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**Comparison of Potable groundwater Quality in Districts Bhiwani, Rewari and Gurgaon and its Suitability Assessment for Drinking Purpose: Focus on Fluoride**

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**Manjeet****Chemistry Department, Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Haryana, India****Abstract**

Groundwater quality survey of districts Bhiwani, Rewari and Gurgaon was done to check the suitability of the underground water samples for drinking purpose. Samples were collected from the wells, tube wells and hand pumps for the analysis of various physico-chemical parameters including total dissolved solids (TDS), total hardness (TH), calcium ( $\text{Ca}^{2+}$ ) and magnesium contents ( $\text{Mg}^{2+}$ ), total alkalinity (TA), pH and fluoride ion concentration ( $\text{F}^-$ ). The analysis of the physico-chemical parameters of ground water in Gurgaon, Bhiwani and Rewari districts shows that the total hardness and fluoride ion concentration are high above the permissible limits.  $\text{Mg}^{2+}$  in Gurgaon district is extremely high and moderately high in Rewari district. pH values of all the three districts are within the range prescribed by WHO and BIS. TA in Bhiwani district is moderately high, in Gurgaon and Rewari district it is within the prescribed limit. TDS in the entire three districts is extremely high. Though ground water of the districts can be used for the drinking purposes, it should be suggested that some kind of treatment for hardness, TDS and fluoride removal is immediately required in these districts.

**Introduction**

Fluorine in the environment is found as fluorides which together represent about 0.06–0.09 percent of the earth's crust. The average crustal abundance is 300 mg/kg [1]. Fluorides are found at considerable levels in a wide variety of minerals, including fluorospar (fluorite), rock phosphate, cryolite, apatite, mica, hornblende and others [2]. Fluorite ( $\text{CaF}_2$ ) is a common fluoride mineral of low solubility occurring in both igneous and sedimentary rocks. Fluoride is commonly related with volcanic activity and fumarolic gases. Thermal water of high pH, are also rich in fluoride [3]. Cryolite and rock phosphates are minerals of commercial importance. The fluoride salt cryolite is used for aluminium production [2] and as a pesticide [4]. Rock phosphates are converted into phosphate fertilizers by the removal of up to 4.2% fluoride [12]; the removed and purified fluoride (as fluorosilicates) is a source of fluoride that is added to drinking-water in some countries to protect against dental caries [5], [6].

The prime aim of the Guidelines for Drinking Water Quality is the protection of public health. The GDWQ offers an assessment of the health risk presented by micro-organisms and chemicals present in drinking water. This assessment can then be applied to the development and execution of national standards for drinking water quality. Further, in response to demands from Member States, the Guidelines have always included guidance material concerning specific problems related to small community supplies [7].

**Materials and Methods****Study area**

Bhiwani district occupies an area of 5,140 square kilometres (1,980 sq mi). It is situated between 28.19 deg. & 29.05 deg. north latitudes and 75.26 deg. and 76.28 deg. east longitudes. The district falls in a hot and semi-arid South western zone of Haryana State (India). Rewari district of Haryana state lies between 27° 46'; 28° 28' North latitudes and 76° 15'; 76° 51' East longitudes. It is around 80 km away from the capital city (New Delhi.) of India. Rewari has a dry, semi-arid climate. Gurgaon is 32 km away from south-west of New Delhi, is the Cyber City of Haryana lies between the 27° 39' and 28° 32' 25" North latitudes, and 76° 39' 30" and 77° 20' 45" East longitudes. The district has a total geographical area of 1254 square

kilometres and support a population of 8,70,539. The climate of the district can be classified as tropical steppe, semi-arid and hot [8].

**Water sampling**

A total of 237 groundwater samples were collected from all the blocks of Gurgaon, Bhiwani and Rewari districts, Haryana, India. The source of these samples was hand-pump, dug-well and tubewell. The water samples were collected in pre-cleaned polyethylene bottles. It was ensured every time that the bottle satisfies the following requirement: Free from contamination, resistant to any internal pressure and do not affect water characteristics. The water was left to run from the sampling source for 5-6 minutes to pump out the volume of water standing in the casing before taking the final sample. The samples were then taken in the pre cleaned bottles and were analysed just after the sampling [9].

**Methodology**

Total dissolved solid was measured by gravimetric method. Total hardness of water was determined by using EDTA titration method. Calcium content of water samples was estimated by using the complexometric titration method (EDTA). Magnesium content of the water samples was calculated indirectly using Ca<sup>2+</sup> and TH content of water samples by following formula:

$$Mg^{2+} \text{ (mg/L)} = [\text{Total hardness} - (\text{Ca}^{2+} \times 2.5)] \times 0.243$$

Total alkalinity of the water sample was estimated by titrimetric method using N/50 H<sub>2</sub>SO<sub>4</sub>. The pH of samples was analysed by using a 'EUTECTIC CYBERNETICS Model pH Scan Meter'. Fluoride was estimated by using Ion-selective meter by Hanna Instruments (Model: Hi 3222-02). [10-11].

**Results and discussion**

All the ground water samples were clear without any visible colour, odour and turbidity. The analysis of the physico-chemical parameters of ground water in Gurgaon, Bhiwani and Rewari districts shows that the total hardness and fluoride ion concentration are high above the permissible limits. Mg<sup>2+</sup> in Gurgaon district is extremely high and moderately high in Rewari district. pH values of all three districts are within the the range prescribed by WHO and BIS. TA in Bhiwani district is moderately high, in Gurgaon and Rewari district it is within the prescribed limit. TDS in the entire three districts is extremely high. Though ground water of the districts can be used for the drinking purposes, it should be suggested that some kind of treatment for hardness, TDS and fluoride removal is immediately required in these districts. The results of analysis of physico-chemical parameters of all the three districts is summarised as:

**Table:-1 Results of analysis of physico-chemical parameters in ground water**

Parameters	District Gurgaon		District Bhiwani		District Rewari		Standards	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Indian standard	WHO standard
TDS	60	3731	390	4705	105	6474	500-1500	500
TH	50.47	2984.2	120.1	588.4	89.5	3805.4	200-600	500
Ca <sup>2+</sup>	9	481	25	144	11	485	200-1000	500
Mg <sup>2+</sup>	6.8	2922	14	185	9	660	200-400	50
TA	102	582	42	212	52	771	200-600	-
pH	5.6	8.4	7.1	8.2	7.15	8.55	7.0-9.2	6.5-9.2
F-	0.02	6.4	1.1	2.1	0.19	2.75	1.0-1.5	1.0

Note: Except pH all parameters are expressed in mg/L.

The result of the water samples analysed and their suitability for drinking purpose is summarized in table 2.

**Table:- 2 Comparison of assessment parameters of three districts with BIS standard**

Parameters (ppm)	District Gurgaon	District Bhiwani	District Rewari
	<b>Range</b>		
TDS	<b>41.23%</b> samples were within the range.	<b>46.67%</b> samples were within the range	<b>7.50%</b> samples were within the range
TH	<b>47.42%</b> samples were within the range.	<b>80%</b> samples were within the range	<b>46.25%</b> samples were within the range
Ca <sup>2+</sup>	<b>23.71%</b> samples were within the range	All of the water samples were below the range	<b>15%</b> samples were within the range
Mg <sup>2+</sup>	<b>12.37%</b> samples were within the range	All of the samples were below the range	<b>2.5%</b> samples were within the range
TA	<b>80.41%</b> samples were within the range	<b>16.67%</b> samples were within the range	<b>87.50%</b> samples were within the range
pH	<b>98.96%</b> sample were within the range	<b>100%</b> water samples were within the range	<b>100%</b> water samples were within the range
F <sup>-</sup>	<p><b>1.</b> Within 0.02 to 6.4 mg/L</p> <p><b>2.</b> 8.25% samples were within the range of BIS</p> <p><b>3.</b> 34.02% having the F<sup>-</sup> conc. greater than 1 mg/L which is the standard prescribed by WHO.</p> <p><b>4.</b> 62.89% were below the limit prescribed by BIS and WHO standards.</p> <p><b>5.</b> 23.71% were found to contain F<sup>-</sup> above 1.5 mg/L which was above the permissible limit of BIS standard.</p>	<p><b>1.</b> Within 1.1 to 2.1 mg/L .</p> <p><b>2.</b> 56.67% were within the limit of BIS.</p> <p><b>3.</b> All the samples having the F<sup>-</sup> concentration greater than 1 mg/L which is the standard prescribed by WHO.</p> <p><b>4.</b> None of the water samples were below the limit prescribed by BIS and WHO standards.</p> <p><b>5.</b> 26 water samples (43.33%) were found to contain F<sup>-</sup> above 1.5 mg/L which was above the permissible limit of BIS standard</p>	<p><b>1.</b> Within 0.19 to 2.75 mg/L.</p> <p><b>2.</b> 16.25% were within the limit of BIS</p> <p><b>3.</b> 50% having the F<sup>-</sup> conc. greater than 1 mg/L which is the standard prescribed by WHO.</p> <p><b>4.</b> 48.75% water samples were below the limit prescribed by BIS and WHO standards.</p> <p><b>5.</b> 33.75% were found to contain F<sup>-</sup> above 1.5 mg/L which was above the permissible limit of BIS standard</p>

As the permissible limit of  $F^-$  in drinking water according to BIS is 1.0-1.5 mg/L and according to WHO standards it is 1.0 mg/L. Thirty four water samples out of 60 water samples (56.67%) in district Bhiwani were within the limit of BIS and all the samples having the  $F^-$  concentration greater than 1 mg/L which is the standard prescribed by WHO. None of the water samples were below the limit prescribed by BIS and WHO standards. 26 water samples (43.33%) were found to contain  $F^-$  above 1.5 mg/L which was above the permissible limit of BIS standard as shown in Fig 1, Fig 2 and Fig 3.

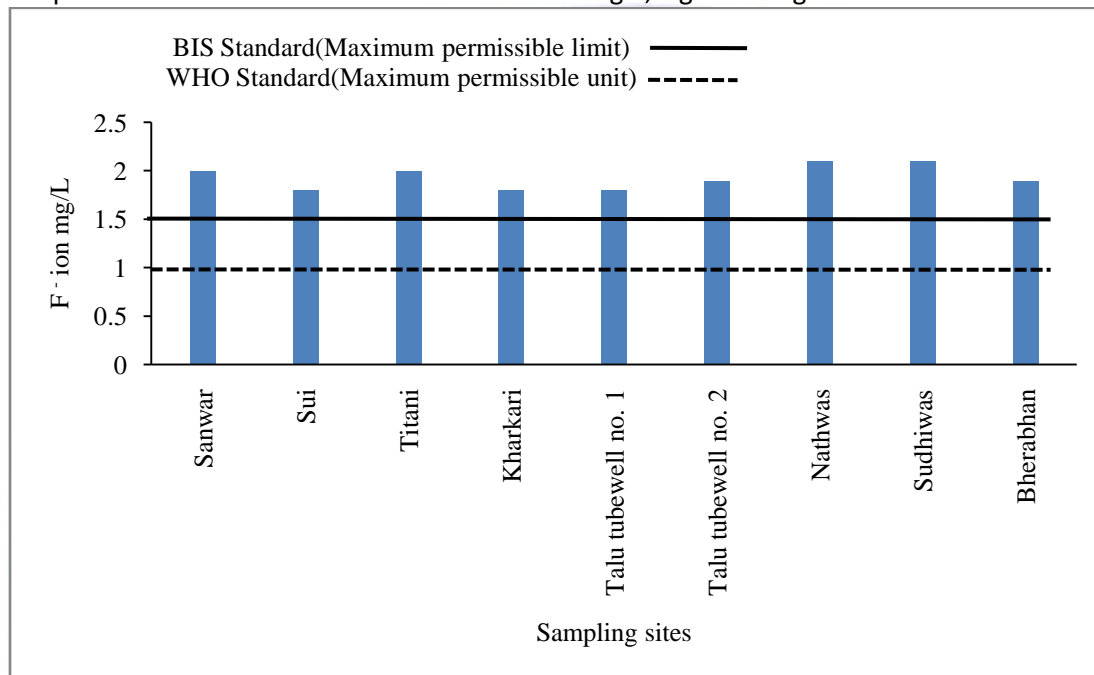


Fig 1 Concentration of  $F^-$  ion of selected sample sites where the  $F^-$  conc. is higher than permissible limit in Bhiwani district

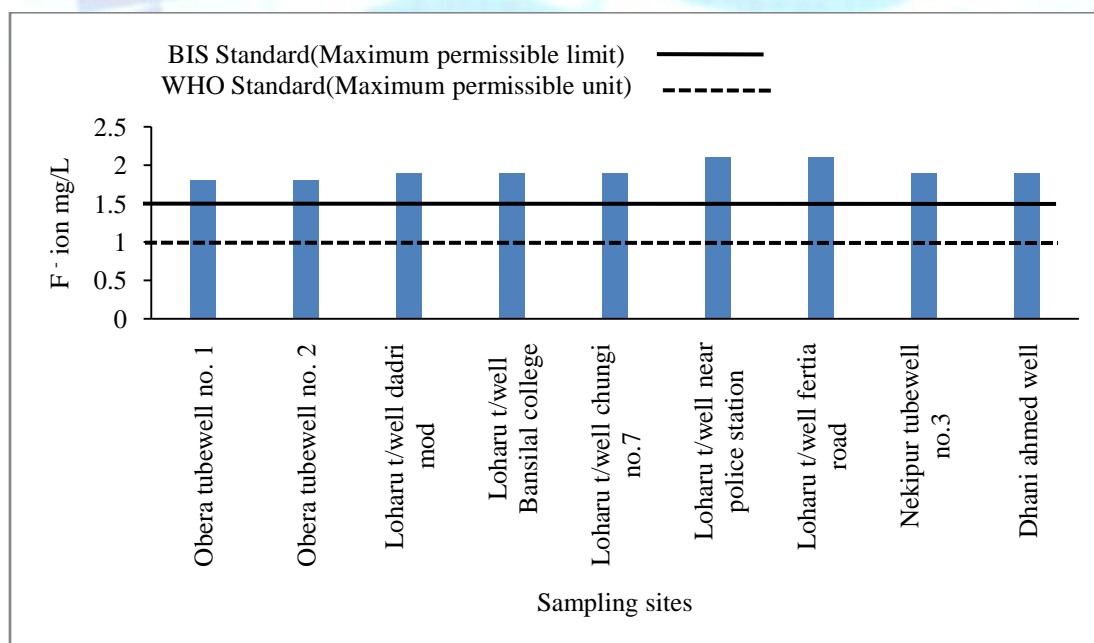


Fig 2 Concentration of F<sup>-</sup> ion of selected sample sites where the F<sup>-</sup> conc. is higher than permissible limit in Bhiwani district

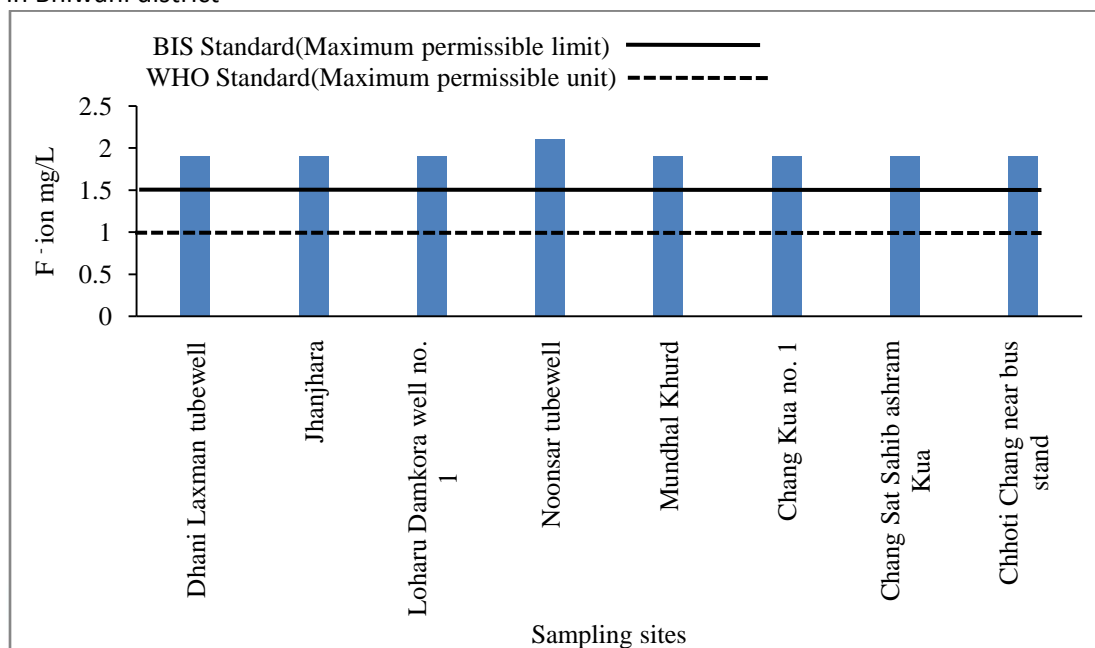


Fig 3 Concentration of F<sup>-</sup> ion of selected sample sites where the F<sup>-</sup> conc. is higher than permissible limit in Bhiwani district. Thirteen water samples out of 80 water samples (16.25%) in district Rewari were within the limit of BIS and forty samples (50%) having the F- concentration greater than 1 mg/L. Thirty nine (48.75%) water samples were below the limit prescribed by BIS and WHO standards. Twenty seven water samples (33.75%) were found to contain F- above 1.5 mg/L which as shown in Fig 4 and Fig 5.

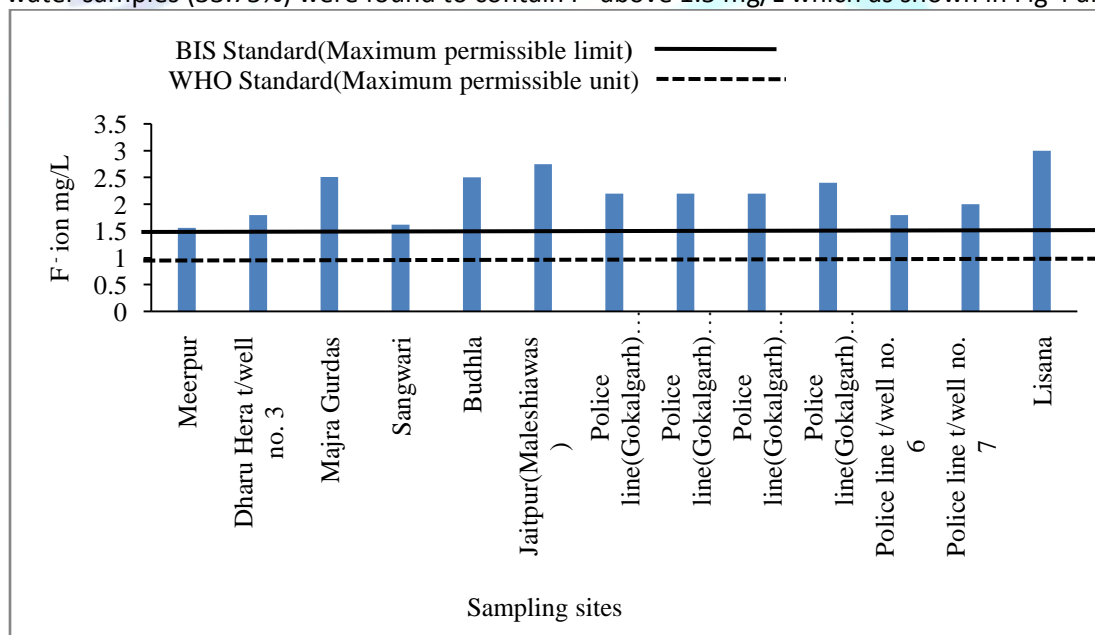


Fig 4 Concentration of F<sup>-</sup> ion of selected sample sites where the F<sup>-</sup> conc. is higher than permissible limit in Rewari district

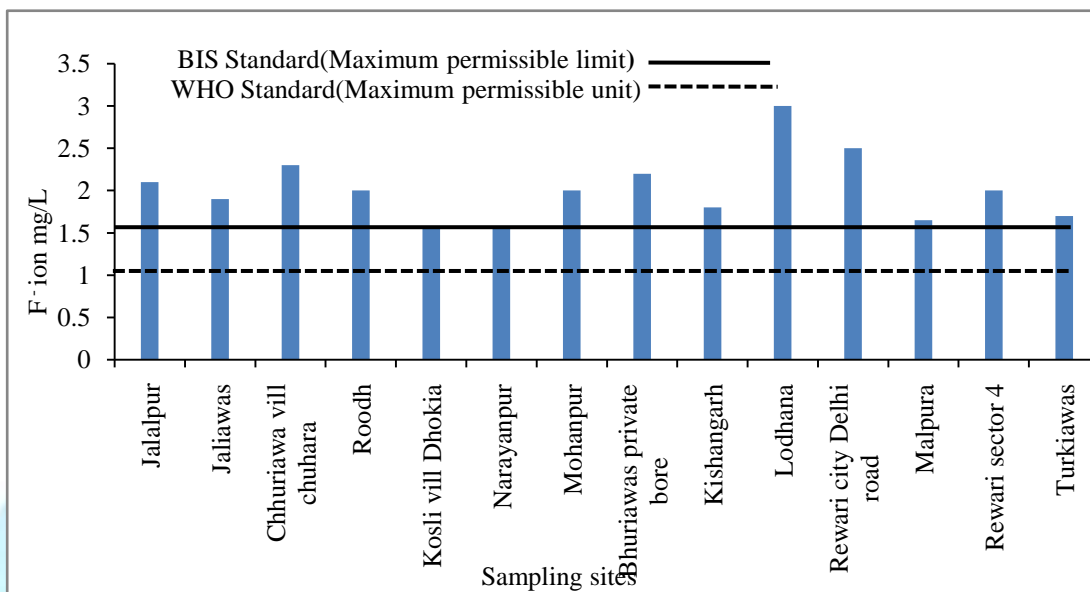


Fig 5 Concentration of F<sup>-</sup> ion of selected sample sites where the F<sup>-</sup> conc. is higher than permissible limit in Rewari district Eight water samples out of 97 water samples (8.25%) in district Gurgaon are within the limit of BIS and only three samples having the F<sup>-</sup> concentration 1 which is the standard prescribed by WHO. Thirty three samples (34.02%) were above the limit prescribed by WHO. Sixty one water samples (62.89%) were below the limit prescribed by BIS and WHO standards. 23 water samples (23.71%) were found to contain F<sup>-</sup> above 1.5 mg/L which was above the permissible limit of BIS standard as shown in Fig 6 and Fig7.

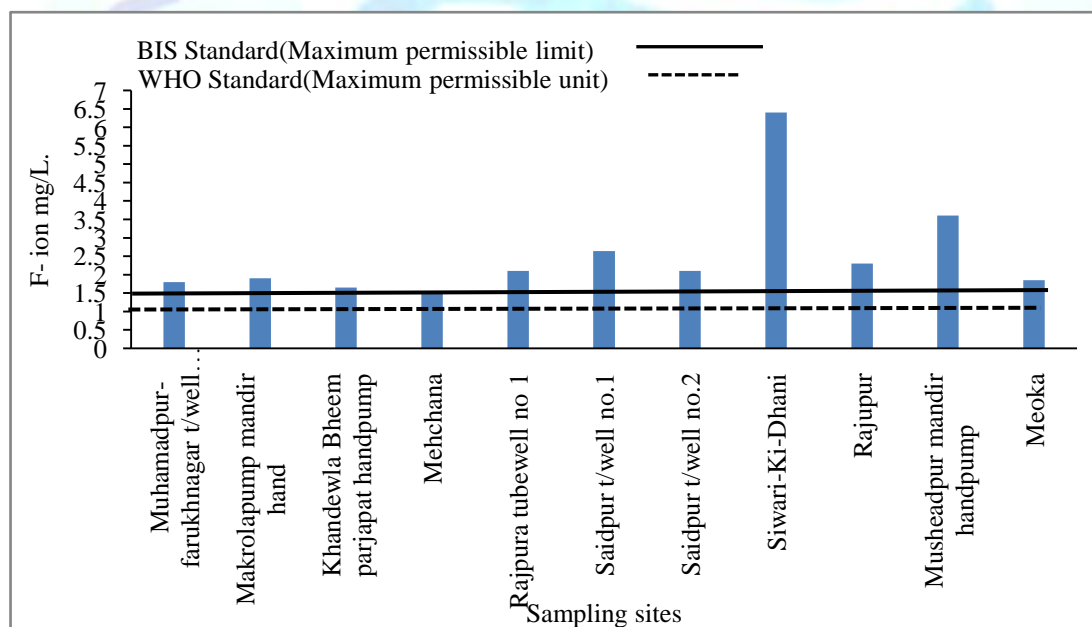


Fig 6 Concentration of F<sup>-</sup> ion of selected sample sites where the F<sup>-</sup> conc. is higher than permissible limit in Gurgaon district

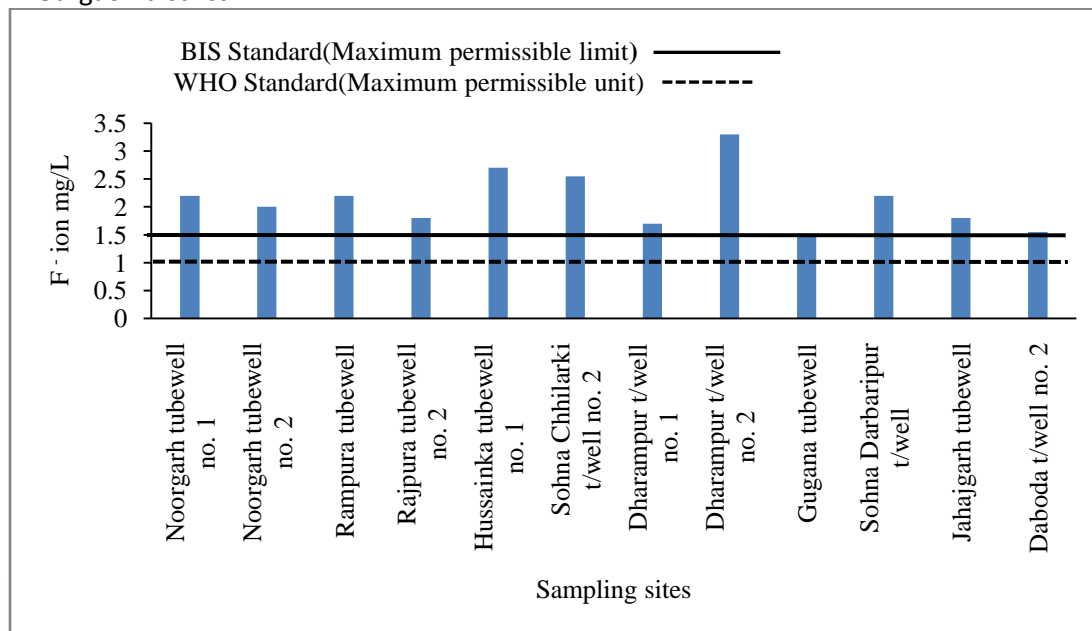


Fig 7 Concentration of F<sup>-</sup> ion of selected sample sites where the F<sup>-</sup> conc. is higher than permissible limit in Gurgaon district

### Conclusion

Majority of water samples in the areas of the three districts shows that the concentration of fluoride in the ground water does not meet to the quality of water standards prescribed by BIS and WHO. The excess of fluoride concentration may be due to the geological formation of the particular areas or rapid ground water depletion. The water in these particular areas is not suitable for drinking or domestic purpose without prior treatment.

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