IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 14, Issue 8 Ser. IV (August 2020), PP 11-19
www.iosrjournals.org

A study on prevalence and impact of fluoride in drinking water in Nuh district of Haryana, India

Lalit Mohan Sharma, Aparajeeta, Yashi Gautam
Adaptive Technologies Water, S M Sehgal Foundation, Gurugram, India

Abstract
Geological characteristics and chemical composition of the substrata formations havehigh influence on the quality of groundwater. The contamination of groundwater may be due to natural (geogenic) or anthropogenic sources that deteriorategroundwater quality. Fluoride in water is the major cause of fluorosis. Fluorosis is a serious widespread health issue in India caused by ingestion of fluoride through water and food. The present study was carried out in four selected blocks (Ferozepur Jhirka, Nagina, Nuh, and Taoru) of Nuh district, Haryana, India to map the prevalence of fluoride concentration in drinking water and dental fluorosis among children up to age fifteen. Dental fluorosis is believed to be caused by consuming water with unsafe levels of fluoride concentration. The present study observed cases of dental fluorosis in schoolchildren even when consuming water within safe limits of fluoride concentration. There might be other possible factors that exaggeratethe impact of fluoride even within a safe range.
Key Words: *fluoride, dental fluorosis, groundwater, drinking water, health issues*

Date of Submission: 17-08-2020 Date of Acceptance: 03-09-2020

I. Introduction

1.1 Fluoride and Fluorosis

Water is an essential natural resource to sustain life and is crucial for human civilization. Groundwater is a vital component of water resources. The quality of groundwater highly depends on geological characteristics and chemical composition of the substrata formations. Groundwater mining is another important factor thatinfluences this in spread and extent. Depletion is causedwhen groundwater mining is more than the recharge. This may further change groundwater flow direction, which in turn causes ingress of seawater or intrusion of other ground/surface water or polluted water from the surrounding areas, affecting the quality of groundwater itself (Sharma, L.M., 2014).

The contamination of groundwatermay originatefromnatural (geogenic) or anthropogenic sources (Nath and Dutta, 2010).Arsenic, fluoride, nitrate, iron, and boron are some of the elements present that pressure the level of contamination in groundwater (Brindha and Elango., 2011). However, presentlyowing to economic growthas well, groundwateris being polluted fast with growing urbanization and industrialization. The deteriorating quality of groundwater due to increasing contamination by various toxic substances is a growing concern (Tariq et al., 2008), especially in the arid the semi-arid regions(Das, et al., 2019).

Fluoride is the most electro-negative element in the halogen group in the periodic table(Greenwood and Earnshaw, 1984; Gillespie, et al., 1989). Its natural abundance in the earth's crust is 0.06 to 0.09 percent(Fawell, et al., 2006), and the average crustal abundance is 300 mg/kg (Tebutt, 1983). Fluoridealso exists in anumber of minerals such asfluorspar, cryolite,fluoroapetite, montmorillonite, kaolinite,and some mica weathered from silicates,igneous, and sedimentary rocks, especially shale (Das, et al., 2019, and AyoobandGupta., 2006). Fluoride dissolves in water easily. Presence of fluoride can be determined only through chemical analysis.The amount of fluoride contamination in groundwater in India ranges up to 48.0 mg/l (Sushila, 2001).

Fluoride is termed as two-edged sword having both favorable and unfavorable consequences (Qureshi, et al., 2013). The World Health Organization (WHO) has fixed the limit from 0.5 mg/L to 1.5 mg/L in drinking water. The Bureau of Indian Standards (BIS) has set the maximum acceptable and permissible limits at 1 and 1.5 mg/L respectively, in water for drinking purposes.At the same time, optimal fluoride concentration provides protection from dental caries.Once fluoride reaches the body through the gastrointestinal tract or through the mouth, it reaches various organs and tissues in the body. Fluoride (F^-), being the most electro-negative element, attracts and binds with electro-positive elements like calcium (Ca^{2+}) and magnesium (Mg^{2+}). Bone and teeth have high amounts of calcium in the body.Fluoride binds with this calcium and makes it complex and isdeposited as calcium fluoride (CaF_2),whichcauses manifestations of fluorosis in different forms.

Prolonged consumption of fluoride causes fluorosis disease, which has detrimental effects on teeth (dental), bone (skeletal) and tissues (non-skeletal). Excessive fluoride exposure has also been linked to a range of other chronic ailments including arthritis, bone fragility, dental fluorosis, glucose intolerance, gastrointestinal distress, thyroid disease, and possibly cardiovascular diseases.Fluorosis is a slow, crippling disease thataffects every organ, cell,and tissue in the body (Mondal., 2018). Fluorosis has been prevailing globally, affecting 200 million people across 25 nations (Ali, et al., 2016). In India, a large number of people suffer from fluorosis disease extensively through high-fluoride-content drinking water.

II. Methodology

2.1 Study area: District Nuh (formally known as Mewat), Haryana, has a geographical area of 1,507 sq. km. The district has a population of 10.9 lakhs (Census 2011)). Due to the non-availability of a perennial river or lake in the district, groundwater is the only source of water. Seventy-eight percent of the district has saline groundwater and remaining 22 percenthas fresh groundwater (Sharma, L.M., 2014). But available fresh groundwater contains fluoride;therefore, the population struggles with both water quality and availability. Four blocks of the district: Ferozepur Jhirka, Nuh, Nagina and Taoru were selected for this study.
The objectives of this study are to. . .
(1) Assess and map the fluoride concentration in drinking water and fluorosis.
(2) Investigate the relationship between fluoride levels in drinking water and the severity of dental fluorosis.
The study is based on primary data. The methodology followed to study the presence of fluoride in drinking water and prevalence of dental fluorosis in four selected blocks of the districtfollows:

2.2 Water Sampling: Samples of water being used for drinking purposes were collected from four scattered, randomly selected households from each village in the focusedblocks. These four sources maybe different from each other in terms of water quality.

2.3 Sample tested: Selective ion electrode (Orion make, Star A214 marketed by Thermo Scientific) was used to determinethe precise concentration of fluoride in water. 0.5 ml of TISAB-III solution was added tothe 5 ml of collected samples (as prescribed by the manufacturer) thenthe solution was tested through said electrode.*pH* (by pH meter-80 by HM Digital) and total dissolved solids (TDS) (by E-1 portable TDS meter by HM Digital) were also measured for all the samples.
In addition to lab tests, samples were tested using a fluoride-testing field kit produced by LTEK, Nagpur, in the presence of community members. Results of these field tests were used to trigger the sensitization process among the community members present.

2.4 Mapping: A QGIS mapping tool was used to depict the prevalence of fluoride in focused blocks. The prevalence of fluoride is shown in terms of range of fluoride concentration (PPM) in the drinking water. Dental fluorosis is mapped in terms of percentage of children population affected and the severity of impact.

2.5 Dental fluorosis survey: Children age six to fifteen were examined for dental fluorosis. With the following categories, the severity of dental fluorosis was rated and categorized based on the following features as shown in the pictures below:

- Normal: no mottling, surface of teeth like glazed white porcelain
- Mild: white opaque appearance of the enamel, with or without faint yellow lines
- Moderate: distinct yellow to light-brown staining in the areas of enamel damage
- Severe: pitting of the surface and sometimes chipping of the teeth

III. Results and Discussion

Table 1 illustrates the overall data collected with block wise distribution. In total, 317 villages were studied, more than 1160 water samples were taken, 41,564 children were surveyed, and 261 schools were involved in this study.

Table 1: Water sampling and fluorosis surveydata for Nuh district

	Blocks				**Total**
	Ferozepur Jhirka	Nagina	Nuh	Taoru	
Villages	85	80	82	70	317
Water samples	339	263	284	280	1166
Children surveyed (DF)	7,749	6,963	16,952	9,900	41,564
No. of schools covered	80	72	64	45	261

The graph in Fig.1shows the distribution of fluoride concentration (percentage of watersamples collected) in defined ranges for each block. The figure indicates that Ferozepur Jhirka has the maximum unsafe sources, showing more than 43 percentof the water samples with fluoride concentration above 1.0 PPM;whereas Taoru has the maximum safe sources, with over 98 percentof the water samples below 1.0 PPM.

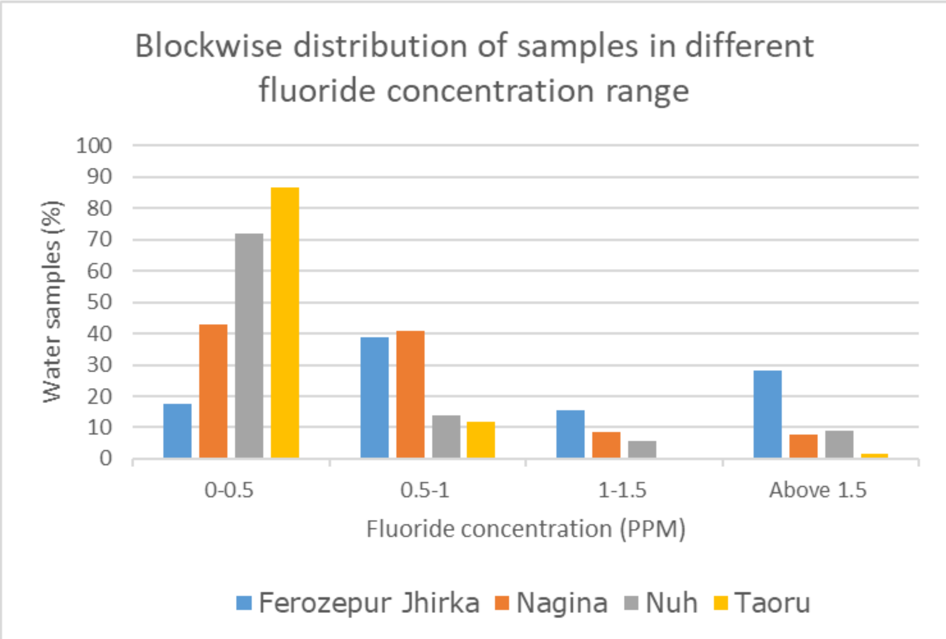
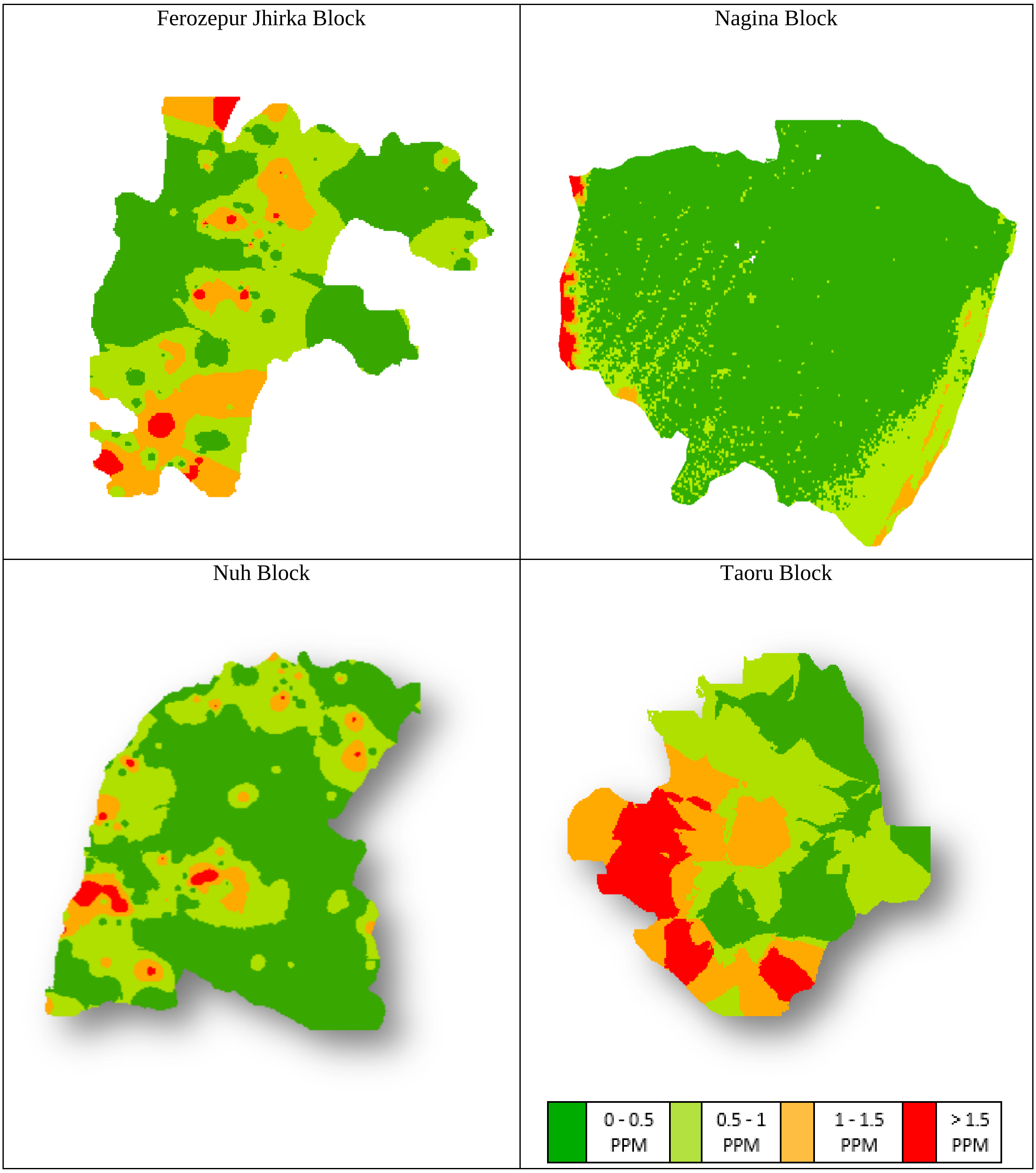


Fig.1. Distribution of fluoride concentration of different ranges

1) Fluoride Mapping

The figure belowshows the collective representation of the fluoride concentration mapping present in drinking water consumed in each block. According to Indian standards, the safe limit is 1mg/L.



It is evident from the maps above that fluoride concentration in water is higher close to the hills and lowerin the alluvium plains. Thissupports that the source of fluoride here is a mostly geogenic natural occurrence.Most of Taoru block has alluvium ground conditions with themaximum safe sources; the unsafe sources here are in close vicinity of hills.

2) Fluoride concentration and TDS level

TDS levels in the water samples were analysed as reported in Table 2 and depicted the description of the characteristics observed from the water samples collected from each of the blocks in the district.

Table 2: Details offindings observed from water samples

Categories	Blocks			
	Ferozepur Jhirka	Nagina	Nuh	Taoru
Total samples	339	263	284	280
% local groundwater source	88	17	68	70
% imported sources	12	83	32	30
% samples found in safe limits of fluoride	56.34	83.65	85.56	98.58
% samples found in unsafe limits of fluoride	43.66	16.35	14.44	1.42
TDS range (low-high) PPM	121–3,410	110–1,000	132–1,000	106–1,700

The water used for drinking and domestic purposes is imported from distant sources where local groundwater is saline. Maximum number of households (83%) importing water are in Nagina followed by Nuh (32%).It is a common practice that water samples having TDS level above 1,000 PPM(being non-palatable) wereeither used for other domestic purposes only or mixed with low TDS water for consumption. TDS ranged from 121 to 3,410 PPM in Ferozepur Jhirka, from 110 to 1,000 PPMin Nagina, from 132 to 1,000 PPM in Nuh, and 106 to 1,700 PPM in Taoru. It is also evident from the table that fluoride is not a consideration for selection of source of imported water.

The fluoride concentration found in water samples (sorted in ranges of concentration) for each block is shown in Table 3.The maximum and minimum fluoride concentration recorded for each block is also reported. With 43.66 percentof the water samples with levels of fluoride above 1 PPM, it can be defined that Ferozepur Jhirka has maximum unsafe sources, whereas Taoru, with only 1.42 percentabove 1PPM, has maximum safe sources.

Table 3: Summary of details for selected blocks of Nuh district

		Blocks			
		Ferozepur Jhirka	Nagina	Nuh	Taoru
Water samples in fluoride concentration range (%)	0-0.5 PPM	17.70	42.97	71.83	86.79
	0.5-1 PPM	38.64	40.68	13.73	11.79
	1-1.5 PPM	15.63	8.75	5.63	0
	Above 1.5 PPM	28.02	7.60	8.80	1.43
	Safe(<1 PPM)	56.34	83.65	85.56	98.58
	Unsafe (>1 PPM)	43.66	16.35	14.44	1.42
Maximum F concentration (PPM)		13	6.10	5.27	2.8
Minimum F concentration (PPM)		0.19	0.22	0.44	0.08

3) Dental fluorosis study

For dental fluorosis, children under age fifteen were examined. A total of 261 schools and 41,564 students were surveyed.Table 4 elaborates the percentage of dental fluorosis in schoolchildren, whereas Fig.2 shows the graphical representation of the aggregate dental fluorosis surveyresults of focused blocks. It is interesting to see that Taoru block has minimum number in normal status in spite of maximum number of fluoride safe sources.

Table 4: Block wise dental fluorosis data of schoolchildren

		Blocks			
		Ferozepur Jhirka	Nagina	Nuh	Taoru
Children D.F. status (%)	Normal	55	57	39	36
	Mild	18	18	29	23

	Moderate	11	11	15	17
	Severe	7	7	9	14
	Not participated	9	7	8	10

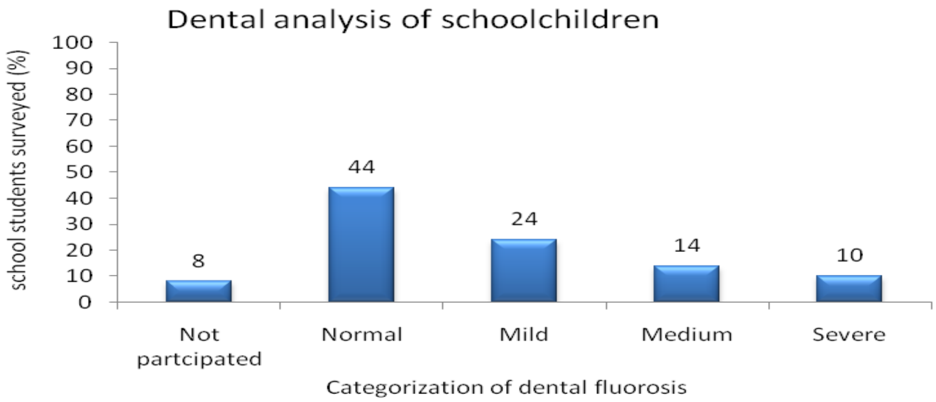


Fig. 2 Dental fluorosis survey distribution in four selected blocks

Figure 3 below shows percentage ofchildren in dental fluorosis severitycategoriesin different blocks.

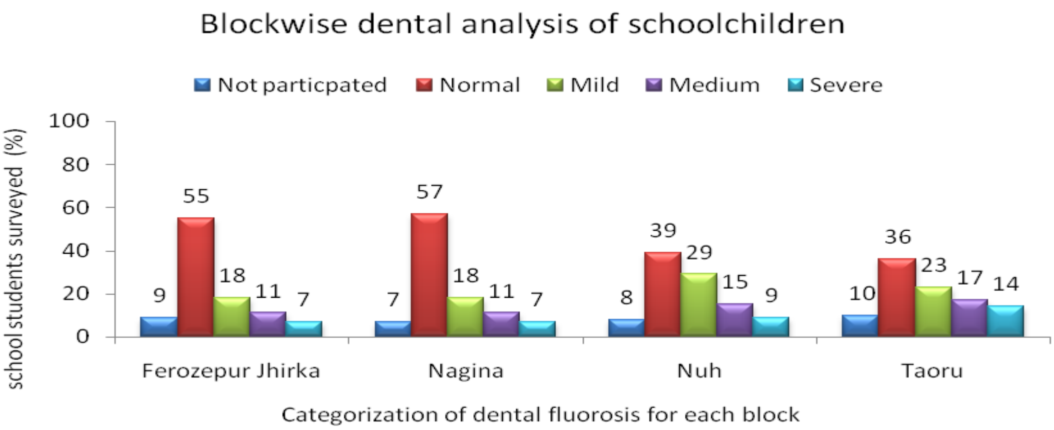


Fig. 3 Block wise prevalence of dental fluorosis ineach block.

Even the safe is doubtful!

Invariably dental fluorosis is believed to be caused by consumption of water with higher concentrations of fluoride (Yadav, et al., 2018). Surprisingly, dental fluorosis was observed even in villages wherethe concentration of fluoride ismuch lower than safe limits. To explore this further, a village wise analysis of dental fluorosis severity against fluoride concentration within safe limitswas carried out.

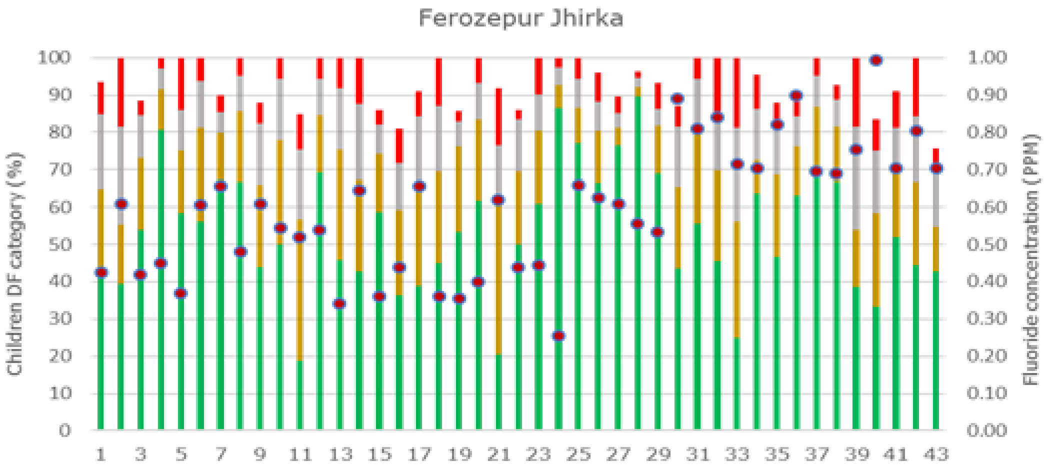
To analyze the blockwise status of dental fluorosis in these fluoride-safe-water villages, sources were grouped into three ranges of fluoride concentrations, i.e. 0–0.33 PPM, 0.34–0.66 PPM, and 0.67–1 PPM. Dental fluorosis severity was analysed against these ranges of concentrations. Results are shown in the Table 5.

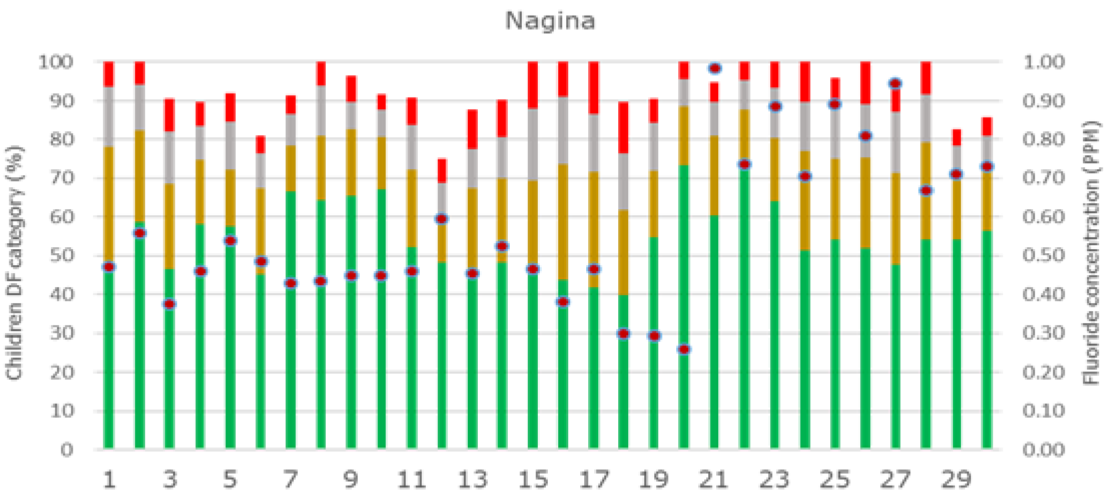
Table 5: Listing the dental fluorosis status and fluoride concentration

Children: Dental fluorosis status (%) in villages	Fluoride concentrationRange (PPM)	Fluorosis Category	Block wise and Fluorosis Category wise distribution of children			
			Ferozepur Jhirka	Nagina	Nuh	Taoru
	0–0.33 PPM	Normal	86	54	45	43
		Mild	6	22	31	24
		Moderate	5	14	16	19
		Severe	2	10	8	14
	0.34–0.66	Normal	63	64	40	36
		Mild	19	18	27	30
		Moderate	11	11	20	20

		Severe	7	7	12	15
	0.67–1.00	Normal	56	64	9	38
		Mild	20	19	29	15
		Moderate	15	10	36	21
		Severe	9	7	26	26

Figure 4 maps village wise fluoride concentration with severity distribution of dental fluorosis among children of four selected blocks having fluoride within safe limits. X-axis represents the village codes.





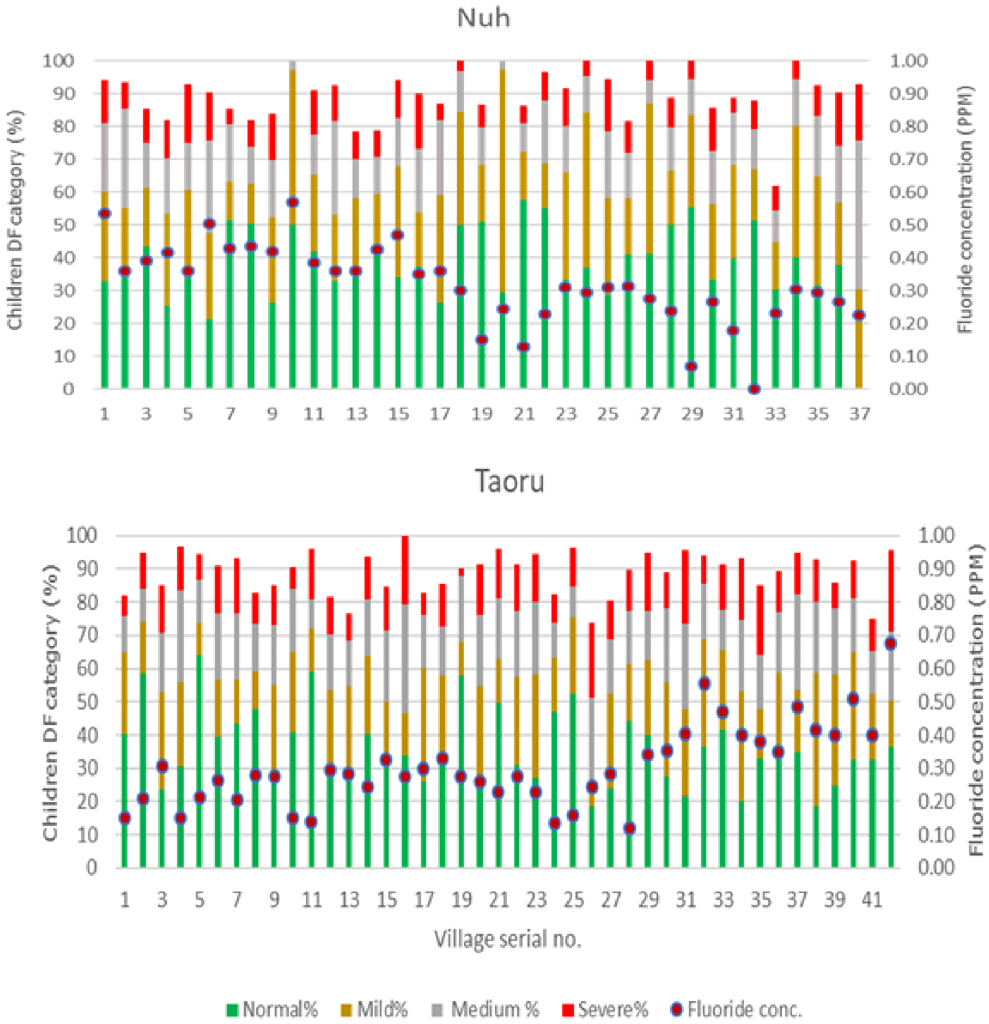


Fig. 5. (contd.) Villagewise fluoride concentration with DF in children in selected blocks

The graphs above do not follow a uniform trend between the fluoride concentration and dental fluorosis severity.

Though dental fluorosis among children is an indicator of exposure to fluoride (Indu and Krishnan,2014),means graphs of dental fluorosis severity and overall blockwise scenario tables should showa rising trend in fluorosis severity with an increase of fluoride concentration uniformly. However, in this study, the data does not follow uniform distribution, implying that there are some other factors also which contribute or influence the incidence of dental fluorosis and its severity. The following maybe few of those factors:

i. Climatic conditions: Hotter climatic conditions can affect the dietary habits in that area. More importantly,increasedwater consumption due to increasedsweating and thereby increasedtotal intake of fluoride (Fawell, et al., 2006).
ii. Nutrition: Nutrition level has a direct link with fluorosis as consumption of calcium, magnesium, and vitamin C counteract fluoride by neutralizing and flushing fluoride from the body. So food habits and consumption patternsmayplay an important role (Indu and Krishnan, 2014).
iii. Profession: Individuals doing physical labor sweat more and consume more water than otherwise, so they might consume more fluoride and develop fluorosis even with consuming water having fluoride within a safe limit (Indu and Krishnan,2014).
iv. Environmental exposure: An individual might also be subjected to intake of fluoride through air pollution in addition to fluoride in water. (Fawell, et al., 2006).
v. Presence of other contaminants: There might be a situation like the presence of other elements thatcan aggravate the impact of fluoride in body (Fawell, et al., 2006).
vi. Consumption of fluoride through other sources: Use of dental products (includes toothpaste with 1-1.5PPM of fluoride), food items like tea andblack rock salt; tobacco, intake of drugs/antioxidants that contain fluoride increase the total consumption of fluoride (http://www.inrem.in/fluorosis/pdf/nutrition.pdf).

IV. Conclusion and Way Forward

Presence of fluoride in groundwater has been a potential problem to human society. The study conducted for selected blocks of Nuh district of Haryana has following conclusions:

1. In the four blocks studied, a total of 1,268 water samples were collected. Fluoride concentration ranged from 0to 13 PPM, and the maximum concentration of fluoride in water found was 13PPM in Mundaka village of Ferozepur Jhirka block.
2. Prevalence of dental fluorosis can be seenin the villages having fluoridesafe drinking water.
3. The dental fluorosis severity distribution in fluoride-safe-water village showed a non-uniform pattern indicating that there are other factors exaggerating the impact of fluoride.Thusthere is a need tostudy these in further detail.

Acknowledgment

Authorsthank Dr. Suri Sehgal, Jay Sehgal, and Anjali Makhija(Sehgal Foundation) for their encouragement and motivation to work on this study; and to Suneel Rajavaram and Marcio Botto (CAWST) for their support; and MsMarly Cornell and Ms Pooja O. Murada for their valuable inputs. We thankfully acknowledge the support of communities of district Nuh for their cooperation in providing water samples and fluorosis surveys among their children. The entire Sehgal Foundation team deserves special thanks for their support in the overall process.

References

[1]. AIMU, (2017) Fluorosis: Causes, Diagnosis, Management and Preventionhttps://www.aimu.us/2017/08/15/fluorosis-causes-diagnosis-management-and-prevention/.

[2]. Ali S., Thakur S. K., Sarkar, A., &Shekhar, S. (2016) Worldwide contamination of water by fluoride. *Environment Chemistry* Lett 14(3):291–315.

[3]. Ayoob S., &Gupta A.K. (2006) Fluoride in drinking water: a review on the status and stress effects. Critical Review Environmental Science Technology 36:433–487.

[4]. Brindha, K,. &Elango, L. (2011)Fluoride in Groundwater: Causes, Implications and Mitigation Measures. In: Monroy, S.D. (Ed.), *Fluoride Properties, Applications and Environmental Management*, 111–136.

[5]. Census (2011). Mewat District Religion Census 2011. Available at: https://www.census2011.co.in/data/religion/district/226-mewat-.html.

[6]. Das, S.V.G., Adimalla, N., &Venkatayogi S., (2019) Assessment of fluoride contamination and distribution: A case study from rural part of Andhra Pradesh, Applied water science Water Science 9:94. https://doi.org/10.1007/s13201-019-0968.

[7]. Fawell, J, Bailey K., Chilton J., Dahi, E., Fewtrell,L., & Magara, Y. (2006). *Fluoride in drinking water*, WHO, IWA publishing, 1–144.

[8]. Gillespie, R. J., Humphries, D. A., Baird, N. C., & Robinson, E. A., (1989). *Chemistry. Second ed*. Allyn and Bacon, Boston.

[9]. Greenwood, N. N., &Earnshaw, A. (1984). *Chemistry of the Elements*. Pergamon Press, Toronto.

[10]. Guidelines for drinking water quality. Geneva: WHO,2004. WHO.

[11]. Indu, R., &Krishnan, S. (2014) Making it easier to deal with fluorosis: Unwrapping the layers, simplify some answers, Inrem Foundation, Gujarat.

[12]. Mondal, N.K, (2018) Diagnosis of fluorosis and recovery through easy to practice interventions, research report, 230–242.

[13]. Nath, S.K., &Dutta, R.K., (2010), Fluoride removal from water using crushed limestone, *Indian Journal of Chemical Technology*, vol. 7, 120–125.

[14]. Qureshi A.I., Srinivas. R., &Arlappa, N., (2013) Fluorosis in India: An overview, *International Journal of Research and Overall Health*. Volume 1(2).

[15]. Sharma, L.M. (2014) Innovation for making potable water available in saline groundwater areas, *Journal of Water Resources and Protection*, vol. 06 10.4236/jwarp.2014.614118.

[16]. Sushila, A.K., (2001) Fluorosis in developing countries: remedial measures and approaches. *ProcInd Natl SciAcad* B 68(5):389–400.

[17]. Tariq, R.S., Shah, M.H., Shaheen, N., Jaffar, M., &Khalique, A., (2008), Statistical source identification of metals in groundwater exposed to industrial contamination, *Environmental monitoring and assessment*, 138(1–3): 159–65.

[18]. Tebutt, THY (1983), Relationship between natural water quality and health. United Nations Educational, Scientific and cultural organization, Paris.

[19]. UNICEF's Position on Water Fluoridation. Fluoride in water: An overview. http://www.nofluoride.com/Unicef_fluor.cfm

[20]. Yadav, S., Bansal, S.K., Kumar, S., &Yadav, S., (2018) Prevalence of Fluorosis among school going children in district Mahendergarh, Haryana, India, *International Journal of Basic and Applied Research*, vol 8, no 9.

Lalit Mohan Sharma. "A study on prevalence and impact of fluoride in drinking water in Nuh district of Haryana, India." *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 14(8), (2020): pp 11-19.