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Fluoride contamination status of groundwater in Phulera tehsil of Jaipur district, Rajasthan

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Abstract: *Over the last few decades the water quality is deteriorating in arid and semi-arid regions. Phulera tehsil is facing the problem of groundwater pollution. In the present investigation, determination of fluoride (F) in drinking water was conducted in (200 samples of) 40 villages of Phulera tehsil having fluoride content more than permissible limits (>1.5 mg l^{-1}). After the pilot survey symptoms of skeletal and gut fluorosis have been found in almost every inhabitant. The water samples were alkaline with pH ranging from 7.05 to 10.16. Electrical conductivity (EC) ranged from 157 µmhoScm^{-1} to 1018 µmhoS cm^{-1}. Calcium hardness (Ca-H) ranged from 10 to 127 mg l^{-1}. Total hardness (TH) varied from 69 to 572 mg l^{-1}. Chloride varied from 92.00 mg l^{-1} to 1422.00 $mgl^{-1}$and fluoride from 1.20 to 18 mg l^{-1}. The alkalinity of all water samples were found to be more than the permissible limit. The results envisaged that the quality of ground water of Phulera is very poor, and is not suitable for drinking purpose and can only be used after proper treatment.*

Key words: *Groundwater, Fluoride, Toxic effects*
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Introduction

Fluoride is a natural beneficial nutrient found in varying concentrations in air, water and soil. When consumed in optimal amounts, it improves dental health but excess intake (>1.5 mgl^{-1}) may cause fluorosis including dental, skeletal and non-skeletal fluorosis along with secondary neurological complications (Indermitte *et al*., 2007; Lineswara, 2003; Rajkumari and Rao, 1985; Shailaja and Jhonson, 2007; Susheela, 1993). According to safe drinking water quality standards, the concentration of fluoride should be in the range of 1.00 to 1.50 mgl^{-1} and beyond the upper level; it leads to harmful effects on the body (WHO, 1984).

The threat of fluorosis has been rapidly increasing through out the world. India is also confronting the same problems. Presently, seventeen Indian states including Rajasthan have been identified as having excess fluoride in drinking water. In Rajasthan, people of 22 districts (out of 32) are presently consuming fluoride (Samal and Naik, 1988) greater than permissible limit. Earlier workers (Bishnoi and Arora, 2007; Chandrasekhram and Saji, 2008; Chinoy *et al*., 2005; Gangal, 2005; Gupta, 1991; Handa, 1988; Sharma *et al*., 2005; Stanley *et al*., 1997; Yadav *et al*., 2003) reported that fluoride and fluorosis was correlated with high concentration of fluoride ion in drinking water. Usually, the surface water does not contain high fluoride where as groundwater may be contaminated with high fluoride content because the usual source of fluoride is fluoride rich rocks. When water percolates through rocks, it leaches out the fluoride from these rocks. Therefore major source of Fluoride in the groundwater is leaching from earth crust. Various rock types contain fluoride ranging from 180 µg g^{-1} in sandstone and greywache to 800 µg g^{-1} in granites (Sharma *et al*., 1990).

In our study area, more than 90% population gets it requirement of drinking water from groundwater sources such as hand pump and open well. Realising the adverse effect of water-borne fluoride in the human body, especially on the teeth and bones and because of the widespread occurrence of dental and skeletal fluorosis. A survey was conducted in the study area. Groundwater samples were collected from forty villages of study area.

Materials and Methods

The ground water samples (open well / hand pump) were collected from selected forty villages of Phulera tehsil (Jaipur district) of Rajasthan as given in Table 1. A total of 200 water samples (5 samples per village) were collected in precleaned polyethylene bottle of 1 litre. Sampling was done randomly in the months of July and August 2005. Water samples were brought to the laboratory for analysis using standard techniques for physico-chemical parameters.

Fluoride (F) concentration was determined with the help of selective ion meter (Mettler Toledo MA 235 pH/ ion Analyzer). Standard procedure for determining the fluoride concentration was followed (APHA, 2005). For satisfactory results total ionic strength adjustment buffer (TISAB) was used to maintain a suitable ionic strength and to avoid complex formation. In addition, physico-chemical parameters like pH, EC, Ca-hardness, total hardness, chloride and alkalinity were also estimated as per standard methods (APHA, 2005). The standard values of drinking water according to WHO, (1996), USPH (1985) and ISI (1982) has been mentioned in Table 1.

Results and Discussion

Analytical results of different samples collected from the study area (forty villages) of Phulera tehsil have been mentioned in

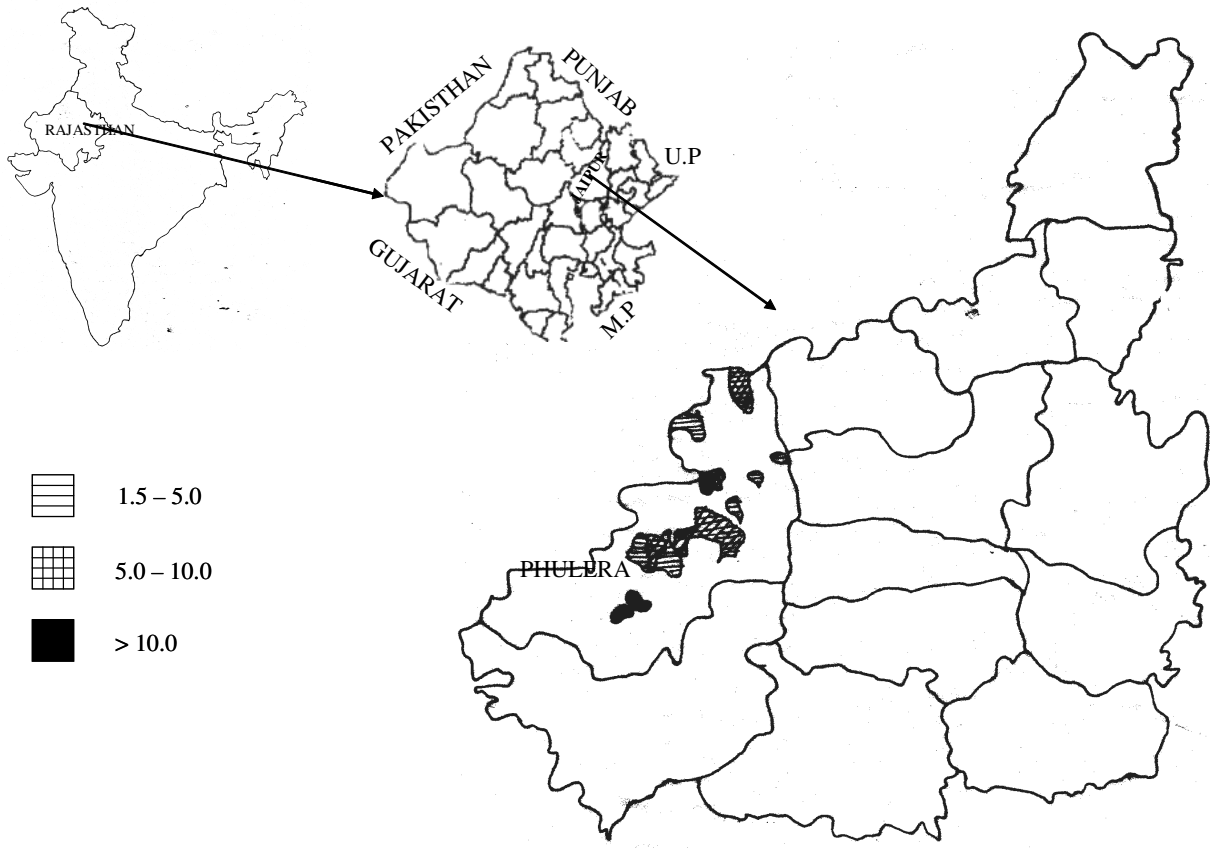

Fig. 1: Map of study area (Phulera tehsil) showing distribution of fluoride concentration (ppm)

Table 1. The result reveals that fluoride concentration in groundwater samples of twenty-four villages varies from 1.5- 5.0 mg l^{-1}. In thirteen villages, fluoride concentration ranged from 5.0-10.0 mg l^{-1} followed by more than 10.0 mg l^{-1} in three villages (Table 1). Fluoride concentration in three villages is very alarming. The maximum concentration of fluoride was recorded in Macharkhani (16.0±0.13 mg l^{-1}), Phulera (18.0±0.09 mg l^{-1}) and Shyosinghpura (11.0±0.16 mgl^{-1}). The permissible limit for fluoride concentration is 1-1.5 ppm according to WHO (1996). The data revealed that 7.5% villages of Phulera tehsil are affected with very high concentration of fluoride, where as 60% villages had moderate fluoride content. However, 32.5% villages contained optimum limit of fluoride concentration (Fig. 1, 2). Difference in fluoride concentration is probably because of difference in chemical strata of rocks. pH is expressed as a number ranging from 0-14. The number is an expression of the concentration of H^+ ion in the solution. The value of pH with respect to the study area was found in the range of 7.05 to 10.16. The maximum value of pH was found in sample of Macharkhani village (10.16) and minimum pH (7.05) was observed from Palwas village (Table 1 and Fig. 3). According to WHO (1996) pH should be between 6.9-9.2. The pH was found to be within the permissible limit (Table 3) in 77.5% where as 22.5% villages showed pH higher than limit. It has been observed that pH brought out positive correlation (r=+1.33) with fluoride concentration, indicating that higher alkalinity of water promotes leaching of fluoride and thus affects the groundwater (Teotia *et al.*, 1981; Wodeyar and Sreenivasa, 1996) (Table 4 and Fig. 4). Fluoride concentration also associated with alkalinity (Trivedi, 1988) Electrical conductivity is a numerical expression of ability of an aqueous solution to carry electrical current. USPH recommended permissible limit for electrical conductivity (EC) is 300 µmhoS cm^{-1} (Table 2). Minimum (157 µmho Scm^{-1}) and maximum (1018 µmhoS cm^{-1}) EC was reported from Maheshwas and Phulera villages respectively (Table 1 and Fig. 5). By analyzing the results, 70% water samples found to be within the permissible limit. About 20% of total samples have less than permissible limit while 10% of sample was found to be higher than permissible limit (Table 3). A positive correlation (r=+0.03) was observed between EC and F (Table 4 and Fig. 6) as earlier reported by (Devi *et al.*, 2003).

Hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. The principal hardness causing ions are calcium and magnesium. Calcium hardness (Ca-H)

Table - 1: Showing chemical quality of groundwater of Phulera tehsil

S.No.	Name of villages	pH	Fluoride (mgl^{-1})	Electrical conductivity ($\mu mhoS\ cm^{-1}$)	Ca hardness (mgl^{-1})	Total hardness (mgl^{-1})	Chloride (mgl^{-1})	Alkalinity (mgl^{-1})
1	Badhal	8.60 ± 0.03	7.40 ± 0.00	346 ± 11.07	34 ± 0.07	98 ± 15.06	781.00 ± 21.19	514 ± 15.04
2	Bhainsana	7.49 ± 0.07	7.70 ± 0.11	383 ± 29.13	31 ± 0.11	84 ± 8.01	846.00 ± 47.28	635 ± 0.21
3	Chainpura	7.21 ± 0.09	1.51 ± 0.07	22 ± 31.08	115 ± 12.01	349 ± 0.09	185.00 ± 19.85	321 ± 11.08
4	Charan Ka Bas	9.45 ± 0.01	10.00 ± 0.05	665 ± 8.17	17 ± 0.03	69 ± 0.17	1023.00 ± 71.2	827 ± 22.71
5	Dyodhi	9.20 ± 0.04	9.00 ± 0.14	567 ± 13.09	19 ± 0.08	71 ± 11.03	885.00 ± 68.12	703 ± 0.07
6	Govindpura	7.56 ± 0.11	1.60 ± 0.02	89 ± 0.03	123 ± 1.03	457 ± 21.08	213.00 ± 31.64	218 ± 0.84
7	Gumanpura	8.90 ± 0.03	4.50 ± 0.06	224 ± 1.59	79 ± 7.81	204 ± 0.01	512.00 ± 41.10	478 ± 1.31
8	Haripura	8.87 ± 0.02	2.80 ± 0.10	165 ± 12.37	51 ± 0.15	326 ± 13.17	254.00 ± 81.94	287 ± 0.05
9	Hachwokra	7.76 ± 0.08	6.00 ± 0.04	323 ± 17.06	34 ± 2.07	118 ± 10.18	674.00 ± 23.09	456 ± 11.65
10	Jagmalpura	9.25 ± 0.02	6.40 ± 0.07	362 ± 0.07	29 ± 3.02	106 ± 2.04	714.00 ± 14.84	470 ± 0.01
11	Jaisinghpura	8.10 ± 0.04	3.20 ± 0.03	251 ± 0.01	49 ± 0.04	225 ± 7.11	429.00 ± 50.91	368 ± 28.12
12	Jetpura	8.50 ± 0.06	1.90 ± 0.12	187 ± 9.85	107 ± 0.15	572 ± 5.16	230.00 ± 27.67	266 ± 15.08
13	Jobner	8.69 ± 0.11	6.80 ± 0.11	428 ± 3.19	29 ± 0.19	121 ± 16.03	715.00 ± 74.81	345 ± 11.01
14	Kamrasa	7.40 ± 0.09	1.60 ± 0.09	217 ± 0.01	95 ± 2.13	430 ± 0.09	196.50 ± 25.55	224 ± 0.03
15	Kazipura	8.40 ± 0.01	2.40 ± 0.15	284 ± 0.15	78 ± 0.07	226 ± 0.15	239.15 ± 17.92	151 ± 9.83
16	Khandel	8.95 ± 0.03	6.60 ± 0.10	495 ± 1.28	37 ± 0.10	108 ± 23.08	574.90 ± 84.22	320 ± 0.09
17	Kishangarh Renwal	7.35 ± 0.07	3.60 ± 0.02	293 ± 10.12	63 ± 1.33	299 ± 11.87	314.00 ± 18.74	291 ± 17.08
18	Macharkhani	10.16 ± 0.02	16.00 ± 0.13	985 ± 0.05	13 ± 0.12	81 ± 0.02	1209.80 ± 97.05	612 ± 2.01
19	Maheshwas	8.05 ± 0.01	1.56 ± 0.05	157 ± 0.01	127 ± 0.01	493 ± 2.17	92.60 ± 6.21	324 ± 1.08
20	Manoharpura	8.40 ± 0.03	2.00 ± 0.08	230 ± 12.17	83 ± 0.20	264 ± 7.02	124.00 ± 13.85	343 ± 13.18
21	Mohan Ka Bas	8.20 ± 0.07	3.70 ± 0.11	267 ± 5.01	55 ± 0.07	196 ± 0.14	376.50 ± 61.27	361 ± 11.02
22	Moondoti	7.65 ± 0.09	2.54 ± 0.03	242 ± 0.06	80 ± 2.01	248 ± 0.01	284.00 ± 33.64	315 ± 0.04
23	Murlipura	8.85 ± 0.05	3.60 ± 0.16	186 ± 18.01	69 ± 0.05	225 ± 12.08	419.00 ± 29.00	362 ± 12.01
24	Nagal	8.95 ± 0.03	4.00 ± 0.04	343 ± 2.17	57 ± 0.17	248 ± 3.06	382.00 ± 21.81	450 ± 1.01
25	Naradpura	8.92 ± 0.03	6.60 ± 0.17	574 ± 1.03	42 ± 0.23	149 ± 0.17	770.00 ± 72.20	656 ± 5.13
26	Pachkodiya	8.92 ± 0.01	6.20 ± 0.13	486 ± 0.02	46 ± 0.04	123 ± 0.01	716.80 ± 16.75	620 ± 0.08
27	Palwas	7.05 ± 0.08	1.60 ± 0.08	227 ± 7.13	71 ± 0.13	296 ± 15.86	164.00 ± 20.91	225 ± 2.087
28	Panhari	9.51 ± 0.03	7.60 ± 0.12	692 ± 2.04	14 ± 0.02	105 ± 21.04	936.00 ± 98.11	465 ± 10.13
29	Phulera	9.87 ± 0.02	18.00 ± 0.09	1018 ± 11.07	10 ± 0.08	87 ± 0.89	1422.00 ± 219.05	894 ± 17.08
30	Prithvipura	8.20 ± 0.07	4.70 ± 0.03	358 ± 5.01	32 ± 0.17	115 ± 1.05	580.00 ± 12.47	362 ± 0.09
31	Rampura	7.76 ± 0.05	1.50 ± 0.15	210 ± 0.08	56 ± 2.01	263 ± 0.02	156.00 ± 32.55	214 ± 20.01
32	Rasoolpura	9.46 ± 0.01	8.30 ± 0.13	529 ± 0.01	37 ± 0.06	96 ± 0.18	824.00 ± 21.08	565 ± 0.01
33	Rajori	8.90 ± 0.01	4.80 ± 0.19	324 ± 3.15	45 ± 0.15	253 ± 0.79	671.00 ± 11.71	351 ± 5.03
34	Saipura	7.75 ± 0.10	4.60 ± 0.03	279 ± 11.02	49 ± 0.02	125 ± 3.17	540.00 ± 37.48	403 ± 0.14
35	Sardarpura	7.30 ± 0.03	1.80 ± 0.11	206 ± 0.03	113 ± 2.03	354 ± 5.09	245.00 ± 12.07	293 ± 11.02
36	Shyosinghpura	9.86 ± 0.15	11.00 ± 0.16	734 ± 0.11	11 ± 1.15	83 ± 0.57	1170.00 ± 26.81	510 ± 0.07
37	Sukalpura	7.30 ± 0.09	1.58 ± 0.07	226 ± 7.23	92 ± 4.02	287 ± 0.64	327.00 ± 53.01	187 ± 0.13
38	Sursinghpura	8.90 ± 0.01	3.30 ± 0.04	257 ± 0.17	39 ± 0.09	174 ± 0.03	359.00 ± 45.93	412 ± 1.05
39	Sundariyawas	8.15 ± 0.03	2.56 ± 0.13	189 ± 4.10	79 ± 1.10	238 ± 21.98	297.00 ± 81.27	235 ± 8.01
40	Teja Ka Bas	8.25 ± 0.03	8.80 ± 0.05	651 ± 0.05	17 ± 0.16	92 ± 13.02	922.00 ± 10.06	610 ± 0.16

All the values are means ± SD

Table - 2: Standards of drinking water (WHO, 1996)

Parameters	Standards by		
	WHO	USPH	ISI
pH	6.9-9.2	-	6-9
Fluoride ($mg\ l^{-1}$)	1-1.5	1.5	3
EC ($\mu mhoS\ cm^{-1}$)	-	300	-
Chloride ($mg\ l^{-1}$)	200-600	250	600
Ca-hardness ($mg\ l^{-1}$)	75-200	-	-
Total hardness ($mg\ l^{-1}$)	100-500	-	-
Alkalinity ($mg\ l^{-1}$)	100	-	-

Table - 3: Showing permissible limit and percentage of villages of Phulera tehsil

Parameters	Permissible limit	Villages (%)		
		Below	Optimum	Higher
pH	6.9-9.2	-	77.5	22.5
EC $\mu mhoS\ cm^{-1}$	300	20	70	10
Ca-H $mg\ l^{-1}$	75-200	55	45	-
TH $mg\ l^{-1}$	100-500	20	70	10
Cl^{-} $mg\ l^{-1}$	200-600	15	45	40
Alkalinity $mg\ l^{-1}$	100	-	-	100

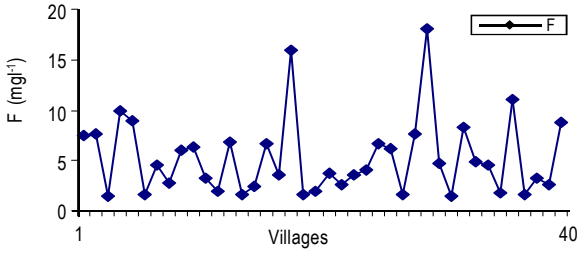

Fig. 2: Showing fluoride of villages of Phulera tehsil

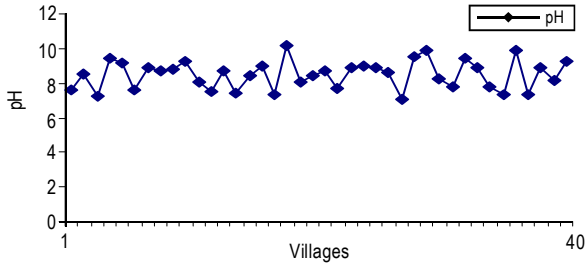

Fig. 3: Showing pH of villages of Phulera tehsil

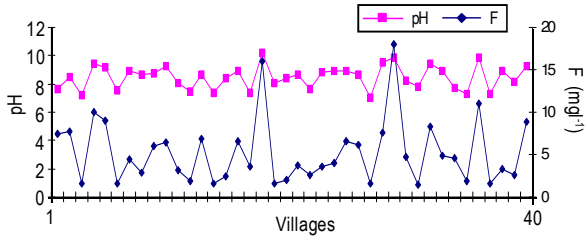

Fig. 4: Showing correlation between pH and F of villages of Phulera tehsil

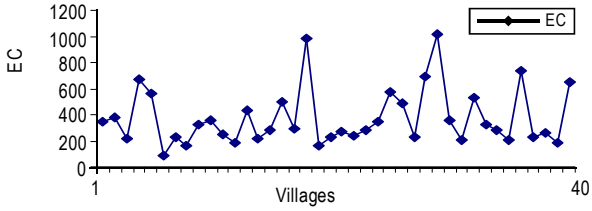

Fig. 5: Showing EC of villages of Phulera tehsil

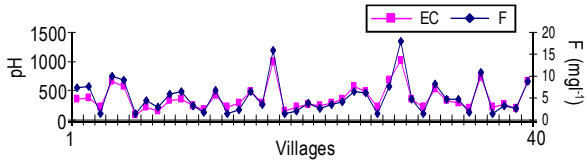

Fig. 6: Showing correlation between EC and F of villages of Phulera tehsil

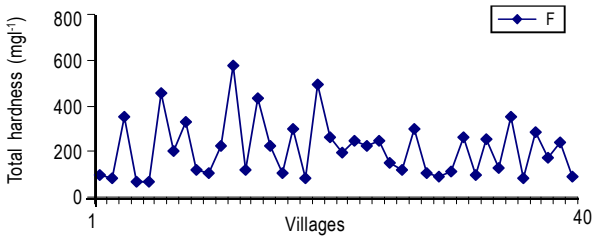

Fig. 7: Showing TH of villages of Phulera tehsil

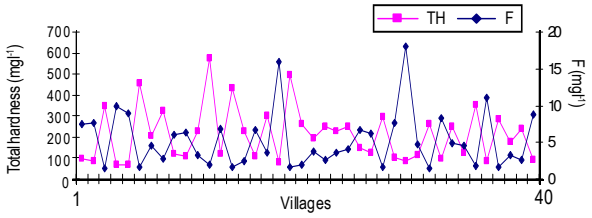

Fig. 8: Showing correlation between TH and F of villages of Phulera tehsil

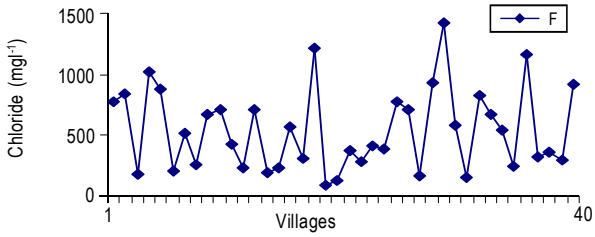

Fig. 9: Showing chloride of villages of Phulera tehsil

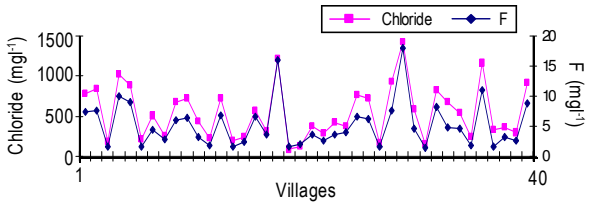

Fig. 10: Showing correlation between chloride and F of villages of Phulera tehsil

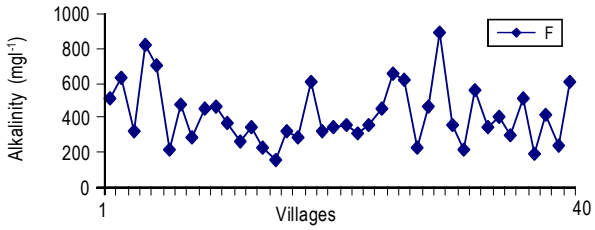

Fig. 11: Showing alkalinity of villages of Phulera tehsil

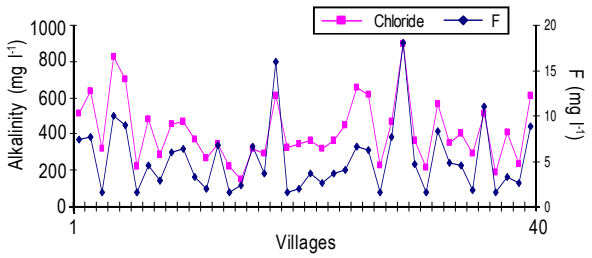

Fig. 12: Showing correlation between alkalinity and F of villages of Phulera tehsil

Table - 4: Showing correlation among various parameters of water samples of villages of Phulera tehsil

Parameter	pH	F^-	EC	Ca-H	TH	Cr^-	TA
pH	1	+1.33	+0.16	-0.15	-0.14	+0.16	+0.14
F^-		1	+0.03	-0.78	-0.72	+0.96	+0.84
E C			1	-0.76	-0.69	+0.92	+0.79
Ca-H				1	+0.89	-0.84	-0.69
TH					1	-0.78	-0.69
Cl^-						1	+0.86
TA							

F = Floride, EC = Electrical conductivity, Ca^{-H}, Calcium hardness, TH = Total hardness, Cl^- = Chloride, TA = Total alkalinity

ranged from 10 to 127 mg l^{-1}. Minimum Ca-H (10 mg l^{-1}) was observed from Phulera village where as maximum Ca-H (127 mg l^{-1}) was reported from Maheshwas village. Total hardness (TH) varied from 69 to 572 mg l^{-1}. Minimum (69 mg l^{-1}) and maximum (572 mg l^{-1}) was reported from Charan Ka Bas and Jetpura villages respectively (Table 1 and Fig. 7). WHO recommended safe permissible limit for hardness *i.e*. 100-500 mg l^{-1} (Table 2). In ground water, hardness is mainly due to carbonates, biocarbonates, sulphates and chlorides of Ca and Mg. Ca-H was within permissible limit in 45% villages where as 55% villages contained Ca-H below than limit (Table 3). Total hardness was higher in 10% villages; below than limit in 20% villages where as 70% samples contained TH within optimum limit (Table 3). In this study hardness showed negative correlation with fluoride, pH and EC (r=-0.72; r= -0.14; r=-0.69) (Table 4 and Fig. 8). The results are in agreement with the finding of (Jain *et al.*, 2005; Trivedi, 1988). This is mainly due to low fluoride solubility (Hem, 1991). Chloride varied from 92.60 to 1422 mg l^{-1}. Minimum (92.60 mg l^{-1}) was reported from Maheshwas village and maximum (1422 mg l^{-1}) was observed from Phulera village (Table 1 and Fig. 9). The chloride content was higher than permissible limit (200-600 mg l^{-1}) in 40% villages where as lower in 15% villages. Only 45% villages were within optimum limit (Table 3). However, chloride showed positive correlation with fluoride (r=+0.96) (Table 4 and Fig. 10). Higher content of chlorides gives salty taste to water. Alkalinity ranged from minimum (151 mg l^{-1}) Kazipura to maximum (894 mgl^{-1}) from Phulera villages (Table 1 and Fig. 11). Alkalinity of all water samples was found to be out of permissible limit (Table 3). High value of alkalinity gives an undesirable taste to water. It showed positive correlation with pH, F, EC and Cl^- (Table 4 and Fig. 12). The results are in agreement with the results of (Jain *et al.*, 2005).

The data indicate that the groundwater of Phulera Tehsil is highly deteriorated with high amount of fluoride and alkalinity, which is really a serious menace to human health. Most of the parameters were either more than permissible limit or below limit. Calculated correlation coefficient between physico-chemical parameters indicated considerable variations among the water samples with respect to their chemical composition. Thus, it was concluded that fluoride intake especially through groundwater contributed to the development of dental and skeletal fluorosis. Therefore, the drinking water of villages of Phulera tehsil is not potable. To maintain quality of ground water, the continuous monitoring of physico-chemical parameters should be done and can be used for cooking and drinking only after prior treatment. The authors strongly recommended that some immediate measures should be taken for defluoridation of drinking water *e.g.* Nalgonda technique, which is developed by National Environmental Engineering Research Institute. It is a process involves rapid mixing of water with lime (sodium or calcium carbonate), alum (aluminium sulphate) and bleaching powder. This results in flocculation, sedimentation and the supernatant which will have only permissible amount of fluoride can be filter or decanted and then used for cooking and drinking purposes. Some other preventive majors are intake of vitamin C in rich food items in large amount, drink more milk and consume calcium rich vegetables such as leafy vegetables. If any of the symptoms of fluorosis detected avoid the major sources of fluoride intake.

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References

APHA: Standard methods for the examination of water and wastewater. 21st Edn., American Public Health Association, New York, USA (2005).

Bisnoi, M. and S. Arora: Potable groundwater quality in some villages of Haryana, India: Focus on fluoride. *J. Environ. Biol*., **28**, 291-294 (2007).

Chandrasekhram, D. and S. Saji: High fluoride groundwater of Karbi-Anglong district, Assam. Int. Conference on Groundwater Dynamics and Global Change. pp. 19-22 (2008).

Chinoy, N.J., E. Sequeria, M.V. Narayana, M. Mathews, W. Barot, P.R. Kandoi and D.D. Jhala: A survey of fluoride in 90 endemic villages of Mehsana and Banaskantha districts of north Gujrat, India. *Fluoride,* **38**, 224 (2005).

Devi, S., S.B. Barbuddhe, D. Hazel and C. Dolly: Physico-chemical characteristics of drinking water at velsao, Goa. *J. Environ. Biol*., **13**, 203-209 (2003).

Gangal, R.K.: Fluoride hazard of groundwater in the Jaipur district, Rajasthan, India and methods to mitigate it. *Fluoride*, **38**, 241 (2005).

Gupta, S.C.: Chemical character of groundwater in Nagaur district, Rajasthan. *Ind. J. Environ. Hlth*., **33**, 341-349 (1991).

Handa, B.K.: Fluoride occurrences in natural water in India and its significance. *BHU-Jal News*, **3**, 21-24 (1988).

Hem, J.D.: Study and interpretation of the chemical characteristic of natural water, United States geological survey water supply paper 2254, 3rd Edn. Scientific Publishers, Jodhpur. p. 120 (1991).

Indermitte, E., E. Karro and A. Saava: Tap water fluoride levels in Estonia. *Floride,* **40**, 244-247 (2007).

ISI: Draft Indian Standard Specification for Drinking Water DOC:CDC. 26,8626, New Delhi (1982).

Jain, P., J.D. Sharma and P. Sharma: Chemical analysis of drinking water of villages of Sanganer Tehsil, Jaipur district. *Int. J. Environ. Sci. Tech.,* **2**, 373-379 (2005).

Lineswara Rao, S.V.: Fluoride toxicity in Raptadu mandal, Anantapura district, Andhra Pradesh, India. *J. Curr. Sci.,* **3**, 329-334 (2003).

Rajkumari, K.R. and R.M. Rao: Fluorosis in Nagaland district in relation to chemical characterization of potable water and staple food. *Fluoride,* **18**, 198-202 (1985).

Shailaja, K. and M.E.C. Jhonson: Fluorides in groundwater and its impact on health. *J. Environ. Biol.*, **28**, 331-332 (2007).

Sharma, D.K., C.P.S. Chandel and C.M. Gupta: Fluoride levels in all types of water from various sources in near by villages around Jaipur. *Int.Indian Water Works Association*, **10**, 121 (1990).

Sharma, J.D., P. Jain and S. Deepika: Geological study of fluoride in groundwater of Sanganer tehsil of Jaipur district, Rajasthan, India. *Fluoride,* **38**, 249 (2005).

Samal, U.N. and B.N. Naik: Dental Fluorosis in school children in the vicinity of an Aluminium factory in India. *Fluoride,* **21**, 142-148 (1988).

Stanley, V.A., N. Ramesh, K.S. Pillai and P.B.K. Murthy: Epidemiological survey of fluorosis in ennore, Madras. *Proc. Acad. Environ. Biol.,* **6**, 121-125 (1997).

Susheela, A.K.: Prevention and control of fluorosis in India. Rajeev Gandhi National Drinking Water Mission, Health Abstract, Vol. I (1993).

Teotia, S.P.S., M. Teotia and M.K. Singh: Hydrogeochemical aspects of endemic skeletal fluorosis in India. An epidemiological study. *Fluoride*, **14**, 69-74 (1981).

Trivedi, P.: Relationship between fluoride, total alkalinity, total hardness in groundwater of Pali district in arid and semi-arid region of western Rajasthan. *Proc. Natl. Acad. Sci., India*, **58**, 7-11 (1988).

USPH: Fluoridation Census. Department of Health and Human Services. Bethesda MD. pp. 28-32 (1985).

WHO: Fluorine and fluoride. Environmental Health Criteria. Geneva, 36, 93 (1984).

WHO: Guidelines for drinking water quality. 2, 231(1996).

Wodeyar, B.K and G. Sreenivasan: Occurrence of fluoride in the groundwater and its impact in Peddvankahalla basin, Bellary district, Karnataka- A preliminary study. *Curr. Sci.*, **70**, 71-74 (1996).

Yadav, A.K., P.K. Jain and S. Lal: Geochemical study of fluoride in groundwater of Behror tehsil of Alwar district (Rajasthan). *Res. J. Chem. Environ.,* **7**, 43-47 (2003).