International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 11, Issue 11 (November 2015), PP.01-06

Revisiting Fluoride Assay of Groundwater of Sanganer Tehsil, Jaipur (Rajasthan), India

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Abstract:- Fluoride in ground water is a critical health issue in many parts of India and is responsible for many ailments. Jaipur being capital of Rajasthan and recently identified as one of smart cities and with many tehsils affected with high fluoride content prompted us to revisit this aspect and reevaluate the status of fluoride content. Keeping these in consideration, we attempted to identify hydro geochemical processes influencing fluoride concentration in groundwater of forty villages of Sanganer tehsil, Jaipur (Rajasthan). Sampling was done during pre-monsoon, monsoon & post-monsoon periods of year 2014. Fluoride concentrations along with other physico chemical parameters were determined. Fluoride concentration varied from 0.1 to 3.6 mg/L in the study area in variance to earlier findings indicating situation going from bad to worse and becoming a cause of concern as this area is going to become a fast developing suburb of Jaipur in future. Due to high concentration, people suffer from dental fluorosis and skeletal fluorosis such as mottling of teeth, deformation of ligament and ageing problems. As a result fluoride is adding aggressively to health hazards. The study also correlated fluoride concentration with other parameters in groundwater for having an insight in quality of soil as well. Our study parameters indicate that overall water quality was unsatisfactory for drinking purposes and using it without any prior treatment is harmful to life quality. High fluoride concentration in post-monsoon period was also observed. Moreover, an attempt has been made to statistically correlate the concentration of fluoride with other measured parameters and the condition affecting the groundwater quality.

Keywords:- Health, Fluoride, Physico-chemical parameters, Dental fluorosis, Monsoon.

I. INTRODUCTION

Fluorine is one of the elements necessary for human life but has double edged effect as deficiency as well as excess of it is detrimental in causing diseases. Fluorine in drinking water is totally in an ionic form and hence it rapidly and passively passes through the intestinal mucosa and interferes with metabolic activities of the living system. Evidence so far accumulated shows that upward adjustment of fluoride in water supplies to the extent of 1.0 mg/L results in a great reduction in the incidence of dental caries. Mild mottling of teeth has been observed at fluoride concentration between 1.0 and 1.5 mg/L and severe mottling at concentrations greater than 3.5 mg/L. Still high concentrations cause other physiological changes. [1] The amount of fluoride occurring in groundwater is governed by climate, composition of the host rock and hydrogeology. The major sources of fluoride in groundwater are due to fluoride bearing rocks such as fluorspar (CaF_2), cryolite (Na_3AlF_6), fluorapatite [$Ca_3\ (PO_4)_2Ca\ (F.Cl)_2$] and hydroxylapatite. Modern agricultural practice involving application of fertilizer coupled with pesticides also contributes fluoride to groundwater. The fluoride content is a function of many factors such as availability or solubility of fluoride minerals, velocity of flowing water, temperature, pH and concentration of calcium and bicarbonate ion in water.

High fluoride groundwater occurs in many parts of the world. Fluoride level studies in drinking water and its effect on health have been carried out in developing countries. In Indian context and, in particular, Rajasthan is no exception as all its 33 districts are endemic for fluoride. Rajasthan with an area of 3.42 lakh sq. km. is the largest state of country having 10.41% of the country's area and 5.5% of the nation's population but with meagre water resources. In most of the parts of the state, groundwater is either saline or has excess fluoride.

Earlier attempts on studies of groundwater of Sanganer tehsil, Jaipur, Rajasthan not only indicated that drinking water is not potable but also is poor in quality as far as cooking aspect is concerned. [2-3] The hazardous quality of ground water has been found to be responsible for dental fluorosis and skeletal fluorosis as 75% villages have such populations with such ailments. [4] Similar results have been reported for Malpura, a very near area to Sanganer. [5] Such studies in nearby district Tonk revealed that groundwater is contaminated with fluoride by naturally fluoride rich rock salt system. [6] Assessment of groundwater quality of Sriganaganagar and Hanumangarh districts of Rajasthan showed high concentration of fluoride and it shows highly positive correlation with HCO_3^- in irrigated soil. [7] Many preliminary attempts have been made to unveil the mystery of fluoride concentrations and its probable causes and its impact with regards to deteriorating health

conditions in all over Rajasthan.[8-13] Our earlier studies based on various physico chemical parameters also categorically pointed out about poor groundwater quality of Sanganer tehsil for drinking and irrigation purposes. [14] We also reported that most of the samples are highly contaminated for one reason or the other and are not suitable for use before any prior and proper treatment. [15]

So we find that many studies have been reported for Sanganer tehsil of Jaipur for highlighting fluoride and fluorosis problem. Sanganer is very significant for capital of Rajasthan due to its close vicinity to capital as well as due to its developing as an important suburb of Jaipur. As Jaipur has been declared a smart city and parameters relating to smart city have to be redressed, it was thought appropriate to revisit quality of groundwater of this area [an important parameter of smart city] in particular with reference to fluoride concentration and its long term effects on human health and irrigation.

I. MATERIALS AND METHODS

A. Study area

Sanganer Tehsil is attached with main city of Jaipur with geographical coordinates of in North and in East. It is widely known for the industry of handmade papers, textile printings as well as for the Jain temples found here. The total population of Sanganer tehsil is 573171 as per census 2011. There are about 142 villages in Sanganer tehsil.

B. Water sampling

A total forty samples were collected from wells, tube-wells or hand-pumps from different villages of Sanganer Tehsil during pre-monsoon period (June), monsoon period (August) and post-monsoon period (October) of year 2014. Before sampling, the water was left to run from the source for few minutes. Then in the laboratory conditions, water sampling was done from every selected location as given in Fig.1:

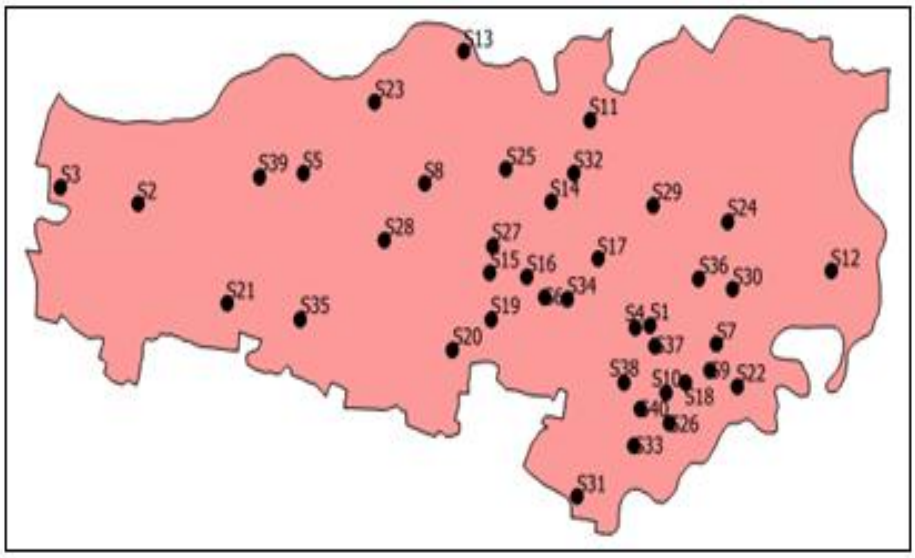

Fig.1: GIS map of Sanganer tehsil sampling stations

Samples were preserved in laboratory and analysed as per APHA [15].

C. Analysis

The analysis for physico-chemical parameters and fluoride in groundwater samples was carried out as per APHA standard methods. Fluoride concentration was determined by SPANDS method spectrometrically by using Zrconyl-SPADNS (sodium 2-(parasulphophenylazo-)-1, 8-dihydroxy-3, 6-naphthalene disulphonate) reagents.

II. RESULTS AND DISCUSSIONS

The fluoride concentration in groundwater samples varied significantly in different sampling sites of study area. The results of fluoride analysis of different periods are presented in Table I and Fig.2.

Table I: Fluoride concentration in sampling sites of Sanganer tehsil in different periods

Sample No.	Village	Fluoride (mg/L)		
		Pre-monsoon	Monsoon	Post-monsoon
S1	Asawala	0.4	0.3	0.6
S2	Bagru	1.0	1.1	1.2
S3	Bagru Rawan	0.6	0.6	0.7
S4	Baksawala	1.2	1.1	1.5
S5	Bamoriya	1.4	1.2	1.5
S6	Bar ka Balaji	0.6	0.5	0.9
S7	Beelwa	0.6	0.5	1.0
S8	Bhankrota	0.8	0.8	1.2
S9	Bhatawala	1.0	1.0	1.0
S10	Dayalpura	0.6	0.5	0.7
S11	Durgapura	0.5	0.6	0.5
S12	Goner	0.8	0.8	1.2
S13	Govindpura	1.0	0.9	1.3
S14	Hajiwala	0.6	0.6	0.6
S15	Heerapura	0.7	0.6	0.7
S16	Jagannathpura	0.2	0.1	0.5
S17	Jaranwala	1.2	1.2	1.5
S18	Khetapura	1.3	1.1	1.4
S19	Khori	0.4	0.2	0.6
S20	Kishorpura	0.8	0.6	1.0
S21	Lakhawas	0.6	0.7	0.7
S22	Laxmipura No. 1	0.8	1.0	0.8
S23	Mahapura	1.3	1.0	1.5
S24	Mahel	0.4	0.2	0.5
S25	Manoharpura	0.6	0.5	0.6
S26	Mohanpura	0.6	0.6	0.8
S27	Muhana	1.2	0.9	1.3
S28	Nevta	2.6	2.8	3.0
S29	Pratapnagar	1.0	1.4	1.3
S30	Ramchandrapura	0.8	1.0	1.5
S31	Ramsinghpura	1.2	1.3	1.6
S32	Sanganer	0.8	0.6	1.2
S33	Seemliya	0.6	0.6	0.6
S34	Shikarpura	1.0	1.0	1.6
S35	Sirani	0.8	0.8	0.9
S36	Sitapura	0.6	0.6	0.8
S37	Sukhdeopura	0.6	0.6	0.6
S38	Surajpura	0.4	0.4	0.4
S39	Teelawas	1.4	1.3	1.6
S40	Vatika	3.5	3.6	3.5

Table II: Minimum, maximum, average and standard deviation of fluoride concentration in different periods

Sample No.	Fluoride (mg/L)		
	Pre-monsoon	Monsoon	Post-monsoon
Minimum	0.2	0.1	0.4
Maximum	3.5	3.6	3.5
Average	0.91	0.88	1.11
Standard Deviation	0.59	0.63	0.63

Fluoride ranged from 0.2 mg/L (S16) to 3.5 mg/L (S40) with an average of 0.91 mg/L and a standard deviation of 0.59 in pre-monsoon period, 0.1 mg/L (S16) to 3.6 mg/L (S40) with an average of 0.88 mg/L and

standard deviation of 0.63 in monsoon period and 0.4 mg/L (S38) to 3.5 mg/L (S40) with an average of 1.11 mg/L and standard deviation of 0.63 (Table II). Permissible limit for fluoride is 1.0-1.5 mg/L according to W.H.O. standards. The data revealed that 12.5% samples are affected with high concentration of fluoride in post monsoon period (Table III).

Table III: Concentration of fluoride of Sanganer tehsil comparison with W.H.O. standards

Parameter	WHO standard		% of the total samples exceeding limits		
Fluoride (mg/L)	Desirable limit	Permissible limit	Pre-monsoon	Monsoon	Post-monsoon
	0.5	1.5	5.00%	5.00%	12.50%

The names of sample sites with high fluoride concentration are S28 (Nevta) and S40 (Vatika) in all three periods. In addition, S31 (Ramsinghpura), S34 (Shikarpura) and S39 (Teelawas) are also having high fluoride concentration in post-monsoon period.

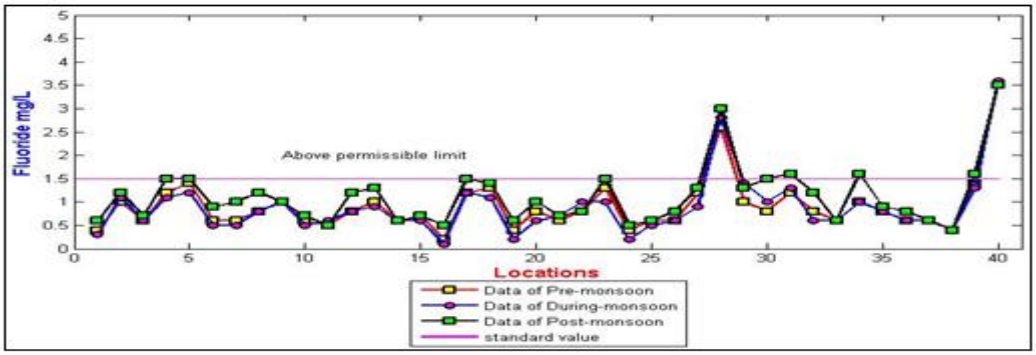

Fig.2: Comparative analysis of fluoride in groundwater of Sanganer tehsil in various seasons

Statistical analyses of groundwater parameters

The physico-chemical analysis was carried out using computer software package **SPSS** (**Statistical Package for Social Sciences**, later modified to **Statistical Product and Service Solutions**), version 16.0. Descriptive statistics is used to summarize and present data in a meaningful manner so that information can be easily understood. In our studies, Correlation matrix showed relationships of varied types between different hydrochemical parameters with fluoride (Table IV).

Table IV: Correlation matrix between different parameters with fluoride in pre-monsoon period

Parameter	EC	pH	TDS	HCO_3^-	CO_3^{2-}	TH	Ca^{2+}	Mg^{2+}	Cl^-	F^-	SO_4^{2-}	NO_3^-	Na^+	K^+
Pre-monsoon	0.089	-0.126	0.417	0.668	-0.037	0.066	0.091	0.011	0.179	1	0.068	0.039	0.508	0.424
Monsoon	0.076	0.024	0.21	0.411	-0.075	0.008	0.098	-0.071	0.039	1	-0.076	0.199	0.347	0.136
Post-monsoon	0.086	-0.059	0.406	0.626	0.134	0.135	0.221	0.011	0.214	1	0.055	0.066	0.437	0.31
Red colour indicates highly positive correlation and blue colour indicates positive correlation.														

HCO_3^- showed a highly positive correlation with F^- in pre-monsoon and post-monsoon periods having correlation 0.668 and 0.626 respectively (as shown in Table IV with red colour and Fig.3) compared to other physico-chemical parameters, and it has been observed that low Ca^{2+} and high HCO_3^- favour high fluoride content in groundwater.

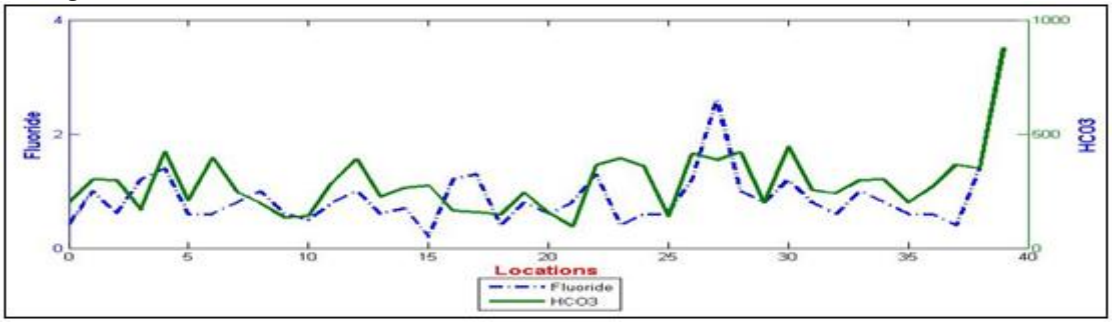

Fig.3: Correlation between fluoride and HCO3$^-$

Presence of fluoride in drinking water is both beneficial and detrimental to the consumer. Low level of fluoride in drinking water results in incorporation of fluoride into teeth during the formative years of children, which makes the teeth resistant to decay and development of dental caries. However, mottling of teeth may occur when the concentration increases more than 1.5 mg/L. Long term intake of water containing excessive concentration in the range of 4 mg/L to 10 mg/L causes skeletal fluorosis in which the bone structure is affected causing bone deformation and crippling (Table V).

Table V: Concentration of fluoride in drinking water

Parameter	Fluoride concentration (mg/L)	Effect on human health	Pre-monsoon samples	Monsoon samples	Post-monsoon samples
Fluoride	< 0.5	Dental caries	S1,S11,S16,S19,S24,S38	S1,S6,S7,S10, S11,S16,S19,S24, S25,S38	S11,S16,S24,S38
	0.5-1.5	Prevents tooth decay	S2toS10,S12toS15, S17,S18,S20toS23, S25toS27,S29toS37,S39	S2toS5,S8,S9,S12toS15,S17,S18, S20toS23,S26, S27,S29toS37, S39	S1toS10, S12toS15, S17toS23, S25toS27, S29,S30,S32,S33, S35toS37
	1.5-4.0	Mottling and pitting of teeth (Dental fluorosis)	S28,S40	S28,S40	S28,S31,S34,S39,S40
	> 4.0	Pain in neck bones and back(Skeletal fluorosis) and crippling fluorosis	-	-	-

Fluorosis, which was considered to be a problem related to teeth, has now, turned up to be a serious health hazard. This is also revealed in our investigations that samples collected from sample point Nos S11,S16,S24,S38 are cause of concern for dental caries and S28,S31,S34,S39,S40 are responsible for Mottling and pitting of teeth (Dental fluorosis). No doubt, most of the samples S1 to S10, S12 to S15, S17 to S23, S25 to S27, S29, S30, S32, S33, S35 to S37 are in the safe range of 0.5-1.5 as far as fluoride concentration is concerned but fluoride rich rock salt system in the area of study can easily disturb this range.

Dental fluorosis occurs because of the excessive intake of fluoride. The damage in tooth development occurs between the ages of 6 months to 5 years, from the over exposure of fluoride. Teeth are generally composed of hydroxyl apatite and carbonated hydroxyl apatite; when fluoride is present, fluorapatite is created. Fig.4 reflects the irreparable damage caused to human beings and these being recent photographs depict present status of impact of higher fluoride concentrations on human health. Excessive fluoride can cause yellowing of teeth (Fig.4), white spot and pitting or mottling of enamel. Dental fluorosis affects both the inner and outer surface of the teeth.

Fig.4: Various ailments related to high fluoride concentration of Sanganer

In a nut shell, the scenario of fluoride concentration appears to be detrimental to health in whole of Sanganer as the quality of groundwater is either poor or is at the risk of fluoride contamination.

III. CONCLUSION

The study provides an overview of the fluoride concentration in drinking water and points to an acute fluoride problem in Sanganer tehsil. The favourable factor which contributes to rise of fluoride in groundwater is presence of fluoride rich rock salt system in the area of study. The samples collected in post-monsoon period were more contaminated with fluoride due to low dilution and low dilution tends to the accumulation of ions. Being an important suburb of Jaipur [capital of Rajasthan and also now a smart city], Sanganer tehsil needs groundwater of the quality needed for smart city. It is desirable that potable water be provided in tehsil of Sanganer and the results of current study as well as other available data should be taken into account to ensure quality of water in minimum possible time so as to ensure water quality parameters of smart city fulfilled.

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