Distribution of fluoride in groundwater and its suitability assessment for drinking purpose.

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Abstract:

Groundwater samples collected either from the bore-wells (forms a part of municipal water supply) or from the handpumps (direct consumption) were analyzed for fluoride in Hisar city (India). The results indicate considerable variations among the analyzed groundwater samples and the concentration of fluoride ranged from 0.03 to 16.6 mg/l. In most of the groundwater samples the concentration of fluoride was found to be moderately higher, when compared to WHO standard for drinking water, which may leads to the associated health risks in urban population, if the groundwater is being used without proper treatment. Further it is suggested that the sources of municipal water supply must be established in a region where an adequate level of fluoride was observed.

Key Words: Ground water, Monitoring, Fluoride, Fluorosis,

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Introduction

The fluoride intake in the general public derives chiefly from drinking water (70 – 90% of daily intake). Small amounts in ingested water are usually considered good to have a beneficial effect on the rate of occurrence of dental caries, particularly among children. On the other hand due to its strong electronegativity, fluoride is attracted by positively charged calcium ions in teeth and bones. Excessive intake results in pathological changes in teeth and bones, such as mottling of teeth or dental fluorosis followed by skeletal fluorosis (Saralakumari and Ramakrishna, 1993). As per WHO (1997) permissible limit for fluoride in drinking water is 1.0 mg/l, whereas USPHS (1962) has set a range of allowable concentrations for fluoride in drinking water for a region depending on its climatic conditions, because the amount of water consumed and consequently the amount of fluoride ingested being influenced primarily by the air temperature (Heyroth, 1953). Accordingly, the maximum allowable concentration for fluoride in drinking water in Indian conditions comes to 1.4 mg/l, while as per Indian standards it is 1.5 mg/l (BIS, 1991).

The routine monitoring of water can assure the populace that the quality of their drinking water is adequate. It can also be beneficial in detecting deterioration in the quality of drinking water and facilitate appropriate timely corrective actions with minimal negative impacts on population health. In the present study, groundwater of Hisar city was mapped for fluoride distribution, which is mainly used for drinking and other domestic purposes.

Experimental

Site specifications and sampling

Hisar city (29^{o} 10' N and 75^{o} 46' E) falls in a hot and semi-arid Southwestern zone of Haryana State (India) and approximate 166 thousand people live in urban area. The city was divided in to 5 zones i.e. north, south, east, west and central. A total of 127 groundwater samples were collected from 47 localities including various residential, commercial and industrial areas. The samples were collected after the extraction of water either from privately owned manually operated hand-pumps or from electricity operated bore-wells. The water was left to run from the source for about 4 min to equate the minimum number of well volume and to stabilize the electrical conductivity.

Methodology

Fluoride content in the groundwater samples was determined directly after dilution with equal volumes of TISAB buffer (pH = 5.2) as reported by Czarnowski et al, (1996) and the concentrations were measured by a fluoride ion-specific electrode and using a reference pH-meter (Orion). All the experiments were carried out in triplicate and the results were found reproducible with ± 3% error.

Results and Discussions

The subsoil water in Hisar is stored in sand and gravel beds. The depth of water table varies from 6 to 30 meters. Manually operated hand-pumps can easily be installed in study area and are extensively used to pump out the groundwater. Water is pumped out from shallow aquifers by manually operated hand-pumps (installed at approximately 30 meters depth) and from deep aquifers by electricity operated bore-wells (installed at approximately 110 meters depth). Groundwater extracted from the hand-pumps is used by near-by residents, whereas the bore-wells form a part of Public Water Supply system to near-by residential communities.

The fluoride content in the groundwater is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water, etc. (Chandra et al, 1981). No clear trend of fluoride was observed in the groundwater samples obtained either from hand-pumps or from electrically operated bore-wells. The level of fluoride varies from 0.03 to 16.6 mg/l in various regions of Hisar city (Table 1). Fluoride could have originated from fluoride bearing minerals such as fluorite in the rocks. Apambire et al., (1997) have suggested that the main source of groundwater fluoride in granitic rocks are the dissolution and anion exchange with micaceous minerals and their clay products. But considering the geology of Hisar city it can be suggested that other source also exists for fluoride in ground water.

Although fluoride at low concentration in drinking water has been considered beneficial but high concentration may cause dental fluorosis (tooth mottling) and more seriously skeletal fluorosis. The frequencies of fluoride concentrations are given in Fig. 1, which show that around 42 % samples have the fluoride levels higher than 1.5 mg/l. Taking into account the BIS recommended fluoride concentration (1.5 mg/l) in drinking water, people in these localities should be advised to adopt some defluoridation technique prior to use of groundwater for drinking purposes. On the other hand, in about 39% samples F^- content was lesser than (0.7 mg/l) recommended fluoride concentration for caries control.

The data also revealed that there is no uniform distribution of fluoride in the groundwater of Hisar city. Samples collected from east and south of Hisar city have highest fluoride concentration i.e. 2.34± 3.6 and 2.37± 2.2 mg/l respectively, whereas the

minimum levels of fluoride were observed in west of Hisar (0.51± 0.4 mg/l). Further it has been observed that in most of the studied localities, in one or two sample(s) the fluoride content was with in the permissible limits whereas in other samples it was much higher or lower than recommended limit. This uneven distribution of fluoride in groundwater can be attributed to uneven distribution of fluoride containing minerals in the rocks.

A correlation matrix between various physico-chemical parameters was also studied, which shows that fluoride bears a significant correlation only with carbonate (r =0.41, p<0.01). Ravindra et al., 2004 has suggested total dissolved solid as an indicator of water quality, whereas our study recommend that fluoride should also be used as a marker of groundwater quality, where it is used for domestic and especially for drinking purposes.

Conclusions

There was no clear trend observed for the distribution of fluoride in various regions of Hisar city. Although groundwater samples collected from west zone show the minimum levels of fluoride, most of the groundwater samples collected from east and south zone show the maximum variation and also exceed the WHO standard for fluoride in drinking water. Though ground water of Hisar city can be used for drinking purposes, it is suggestible that the drinking water should be supplied form other regions, where concentration of fluoride is suitable for drinking purposes.

References

Apambire WB, Boyle DR, and Michel FA. 1997. Geochemistry, genesis, and health implications of fluoriferous groundwaters in the upper regions of Ghana, Environ Geology 33: 13.

Bureau of Indian Standards (BIS), 1991. *Indian standard specification for drinking water*, IS 10500, pp. 2-4.

Chandra SJ, Thergaonkar VP, and Sharma R. 1981. Water quality and dental fluorosis. Indian J Public Health 25: 47.

Czarnowska W, Wrzesniowska K, and Krechniak J. 1996. Fluoride in drinking water and human urine in Northern and Central Poland. Sci Total Environ 191: 177.

Heyroth FF. 1953. Effectiveness and safety of fluoridation of public water supplies. Ind. Chem. 45: 2369.

Ravindra K, Ameena, Meenakshi, Monika, Rani, and Kaushik A. 2003. Seasonal variation in physico-chemical characteristics of river Yamuna in Haryana and its ecological best-designated use. J Environ Monit 5: 419.

Saralakumari D, and Ramakrishna PR.1993. Endemic fluorosis in the village Ralla Anantpuram in Andhra Pradesh: an epidemiological study. Fluoride 26: 177.

United States Public Health Service Drinking Water Standards-1962, USPHS, Publication 956, USGPO, Washington, DC.

World Health Organization (WHO), 1997. Guideline for drinking water quality, 2nd ed., Vol 2 Health criteria and other supporting information, World Health organization, Geneva, pp 940-949.

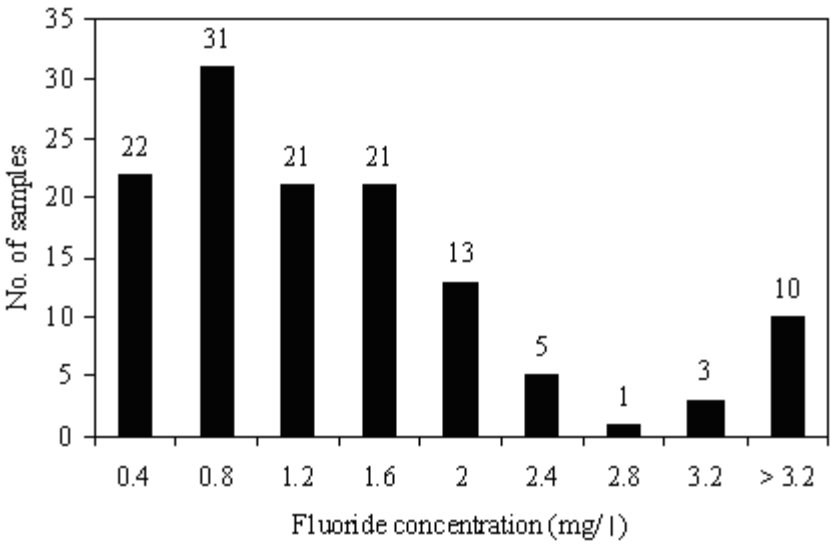

Fig. 1: Frequencies of Fluoride in groundwater of Hisar city.

Table 2: Concentration of F^- in different zones of Hisar city.

Zones	n	F^- concentration (mg/l)	
		Mean± SD	Range
North Hisar	31	0.93 ±0.8	0.14 – 3.5
East Hisar	28	2.34 ±3.6	0.17 – 16.6
West Hisar	15	0.513 ±0.43	0.03 – 1.1
South Hisar	23	2.37 ±2.2	0.38 – 9.0
Central Hisar	30	1.57 ±1.1	0.60 – 6.6

n =number of sampling sites in each zone.