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Distribution of Fluoride in Groundwater in Bhiwani District 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 hand pumps (direct consumption) were analyzed for fluoride in Bhiwani District (India). The results indicate considerable variations among the analyzed groundwater samples and the concentration of fluoride ranged from 1.1 to 2.1 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.**

***Keywords*— Ground water, Monitoring, Fluoride, Fluorosis**

I. 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**1**. As per WHO (1997) permissible limit for fluoride in drinking water is 1.0 mg/l, **2** whereas USPHS (1962) has set a range of allowable concentrations for fluoride in drinking water for a region depending on its climatic conditions, **3** because the amount of water consumed and consequently the amount of fluoride ingested being influenced primarily by the air temperature **4**. 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 **5**. 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 Bhiwani District was mapped for fluoride distribution, which is mainly used for drinking and other domestic purposes.

Experimental

Site specifications and sampling: The 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. It has 444 villages with a population of 1,425,022. Bhiwani District falls in a hot and semi-arid Southwestern zone of Haryana State (India) and approximate 166 thousand people live in urban area.Fig:1 showing the location of bhiwani district in Haryana. The city was divided in to 9 blocks-Badhra, Bawani Khera, Bhiwani, Dadri-I, Dadri-II, Loharu, Tosham, Kairu, Siwani. A total of 60 groundwater samples were collected from various 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.

Fig:1

Methodology used in the determination of physico-chemical parameters

The collected samples were analyzed for following major physical and chemical parameters:

1. pH was determined by Eutech instruments pH tutor.
2. Total dissolved solid(TDS) was determined by gravimetric analysis method.**6**
3. Total hardness (TH), Ca^{2+} and Mg^{2+} hardness was determined by titrimetric method using standard EDTA solution. **6**
4. Total alkalinity (TA), was determined by titrimetric method using standard sulphuric acid solution. **6**
5. Fluoride content in the groundwater samples was determined directly after dilution with equal volumes of TISAB buffer (pH = 5.2) using a reference pH-meter ((Hanna Instruments Model=Hi 3222-02).**7**

All the chemical used were of Analytical Grade. All the experiments were carried out in triplicate and the results were found reproducible with ± 3% error.

Table - 1: Comparison of ground water quality at the village under study with drinking water standards (Indian and WHO)

Parameters	Minimum	Maximum	Indian standard	WHO
TDS	390	4705	500-1500	500
TH	120.1	588.4	200-600	500
Ca2+	25	144	200-1000	500
Mg2+	14	185	200-400	50
TA	42	212	200-600	-
pH	7.1	8.2	7.0-9.2	6.5-9.2
F-	1.1	2.1	1.0-1.5	1.0

Except pH all parameters are expressed in mg/lt.

Results and Discussions

The shallow tube wells in the district range from 20 to 90m.Water is pumped out from shallow aquifers by manually operated hand-pumps (installed at approximately10- 30 meters depth) and from deep aquifers by electricity operated bore-wells (installed at approximately 111 meters depth).

The groundwater has no colour, odour and turbidity. Taste of the water was slightly brackish at most of the locations. The minimum and maximum values of various physico-chemical parameters for the selected sites are provided in Table-1. The results indicate that the quality of water varies considerably from location to location.

pH Varies from 7.1 to 8.2. This shows that all samples are existed within the minimum and maximum tolerable limit of WHO and BIS. The water samples were found to be slightly basic in nature. Hardness is measured in terms of total hardness and calcium hardness. Total hardness varies form 120.1-588.4 mg/lt, mostly exceeds the maximum permissible limits of WHO. Ca2+ varies from 25-144 mg/lt which were within the WHO and Indian Standard. Mg2+ concentration varies from 14-185 mg/lt which were very high compared with the WHO. Alkalinity varies from 42-212 mg/lt and most of the water sample exceeds the maximum permissible limit of WHO.

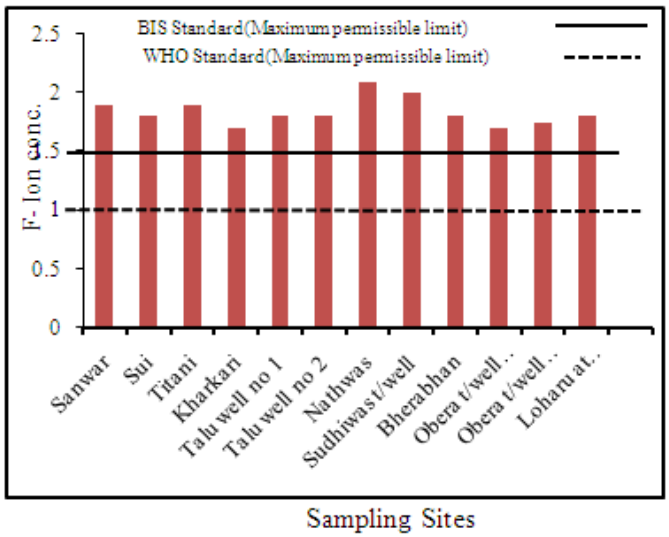


Fig. 2

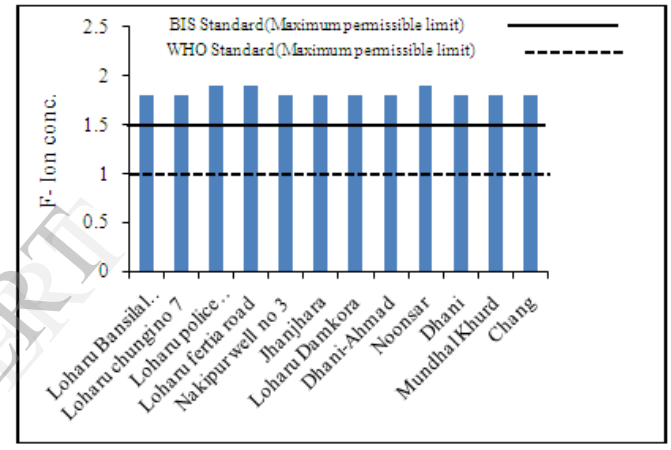
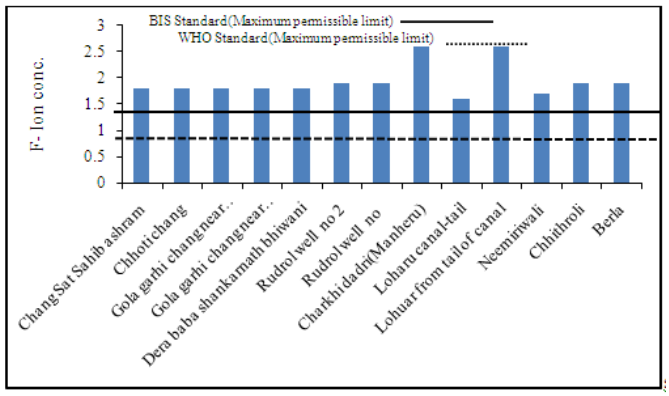


Fig. 3

The major natural resource of fluoride is amphiboles, apatite, fluorite and mica. It's concentration in natural waters generally should not exceed 10mg/lit **8**. The values of various physico-chemical parameters for the selected sites are provided in Table-2.

The factor responsible for ground water contamination with fluoride are geological factors such as weathering of minerals, rock dissolution and decomposition containing fluoride over a long period of time resulting in the leaching it into ground water **9**. An anthropogenic factor such as industrial process liberates higher concentration of fluoride into atmosphere. 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. **10**. 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 1.1 to 2.1 mg/l in various regions of Bhiwani District. The analyzed fluoride concentration of the sites shows that 26 seven sampling sites out of 60 were having the fluoride concentration greater than the BIS and WHO permissible limits (as shown in fig 2, fig 3 and fig 4). Fluoride could have originated from fluoride

bearing minerals such as fluorite in the rocks. It was suggested that the main source of groundwater fluoride in granitic rocks is the dissolution and anion exchange with micaceous minerals and their clay products **11**. But considering the geology of Bhiwani District it can be suggested that other source also exists for fluoride in ground water. It was 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 **12**.



Sampling Sites

Fig. 4

The frequencies of fluoride concentrations are given in table no:2, which shows that around 44 % 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.

CONCLUSIONS

There was no clear trend observed for the distribution of fluoride in various regions of Bhiwani District. 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 Bhiwani District can be used for drinking purposes, it is further suggested that some kind of treatment for hardness and fluoride removal is immediately required in the studied villages to avoid waterborne health problems in residents.

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Table no: 2

Village		Physical Parameter/Value						
		Total Dissolved Solid(ppm)	Total Hardness as CaCO3(ppm)	Ca Hardness (ppm)	Mg Hardness (ppm)	Alkalinity(ppm)	pH	F ion conc.
BAPORA	well no 1	968	182.5	50	14	52	7.1	1.1
	well no 2	1074	289.8	60	34	66	7.4	1.2
SANJARWAS	well no 1	970	186.5	45	18	54	7.2	1.3
	well no 2	1270	318.9	70	35	120	7.6	1.3
SANWAR	well no 1	2510	438.9	90	52	180	8.2	2.0
BOND KALAN	well no 1	906	174	40	18	66	7.5	1.2
SUI	well no 1	2166	405.3	98	39	147	8.1	1.8
Titani	well no 1	2250	403.7	99	38	165	8.1	2.0
Hetampura	well no 1	1050	260.1	58	28	93	7.5	1.1
LEGHA	well no 1	1218	321.8	86	26	118	7.5	1.1
DHANI JANGA	well no 1	766	861.7	40	185	66	7.2	1.1
JHARWAI	well no 1	845	454.3	144	23	63	7.3	1.3
KHARKARI	well no 1	2315	392.9	98	36	167	8.2	1.8
ROOP GARH	well no 1	746	191.3	42	21	63	7.2	1.1
TALU	well no 1	1966	421.2	106	38	122	8.1	1.8
	well no 2	2144	441.1	114	38	135	8.1	1.9
BHIWANI WARD NO.2	tubewell	390	120.1	25	14	42	7.2	1.2
NATHWAS	tubewell	2705	478.1	109	50	212	8.2	2.1
GARWA	tubewell	1300	318.9	70	35	74	7.3	1.3
SUDHIWAS	tubewell	4705	588.4	140	58	200	8.1	2.1
ASALWAS	dubia tubewell	746	184.6	36	23	54	7.2	1.2
	meheretha tubewell	728	176.4	36	21	44	7.3	1.1
BARDU	mugal tubewell	1689	321.8	86	26	82	7.4	1.3
	jogi tubewell	1670	334.2	86	29	88	7.6	1.4
	jogi tubewell	1670	334.2	86	29	88	7.6	1.4
Bherabhan	tubewell	2504	466.3	101	52	168	8.0	1.9
OBERA	tubewell no.1	2096	432.2	89	51	140	8.1	1.8
	tubewell no.2	2178	434.7	90	51	153	7.8	1.8
LOHARU	tubewell(at stadium dadri mod)	2274	362.4	94	31	172	8.1	1.9
	tubewell(at polytechnic college)	1465	307.3	67	34	121	7.2	1.2
	tubewell(at bansi lal college)	2201	375.3	86	39	143	7.8	1.9
	tubewell(near pnb)	2096	316.3	64	38	121	7.7	1.4
	tubewell chungi no.7)	2204	360.2	75	42	132	7.6	1.9
	tubewell (near police station)	1498	277.6	65	28	112	7.8	2.1
	fertia road tubewell	2367	437.2	91	51	171	8.2	2.1
	(near rambagh) tubewell	1440	277.5	60	31	77	7.4	1.4

	polytechnic college tubewell no. 1	1052	262.5	54	31	76	7.2	1.2
NEKIPUR	tubewell no. 1	976	201.3	46	21	46	7.2	1.2
	well no.2	1102	262.6	59	28	74	7.4	1.2
	well no.3	1702	398.7	97	38	127	8.1	1.9
Dhani	todawell	970	186.5	45	18	44	7.3	1.2
	ahmad well	2221	424.0	89	49	147	7.7	1.9
	laxman tubewell	2201	403.3	84	47	143	7.9	1.9
Loharu	(mansukh) well	1254	272.5	58	31	93	7.3	1.2
Jhanjhara	hasanpur	1186	303.2	67	33	85	7.6	1.4
	well at sheoran	2030	376.5	98	32	147	7.9	1.9
Gothara	well	991	188.1	44	19	96	7.4	1.4
Loharu(Damkora)	well no 1	2383	371.2	86	38	166	8.2	1.9
	well no 2	2272	352.2	85	34	154	8.1	1.2
Sehar 2	tubewell	878	188.1	44	19	44	7.3	1.4
Khushal pura	tubewell	1238	295.8	69	30	142	7.3	1.3
Nigana Kalan	tubewell	2166	330.9	88	27	114	7.8	1.4
Noonsar	tubewell no.1	2679	502.2	117	51	171	8.2	2.1
Bardu	puran tubewell	918	266.7	59	29	74	7.5	1.4
Badheri	tubewell	1290	284.8	58	34	87	7.4	1.4
Mundhal khurd	tubewell	2322	495.2	101	59	171	8.0	1.9
Chang	kua no.1	2440	458.8	98	52	176	8.1	1.9
	kua no.2	836	182	51	20	69	7.4	1.2
	sat sahib ashram kua	2202	425.1	101	42	152	8.0	1.9
	chhoti chang (bus stand k pas kua)	2202	425.1	101	42	152	8.2	1.9
Manheru	(baba dudha dhari ashram)kua no.2	1801	333.4	89	27	126	7.8	1.2