**Poll Res. 41 (3) : 918-924 (2022)**

ISSN 0257–8050
**DOI No.: http://doi.org/10.53550/PR.2022.v41i03.022**

# FLUORIDE OCCURRENCE IN GROUND WATER OF GURUGRAM DISTRICT, HARYANA

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(Received 22 February, 2022; Accepted 20 April, 2022)

## ABSTRACT

**Human health is affected by fluoride deficit or excess in the environment. Fluorosis is a disease that affects about 200 million individuals in 25 nations throughout the world. Fluorosis is endemic in 17 Indian states, which is surprising. The purpose of this study was to determine the fluoride content in groundwater in various villages in Haryana's Gurugram district, where groundwater is the primary source of drinking water. A total of 186 groundwater samples were collected using hand pumps and examined for fluoride levels. Fluoride levels in four tehsils range from 0.08 mg/l (village Haiderpur, Grurgram Tehsil) to 10.5 mg/l (Village Haiderpur, Grurgram Tehsil). According to the study, fluoride concentrations in 106 villages/towns (65.84 percent) are below 1.0 mg/l, the maximum desirable limit of drinking water standards recommended by the Bureau of Indian Standards (IS: 10500, 2012), and fluoride concentrations in 12 villages/towns are above 1.0 mg/l but below or equal to 1.5 mg/l. Fluoride levels in 41 villages/towns were found to be above the permitted limit, rendering them unsafe for drinking. Fluoride in groundwater is thought to be caused by the presence of fluoride-bearing minerals in the host rock, their chemical features such as breakdown, dissociation, and dissolution, and their interaction with water. Dilution by blending, artificial recharge, effective irrigation methods, and well construction are some of the suggested remedial measures to mitigate fluoride pollution in groundwater.**

**KEY WORDS:** Groundwater, Fluoride, Gurugram District, Haryana

## INTRODUCTION

In rural India, groundwater is a major source of drinking water. The groundwater is rich in mineral concentration in comparison to surface water. The use of water for various activities can be determined by the strength of dissolved ions. The higher concentration of the dissolved ions present in water makes it unpotable to human by creating serious health effects. Fluoride is one of the chemical elements present in a minor concentration in water and is essential for human life. Human health is at stake both the conditions of fluoride being in excess and being deficient (Zhang *et al*., 2003; Hussain *et al*., 2004a). One of the most important toxicological and geo-environmental challenges in India was the high concentration of fluoride in groundwater sources.

Fluoride concentrations of less than 0.7 mg/l may cause tooth decay where concentrations above 1.5 mg/l (as recommended by WHO, BIS, ICMR) cause a variety of fluorosis and certain body fluids. A well-recognized correlation exists between the fluoride level of water in an area and the incidence of fluorosis (dental and skeletal).

Fluorosis is endemic not only in India but also in many parts of the world. Seventeen of the Indian states have been known to have endemic for fluorosis. Haryana is one on the list. Fluoride is supposed to cause dental, skeletal, and non-skeletal fluorosis. It has been estimated that 62 million people which also includes children are suffering from the same due to the drinking of fluoride contaminated water (Susheela, 1999). The number of people affected by dental fluorosis rises to more than 200 million people. The chief reason behind this is also the consumption of drinking water with an excess of fluoride (Chandrajith *et al.*, 2007). Fluorosis is a chronic disease caused by the absorption of fluoride-rich water by humans. Inhaled fluoride, when comes in contact with calcium-rich body parts (bones), reacts with its constituent (calcium phosphate hydroxide) and forms a yellow-colored highly stable compound (calcium appetite). This yellow-colored compound deposits in the bones and the teeth as a yellow-colored precipitate. This causes a major problem in the normal functioning of the bones and results in teeth decay.

$$Ca_{10}(Po_4)_6(OH)_2 + 2F^- \longrightarrow Ca_{10}(Po_4)_6F_2 + 2\,OH^-$$

A huge population of rural Haryana is utilizing groundwater for drinking purposes. Despite the prevalence and severity only a few studies in Haryana covers up endemic fluorosis (Garg *et al.*, 1998; Dahiya *et al.*, 2000, 2001; Yadav and Lata, 2002; Meenakshi *et al.*, 2004; Bisnoi and Arora, 2007; Yadav *et al.*, 2009; MohdArif *et al.*, 2014a; Kumar and Sharma, 2017; Yadav *et al.*, 2019; Deswal *et al.*, 2020). The purpose of this study was to determine the fluoride concentration in groundwater in Gurugram District, Haryana, India. The present study will help reduce the problem of high fluoride levels through a government and NGO program to achieve the goal of health for all.

## GUIDELINES AND STANDARDS

The fluoride content of 1.5 mg/l is the recommended upper limit for drinking water, according to WHO recommendations. With the condition that "less is preferable", India cuts the upper limit of fluoride in drinking water from 1.5 to 1.0 mg/l. (BIS 10500, 2012). Deficiency in the diet of essential nutrients, namely calcium, vitamins, and antioxidants, and the extreme climatic conditions are responsible for it. Hence, the maximum desirable limit (MDL) according to the Indian Standard (IS), 10500:2012 for fluoride in drinking water is 1.0 mg/l and the value set for the maximum permissible limit (MPL) is 1.5 mg/l. Since a large amount of fluoride is ingested through drinking, therefore, amount of ingested fluoride depends primarily on the air temperature. The United States Public Health Service (1962) has established a concentration range for families living in community areas for maximum allowable fluoride in drinking water. These are listed in Table 1.

### Study Area

Gurgaon, one of Haryana's southern districts, has been designated as a "dark zone" due to the gradually declining amount of groundwater. Gurgaon district is 1200 square kilometers in size and is located in Haryana's south-eastern section. It is bordered on the north by the Union Territory of

**Table 1.** U.S. Public Health Service recommendation for maximum allowed fluoride in drinking water

| Annual average maximum daily air temperature (°C) | Recommended fluoride concentration (mg/l) | | | Maximum allowable fluoride concentration (mg/l) |
|---|---|---|---|---|
| | Lower | Optimum | Upper | |
| 10–12 | 0.9 | 1.2 | 1.7 | 2.4 |
| 12.1–14.6 | 0.8 | 1.1 | 1.5 | 2.2 |
| 14.7–17.7 | 0.8 | 1 | 1.3 | 2 |
| 17.8–21.4 | 0.7 | 0.9 | 1.2 | 1.8 |
| 21.5–26.2 | 0.7 | 0.8 | 1 | 1.6 |
| 26.3–32.5 | 0.6 | 0.7 | 0.8 | 1.4 |

Delhi, on the east by Faridabad, on the northwest by Haryana's Jhajjar and Rewari districts, on the west by Rajasthan's Alwar district, and the south by Haryana's Mewat district. Gurgaon is divided into four districts: Gurgaon, Sohna, Farukhnagar, and Pataudi.

## GEOLOGY

The Gurgaon district has Quaternary alluvium and Pre-Cambrian meta-sediments from the Delhi Super Group. Thick strata of fine to coarse-grained sand are intermingled with thin clay layers in the alluvium.

## MATERIALS AND METHODS

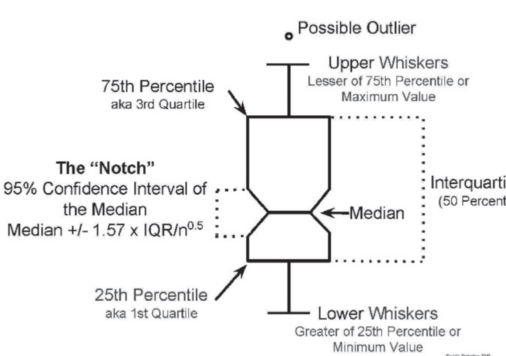
Groundwater samples from 161 villages located in the Gurugram district are collected in polythene bottles pre-cleaned with the necessary safety measures. Groundwater samples were transported to a water quality laboratory, where fluoride concentration was determined using the APHA's 23rd Edition Ion-Selective Electrode (ISE) method. All chemicals used will be Anal. R. Grade. The fluoride concentration data are shown as Frequency histogram and Notched box and Whisker Plot.

### 1. Frequency histogram

The graphical representation of variables in the X-axis observations in the Y-axis is termed as Frequency Histogram. This is useful in depicting data of frequency when the measurement data is on an interval or ratio scale (Figure 1). The histogram of frequency distribution is plotted vertically. The bars in the chart are representative of several observations within certain ranges of values.

### 2. Notched Box and Whisker Plot

Notched box and Whisker Plot is anappropriate way of visually presenting the data distribution through their quartiles. In its simplest form, the boxplot presents seven sample statistics – Upper quartile, Lower quartile, Median, Upper, and Lower Whiskers, the notch, minimum, and maximum.




## RESULTS AND DISCUSSION

161 villages of Farrukh Nagar, Gurugram, Patodi, and Sohana tehsil of Gurugram district were selected and the groundwater is analyzed for quantitative examination of fluoride.

Fluoride causes serious health effects hence villages are categorized into five risk levels-

1. No-Risk Level – I concentration below 1.0 mg/l,
2. Low-Risk Level – II concentration between 1.0 and 1.50 mg/l
3. Moderate risk Level – III concentration between 1.50 and 3.0 mg/l
4. High-Risk Level – IV concentration between 3.0 and 5.0 mg/l and
5. Very High-Risk Level – Vconcentration above 5.0 mg/l.

Figure 1 depicts the distribution of fluoride in the groundwater of four districts of the study area.

The concentration of fluoride varies from 0.08 mg/l (village Haiderpur of Grurgram Tehsil) to 10.5 mg/l (village Chandu of Farukh Nagar Tehsil).

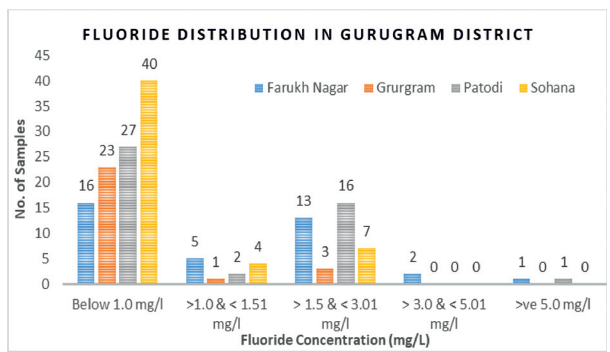
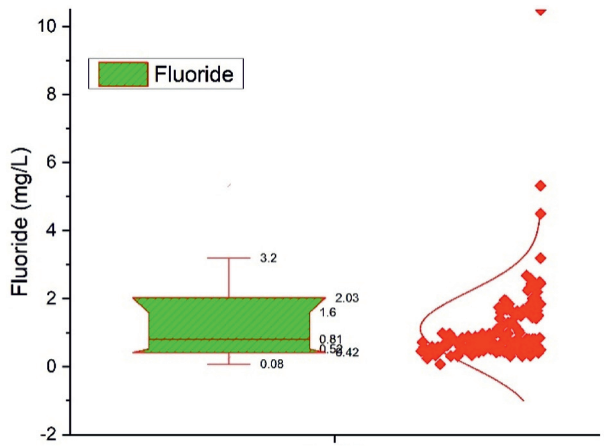



Figure -2 represents the frequency of fluoride concentration in the district. From the figure, it is clear that the frequency of fluoride concentration is high on 1.0 mg/l fluoride concentration. Maximum villages have fluoride concentrations between 0.5 and 1.6 mg/l. The Study shows 106 villages (65.84%) in No risk Level -I. These villages have fluoride concentrations below 1.0 mg/l which is the maximum desirable limit of IS: 10500, 2012; standards for drinking water. There is no possibility of fluorosis in these villages however fluoride level in these villages is beneficial for calcification of dental enamel especially for children below 10-year




age. Once fluoride is incorporated into teeth, it reduces the solubility of the enamel under acidic conditions and thereby protects dental carries.

12 villages are at low-risk level – II as the fluoride concentration falls in the range of 1.0 – 1.5 mg/l. According to the Indian Standard for drinking water, the maximum permissible limit (MPL) is 1.5 mg/l for fluoride (IS: 10500; 2012). Due to this population of these villages, the average consumption gets to as much as 4mg/day as an individual thus causing the prevalence of 1$^{st}$ and 2$^{nd}$-degree dental fluorosis.

24.22% which accounts for 39 villages consume water with a concentration of fluoride ranging from 1.5 to 3.0 mg/l. These villages are at moderate risk level – III. This fluoride concentration leads to dental fluorosis causing loss of shiny appearance on teeth and further deposition of chalky black, grey, or white patches. This condition is called mottled enamel (Arif *et al.*, 2012).

In 2 villages (1.24%) the fluoride concentration falls between 3.0 mg/l and 5.0 mg/l. This range allows it to fall under High-risk level - IV. Per-day intake of fluoride by an adult is very high. The cases of dental fluorosis in the area will account for a total of 6% of the population. This percentage also accounts for the cases of skeletal fluorosis in people above the age of 30. The second stage of skeletal fluorosis is probable to be affecting people above the age of 45 (Hussain *et al.,* 2003; 2004b; 2005; 2010; 2012).

In the entire survey, two villages (1.24%) Chandu (10.5 mg/l), and Parasali (5.32 mg/l) are at very high-risk levels - V. The area's lithology and geology were largely responsible for the high fluoride concentration in groundwater. Amphiboles, biotite, fluorite, and fluorapatite are some of the major fluoride minerals found in these rock types. Because these minerals are easily soluble in water, groundwater interacting with them during percolation has a higher concentration of fluoride (Haritash *et al.,* 2018). Other factors that may contribute to excessive fluoride concentrations in some homes include water depth and weather conditions. Hand pumps / bore wells with deep groundwater are thought to have a higher fluoride concentration than shallow groundwater hand pumps / bore wells. (Handa, 1975).

The fluoride concentration of these villages exceeded 5.0 mg/l which may be the cause for all stages of fluorosis in the residents. In the second clinical stage, the people affected exhibit pain in bones which causes ligaments to calcify further. These concentrations are supposed to cause stiffness in joints, *crippling skeletal fluorosis (*a condition where vertebrae partially fuse and thus cause crippling), hemorrhagic gastroenteritis, and damage to the heart and liver (Suttie, 1980). The conditions of plasma epinephrine and hyperglycemia-induced due to fluoride are at a significant rise. Fluorosis is also responsible for affecting other organsof the body too, which are lungs, heart, liver, and hormonal functions(WHO, 2002; USDA, 2005; USEPA, 2010). The primary organ responsible for the elimination of fluoride through the body is the kidney. Elevated concentrations of fluoride are expected to result in kidney failure too (Susheela, 1999; Arif *et al.,* 2012)

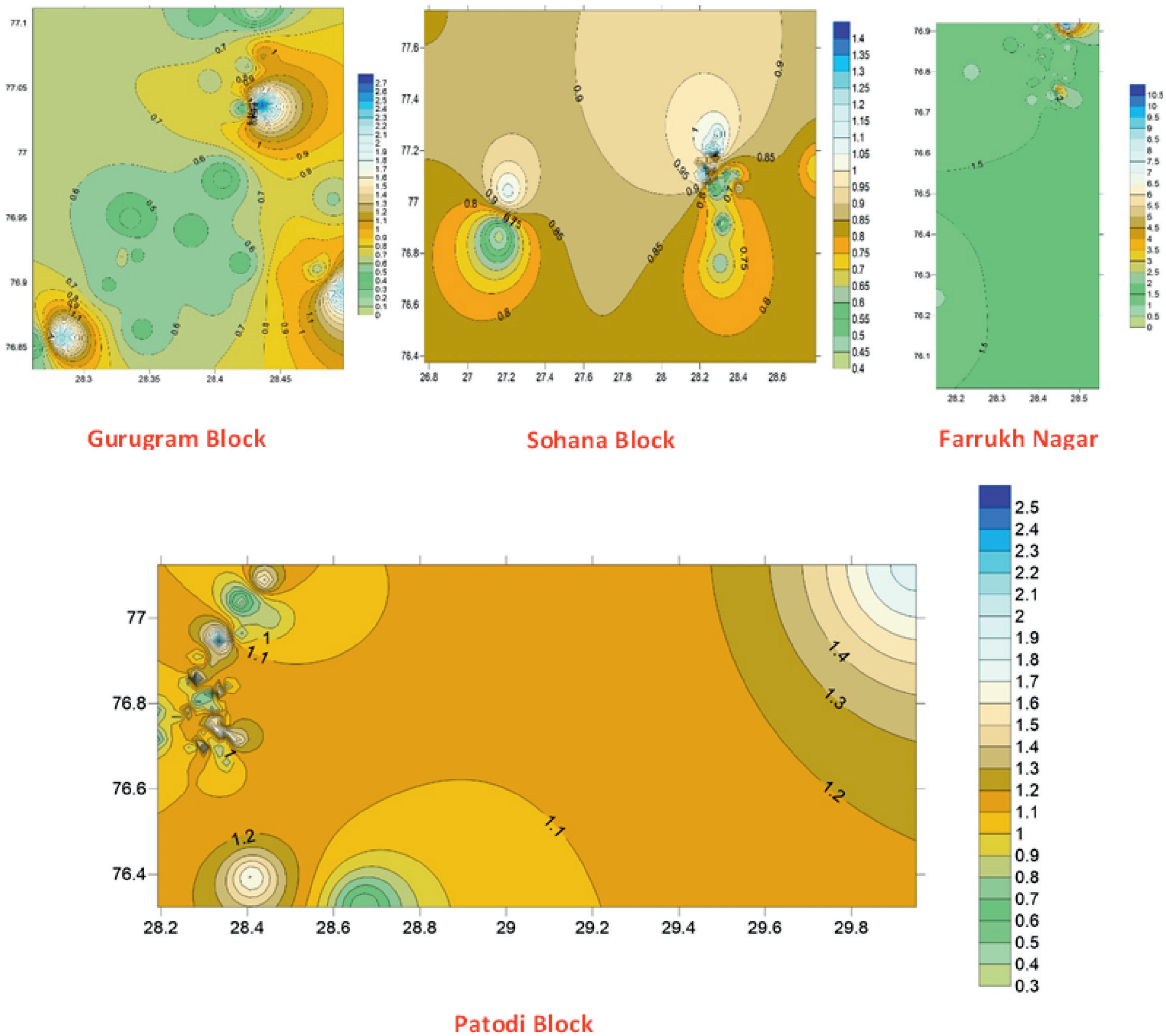
**Spatial distribution of fluoride using Inverse distance weighted method**

GIS stands for Geographic Information System, and it is a computerized data-based system for capturing, storing, retrieving, analysing and displaying spatial data. GIS is a general-purpose technology for handling digital geographic data and meeting the needs listed below, among others.

The inverse distance weighted (IDW) interpolation implements the premise that objects that are near together are more similar than things that are farther apart. IDW uses the measured values surrounding the prediction location to forecast a value for any unmeasured location. The measured values that are closer to the prediction location have a greater impact on the anticipated value than those that are further away. Each measured point, according to IDW, has a local influence that decreases with distance. It gives more weight to points that are closer to the prediction location, and the weights decrease as distance

**Table 2.** Fluoride Concentration in Gurugram District

| Tehsil | Below 1.0 mg/l | Above 1.0 & Below 1.51 mg/l | Above 1.5 & Below 3.01 mg/l | Above 3.0 & Below 5.01 mg/l | Above 5.0 mg/l |
|---|---|---|---|---|---|
| Farukh Nagar | Duman (0.55); Banslambi (0.84); Basonda (0.78); Bhangrola (0.6); Dhanawas (0.42); Farid pur (0.32); Gugana (0.36); Jamal pur (0.75); Joniawas (0.8); Khawaspur (0.82); Khurampur (0.78); Palri(0.32); S. Mohmad pur (0.96); Shekhupurmajra (0.7); Sultan pur (0.63); Taz nagar (0.9) | Farukhnagar (1.32); Jatola (1.25); Karola (1.3); Mehchana (1.2); Sanpka (1.42); | Basria (1.56); Dabodha (1.62); Fazalpurbadli (2.5); Jhundsarai (1.85); Khandewala (1.68); Kharkhadi (1.95); Khentawas (1.96); Kherikanhei (1.78); Kheri sultan (2.01); Patli (1.6); Siwari (2.45); Sunder pur (2.6); Tripari (1.75) | Jaraun (3.2); Mushed pur (4.5) | Chandu (10.5) |
| Grurgram | Badshahpur (0.66); Budhera (0.64); Chandu (0.98); Gwaliar (0.51); Haiderpur (0.08); Jhund Sarai Viran (0.56); Kharki Majra Dhankot (0.58); Naharpur Kasan (0.43); Nainwal (0.33); Sadhrana (1.0); Sehrawan (0.45); Danokri (0.46); Shamshpur (0.58); Kadarpur (0.46); Fazalwas (0.47); Sihi (0.34); Rathiwas (0.25); Tikri (0.39); Wazirpur (0.43); Sidhrawali (0.57); Kankrola (0.72); Tatarpur(0.46); Sadhrana (1.0) | Bindapur (1.12) | Bilaspur (2.3); Iqbalpur (2.25); Islampur (2.68) | | |
| Patodi | Balewa (0.506); Chandla (0.85); Dadawas (0.42); Dungarvas (0.62); Gadaipur (0.52); Ghaushgarh (0.81); Gudhana (0.81); Heliaki (0.81); Helimandi (0.72); Jasat (0.32); Kadipur (0.81); Kumlawas (0.51); Langra (0.82) ; Lokra (0.71); Mandir dhani (0.65); Mau (0.42); Rampura (0.74); Nurpur (0.31); Pahari (0.65); Pataudi (0.41); Pathredi (0.71); Rajoridhani (0.81); Rajpura (0.65); Rathiwas (0.62); Safed nagar (0.71); Turkan pur (0.42); Unchamajra (0.32) | Lokri (1.42); Mirza pur (1.45) | Darapur (1.85); Dhanokari (1.84); Husainka (1.51); Khalil pur (2.45); Khetiawas (1.65); Luhari (1.82); Mandpura (2.5); Milakpur (1.87); Mumtajnagar (1.71); Nainwal (2.45); Nareda (1.85); Panchgaon (1.61); Ransika (1.65); Sherpur (1.62); Vazirabad (1.65); Vilaspur (2.2) | | Parasali (5.32) |
| Sohana | Alipur (0.7); BadshahpurThethar (0.98); Baikhera (0.84); Baluda (0.45); Behlpa (0.44); Berka (0.46); Bhogpur Mandi (0.93); Chuharpur (0.68); Daula (0.47); Dhunela (0.58); Ghamroj (0.5); Gwalior (0.43); Hariyahera (0.66); Hazipur (0.96); Heraheri (0.57); Isaki (0.91); Johlaka (1.0); Kadarpur (0.52); Khaika (0.97); Khuntpuri (0.75); Kiranki (0.77); Kuliyaka (0.68); Lakhuwas (0.82); Lala Kherli (0.47); LohSinghani (0.97); Lohtaki (0.73); M.P Gujjar (0.5); Mandawar (0.43); Nimoth (0.61); Nunhera (0.84); Rahaka (0.88); Raiseena (0.55); Rani ka Singola (0.63); Samp ki Nangli (0.34); Satlaka (0.64); Sehjawas (0.43); Silani (0.9); Sirska (0.84); Sohna (0.5); Sohna Dhani (0.52) | Harchandpur (1.49); Kherli Nangli (1.07); Lakhuwas (1.5); Sirmathla (1.2) | Bai khera (2.03); Bidhwaka (1.62); Bilaka (1.68); Ghangola (1.6); Lakhuwas (1.63); Lakhuwas (1.5); Sancholi (2.47) | | |




increases, hence the term IDW. Spatial distribution of fluoride in the Gurugram district is shown in figure 03.

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