To Assess the Quality of Ground water in Malpura Tehsil (Tonk, Rajasthan, India) with emphasis to Fluoride Concentration

Girja Shanker Tailor [1] and C. P. Singh Chandel [1, *]

1. Department of chemistry, University of Rajasthan, Jaipur, Rajasthan, India
* Email: chandelcps2rediffmail.com

Abstracts: Fluoride is one of the critical chemical parameter, which influences the quality of ground water. Excess intake of fluoride through drinking water causes fluorosis on human beings in many states of India, including Rajasthan .This study aims to identify the hydro geochemical processes influencing the high fluoride concentration in ground water of Malpura Tehsil, Tonk (Rajasthan, India). For this purposes twenty six ground water samples were collected during the post monsoon session of 2008. The fluoride concentration along with physico chemical parameters in ground water samples was determined in various sampling sites of Malpura Tehsil, since in most of the sampling point it is only sources of drinking water. The Fluoride concentration in these sampling points varied from 0.08 to 11.30 mg/L with highest level at G7 sample (11.30 mg/L) and lowest at G8 sample (0.08 mg/L). Most people in these study areas suffer from dental fluorosis and skeletal fluorosis such as mottling of teeth, deformation of ligament, bending of spinal column and ageing problem. [Nature and Science 2010;8(11):20-26]. (ISSN: 1545-0740).

Key Words: Malpura Tehsil, Groundwater, Skeletal fluorosis, Dental fluorosis

1. Introduction

Ground water is the most appropriate and widely used source of drinking water. Groundwater is the major source of drinking water and over 91% of the drinking water demand is met by groundwater.Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at focal point. Fluoride in ground water is known to contaminate the water resources globally. Fluoride is one of the chemical elements necessary for human life. Fluoride exists naturally in water sources and is derived from fluorine, the thirteenth most common element in the Earth's crust. Fluorine is the most electro negative of all elements and is physiologically more active than any other ion. Fluorine in drinking water is totally in an ionic from and hence it rapidly and passively passes through the intestinal mucosa and interferes with metabolic activities of the living system. Naturally, the fluorides occurs in the combined from because of its high reactiveness. Fluorspar(CaF_2),Cryolite (Na_3AlF_6) and Fluoroapatite ($Ca_3(PO_4)_2Ca(F.Cl)_2$) are the parent form taking berth in the surface water ,ground water and sea water .Modern agriculture practice ,which involves the application of fertilizer coupled with pesticides, contributes the fluoride to the ground water.

2. Review of literature

High fluoride ground water occurs in many areas of the world .The studies about fluorides level in the drinking water and their health effect have been carried out in developing countries in Asia, Africa and Middle East. In Tanzania, an attempt was made to evaluate the fluoride content in drinking water and dental fluorosis grade in children (Awadia et al, 2000). Ncube etal (2005) conducted to identify areas of high ground water fluoride concentration in South Africa and to relate this to the occurrence of dental fluorosis in most communities using the ground water for domestic use. Rubina et al (2003) concluded that in the Faisalabad city (Pakistan) areas having high fluoride contents, the incidence of dental fluorosis might be occurred while in the areas having fluoride contents less than optimum limit dental caries is likely to be occur.

India is also confronting the same problem and about 25 million people in 8700 villages are consuming water having high fluoride. Kiriti et al (2009) assessment the water quality with special references to fluoride in Majhiaon block of Garwa district in Jharkhand. Yadav et al (2009) assess the association between water fluoride levels and prevalence of dental fluorosis among school children of the Jhajjar District, Haryana, India.

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 has low water resources (just 1% of the country's resources). In most of the parts of the state, groundwater is either saline or has excess fluoride. In Rajasthan, all 33 districts are endemic for fluorides. Surinder et al (2008) studied the fluoride contamination in drinking water in rural habitations of Northern Rajasthan. Fluorosis has been appeared as an alarming problem in this region. Gangal (2006) studied the ground water quality of Sanganer area of Jaipur District .75% of the villagers are suffering from dental fluorosis and skeletal fluorosis. Study of ground water quality and pollution problems in ground water have also been studied in our laboratory (Sharma & Chandel, 2004; Singh & Chandel, 2003, 2006). Yadav et al (2009) found that ground water of Tonk district is contaminated with Fluoride by naturally fluoride rich rock salt system.

A survey has shown that yet no studies have been undertaken in the Malpura Tehsil with regard to fluoride and fluorosis problem .So objective of this study was to investigate the quality of water with special references to fluoride.

3. Materials and Methods

3.1 Study area

The study area Malpura Tehsil (Figure 1)is located at 26°17′N 75°23′E26.28°N 75.38°E.Malpura is a Tehsil and a municipality in Tonk district in the Indian state of Rajasthan. Malpura is situated at Jaipur - Kekri route, 100 km from Jaipur. There are no major surface water sources in the study area; however, main sources of drinking water are open wells, hand pumps and bore wells.

3.2 Water sampling

A total of twenty six ground water samples were collected from hand pumps, open wells and bore wells of different sampling sites of Malpura Tehsil .The ground water samples were collected during the post monsoon session (Oct.2008 to Jan. 2009).The ground water samples were collected in systematically using clear acid washed polythene bottles of one litre capacity.

3.3 Analysis

Fluoride testing in water quality analysis should be given importance because fluoride is known to cause a variety of health problems like dental fluorosis, skeletal fluorosis and non-skeletal manifestations when the level is beyond 1.5 ppm. The analysis for fluoride in ground water samples was carried procedure of standard method (APHA, 1998).SPADNS Reagents method, Alizarin visual method and Ion Selective Electrode method are available for testing of fluoride in ground water .But in our laboratory Fluoride concentration was determined SPANDS method. In this method fluoride concentration was determined spectrophotometrically by using acid Zirconyl and Sodium -2 para sulfophenyl azo -1, 8 dihydroxy -3, 6-napthalene disulfonate (SPAND) reagents (Bellack and Schouboe, 1968).

4. Results and Discussions

All the ground water samples collected in the Malpura Tehsil were clear without any visible color, odor and turbidity. The fluoride concentration in ground water varied greatly in different sampling sites of study areas (Figure1).The results of fluoride concentration in ground water is presented in Table 1.

4.1 Fluoride monitoring

The variation of fluoride concentration in ground water samples of study area is depicted in figure 2. The fluoride concentration in the ground water samples showed a define trends with respect to sampling sites of Malpura Tehsil. Fluoride concentration varied from 0.08 to 11.30mg/L in ground water samples, with lowest value 0.08 mg/L (G8) and highest value 11.30mg/L (G7). About 38% of samples showed fluoride concentration below 0.5 mg/ L and 31% samples showed fluoride concentration in between 0.5 to 1.5 mg/L.(Table 2). It is evident from the research analysis data; it is obvious that the fluoride concentration in31% of samples is more than permissible limit (> 1.5 mg/L, WHO) for drinking purpose (Table3). Almost all bore wells and hand pumps, which are exclusively used for drinking and cooking purpose, were found to be high in fluoride concentration.

4.2 Sources of Fluoride

Fluoride exists naturally in water sources. In case of natural waters, the variation in the fluoride

content from region to region is dependent upon factors such as the source of water, type of geological formation and the amount of rainfall. Surface water generally has low fluoride while ground water may have high concentrations of fluoride. The origin of fluoride in groundwater is through weathering of alkali, igneous and sedimentary rocks. The common fluoride bearing minerals are

a. Fluorspar (CaF_2)
b. Cryolite (Na_3AlF_6)
c. Fluor-apatite ($Ca_3(PO_4)_2Ca(F.Cl)_2$)

Fluoride may also be introduced to the environment due to burning of coal and during manufacturing process of aluminum, steel, bricks. In the phosphate fertilizers used in the agricultural activities, fluoride is an impurity which results in high fluoride concentration in the soils. Accumulation of fluoride in the soils eventually results in leaching by percolation into the groundwater aquifer and thereby increases the concentration of fluoride level.

4.3 Effect of fluoride on human health

Fluoride is the most exclusive bone seeking anion owing to its affinity for calcium phosphate, up to 99% of the body burden of fluoride is found in bone. Presence of fluoride in drinking water is both beneficial and detrimental to the consumer. Low levels of fluoride in drinking water results in incorporation of fluoride in to 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 to 10 mg/L causes skeletal fluorosis, in which the bone structure is affected causing bone deformation and crippling (Table 2).

Fluorosis, which was considered to be a problem related to teeth, only, has now, turned up to be a serious health hazard. It seriously affects bones and problems like joint pain, muscular pains etc. So the various forms of fluorosis arising due to excessive intake of fluoride are briefly discussed below.

4.3.1. Dental fluorosis

Dental fluorosis occurs because of the excessive intake of fluoride either through fluoride in the water supply, naturally occurring or added to it; or through other sources. The damage in tooth development occurs between the ages of 6 months to 5 years, from the overexposure to fluoride. Teeth are generally composed of hydroxyl apatite and carbonated hydroxyl apatite; when fluoride is present, fluorapatite is created. Excessive fluoride can cause yellowing of teeth (Figure 3), white spots, and pitting or mottling of enamel. The natural shine or lustre of the teeth disappears. In the early stage, the teeth appear chalky white and then gradually become yellow, brown or black. The discoloration will be horizontally aligned on the tooth surface as “lines” away from the gums. Dental fluorosis affects both the inner and outer surface of the teeth. The disease has mostly cosmetic implications and has no treatment.

4.3.2. Skeletal fluorosis

Skeletal fluorosis is a bone disease exclusively caused by excessive consumption of fluoride. In advanced cases, skeletal fluorosis causes pain and damage to bones and joints. Skeletal fluorosis affects the bones/skeleton of the body. Skeletal fluorosis ((Figure 4) can affect both young and old alike. One can have aches and pain in the joints. The joints which are normally affected by skeletal fluorosis are neck, hip, shoulder and knee that makes it difficult to walk and movements are painful. Rigidity or stiffness of joints also sets in.

4.3.3. Non-skeletal fluorosis

The soft tissues of the body are may be affected by excessive consumption of fluoride. The symptoms include gastro-intestinal complaints, loss of appetite, pain in stomach, constipation followed by intermittent diarrhoea. Muscular weakness and neurological manifestations leading to excessive thirst tendency to urinate more frequently are common among the afflicted individuals. Cardiac problems may arise due to cholesterol production. Repeated abortions or still birth, male infertility due to sperm abnormalities are also some of the complications.

Table 1. Fluoride concentration in sampling sites of Malpura Tehsil (Tonk, Rajasthan, India)

S.No.	Sampling Site	Code of Sampling site	Fluoride (mg/L)
1.	Jaisinghpura	G1	0.15
2.	Soda	G2	3.60
3.	Dholi	G3	1.10
4.	Diggi –Kalyan Temple	G4	0.40
5.	Lawa	G5	0.26
6.	Ajmer road –Malpura	G6	1.61
7.	Dudu road –Malpura	G7	11.30
8.	Vyas marg –Malpura	G8	0.08
9.	Charbuja Temple-Malpura	G9	8.12
10.	Subash colony –Malpura	GA	0.83
11.	Manak Chowk –Malpura	GB	0.31
12.	Chosla	GC	0.31
13.	Kekari Road –Malpura	GD	1.54
14.	Dadabari –Malpura	GE	1.00
15.	Jaipur road –Malpura	GF	3.18
16.	Ambapura	GG	0.14
17.	Todaraisingh road –Malpura	GH	0.77
18.	Ban ka Kheda	GI	0.59
19.	Tordi Sager	GJ	0.15
20.	Tordi Bus Stand	GK	0.15
21.	Tilungu	GL	1.22
22.	Rampura	GM	3.35
23.	Brajlal nager	GN	1.03
24.	Malpura bus stand	GO	2.58
25.	Avikanager	GP	1.33
26.	Diggi nuked	GQ	0.16
27.	Minimum		0.08
28.	Maximum		11.30
29.	Average		1.740

Table 2.Concentration of Fluoride in drinking water

Parameter	Fluoride concentration (mg/L)	Effect on human health	Representing Samples
Fluoride	<0.5	Dental caries	G1,G4,G5,G8,GB,GC,GG, GJ,GK, GQ
	0.5-1.5	Prevents tooth decay	G3,GA,GE,GH,GI,GL,GN,GP
	1.5-4.0	Mottling and pitting of teeth (Dental Fluorosis)	G2,G6,GD,GF,GM,GO
	>4.0	Pain in neck bones and back (Skeletal Fluorosis) and Crippling Fluorosis	G7,G9

Table 3.Concentration of Fluoride of Malpura Tehsil (Tonk, Rajasthan, India) comparison with WHO standards

Parameter	WHO standards(1983)		Percentage of the total samples exceeding limits
Fluoride	Highest desirable limit(mg/ L)	Maximum permissible limit(mg/ L)	
	0.5	1.5	31%

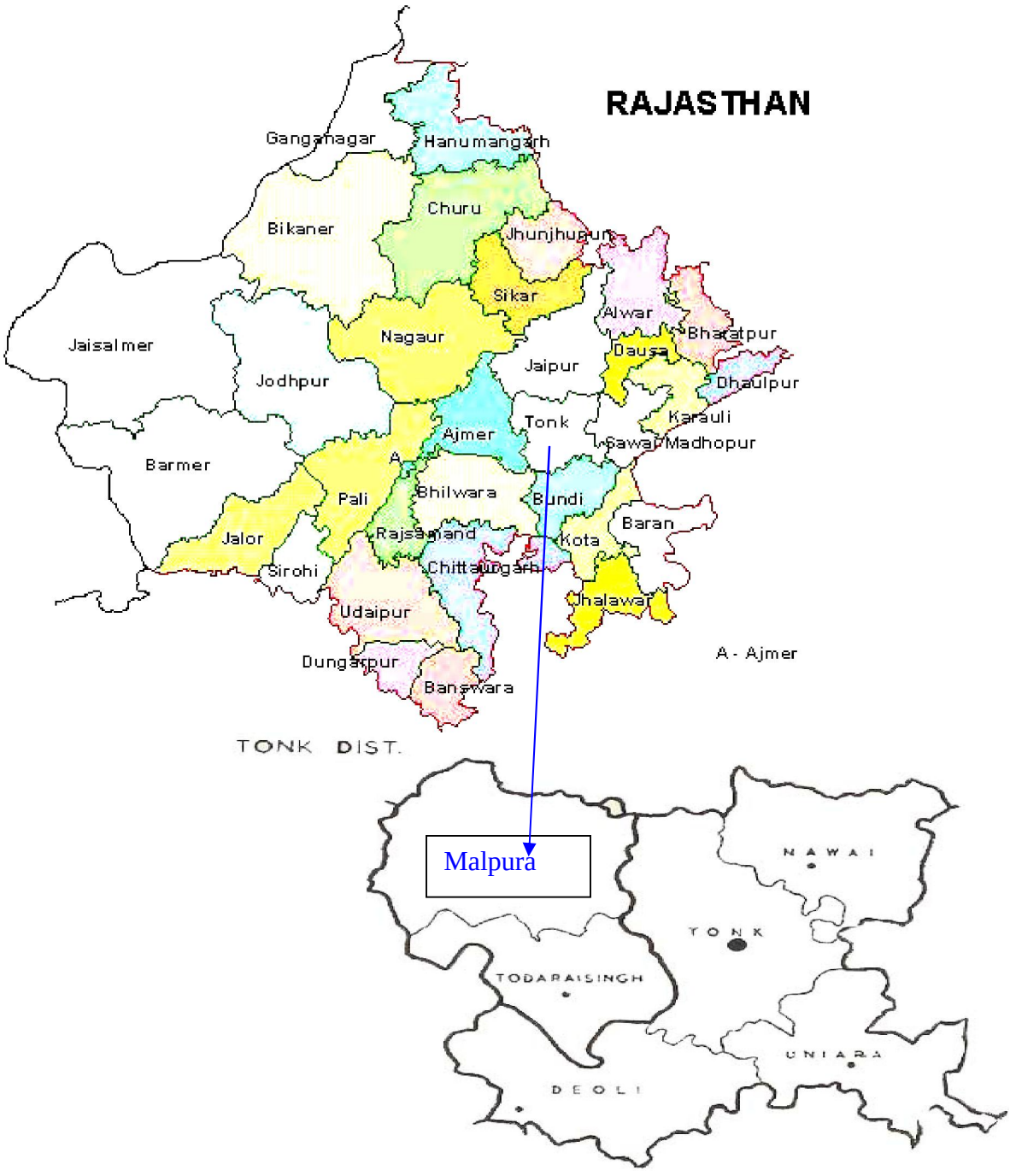

Figure 1. Study area

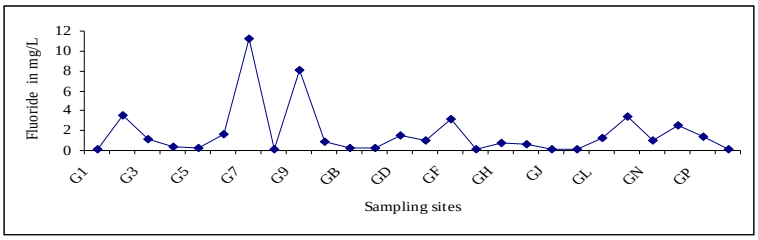

Figure 2 Variation in Fluoride (mg/L) with sampling sites of Malpura Tehsil

Figure 3. Dental fluorosis

Figure 4. Skeletal fluorosis

5. Conclusions

This study provides an overview of the fluoride content in drinking water and show that there is an acute fluoride problem in Malpura Tehsil. The favorable factor which contributes to rise of fluoride in ground water are 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.

Acknowledgement:

One of the author(s) (Girja shanker tailor) express his thanks to the Head, Department of Chemistry, University of Rajasthan, Jaipur for providing the necessary laboratory facilities and also thankful to the UGC, New Delhi, for the award of a Junior Research Fellowship.

Correspondence to:
Dr. C.P. Singh Chandel
Department of chemistry, University of Rajasthan
Jaipur 302055, Rajasthan, India
Telephone: 0141 2590586
Cellular phone: 09414269654
Email: chandelcps2rediffmail.com

Affiliations
(1) Girja Shanker Tailor
Department of Chemistry, University of Rajasthan, Jaipur – 302055, Rajasthan, India
(2) Dr. C. P. Singh Chandel
Assistant professor
Department of Chemistry, University of Rajasthan
Jaipur – 302055, Rajasthan, India
Email address: chandelcps2rediffmail.com

References

1. Shekhar TRS, Babu KH, Kumara V, Puttaiah ET. Effect of fluoride level in drinking water and socioeconomic status on the prevalence of fluorosis in Mundagri Taluk. Indian J.Environmental Protection. 2006; 26(6):528-530.
2. Ramaniah SV, Venkatmohan S, Rajkumar B, Sarma PN. Monitoring of fluoride concentration in ground water of Prakasham District in India: Correlation with Physico-Chemical parameters. Journal of Environ.Science and Engg. 2006; 48(2):129-134.
3. Shanthakumari D, Srinivasalu S , Subramanian S. Fluoride contaminated water and its implications on human health in Vellore District, TamilNadu, India. Research Journal of Environmental Toxicology. 2007; 1(1):16-26.
4. GangalRK. Geochemical study of ground water of Sanganer area of Rajasthan (India) and Different methods to mitigate fluoride problem. Asian Journal of water Environmental and Pollution.2007; 4(2):93-97.
5. Suthar S, GargVK , Jangir S , Kaur S, Goswami N , Singh S.Fluoride concentration in drinking water in rural habitations of Northern Rajasthan, India. Environ.Monit. Assess.2008; 145:1-6.
6. Ncube EJ, Schutte CF. The occurrence of fluoride in South African ground water: A water quality and health Problem .Water SA. 2005; 31(1):35-40.
7. Yadav AK, Khan P, Saxena.U. Geo-chemical observation of fluoride in ground water of Tonk (Rajasthan).Rasayan J.Chem .2009; 2 (4):994-1000.
8. Avishek K, Pathak G, Nathawat MS, Jha U, Kumari N. Water quality assessment of Majhiaon block of Garwa district in Jharkhand with special focus on fluoride analysis. Environ.Monit. Assess. . 2009; DOI 10. 1007/s10661-009-1077-4.
9. Raju NJ, Dey S, Das K. Fluoride contamination in ground water of Sonbhadra District, Uttar Pradesh, India. Current Science. 2009; 96(7):979-985.
10. Kausar R, Ahmad S, Rehman K, Ahmad R. Fluoride status of under ground water of Faisalabad city area International Journal of Agriculture and Biology . 2003; 5(4):536-539.
11. Yadav JP, Lata S, Kataria S K, Kumar S. Fluoride distribution in ground water and survey of dental fluorosis among school children in the villages of the Jhajjar District of Haryana,India. Environ.Geochem.Health. 2009; 31:431-438.
12. APHA.As per standard methods for the examination of water and waste water 20th Edition .1998.
13. Bellack,E, Schouboc PJ. Rapid photometric determination of Fluoride with SPANDS-Zirconium Lake.AnalyticalChemistry.1968; 30, 2032-2035, doi: 10.1021/ac 60144a050.
14. Sharma JD, Sohu D, Jain P. Prevalence of neurological manifestations in human population exposed to fluoride in drinking water.This work has been presented in the XXVIIIth Conference of International Society for Fluoride Research, 7-11 August 2008, Toronto, Canada. Research report Fluoride. April-June 2009; 42(2):127–132.
15. Awadia AK, Birkeland JM, Haugejorden O , Bjorvatn K. An attempt to explain why Tanzanian children drinking water containing 0.2 or 3.6 mg fluoride per liter exhibit a similar level of dental fluorosis. Clinical Oral Investigations. 2000 Dec; 4(4):238-244.
16. Sharma SK, Singh V, Chandel CPS. Ground Water Pollution Problem and Evaluation of Physico-Chemical Properties of Ground Water. Environment and Ecology. 2004; 22 (spl-2): 319-324.
17. Singh V, Chandel CPS .Analysis of Wastewater of Jaipur City for Agricultural Use. Research Journal of Chemistry and Environment.2006; 10(1): 30–33.
18. Singh V, Chandel CPS. Study of Nitrate Concentration of Industrial Wastewater and Ground Water. J. Indian Water Works Association. 2003; 35(3): 228–22.
19. World health organization. Guidelines for drinking water. 1983; Vol. 1. (pp. 52–82). Geneva.

Date of Submission 1-07-2010