

The Quality of Groundwater in Jaipur Region with Emphasis to Fluoride Concentration

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The problem of high fluoride in groundwater is one of the most important health related geo-environmental issue. It is beneficial up to certain limits but excess intake (i.e. >1.5mg/L) may cause fluorosis. Fluoride in groundwater was studied in Sanganer tehsil of Jaipur district. 18 villages were under surveillance. Groundwater samples were periodically collected and analyzed for physico-chemical parameters including Fluoride (F), pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), total hardness, Calcium (Ca²⁺), Chloride (Cl) and alkalinity. The analytical results revealed considerable variations in the chemical composition of water samples. Fluoride concentration varies from 0.20 to 6.45 mg/L.

Keywords: Water quality, Fluoride, Fluorosis.

1. INTRODUCTION

Fluoride has been used as a therapeutic agent in dental caries but excess intake (1.5 mg/L) may causes serious health hazards including dental fluorosis, skeletal fluorosis and non-skeletal fluorosis in children as well as in adults along with secondary neurological complications [1-4]. During the last three decades high Fluoride concentration in water resources and the resultant disease 'fluorosis' is being highlighted considerably throughout the world. Nearly three million people of our country are consuming excess fluoride containing water, especially rural population [5-8]. In Rajasthan, groundwater is characterized by comparatively high concentration of fluoride. 22 districts out of 32 are presently consuming water contaminated with Fluoride [9-12]. Earlier workers [13-17] reported that fluorosis was correlated high concentration of Fluoride ion in drinking water. Thus water samples were randomly collected from various location of the study area to assess the quality of groundwater bodies, with special attention to Fluoride.

2. MATERIALS AND METHODS

Groundwater samples were randomly and periodically collected in pre-cleaned polyethylene bottle from 18 villages of Sanganer tehsil (Jaipur district) of Rajasthan as given in Table 1.

Table 1: Showing Chemical Analysis of groundwater of Sanganer Tehsil, Jaipur.

S. No.	Villages	pH (H ⁺ ion)	TDS (mg/L)	EC (μ mho/cm)	F ⁻ (mg/L)	Cl ⁻ (mg/L)	TH (mg/L)	Ca (mg/L)	Mg (mg/L)	Alkalinity (mg/L)
1.	Mohanpura	8.20	920	1650	1.30	125	220	35	30	640
2.	Jaichandpura	8.10	2650	4670	0.5	825	680	149	122	1090
3.	Shrirampura	8.34	790	1410	1.2	101.5	175	26.8	30.2	570
4.	Sukhalpura	8.40	685	1370	1.1	82.7	185	23	27	489
5.	Vatika	7.02	177	630	3.24	345.75	1032.5	63.2	960.2	950
6.	Ashawalla	7.62	82	480	6.20	221.2	719.2	51.1	670.2	720
7.	Chak vatika	7.10	114	630	3.35	205.1	929.2	82.5	847.5	570
8.	Tellawala	7.30	419	760	4.49	337.3	938.5	69.8	842.7	570
9.	Magyawas	8.20	1502	2677	0.4	201	347	49	53.8	903
10.	Ramsinghpura	8.0	4655	9460	0.2	2175	705	170	127	1465
11.	Singarpura	8.30	1460	2601	0.5	200	321	49	41	940
12.	Lilya ka bas	7.20	100	520	6.45	332	835	57	790	470
13.	Badvokidhani	7.0	102	610	3.2	301	1024	62	940	870
14.	Muhana	8.4	680	1270	1.2	69	145	19	23	435
15.	Ramjipura	8.6	601	1132	1.3	56	129	13	17	390
16.	Sanganer	7.3	870	1360	2.5	267	400	200	205	110
17.	Sitapura RIICO	7.10	1030	647	3.82	88.6	160	90	70	266
18.	Goner	7.33	1800	920	1.70	90	97	11	27	297

A total of 100 water samples (5 samples per village) were collected in pre-cleaned polyethylene bottles and brought to the laboratory for analysis using standard techniques for physico-chemical parameters. Analytical Water analysis: Physico-chemical parameter like pH, Electrical conductivity, TDS, total hardness, Calcium, Chloride and alkalinity were determined as per standard method [18]. The apparatus for study of parameters and their effect on human body are as shown in Figure 1.



Fig.1: Images showing the study and its observations.

2.1. Fluoride Analysis

Fluoride concentration was determined with the help of selective ion meter (Orion Research Ion Analyzer Model 407 A). Standard procedure for determining the Fluoride was followed [18]. In order to achieve satisfactory results; total Ionic strength adjustment buffer (TISAB) was used to maintain a suitable ionic strength.

3. RESULTS AND DISCUSSION

The physico-chemical examinations including fluoride content are presented in the Table 1. The result reveals that Fluoride content in groundwater samples of four villages varied from 0.2-0.99 mg/L. In five villages Fluoride content ranged from 1.0-1.49 mg/L followed by more than 1.50 mg/L in nine villages as given in Table 1. Fluoride content in three villages was very alarming. The maximum content of Fluoride was recorded in Lilya ka bas (6.45 ± 0.02 mg/L), Ashawalla (6.20 ± 0.01 mg/L) and Tellawala (4.49 ± 0.09 mg/L). The permissible limit for Fluoride content is 1-1.5 mg/L according to W.H.O.. The data revealed that 50% villages of Sanganer tehsil are affected with high concentration of Fluoride, where as 50% villages it was within limit. As, teeth appear to be most susceptible organs to fluorine poisoning and concentration higher than 2 ppm of Fluorine initiate mottling [19]. Ruan *et al.* [20] showed that even with 1.2 ppm, cause dental fluorosis during period of tooth mineralization. The pH of almost all the sources was slightly alkaline in the range of 7.0 to 8.6. The correlation analysis indicated that F^- is positively correlated with pH ($r = 0.374$, $p < 0.01$) which in agreement with earlier studies

[21,22]. The positive correlation of pH with F^- suggests that pH is important in determining fluoride in the ground water. Electrical conductivity (EC) is used for detection of impurities in water. USPH [23] recommended permissible limit for electrical conductivity (EC) is 300 $\mu\text{mhos/cm}$ as shown in Table 2.

Table 2: Showing standards of drinking water.

Parameter	WHO	USPH
Fluoride (mg/L)	1-1.5	1.5
pH	6.9-9.2	-
E.C. ($\mu\text{mhos/cm}$)	-	300
TDS (mg/L)	500-1500	500
Total Hardness (mg/L)	100-500	-
Ca-Hardness (mg/L)	75-200	100
Mg-Hardness(mg/L)	30-100	30
Chloride (mg/L)	200-600	250
Alkalinity (mg/L)	200	-

Among groundwater samples Ramsinghpura area had maximum EC (9460 $\mu\text{mhos/cm}$) while Ashawalla area had minimum (480 $\mu\text{mhos/cm}$). Total dissolved solid reduces utility of water for drinking, irrigation and industrial purposes according to W.H.O. [24]. In the groundwater samples of Sanganer tehsil, Ramsinghpura area had maximum TDS (4655 mg/L) while Ashawalla area had minimum (82 mg/L). The Rajiv Gandhi National Drinking Water Mission [25] identified high total dissolved solids as a water quality problem in Rajasthan along with high nitrates and high fluorides. The increase in TDS is due to increase in salts containing carbonates, bicarbonates and chlorides [26]. The measured chloride concentration in the water samples ranged from 56 mg/L to 2175 mg/L. Maximum chloride was recorded at Ramsinghpura and minimum was found at Ramjipura. W.H.O. recommended safe permissible limit for chloride i.e. 200-600 mg/L. The chloride in groundwater may be contributed from minerals like mica and apatite as also from the liquid inclusions in the igneous rocks [27]. Moreover, higher content of chloride may have deleterious effects on metallic pipes as well as aquatic flora and crops [28]. Hardness of water is a complex mixture of cations and anions. The principal hardness causing ions are calcium and magnesium. The total hardness, calcium and magnesium in the water are interrelated. In the present study concentration of Total hardness (TH) varied from 97 to 1032.5 mg/L. Minimum and maximum was reported from Goner and Vatika villages respectively. The permissible limit of total hardness for drinking water is 100-500 mg/L as per W.H.O.. Further, Calcium hardness (Ca-H) was recorded minimum 11 mg/ L in Goner and maximum 200 mg/L in Sanganer. The permissible limit for Calcium is 75-200 mg/L as per W.H.O. Further, magnesium hardness (Mg-H) was recorded minimum 27 mg/L in Goner and maximum 960.20 mg/L in Vatika. Nanyaro *et al.* [29] have attributed high fluoride content in water of Northern Tanzania to their exceptionally low Calcium and Magnesium concentrations. Maina and Gaciri [30] have found in a study of forty-seven bore-wells, that low Calcium and negligible Magnesium concentrations corresponded to relatively high Fluoride values.

High value of alkalinity gives an undesirable taste to water. Among the total samples seventeen samples were beyond permissible limit (200 mg/L). The maximum value of alkalinity was found in sample of Ramsinghpura village (1465 mg/L) and minimum (110 mg/L) was observed from Sanganer. The adverse effects on human health are due to consumption of fluoridated, water. It is recommended to take some measures for defluoridation of drinking water. Otherwise major health hazards will inevitably experienced as some of the areas have very high Fluoride content in the drinking water.

4. CONCLUSION

This study provides an overview of the Fluoride content in drinking water and show that there is an acute fluoride problem in Sanganer Tehsil, Jaipur. The favorable factor which contributes to rise of Fluoride in ground water is presence of Fluoride rich rock salt system. The result of current study as well as other available data from water quality should be taken in to account when developing strategies for safe drinking water supplies. Environmental awareness programme for health implication should be emphasized through education of the public and community participation

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REFERENCES

- [1] K.K. Satpathy, R.K. Padhi, M. Sowmya and M.K. Samantara; "Fluoride in ground water: a comment on "fluorine contamination in ground water: a major challenge", published in *Environmental Monitoring and Assessment*, Vol.173, pp. 955-968, 2011. DOI:10.1007/s10661-013-3525-4.
- [2] S. Shekhar, A.C. Pandey and M.S. Nathawat; "Evaluation of fluoride contamination in groundwater sources in hard rock terrain in Garhwa district, Jharkhand, India", *International Journal of Environmental Sciences*, Vol. 3(3), pp. 1022-1030, 2012. DOI:10.6088/ijes.2012030133010.
- [3] Punita parikh and Rahul parikh; "Current status of fluoride contamination in ground water of kheralu block of Mehasana district, Gujrat", *International Journal of Environmental Sciences*, Vol. 3(6), pp. 2199-2207, 2013. DOI:10.6088/ijes.2013030600035.
- [4] K. Avishek, G. Pathak, M.S. Nathawat, U. Jha and N. Kumari; "Water quality assessment of Majhiaon block of Garwa district in Jharkhand with special focus on fluoride analysis", *Environ. Monit. Assess.*, Vol. 167(1-4), pp. 617-623, 2010. DOI 10. 1007/s10661-009-1077-4.
- [5] N.J. Chinoy, E. Sequeria, M.V. Narayana, M. Mathews, V.V. Barot, P.R. Kandoi and D.D. Jhala; "A survey of fluoride in 90 endemic villages of Mehsana and Banaskantha districts of North Gujrat, India", *Fluoride*, Vol. 38(3), pp. 224, 2005.

- [6] P.K. Das and S.D. Malik; "Groundwater of Khatra region of Bankura district, West Bengal: some chemical aspects in reference to its utilization", *Journal of Indian Water Resources Society*, Vol. 8(3), pp. 31-41, 1988.
- [7] S.K. Mittal, A.L. Rao, R. Kumar and Singh; "Groundwater quality of some areas in Patiala city", *Indian Journal of Environmental Health*, Vol. 36(1), pp. 51-53, 1994.
- [8] M. Murali and T. Indira; "Some studies on groundwater contamination due to integrated low cost sanitation in slum areas of Visakhapatnam", *Nature Environment and Pollution Technology*, Vol. 3(3), pp. 249-254, 2004.
- [9] S.K. Jha, A.K. Nayak and Y.K. Sharma; "Potential fluoride contamination in the drinking water of Marks Nagar, Unnao district, Uttar Pradesh, India", *Environ Geochem Health*, Vol. 32, pp. 217-226, 2010. DOI 10.1007/s10653-009-9277
- [10] M. Arif, I. Hussain, J. Hussain, S. Sharma and S. Kumar; "Fluoride in the Drinking Water of Nagaur Tehsil of Nagaur District, Rajasthan, India", *Bull Environ Contam Toxicol*, Vol. 88(6), pp.870-875, 2012. DOI 10.1007/s00128-012-0572-4.
- [11] M. Arif, J. Hussain, I. Hussain and S. Neyol; "Fluoride Contamination of Ground Water of Merta Block in Nagaur District, Rajasthan, India", In The conference of advance in Environmental chemistry (AEC), Aizwal, Mizoram, pp.146-148, 2011.
- [12] V. Agrawal, A.K. Vaish and P. Vaish; "Groundwater quality: focus on fluoride and fluorosis in Rajasthan", *Current Science*, Vol. 73(9), pp. 743-746, 1997.
- [13] R.K. Gangal; "Fluoride hazard of groundwater in the Jaipur district, Rajasthan, India and methods to mitigate it", *Fluoride*, Vol. 38(3), pp. 241, 2005.
- [14] S.C. Gupta; "Chemical character of ground-waters in Nagaur district, Rajasthan", *Indian J. Environ Hlth.*, Vol. 33(3), pp. 341-349, 1991.
- [15] S.C. Gupta, C.S. Doshi and B.L. Paliwal; "Occurrence and chemistry of high ground waters in Jalore district of western Rajasthan", *Ann Arid Zone*, Vol. 25, pp. 255-264, 1986.
- [16] J.D. Sharma, P. Jain and S. Deepika; "Geological study of fluoride in groundwater of Sanganer tehsil of Jaipur district, Rajasthan, India", *Fluoride*, Vol. 38(3), pp. 249, 2005.
- [17] D. Sabal and T.I. Khan; "Fluoride distribution in ground-water of Phagi tehsil (Jaipur district)", *Inter. J. Bioscience Reporter*, Vol. 4(2), pp. 243-246, 2006.
- [18] D. Agrawal; "Study of Physiological and biochemical aspects of fluorosis (non-skeletal) in Dausa district", Ph.D. Thesis. University of Rajasthan, Jaipur, 2006.
- [19] U.N. Samal and B.N. Naik; "Dental Fluorosis in school children in the vicinity of an Aluminium factory in India", *Fluoride*, Vol. 21(3), pp. 142-148, 1988.
- [20] J.P. Ruan, Z.Q. Liu, J.L. Song, K. Bjorvatn and M.S. Ruan; "Effect of drinking water change upon the dental fluorosis", *Zhonghua. Kou. Qiang. Yi. Xue. Za. Zhi.*, Vol. 39(2), pp. 139-141, 2004.
- [21] V.A. Stanley, N. Ramesh, K.S. Pillai and P.B.K. Murthy; "Epidemiological survey of fluorosis in ennore, Madras", *Proc. Acad. Environ. Biol.*, Vol. 6(2), pp. 121-125, 1997.

- [22] M.C. Smith, E.N. Lantz and H.V. Smith; "The cause of mottled enamel", *Science*, Vol. 74, pp. 244-246, 1931.
- [23] USPH; "Fluoridation Census", Department of Health and Human Services. Bethesda MD., pp. 28-32, 1985.
- [24] W.H.O. Total dissolved solids in Drinking-water, Guidelines for drinking water quality, Vol. 2, 1996.
- [25] RGNDWM; "Prevention and control of fluorosis in India - water quality and defluoridation techniques", Vol. 2, Published by Rajiv Gandhi National Drinking Water Mission, Ministry of Rural Development, New Delhi, 1993.
- [26] A.K. Susheela; "Prevention and control of fluorosis in India", Rajeev Gandhi National Drinking Water Mission, Health Abstract, Vol. 1, 1993.
- [27] W.H.O.; "Fluorine and Fluoride", Environmental Health Criteria, Geneva, Vol. 36, pp. 93, 1984.
- [28] "Standard methods for the examination of water and wastewater", 21st edition, American Public Health Association, New York, U.S.A., 2005.
- [29] J.T. Nanyaro, U. Aswathanarayana and J.S. Mungure; "A geochemical model for the abnormal fluoride concentrations in waters in parts of Northern Tanzania", *J. Afr. Earth Sci.*, Vol. 21(3), pp. 129-140, 1984.
- [30] J.W. Maina and S.J. Gaciri; "Contributions to the hydrochemistry of the area of the immediate north of Nairobi conservation area", *J. Afr. Earth Sci.*, Vol. 2(3), pp. 227-232, 1984.