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Fluoride and Flurosis Status in Groundwater of Todaraisingh Area of District Tonk (Rajasthan, India): A Case Study

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ABSTRACT

The continuous uses of water carrying high amount of fluoride may prove toxic to human, animal and plants. Excessive fluoride concentrations have been reported in ground water of more than 20 developed and developing countries including India where 18 states are facing fluoride problem. In view of this an attempts were made to find out the fluoride content in groundwater of Todaraisingh Tehsil of Tonk (Rajasthan). Fluoride concentration over permissible limit (1.5mg/l) in drinking water lead to human health hazards such as dental fluorosis and skeletal fluorosis affecting millions of people. Preliminary investigation indicates that severe health disorders have been indentified in Todaraisingh area of Tonk district of Rajasthan due to excess intake of fluoride through drinking water. Most of people in this area suffer from dental & skeletal flurosis such as mottling of teeth, deformation of ligaments, bending of spinal column and ageing problem. Overall all water quality was found unsatisfactory for drinking purpose without any treatment. So an urgent need is to educate the people on the causes of flurosis, encouraging rain water harvesting and defluoridation technique for providing fluoride free water in the study area.

Key words: Fluorosis, Fluoride, Ion-Selective Electrode

INTRODUCTION

Water is an essential natural resource for sustaining life and environment that we have always thought to be available in abundance and free gift of nature however chemical composition of surface or subsurface water is one of the prime factors on which the suitability of water for domestic, industrial and agriculture purpose depends. Fresh water occurs as surface water and ground water in this groundwater contributes only 0.6% of the total water resources on earth. It is major and preferred source of drinking water in rural and urban areas particularly in India. Water
content many minerals like calcium, magnesium and fluoride etc. in this fluoride essential in minute quantity for normal mineralization of bone & teeth (for formation of dental enamel) [2] fluoride stimulate growth of many plant species [4] but on other hand when fluoride is taken up in excessive amount may prove toxic to plant and on feeding may toxic to animal & human as fluorosis. Fluorosis is now world wide problem not only India. the 20 developing countries like Argentina, U.S.A., Algeria, Libya, Turkey, Iran, China, Australia, south Africa, Kenya, Iraq, Srilanka, Canada, Thailand, Newzealand, Japan, and India etc[8]. But in the era of economical growth groundwater is getting polluted due to urbanization & industrialization. Presence of various hazardous contaminants like fluoride, nitrate, sulfate and other heavy metals etc. in underground water has been reported from different parts of India. It is well established that India has two acute public health problem induced by utilization of groundwater as a source of drinking water having excess fluoride and arsenic though the origin of these two hazardous elements is attributed to geological reasons. In India fluoride is major inorganic pollutant which natural origin in groundwater. Fluoride concentration is an important aspect of hydro geochemistry because of its impact on human health. Fluoride is a fairly common element that does not occur in the elemental state in nature because of its high reactivity. This is the 17^{th} element in order of abundance of element in earth's crust found as a complex fluoride. Fluoride is an ionic state of fluorine (the 9^{th} element of Periodic Table). Fluorine is most electronegative element hence never found in nature as fluorine. Fluoride occurs in combined form of minerals as fluoride and represents .06 to .09% of the earth crust [13]. Fluorides frequently occurs in igneous as well as in metamorphic rocks, especially in alkali rocks, granite, basalt, shale, clays and calcium phosphate rocks are the main sources of fluoride.

Table-1 represents various minerals having fluoride with their composition and the rocks in which they present. Minerals which have the greatest effect on the hydro geochemistry of fluoride are fluorite, apatite, mica, amphiboles, certain clays and villiamite. Fluoride occurs in almost all water from trace to high concentrations.

Fluoride concentration in natural water depends on various factors such as temperature, pH, solubility of fluoride bearing minerals, anion exchange capacity of aquifer materials (OH for F) and nature of geological formation and contact time of water with particular formation. Fluoride is among the substances for which there are both lower (0.6 mg/l) and upper (1.2 mg/l) limits of concentration in drinking water, with identified health effect and benefits for human beings. Fluoride in minute quantity is an essential component for normal mineralization of bone, teeth and formation of dental enamel[2]. Very low doses of fluoride (<0.6 mg/l) in water promote tooth decay. However, when consumed in higher doses (>1.5 mg/l), it leads to dental fluorosis or mottled enamel and excessively high concentration (>3.0 mg/l) of fluoride may lead to skeletal fluorosis. In general, fluoride content in water between 1.5 and 2.0 mg/l may lead to dental mottling, which is characterized initially by opaque white patches on the teeth and in advanced stages leads to dental fluorosis (teeth display brown to black staining) followed by pitting of teeth surfaces. High manifestations of dental fluorosis are mostly found in children up to the age of 12 years, and skeletal fluorosis [1] may occur when fluoride concentrations in drinking water exceed 4–8 mg/l. The high fluoride concentration manifests as an increase in bone density leading to thickness of long bones and calcification of ligaments. The symptoms include mild rheumatic/arthritic pain in the joints and muscles to severe pain in the cervical spine region along with stiffness and rigidity of the joints. The disease may be present in an individual at sub-clinical, chronic or acute levels of manifestation. Crippling skeletal fluorosis can occur when the water supply contains more than 10 mg/l of fluoride [3,13]. The severity of fluorosis depends on the concentration of fluoride in the drinking water, daily intake, continuity and duration of exposure, and climatic conditions

So it very necessary to understand the present contamination level, distribution and developing a methodology for safe drinking water source. The health problems arising as a result of fluoride contamination are more wide spread in India. The problem of excessive fluoride in ground water in India was first reported in 1937 in the state of Andhra Pradesh [10]. Today fluorosis is a major public health problem in 18 out of 32 constituent state of India [12]. Nearly 177 districts have been confirmed as fluoride affected area. The existence of fluorine as a fluoride in water was first reported in 1937 in India[10]. Recent studies show approximately 62 million People including 6 million children suffer from fluorosis because of consumption of water containing high concentration of fluoride [12]. In Rajasthan the existence of fluoride was first detected from jobner near Jaipur city [7] later during 1964 in the villages of nagour and in 1976 high fluoride content in drinking water were observed in bhilwara district and Mathur et al reported the prevalence of fluorosis in Ajmer district [9].

StudyArea:

Tonk district is located in north eastern part of the state bordering jaipur in north. Swaimadhopur in the east Bundi & Bhilwara in the south & Ajmer in the west. Tonk is known for its unity among Hindus and Muslims for which it is same time called as "Hindus Muslims Ekta Ka Maskan". The history of Tonk is Very old it was called as Nawabi Nagari "Tonk". The Tonk is also known as the "Lucknow of Rajasthan" due to its elegance.Tonk is popular among tourist for its Magnificent Mosques, Mansion and Havelis.

Climate conditions:

Area = 7194 sq.km, Forests area = 27048 hectare, Latitude = 25.41' and 26.24' in north, Longitude = 75.19'&76.16 in east, Temperature = 26-45 ^{o}C in summer Temperature = 8- 20 ^{o}C in winter, Annual rainfall in Tonk = 62mm

MATERIALS AND METHODS

Many methods have been suggested for the determination of fluoride ion in water given by official British and American compilation of Methods. The calorimetric & electrode method are the most satisfactory at the present time [11].10 Samples are collected in good quality polythene bottles of one liter capacity. Sampling has been carried out without adding any preservative in rinsed bottles directly for avoiding any contamination and brought to the laboratory. Fluoride concentration of sample was determined by ion electrode method.

Fluoride Ion-Selective Electrode Method:

Apparatus*:* Ion-Selective Meter, Fluoride Electrode, Magnetic Stirrer

Reagent: Fluoride Standards of various ranges (0.2-20ppm) Fluoride Buffer (TISAB-Total ionic strength adjustment buffer)

Procedure*:* Calibrate the instrument take 10ml sample in a beaker at 10ml buffer solution. Put stirring bar into the beaker immerse electrode & start the magnetic stirrer and wait until reading is constant withdrawal electrode rinse with distilled water.

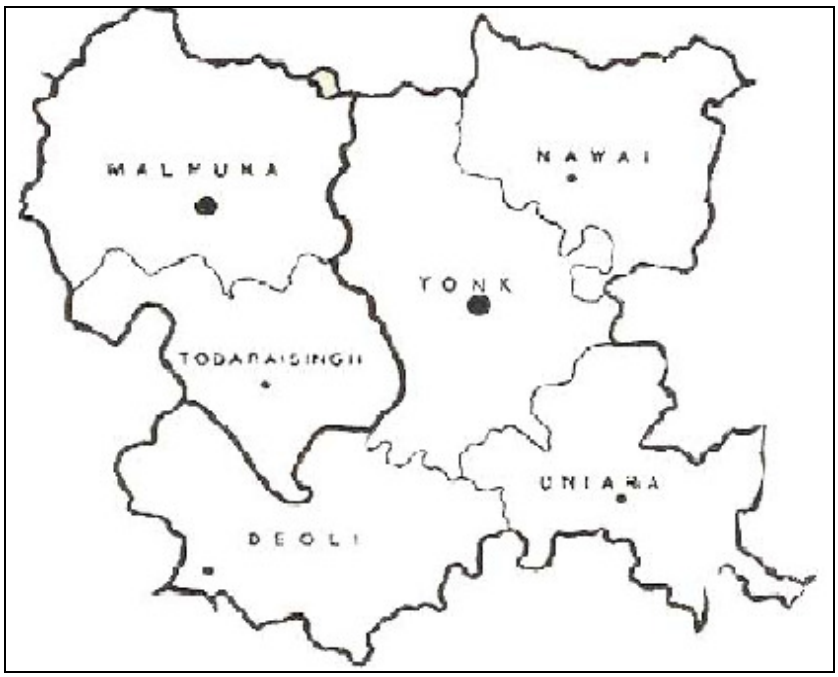

Fig.-1: Study Area- Tonk District (Rajasthan)

Table-1: Minerals containing fluoride

S.No.	Mineral	Chemical Composition	Rocks
1.	Fluorspar	$[CaF_2.3Ca_3(PO4)_2]$	Pegmatite Pneumatolitic deposits
2.	Fluorite	CaF_2	Pegmatite Metamorphosed limestone
3.	Lepidolite	$K_2(Li,Al)_5(Si_6Al_2)O_{20}(OHF)_4$	Gabbros, Dolerites
4.	Tremolite Actinolite	$Ca_2(MgFe^{+2})_5(Si_8O_{22})(OHF)_2$	Clay
5.	Rock Phosphate	$NaCa_2(MgFe^{+2})_4(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$	Limestone, Fossils

RESULTS AND DISCUSSION

In this study 32 sample are selects for fluoride analysis from different site and each direction of tehsil out of 32 samples 21 samples about 65.63% of the groundwater samples analysed in the study area exceeds the maximum permissible limits of fluoride (1.5 mg/l) set by the ISI [5] and WHO [13] In the study area fluoride contamination is mainly a natural process, i.e. leaching of fluorine-bearing minerals, since no man-made pollution has been noticed. Since fluorite, apatite, mica and various other minerals take part during rock–water interaction and liberate fluoride into the groundwater. Preliminary investigation indicates that severe health disorders have been indentified in Todaraisingh area of Tonk district of Rajasthan due to excess intake of fluoride through drinking water. Most of people in this area suffer from dental & skeletal flurosis such as mottling of teeth, deformation of ligaments, bending of spinal column and ageing problem**.** Since there are no published data available on the incidence of fluoride in the groundwater and its health hazards in the Todaraisingh area, Tonk District, we have carried out investigations on the fluoride content in groundwater of the villages affected with dental and skeletal fluorosis and also the probable source of fluoride in groundwater of the study area. Average high fluoride (>1.5 mg/l) distribution was found mainly

in the sample no.- 1, 2, 4, 5, 7, 9-12, 14-17, 19, 22, 23, 25-30, (Table-2). The highest fluoride concentration (9 mg/l) was recorded from sample no. 28. The people suffer from dental (Figure1, 2, 3) and skeletal fluorosis (Figure 4). In the fluoride-affected villages, both children and adults suffer from health disorders like mottling of teeth, deformation of ligaments, bending of spinal column and ageing problem. The rest of the village's sample are not affected by fluoride disorders, because fluoride content in the groundwater is within the permissible limit (<1.5 mg/l).

It is seen on observation of graph that in pre monsoon fluoride range from 0.5 mg/l to 10.7 mg/l and in post monsoon fluoride range from 0.2mg/l to 7.3mg/l. and fluoride has tends high in pre monsoon.

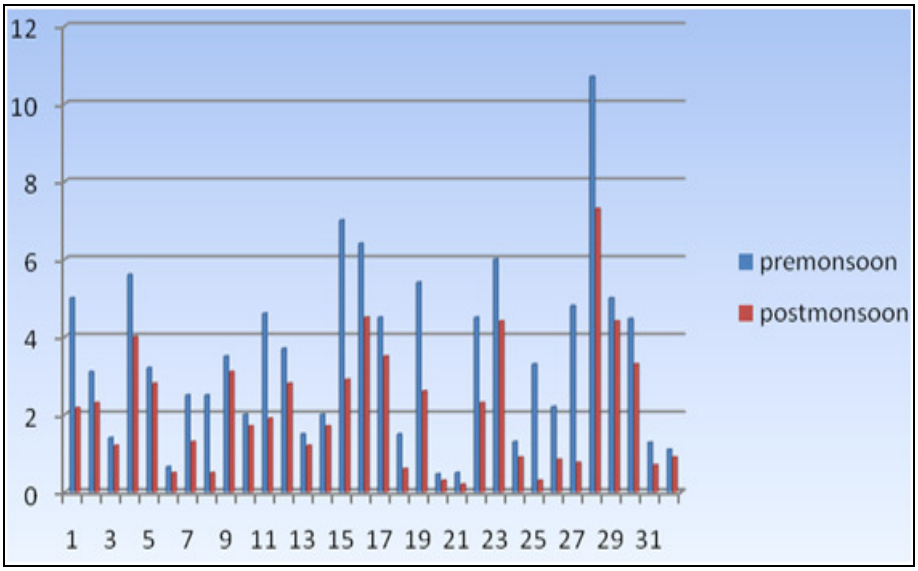

Fig.-2: Comparison of Fluoride Content in Pre Monsoon and Post monsoon session.

Comparison of fluoride content in the groundwater of the study area with drinking water standards						
Parameter	ISI standards		WHO standards		NO of sample exceeding permissible limit	% of sample exceeding permissible limit
	HDL	MPL	HDL	MPL		
Fluoride	0.6–1.2	1.5	0.5	1.5	21	65.63

CONCLUSION

Fluoride in groundwater of this region is mainly due to dissolution from fluoride bearing minerals like Fluorspar, Fluorite etc. the present study was done at tehsil level in Tonk district. In this 65.63% samples are found exceeding permissible limit. A more detailed study is necessary for better understanding of the source and effects of fluoride problem in other tehsil of tonk district.

In the study area local people ingesting the groundwater have not received medical attention till date since these people are dependent on the groundwater for domestic use. So remedial measures such as defluoridation techniques and rain water harvesting are needed Nutritional diet such as calcium and phosphorus rich food should be recommended to those affected with fluorosis as it decrease rate of accumulation of fluoride in the human body. Environmental awareness programme on "fluoride and fluorosis" urgent need is to educate the people for health.

(1) (2)

(3) (4)

Fig.-3: Photographs of some flurosis affected persons
Dental Fluorosis (Snaps 1, 2, 3) and Skeletal fluorosis (Snap 4)

Table-2 : Fluoride level in Todaraisingh area of Tonk

Fluoride status of Todaraisingh Tehsil					
S.NO	Pre monsoon F	Post monsoon F	S.NO	Pre monsoon F	Post monsoon F
1	5	2.17	17	4.5	3.5
2	3.1	2.3	18	1.5	0.6
3	1.4	1.2	19	5.4	2.6
4	5.6	4	20	0.47	0.3
5	3.2	2.8	21	0.5	0.2
6	0.66	0.5	22	4.5	2.3
7	2.5	1.3	23	6	4.4

8	2.5	0.5	24	1.3	0.9
9	3.5	3.1	25	3.3	0.3
10	2	1.7	26	2.2	0.84
11	4.6	1.9	27	4.8	0.76
12	3.7	2.8	28	10.7	7.3
13	1.5	1.2	29	5	4.4
14	2	1.7	30	4.47	3.3
15	7	2.9	31	1.28	0.7
16	6.4	4.5	32	1.1	0.9

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