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Assessment of water quality and occurrence of fluoride in groundwater of various villages of district Ambala (Haryana)

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ABSTRACT

The present work aims to study the level of fluoride in bore well, hand pump water samples of different villages of Mullana block, District Ambala, state Haryana & also to analyzed other water qualities parameters like pH, sulphate ions, chloride ions, total hardness, nitrite ions, methyl orange alkalinity, fluoride ion, iron, copper and cadmium. The analysis showed a minimum fluoride level of .02mg/l and maximum level of .77 mg/l in tube well water of different villages. In Dulyani village of Ambala district showed minimum fluoride concentration of 1.72mg/l and maximum of 1.98mg/l. This water sample was found to be exceeded the WHO 1995 drinking water standards and it reflects on health status of the consumers. Fluorides are known to be beneficial when present in concentration of 0.5 to 1.5mg/l. But when it exceeds the limits of 1.5mg/l it is found to cause fluorosis.

Key words: Ambala district, fluorosis, toxicity, analyses, tubewell, handpump, ground water quality.

INTRODUCTION

Fluorosis is one of the most crippling endemic diseases affecting millions of people in different parts of the world.[1] In India, the disease was first discovered in the Madras province in 1937. Later, the disease was also identified from different states. At present more than 30 million people in 13 states are to be affected by this disease[2]. Till today the newer non-fluoride area owe to geo environmental conditions. Fluorine, the most electronegative element has certain physiological properties of great interest in relation to human health. It is present in varying amounts in animal tissues. It is considered to be beneficial for preventing dental caries when the concentration is less than 1 PPM. Excessive fluoride ingestion can induce either an acute toxicosis or a depilating chronic condition that has been referred to as chronic fluoride toxicity or fluorosis. Fluoride is beneficial to certain extent when present in concentration of 0.8-1.00mg/l for clacification of enamel especially for children below 8 years of age. Water containing fluoride concentration above 1mg/l causes dental fluorosis and fluoride concentration beyond 3mg/l causes skeletal fluorosis if consumed for a period of 8-10 years[3] Inspite of identical concentration of fluoride in water, variation in the incidence of the disease had been noticed which are attributed to other chemical constituents of water, such as alkalinity, total hardness, calcium and magnesium hardness. In general, water containing higher concentration of fluoride is associated with high alkalinity, low total hardness[4], high pH[5] and high conductivity. [6]

Continues ingestion of high fluorides by way of drinking waste water, food and beverages leads to skeletal fluorosis associated with allergic manifestations, gastrointestinal problems, such of loss of appetite, abdominal pain and constipation etc.[7] High fluorides also effects economical important plants[8]. High fluoride levels in human may result in low motility of spematozoa[9].In India presence of excess fluoride levels have been reported in the states of Karnataka, Andhra Pradesh, Haryana, Gujarat, Delhi, Punjab, Rajasthan, Tamilnadu, Uttarpardesh.[10]

Fluoride is more toxic than lead less toxic than arsenic and has dual significance; if its content is less then it may result in problems like dental caries (WHO) world heath organization recommends it in the range of 0.1 – 0.5 PPM. The standards of united states is between 0.6 and 0.9 PPM and of India 1 and 1.5 PPM[11] thus the requirement of fluoride content varies among countries depend on the geography and the age of people involved. Fluoride can damage a fetus and adversely affect the IQ of children.[12]

Location, geomorphology and hydrogeology

Ambala district of Haryana lies between 30^0 10' : 31^0 35' north latitudes and 76^0 30' : 77^0 10' east longitudes. Total geographical area of the district is 1574 sq.km. The district Ambala falls in Yamuna sub-basin of Ganga basin, and is mainly drained by the river Tangri, Beghna and Markanda. The Center Ground Water Board has carried out ground water exploration besides other hydrogeological studies, and mass awareness and training activities in the district. The climate of Ambala district can be classified as subtropical monsoon, mild &dry winter, hot summer and sub-humid which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrates into the district. The district is occupied by Indo-Gangetic alluvial plain of Quaternary age. The Central Ground Water Board has drilled 20 exploratory borehole, 3 slim holes and 13 piezometers to delineate and determine potential aquifer zones, evaluation of aquifer characteristics etc. Seismic surveys conducted in the area reveal that alluvial thickness in the district is large and the basement rock is estimated to be encountered at 3000m depth below MSL. And thickness of alluvium thins down towards southwest. In south west and western parts of the district the sediments are more fine grained in nature, and constituted of fine to medium grained sands, clays, silts and kankars with occasional gravel. The clays are usually brown to yellowish in colour and sticky to salty in nature. The sands are usually fine grained; hence it becomes difficult to develop wells so as to give sand free water with conventional well designs. Towards east and south eastern part of the district the clays are cream or light grey coloured and are soft and salty. The sands are also mostly medium to coarse grained in nature in comparison to the fine texture of sands in south western and western part of the district. The ground water exploration revealed the presence of 3 aquifer groups down to a depth of 450 m. comprising fine to medium grained sand, clay, silt, and kankar with occasional gravel. The formation in general is fine grained in nature.

The first granular zone forms the water table aquifer and occurs upto 167 m depth and is underlain by 10 to 15m thick clay bed. The second aquifer occurs at a depth ranging between 65 to 294m with varying thickness of 26 to 152m.This aquifer constitutes comparatively less coarser material than the first group and is characterized by presence of Kankar. The third one is characterized by fine sandy beds alternating with thick clay beds at a depth ranging from 197 to 385m. exist between 180 and 205 m depth. The fourth aquifer occurs below 212 m onwards. Shallow tubewells are generally constructed upto a depth of 40 m. The discharge of shallow tubewells ranges 100 to 600 litres per minutes for a moderate drawdown. Deep tubewells constructed to a depth of 150m.yield upto 2000 to 3000 litres per minutes for 6m to 10m drawdown. However deeper tubewells tapping aquifer zones between 150m to 400m depth, discharge ranges from 248 to 3293 LPM for a drawdown ranging from 2.84 to 12.93m.In Haryana fluorosis has been identified in mainly two districts Narnaul and Jind. Realizing the damages caused by high content of fluoride in drinking water sources, the present study was undertaken in various villages of Mullana block of Ambala District, Haryana during the year 2008 (Jan 2008 to July 2008).

MATERIAL AND METHODS

Ten water samples from Hand Pump (S_1 – S_5) and tube wells (S_6 – S_{10}) collected in polythene bottles. The samples were analyzed for pH, methyl

Table 1: Physicochemical analysis of water samples collected from Hand Pump of Various Villages, in mg/l except pH

		Jan	Feb	Mar	April	May	June
pH	S_1	7.2	7.1	7.2	7.2	7.1	7.1
	S_2	7.3	7.4	7.3	7.3	7.3	7.4
	S_3	7.4	7.3	7.4	7.2	7.2	7.3
	S_4	7.4	7.2	7.4	7.2	7.2	7.2
	S_5	7.2	7.2	7.2	7.1	7.1	7.2
SO_4^{-2}	S_1	309	320	320	300	62	320
	S_2	33	33	32	35	39	33
	S_3	29	28	28	26	32	28
	S_4	40	41	40	38	36	41
	S_5	24	22	24	24	30	22
Cl^-	S_1	370	370	380	380	60	370
	S_2	88	90	100	85	20	90
	S_3	40	30	40	30	32	30
	S_4	85	90	100	80	30	90
	S_5	60	70	80	80	110	70
TH	S_1	741	750	740	740	220	750
	S_2	300	300	320	310	180	300
	S_3	280	290	300	280	280	290
	S_4	304	300	290	310	280	300
	S_5	310	310	310	300	180	310
NO_2^-	S_1	0.01	0.01	0.01	0.01	0.01	0.01
	S_2	0.001	0.001	0.001	0.001	0.001	0.001
	S_3	0.001	0.001	0.001	0.001	0.001	0.01
	S_4	0.001	0.01	0.01	0.01	0.01	0.01
	S_5	0.01	0.01	0.01	0.01	Nil	0.01
MOA	S_1	400	410	210	400	200	410
	S_2	410	400	380	390	210	400
	S_3	310	320	320	320	320	320
	S_4	310	320	310	310	300	320
	S_5	360	350	340	340	210	350
F^-	S_1	0.37	0.37	0.35	0.37	0.57	0.37
	S_2	0.17	0.16	0.18	0.18	0.21	0.16
	S_3	0.5	0.44	0.44	0.48	0.48	0.44
	S_4	0.7	0.7	0.8	0.8	0.31	0.7
	S_5	0.7	0.7	0.72	0.78	0.72	0.7
Fe^{+2}	S_1	0.2	0.19	0.19	0.18	0.05	0.19
	S_2	0.17	0.18	0.18	0.17	0.03	0.18
	S_3	0.41	0.51	0.51	0.5	0.5	0.51
	S_4	0.44	0.42	0.45	0.4	0.04	0.42
	S_5	0.19	0.19	0.17	0.2	0.07	0.19
Cu^{+2}	S_1	0.07	0.03	0.05	0.05	0.01	0.04
	S_2	0.08	0.04	0.04	0.01	0.04	0.05
	S_3	0.05	0.05	0.03	0.05	0.01	0.04
	S_4	0.05	0.03	0.03	0.04	0.04	0.05
	S_5	0.05	0.04	0.05	0.04	0.03	0.04
Cd^{+2}	S_1	0.004	0.003	0.003	0.002	0.002	0.003
	S_2	0.002	0.009	0.002	0.003	0.004	0.003
	S_3	0.002	0.002	0.003	0.003	0.003	0.003
	S_4	0.002	0.002	0.002	0.004	0.002	0.004
	S_5	0.004	0.003	0.003	0.004	0.002	0.003

S_1 : Salehpur, S_2 : Dheen, S_3 : Dulyani, S_4 : Pounti, S_5 : Alipur

pH = Hydrogen ion concentration, SO_4^{-2} = Sulphate, Cl^{-1} = Chloride, TH = Total hardness, NO_2^{-1} = Nitirite, MOA = Alkalinity, F^{-1} = Fluoride, Fe^{+2} = Iron, Cu^{+2} = Copper, Cd^{+2} = Cadmium

Table 2: Physicochemical analysis of water samples collected from Tubewell of Various Villages, in mg/l except pH

		Jan	Feb	Mar	April	May	June
pp^H	S_6	7.2	7.3	7.3	7.4	7.2	7.3
	S_7	7.4	7.4	7.4	7.4	7.2	7.4
	S_8	7.8	7.7	7.4	7.8	7.7	8.1
	S_9	7.3	7.4	7.3	7.3	7.4	7.4
	S_{10}	7.3	7.4	7.3	7.4	7.3	7.4
SO_4^{-2}	S_6	25	25	25	20	27	25
	S_7	31	31	32	34	25	31
	S_8	26	26	28	22	24	26
	S_9	22	27	28	29	34	27
	S_{10}	25	24	26	26	24	24
Cl^-	S_6	29	30	20	25	20	30
	S_7	20	20	20	25	20	20
	S_8	30	30	40	20	18	30
	S_9	36	30	40	30	20	30
	S_{10}	20	20	30	30	30	20
TH	S_6	180	180	170	190	200	180
	S_7	130	130	150	140	150	130
	S_8	66	60	70	50	55	60
	S_9	141	140	160	150	270	140
	S_{10}	151	160	160	160	180	160
NO^{2-}	S_6	0.001	0.001	0.001	0.001	Nil	0.001
	S_7	0.001	0.001	0.001	0.001	Nil	0.001
	S_8	0.001	0.001	0.001	0.001	0.001	0.001
	S_9	0.01	0.01	0.001	0.001	Nil	0.001
	S_{10}	0.002	0.001	0.001	0.001	Nil	0.001
MOA	S_6	310	300	290	310	210	300
	S_7	260	250	260	260	190	260
	S_8	200	210	210	220	220	210
	S_9	230	230	240	220	250	230
	S_{10}	220	250	240	240	200	250
F^-	S_6	0.69	0.67	0.67	0.65	0.69	0.67
	S_7	0.77	0.77	0.74	0.77	0.69	0.77
	S_8	1.72	1.9	1.91	1.91	1.9	1.96
	S_9	0.55	0.54	0.55	0.58	0.41	0.54
	S_{10}	0.02	0.2	0.03	0.03	0.22	0.02
Fe^{+2}	S_6	0.29	0.29	0.3	0.3	0.07	0.29
	S_7	0.09	0.09	0.08	0.08	0.04	0.09
	S_8	0.01	0.04	0.03	0.05	0.05	0.04
	S_9	0.19	0.19	0.18	0.2	0.84	0.19
	S_{10}	0.21	0.2	0.21	0.2	0.05	0.2
Cu^{+2}	S_6	0.5	0.06	0.05	0.05	0.04	0.05
	S_7	0.07	0.06	0.04	0.05	0.05	0.04
	S_8	0.04	0.045	0.05	0.05	0.008	0.05
	S_9	0.01	0.05	0.05	0.05	0.002	0.04
	S_{10}	0.1	0.05	0.04	0.04	0.04	0.05
Cd^{+2}	S_6	0.001	0.001	0.002	0.001	0.024	0.01
	S_7	0.001	0.001	0.001	0.0001	0.002	0.003
	S_8	0.002	0.003	0.003	0.003	0.002	0.001
	S_9	0.001	0.001	0.001	0.001	0.003	0.003
	S_{10}	0.003	0.002	0.003	0.002	0.003	0.002

S6 : Salehpur, S7 : Dheen, S8 : Dulyani, S9 : Pounti, S10 : Alipur pH = Hydrogen ion concentration, SO4-2 = Sulphate, Cl-1 = Chloride, TH = Total hardness, NO2-1 = Nitirite, MOA = Alkalinity, F-1 = Fluoride, Fe+2 = Iron, Cu+2 = Copper, Cd+2 = Cadmium orange alkalinity, total hardness, chloride ions, fluoride ions, Iron, nitrite ions, sulphate ions, copper & cadmium.

Temp. was measured by celcius thermometer. pH, turbidity and conductivity measured by digital pH meter (type-335), digital Nephlo turbidity meter (type-132) & direct reading conductivity meter resp. TDS was estimated by digital TDS meter (metz-701M) Chloride was estimated by volumetric titration with $AgNO_3$. Total hardness was determined by volumetric titration (EDTA method). Alkalinity was determined by volumetric titration. Sulphate was estimated by UV-VS spectra photometer (type-118). Metals were estimated by atomic absorption spectrophotometer meter (AAS) with a Perkin - Elmer model- 2380 instrument using Perkin- Elmer hollow cathode lamp as light source. Fluoride concentration was determined spectrophotometrically using Alizarin red – S and SPANDS reagents. The Alizarin red- S method was found useful in higher fluoride range while SPANDS reagent was employed in low fluoride range.[13] The results for hand pump water and tubewell water are presented in Table 1 and Table 2.The range of fluoride of tubewell water of various villages is presented through graph.

A result obtained during the analysis has been given in table 1 & 2 that pH of samples collected from various villages were in the range of (7.1 to 7.4 for Hand Pump) & (7.2 to 8.1 for Tube well), Sulphate range (22 mg /l to 320 mg /l for Hand Pump) & (20mg /l to 34 mg/l for tube well), chloride, range (20 to 380 for H.P) & (18 to 40 for T.W), Total hardness, range (180 to 750 for H.P) & (50 to 270 for T.W), Nitrites, range (nil to .01 for H.P) & (Nil to .01 for T.W), alkalinity, range (200 to 410 for H.P) & (190 to 310 for T.W), Fluoride, range (.16 - .80 for H.P) & (.02 to 1.96 for T.W), Iron, range(.03 - .51 for H.P) & (.01 to 84 for T.W) Copper, range(.01 – .08 for H.P) & (.002 to 0.5 for T.W) Cadmium, range, (.002 to .004 for H.P) & (.001 to .003 for T.W)

According to WHO (1995) standards permissible limit for pH is 6.8 to 8.5, for sulphate 250 mg/l, for chloride 250 mg/l, total hardness 500 mg/l, nitrites 0.05 mg/l, alkalinity 200 mg/l, iron 0.3 mg/l, copper 1.8 mg/l, cadmium 0.003 mg/l and fluoride 1-1.5 mg/l.

Prevention and control

Fluorosis was considered to be an irreversible disease till recent study. All opinioned that it can only be prevented but can not be cured.

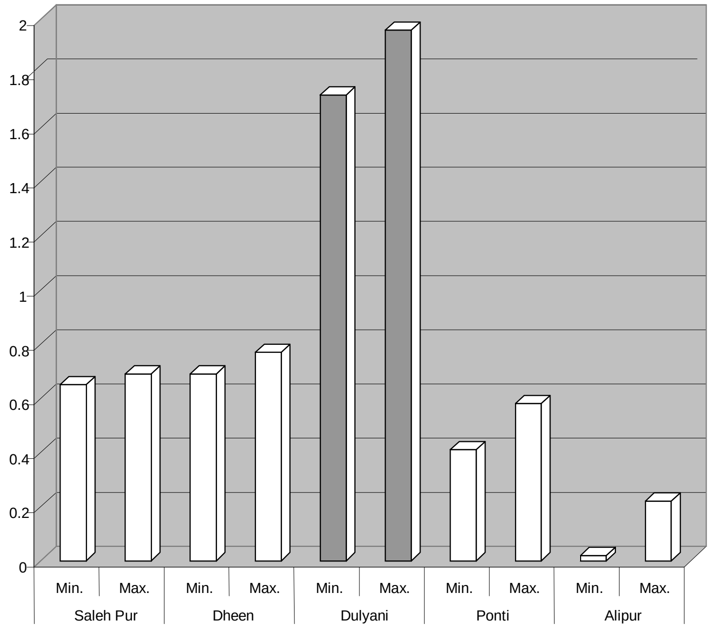

Fig. 1: Fluoride Ion concentration(mg/l) in Tubewell water of Dulyani Village (Sample No. 8)

The children should take more milk. Consumption of tea should be reduced to minimum as it also adds to the fluoride intake. Villagers are advised not to use water sample 8 for drinking and cooking purposes. Instead the villagers are advised to use the other bore well water sample which may be supplied through tap to the villagers which contain comparatively less fluoride content. Another alternative is to defluoridate the drinking water sample 8 supplied to the villagers by standard techniques, such as Nalgonda technique.[14] Bore well water with low concentration (<5ppm) of fluorine can be mixed with water having higher concentration of fluoride (>1.5ppm) and supplied. The short term solution to minimize the fluoride level in drinking water could be the use of domestic defluoridation filters.

CONCLUSION

It is shown that all other parameters are normal when we compare with WHO standards, only fluoride is present in excess amount (1.96 mg/l) in tubewell water of Dulyani Village i.e. sample no. 8. pH of this water is also high i.e. > 7.5. Fluoride ion concentration is higher than the safe level prescribed.

It has been observed that Tubewell water samples have higher fluoride concentrate as compared to hand pump water of Dulyani Village, S. No. 8. Tubewell water from (Jan-June, 2008) shows fluoride concentration above the maximum permissible limit (i.e. 1.5 mg/l) Presence of fluoride bearing minerals in the host rocks, namely fluorite, fluorapatite, cryolite as well as mica and hornblende in which fluoride ions replaces hydroxyl group & their interaction with water is considered to be the main cause for fluoride enrichment in ground water. Chemical weathering under arid to semiarid conditions with relatively high alkalinity seems to have favored high concentration of fluoride in groundwater. Regular in take of fluoride rich water seems to be the main course for high incidence of fluorosis. Along with the fluoride concentration consumed through water, hot climate conditions, unhygienic surroundings, illiteracy lack of awareness about the water quality which they are using, are some of important reasons for this disease. It is recommended that alternative arrangements for supply of portable water from other safe sources to the affected village or supply of treated portable water to this village may be taken up on top priority. The villagers have to be educated through awareness camps on health, sanitation, food nutrition and water quality.

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