* 2006). It is very important to pay attention on quality of groundwater in district because total 62 % of samples from Tohana block which is the highest value among all blocks followed Bhuna (50 %), Fatehabad (46 %), Ratia & Bhattu (21 %) each were above the desirable level of Indian standards and WHO which is 1 mg/l which can be the major reason to enhance the number of patients of dental fluorosis (Chae *et al.,* 2005) and some other kind of dental problems. However, permissible limit prescribed by BIS is 1.5 mg/l in case when no alternate source of water is available.

Table 2.0: Fluoride values of all samples collected from five blocks of district Fatehabad during three seasons.

Name of blocks	Number of samples			Range			Mean ± SD		
	POM	PRM	MON	POM	PRM	MON	POM	PRM	MON
Bhuna	10	10	10	0.3 - 1.7	0.2 - 1.5	0.2 - 1.6	1.09 ± 0.51	0.83 ± 0.44	0.83 ± 0.45
Bhattu	8	8	8	0.06 - 1.7	0.08 - 1.6	0.03 - 1.4	0.66 ± 0.62	0.7 ± 0.6	0.55 ± 0.54
Tohana	11	11	11	0.2 - 1.8	0.04 - 1.6	0.09 - 1.2	1.0 ± 0.5	0.7 ± 0.45	0.7 ± 0.37
Ratia	8	8	8	0.3 - 1.7	0.2 - 1.7	0.3 - 0.7	0.75 ± 0.52	0.6 ± 0.49	0.5 ± 0.2
Fatehabad	13	13	13	0.2 - 1.9	0.2 - 1.4	0.3 - 1.5	0.8 ± 0.57	0.5 ± 0.44	0.67 ± 0.42

POM-post monsoon, **PRM**-pre monsoon, **MON**-monsoon, **SD**-standard deviation

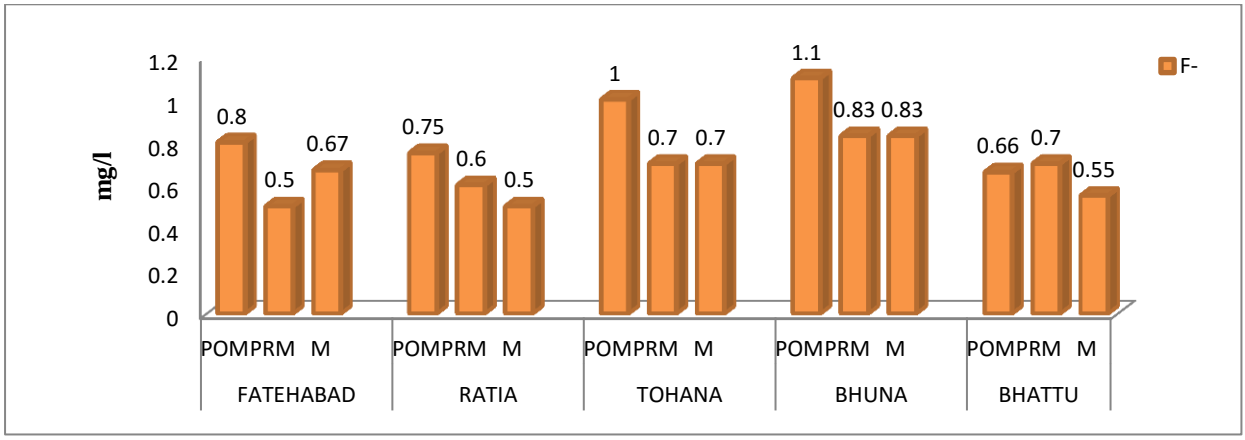

Chart 1.0: **Seasonal variation in mean values of all samples of five blocks.**

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Table 3.0: Classification of samples on Seasonal basis.

Name of blocks	Percent of samples beyond WHO limit (1 mg/l)		
	POM	PRM	MON
Bhuna	50	30	30
Bhattu	25	25	12.5
Tohana	63.6	18.2	27.3
Ratia	25	12.5	0
Fatehabad	30.8	23.1	23.1

Table 4.0: Block wise calculus of total number of samples with different ranges of fluoride.

Name of blocks	Number of samples below 0.6 ppm			Number of samples between 0.6-1 ppm			Number of Samples between 1-1.5 ppm			Number of samples above 1.5 ppm		
	POM	PRM	MON	POM	PRM	MON	POM	PRM	MON	POM	PRM	MON
Bhuna	2	3	3	3	4	4	3	3	2	2	0	1
Bhattu	5	5	4	1	1	3	1	1	1	1	1	0
Tohana	2	3	3	2	6	5	6	1	3	1	1	0
Ratia	4	4	5	2	3	3	1	0	0	1	1	0
Fatehabad	5	9	7	4	1	3	1	3	3	3	0	0

Chart 2.1-2.4: Pie Chart distribution of block wise samples showing different percent range of Fluoride.

Chart 2.1

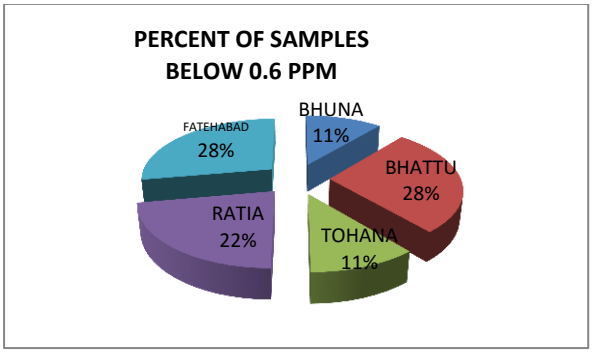


Chart 2.2

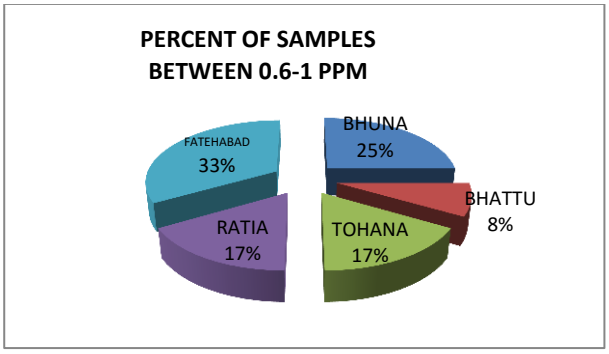


Chart 2.3

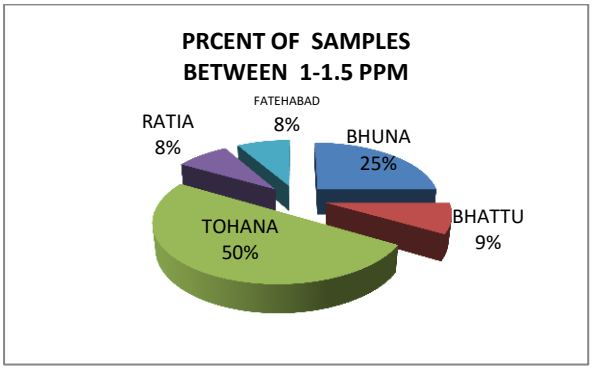
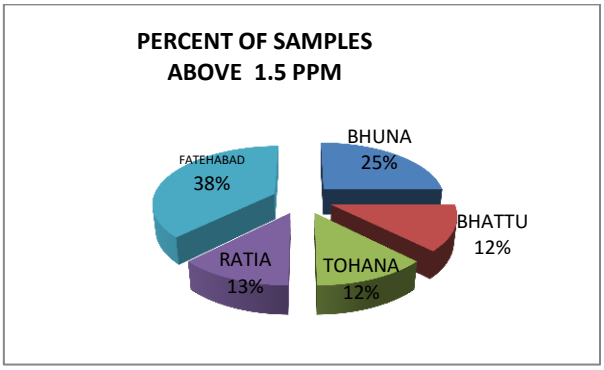


Chart 2.4



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CONCLUSION

Fluoride values between 0.6-1 ppm in drinking water were recorded only in 33 % of samples from Fatehabad, 25 % of Bhuna block, 17 % of Ratia and Tohana each and only 8 % of samples from Bhattu block which can be considered as suitable from drinking point and to prevent any dental ailment because it is the required dose.

Rest of the samples showed either values below 0.6 mg/l or higher than 1 mg/l which makes the water unsuitable from health point may result in to rise in dental caries, dental fluorosis and other health related issues.

Several low cost Defluoridation technologies may be adopted to resolve this problem. Strategy like dilution of Groundwater sources by artificial recharge so as to reduce the concentration of fluoride (Brindha and Elango, 2011).

As fluoride is required in our diet at some concentration, therefore where the values are below 0.6 mg/l, there people can raise the value of fluoride by using tablets, gels, mouth wash and tooth pastes etc (Pizzo *et al.*, 2007). Incorporation of Flouride in common salts may be adopted as effective strategy to counter fluoride deficiency (Alabdulaaly *et al.*, 2013) to fulfill the requirement of fluoride needed on daily basis. According to reports approximately 300 million people of 39 countries in world are supplied with fluoridated water in order to prevent dental carries (Pizzo *et al.*, 2007).

Defluoridation of water is must for high fluoride waters prior to its use for local people (Khaiwal & Garg, 2006). Defluoridation methods such as Adsorption method, ion exchange process, Membrane process and reverse osmosis may be adopted (Brindha and Elango, 2011).

To combat dental fluorosis problem at national level concerned departments should take necessary steps i.e. identification and Closure of wells having high values above 1.5 mg/l for fluoride (Alabdulaaly *et al.*, 2013). Intensive monitoring of fluoride is direly needed as at many places ground water is excessively used in agricultural purposes too which pose hazards to humans along with domesticated plants and animals. Regular awareness programmes should be organized by local administration to make common people aware regarding the ill effects of fluoride. Low cost biosensors should be commercialized to enable common people to regular check of fluoride level in their water. Access of clean drinking water is the right of every citizen of this country.

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