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Fluoride Content in the Groundwater of Dabwali

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Abstract : High concentration of fluoride in the groundwater of different parts of the world is responsible for widespread fluorosis. Haryana, a small state in India is one such region where high concentration of fluoride is present in groundwater. The objective of the present investigation was to determine the fluoride content in the ground water of Dabwali area of Sirsa district of Haryana, India. A total of fifty two groundwater samples were randomly collected at different depths from tube wells and hand pumps. The results showed that fluoride concentration in the ground water of Dabwali ranges from 0.90-34.50 mg/l with a mean of 2.20 ± 18.13 mg/l. Mostly people use groundwater for domestic and irrigation purpose. Therefore, the intake of fluoride concentration is very high as people using groundwater without any prior treatment. The results suggest that the groundwater should be used by the residents only after defluoridation.

Keywords: Defluoridation, Fluoride, Fluorosis, Groundwater, Water Quality.

INTRODUCTION

Safe and pure drinking water is a fundamental right of a human being. It is estimated that more than one billion people lack assess to safe drinking water while more than two billion are without adequate sanitation world wide (UNICEF et al. 2004). Groundwater is a significant source of water in many parts of India especially in semiarid and arid regions and more than 90% of rural population depends on groundwater for drinking, domestic and agricultural use. It is assumed that groundwater appears to be clean and safe as compared to the surface water, it need not necessarily be safe. The indiscriminate use of agrochemicals, disposal of untreated sewage and industrial effluents, has rendered the groundwater unfit for drinking/agriculture or both.

Groundwater is the main source of dietary fluoride intake in human beings. Fluorine is the most electronegative and reactive of all elements that occur naturally within many type of rock. It exists in the form of fluorides in a number of minerals of which fluorspar; cryolite, fluorite and fluorapatite are the most common (Agarwal et al., 1997).Fluorite (CaF2) is a common fluoride mineral. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between rock and the circulating ground water (Gupta et al., 2006).It is well known that small amounts of fluoride (less than 1.0 mg/l) have proven to be beneficial in reducing tooth decay. Community water supplies commonly are treated with NaF or fluorosilicates to maintain fluoride levels ranging from 0.8 to 1.2 mg/l to reduce the incidence of dental carries. However, high concentrations such as 1.5 mg/l of F and above have resulted in staining of tooth enamel while at still higher levels of fluoride ranging between 5.0 and 10 mg/l, further pathological changes such as stiffness of the back and difficulty in performing natural movements may take place (Singh et al., 2007). BIS (1983) has recommended an upper desirable limit of 1.0 mg/l of fluoride as desirable concentration of fluoride in drinking water, which can be extended to 1.5 mg/l of F in case no alternative source of water is available. Water having fluoride concentration of more than 1.5 mg/l are not suitable for drinking purposes.

Nearly 25 countries in the world suffering from excess fluoride in their ground water and India is one of them. Periodic incidences of high fluoride content in ground water have been reported in various states of India. Approximately 20 states of India facing the problem of excessive fluoride in the ground water. In India, approximately 62 million people including 6 million children suffer from fluorosis because of consumption of water with high fluoride concentrations (Susheela, 1999; UNICEF, 1999). It is observed that there are several locations in the States of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Chhattisgarh, Haryana, Orissa, Punjab, Haryana, Uttar Pradesh West Bengal, Bihar, Delhi, Jharkhand, Maharashtra, and Assam where the fluoride in ground water exceeds 1.5 mg/l. The list of districts showing localized occurrence of fluoride in ground water in excess of 1.5mg/l in India is given in table 1.

This paper reviews the status of drinking water quality with respect to fluoride contamination of ground water of some locations of Dabwali town, district Sirsa, Haryana, India. Dabwali in district Sirsa, Haryana is one of the most intensively cultivated, highly fertilized and pesticides using area with alarming rate of depletion of groundwater table. This study was, therefore, undertaken to investigate the high concentration of fluoride in underground waters of Mandi Dabwali, district, Sirsa, Haryana, India.

MATERIALS AND METHODS

Dabwali is a city and a municipal committee in Sirsa district in the Indian state of Haryana. It is located on the border of Haryana and Punjab, and is just a few minutes travel from Rajasthan border. A total of 52 samples of ground water were collected from different locations of the Dabwali town. In Dabwali town, groundwater is the only source of drinking water. The water is extracted using hand pumps and tube wells. The climate of the area is characterized by its dryness, extremes of temperature and scanty rainfall. The mean daily maximum temperature during May and June, which is the hottest period, varies from 41 to 46 °C which may exceed upto 49 °C. The average annual rainfall in varies from 100 to 400 mm.

A total of 52 samples of ground water were collected from different locations of the town from hand pumps and tube wells after flushing for about 10 minutes on March, 2007. Figure-1 shows the location of the study area. The information regarding the depth of hand pumps and tube wells i.e. water table was collected from the local people of the area. The maximum depth of the hand pump for drinking water use is 85 meter below ground level and in case of tube well it was 95 meter. The samples were collected in precleaned, sterilized and polyethylene bottles. The analyses were carried out according to APHA (1995) standard methods for determination of fluoride content in groundwater samples. All the reagents used in the present study were of AR grade and double distilled water used through out the study. Sodium fluoride is used for preparing standard solutions in the range of 1-1.4 mg/l. Fluoride in water samples was determined by SPADANS–zirconyl oxychloride method using UV–VIS spectrophotometer (systronics-118). The absorbance values obtained at ëmax = 570 nm were compared with the standard calibration curve for fluoride concentration. All the analyses were carried out in triplicate and considered the mean value of each sample.

RESULTS AND DISCUSSION

The groundwater had no color, odor and turbidity. The taste of groundwater was slightly salty at most of the locations. There are five major routes of fluoride exposure in human beings e.g. drinking water, food, drugs, cosmetics & dental products and industrial activities. But drinking water is major contributor i.e. up to 75-90% (Sarala and Rao 1993). The results showed that fluoride concentration in the under ground water of Dabwali ranges from

Table 1. Fluoride Content (>1.5mg/litre) at different locations in Ground Water of India

Sr	State	Parts of Districts having F > 1.5mg/litre
1	Andhra Pradesh	Adilabad, Anantpur, Chittoor, Guntur, Hyderabad, Karimnagar,Khammam, Krishna, Kurnool, Mahbubnagar, Medak, Nalgonda, Nellore, Prakasam, Ranga Reddy, Visakhapatnam, Vizianagaram, Warangal, West Godavari
2	Assam	Goalpara, Kamrup, Karbi Anglong, Nagaon
3	Bihar	Aurangabad, Banka, Buxar, Jamui, Kaimur(Bhabua), Munger, Nawada, Rohtas, Supaul
4	Chhattisgarh	Bastar, Bilaspur, Dantewada, Janjgir-Champa, Jashpur, Kanker, Korba, Koriya, Mahasamund, Raipur, Rajnandgaon, Surguja
5	Delhi	East Delhi, North West Delhi, South Delhi, South West Delhi, West Delhi
6	Gujarat	Ahmadabad, Amreli, Anand, Banaskantha, Bharuch, Bhavnagar, Dohad, Junagadh, Kachchh, Mehsana, Narmada, Panchmahals, Patan, Rajkot, Sabarkantha, Surat, Surendranagar,Vadodara
7	Haryana	Bhiwani, Faridabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Kurushetra, Mahendragarh, Panipat, Rewari, Rohtak, Sirsa, Sonepat
8	J & K	Rajauri, Udhampur
9	Jharkhand	Bokaro, Giridih, Godda, Gumla, Palamu, Ranchi
10	Karnataka	Bagalkot, Bangalore, Belgaun, Bellary, Bidar, Bijapur, Chamarajanagar, Chikmagalur, Chitradurga, Davangere, Dharwad, Gadag, Gulburga, Haveri, Kolar, Koppal, Mandya, Mysore, Raichur, Tumkur
11	Kerala	Palakkad
12	Maharashtra	Amravati, Chandrapur, Dhule, Gadchiroli, Gondia, Jalna, Nagpur, Nanded
13	Madhya Pradesh	Bhind, Chhatarpur, Chhindwara, Datia, Dewas, Dhar, Guna, Gwalior, Harda, Jabalpur, Jhabua, Khargaon, Mandsaur, Rajgarh, Satna, Seoni, Shajapur, Sheopur, Sidhi
14	Orissa	Angul, Balasore, Bargarh, Bhadrak, Bandh, Cuttack, Deogarh, Dhenkanal, Jajpur, Keonjhar, Sonapur
15	Punjab	Amritsar, Bhatinda, Faridkot, fatehgarh Sahib, Firozepur, Gurdaspur, Mansa, Moga, Muktsar, Patiala, Sangrur
16	Rajasthan	Ajmer, Alwar, Banaswara, Barmer, Bharatpur, Bhilwara, Bikaner, Bundi, Chittaurgarh, Churu, Dausa, Dhaulpur, Dungarpur, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jalor,Jhunjhunun, Jodhpur, Karauli, Kota, Nagaur, Pali, Rajsamand, Sirohi, Sikar, SawaiMadhopur, Tonk, Udaipur
17	Tamil Nadu	Coimbatore, Dharmapuri, Dindigul, Erode, Karur, Krishnagiri, Namakkal, Perambalur, Puddukotai, Ramanathapuram, Salem, Sivaganga, Theni, Thiruvannamalai, Tiruchirapally, Vellore, Virudhunagar
18	Uttar Pradesh	Agra, Aligarh, Etah, Firozabad, Jaunpur, Kannauj, Mahamaya Nagar, Mainpuri, Mathura, Mau
19	West Benga	Bankura, Bardhaman, Birbhum, Dakshindinajpur, Malda, Nadia, Purulia, Uttardinajpur

Source: CGWB, March 2008

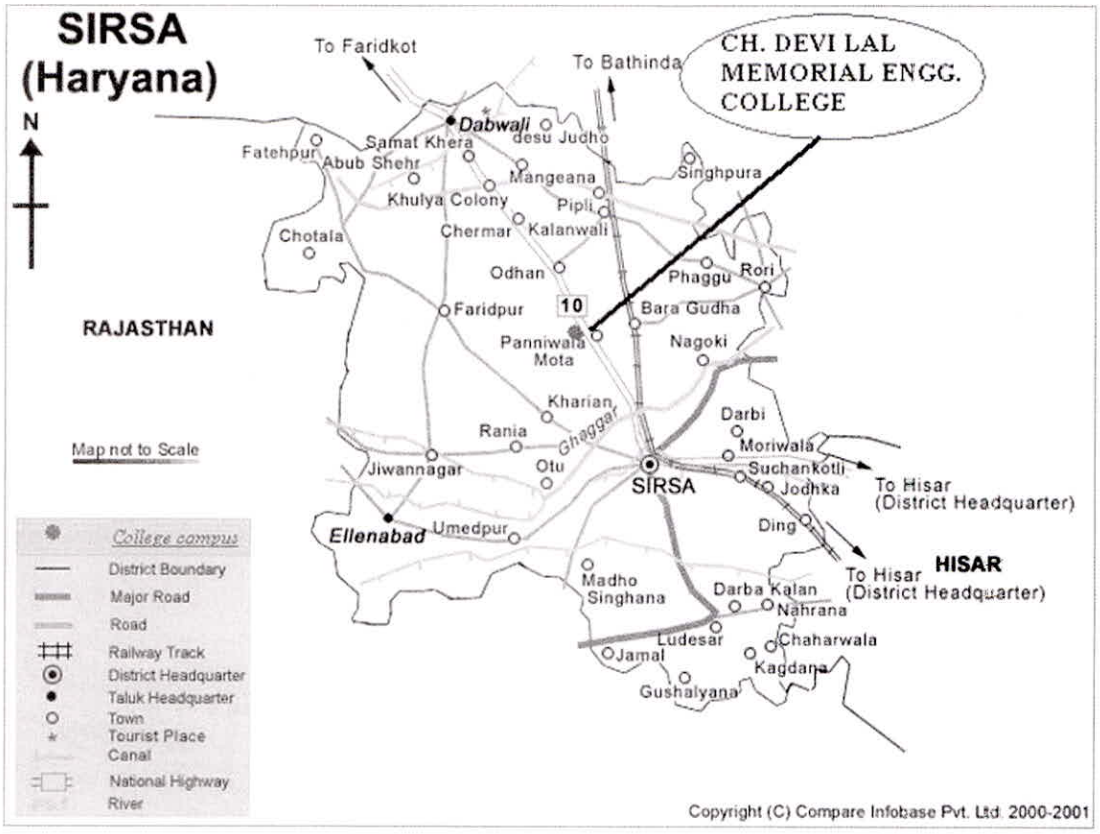

Fig. 1. Location map of the study area

0.90 – 34.50 mg/l with a mean of 2.20 ± 18.13 mg/l. About 75% (n = 39) have fluoride concentration more than WHO (1997) maximum permissible limit of 1.5 mg/l, while 25% (n =13) groundwater samples have fluoride with in permissible limit. The high amount of fluoride present in water may due to leaching and weathering of rocks like fluorspars, rock phosphate and phosphites. Further, usually the fluoride levels are more in the shallow aquifers(hand pumps) in alluvial plains and in the present case also the concentration of F was found relatively high in shallow aquifer (hand pumps) than deep aquifer (tube wells). This is in agreement to the study of Handa (1975). Groundwater in arid and semi arid regions is prone to high fluoride concentrations because groundwater flow is slow which favours water-rock interaction. The figure 2 shows the frequency distribution of fluoride content in the ground water of Dabwali town of Sirsa district of Haryana.

The climate of this region is hot and dry particularly in summer, so higher intake of water is expected. World Health Organization has set the maximum permissible limit at 1.5 mg/l of fluoride in drinking water if alternative source of water is not available globally. But in tropical regions like India where 5-7 litres water is consumed by the people

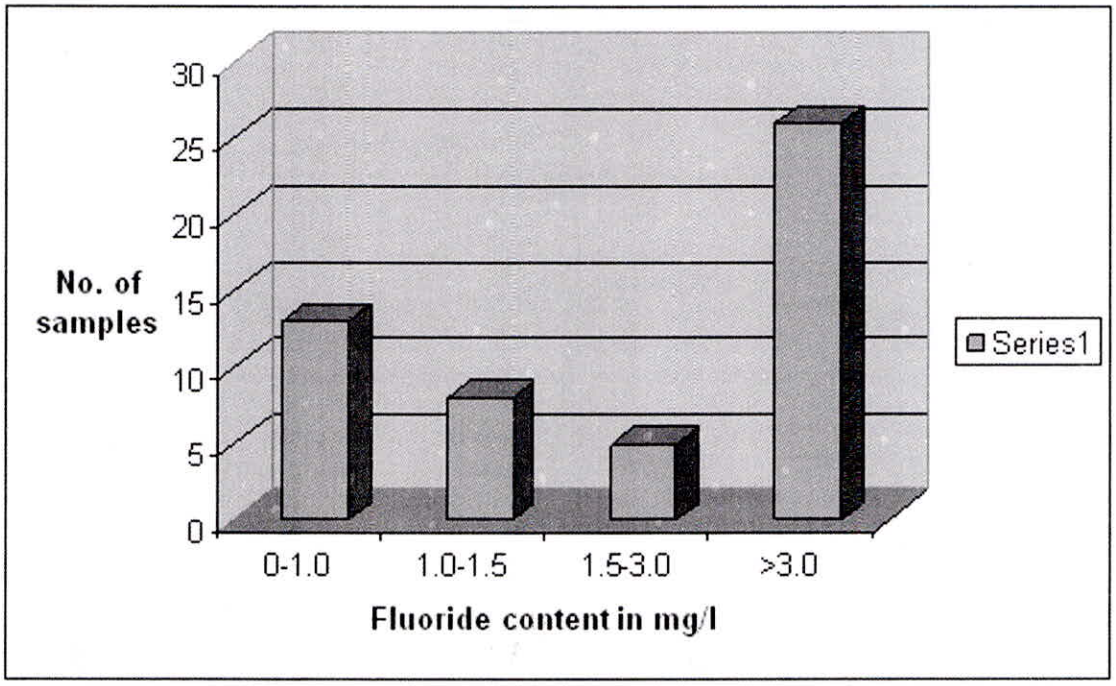

Fig. 2. Frequency distribution of fluoride in the groundwater of Dabwali

daily, this limit seems to more (Khaiwal and Garg 2007 and Suthar et al. 2008). Under such conditions, the consumption of water is high and so is the fluoride exposure and ingestion. Therefore the high concentration of fluoride in most of the sources of water is a cause of concern for health. At this stage, even low concentration of ûuoride in drinking water may cause risks of dental ûuorosis. Ibrahim et al.1995, have reported the prevalence of dental fluorosis to the extent of 91% in a study of Sudanese children consuming water with 0.25 mg/l of fluoride. Hence, the acceptable fluoride concentration in drinking water should be lesser under tropical conditions (Galagan and Vermillion, 1957).Therefore, the probability of fluorosis is maximum in the study area where mean of fluoride concentration in groundwater is 2.20 mg/l. Thus, in this region there is an instant need to warn the people against the threat of dental or skeletal fluorosis and other dysfunctions. People are advised to adopt some techniques of defluoridation of ground water before using for drinking purposes.

The high concentration of fluoride in groundwater of study area may be due to fluoride bearing minerals such as fluorite in the parent rocks of the sediments with in the basin. Apambire et al., (1997) have recommended that the main source of ground water fluoride in granitic rocks is the dissolution and anion exchange with micaceous minerals and their clay products. Presence of fluoride bearing minerals in the host rocks and their interaction with water is considered to be the main cause for fluoride in groundwater (Saxsena and Ahmed, 2003) Weathering and leaching of fluorine-bearing minerals in rock formations under alkaline environment lead to the enrichment of fluoride in the groundwater (Raju et al., 2009) The important parameters also participate in rock water interaction

are concentration of fluoride in rocks, aqueous ionic species and residence time of interaction(Saxsena and Ahmed, 2003).

Fluoride is a highly electronegative element and has a tendency to attract positively charged ions like calcium. Hence the effect of fluoride on mineralized tissues like bones and teeth leading to developmental changes. They have highest amount of calcium and thus attract the maximum amount of fluoride that gets deposited as calcium-flouropatite crystals. Tooth enamel is composed of crystalline hydroxylapatite. Under normal conditions, when fluoride is present in high concentration in groundwater, most of the ingested fluoride ions substitute the hydroxyl ions and formation of fluoroapatite, which is more stable than hydroxylapatite. Thus a large amount of fluoride gets bound in these tissues and only a small amount is excreted through sweat, urine and stool. The intensity of fluorosis is not merely dependent on the fluoride content in water, but also on the fluoride from other sources, physical activity and dietary habits. Excessive intake of fluoride may also lead to muscle fibre degeneration, low haemoglobin levels, deformities in RBCs, skin rashes, depression, gastrointestinal problems, urinary tract malfunctioning, nausea, abdominal pain, tingling sensation in fingers and toes, reduced immunity, repeated abortions, male sterility, etc. It also responsible for alterations in the functional mechanisms of liver, kidney, digestive system, respiratory system, excretory system, central nervous system and reproductive system

As fluoride in drinking water does not change its colour, smell or taste, normally there is no way to detect it unless tested. In recent years, there has been an increased interest in F research because excess concentration of fluoride in drinking water causes adverse impacts on human health. In order to mitigate the excess F in groundwater, it is essential to determine and monitor the causal factors of enrichment of fluoride concentration. Therefore, a systematic assessment of fluoride in groundwater is required for the better management of the fluoride toxicity.

CONCLUSION

The present study of groundwater quality with reference to fluoride concentration in the Dabwali, Sirsa district, indicated that fluoride concentration in the groundwater of the study area varied from 0.90-34.50 mg/l. Only 25% water samples are in the permissible limit, prescribed by WHO. High fluoride concentration in the groundwater was found in the study area may be due to the presence of fluoride in the rocks and their interaction with groundwater. Water–rock interaction and evapotranspiration, which were further, influenced by dry climate and low rainfall, these factors of that area played essential role in the alteration of concentration of fluoride in groundwater. It is evident from the results that the people in study area are chronically exposed to higher levels of fluoride and can be indexed as high risk area for dental and skeletal fluorosis.

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