



Study of fluoride content in groundwater of Nawa Tehsil in Nagaur, Rajasthan

Author Details

Radha Gautam (Corresponding author)	Indira Gandhi Center for Human Ecology, Environmental and Population Studies (HEEPS), University of Rajasthan, Jaipur- 302055, India e-mail: radha_gautam10@yahoo.in
Nagendra Bhardwaj	Department of Botany, University of Rajasthan, Jaipur- 302055, India
Yashoda Saini	Department of Botany, University of Rajasthan, Jaipur- 302055, India

Abstract

There is a severe fluoride problem in Nawa tehsil of Nagaur district. Villagers are suffering from dental fluorosis and skeletal fluorosis. So an extensive geochemical study of 27 villages of eastern, south-eastern and southern zone of Nawa tehsil was done. Total 46 ground water samples were collected and analyzed for various physico-chemical parameters as well as fluoride content. The ground water samples collected in clean polyethylene plastic containers were analyzed for pH, electrical conductivity, total dissolved salts, calcium, magnesium, total hardness, chloride and alkalinity. The fluoride concentration in the three different zones ranged from 0.64 to 14.62 mg l⁻¹ where 13.04% samples were found within permissible limit while 86.96% had fluoride beyond permissible limit (> 1.5 mg l⁻¹). It was found that among the three different zones south-eastern zone was under serious fluoride contamination where fluoride concentration ranged between 1.10 to 14.62 mg l⁻¹. In the eastern zone fluoride concentration was recorded from 1.52 to 5.13 mg l⁻¹ whereas in the southern zone it was found between 0.64 to 3.63 mg l⁻¹.

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Introduction

The fluorides belong to the halogen group of minerals and are natural constituents of the environment. Fluorides are mainly found in ground water when derived by the solvent action of water on the rocks and the soil of the earth's crust. Fluoride is the most electronegative of all chemical elements and is never encountered in nature in the element form. It is seventeenth in the order of frequency of occurrence of the elements and represents about 0.06 to 0.09% of the earth's crust (Wedepohl, 1974). Fluoride is an essential element for life. At low concentrations it is generally believed that fluoride deficiencies can arise but at high fluoride concentrations other deleterious effects can certainly transpire.

In relation to drinking water it is generally believed that too little (< 0.5 mg l⁻¹) or too much (> 1.5 mg l⁻¹) can affect bone and teeth structure (Edmunds and Smedley, 1996, 2003). Due to the scarcity of surface water, Rajasthan has to depend on ground water resources

to a great extent. Ground water fluoride contents in high levels are present in all the 33 districts and have become a serious health related issue in 23 districts of Rajasthan (Agrawal *et al.*, 1997; Maithani *et al.*, 1998; Datta *et al.*, 1999). Estimation finds that 65% of India's villages are exposed to fluoride risk (UNICEF, 1999).

Higher fluoride concentration exerts a negative effect on the course of metabolic processes and an individual may suffer from skeletal fluorosis, dental fluorosis, non-skeletal manifestation or a combination of the above (Susheela and Kharb, 1990; Susheela and Kumar, 1991). Fluorosis has become pandemic and it has assumed global status in the public health point of view (Pillai and Stanley, 2002). Rajasthan state is thought to be the most seriously affected by high fluoride concentrations. People in several districts of Rajasthan are forced to consume water with fluoride concentration up to 44 mg l⁻¹ (Agrawal *et al.*, 1999). The present study has therefore undertaken to analyze the fluoride content and physico-chemical characters of ground water in Nawa tehsil, Nagaur, Rajasthan.

Materials and Methods

The present study was carried out in 27 villages of eastern, south eastern and southern zone of Nawa tehsil in Nagaur district of Rajasthan state. The study area (Nawa tehsil) is situated in the semi-arid region. On the North it is bounded by Sikar district, On the east by Jaipur district, On the south by Ajmer and on the west by Makrana and Parvatsar tehsil. It is located between latitude 26°1'5" N and longitude 75°0'9" E. It has a dry climate with a hot summer. Since there is no major perennial river near the area ground water is the major source of water supply. Water samples were collected from different sources viz. Tube Wells, Hand Pumps, open wells and Public Health Engineering Department (PHED) supply from randomly selected villages and stored in polythene bottles.

Fluoride (FI) concentration in 7, 21 and 18 ground water samples collected from Eastern, South Eastern and Southern zone respectively were analyzed with the help of Orion Research Ion Analyzer Model 407 A, fluoride ion selective electrode (JAOAC, 1975). The electrode does not respond to bound or complexed fluoride therefore a buffer solution (TISAB) of high total ionic strength was added to the samples to achieve satisfactory results. The electrode slope was checked with the ion meter. 10 ml of each 0.2, 2 and 20 mg l⁻¹ fluoride standards were taken and 10 ml of TISAB was added and then the instrument was calibrated. Other physico-

chemical parameters were also analyzed such as pH, total dissolved salts (TDS), electrical conductivity (EC), alkalinity (Al), hardness (TH), calcium (C), magnesium (Mg) and chloride (Cl) by using standard techniques in laboratory (APHA, 1985).

Results and Discussion

The results of physico-chemical parameters of water samples including fluoride concentration are depicted in the Table 2,3 and 4. Very high positive correlation was found between Ca and Mg and EC and TDS. Besides this FI and Al have a good correlation with TDS (Table 1).

Fluoride concentration in the three different regions varied between 0.64 (Pachota village) to 14.62 mg l⁻¹ (Rulaniyo ki dhani in Govindi village). It was revealed that only 15.62% villages out of total villages studied had drinking water within permissible limit for fluoride whereas 84.37% villages had aquifers beyond the permissible limit of fluoride. Similarly 13.04% samples were found within permissible limit for fluoride whereas 86.96% had fluoride beyond permissible limit (>1.5 mg l⁻¹, WHO, 2006).

In the Nawa tehsil different zones had mixed concentration of fluoride *i.e.* some of them were found within permissible limit while others were beyond the permissible limit. Among the three different zones fluoride concentration was found higher in villages of south

Table - 1: Co-efficient correlation between water parameters

	pH	TDS	EC	FI	Cl	TH	Ca	Mg	Al
pH	1.000								
TDS	0.021	1.000							
EC	0.013	0.887	1.000						
FI	0.134	0.568	0.622	1.000					
Cl	0.099	0.344	0.288	0.235	1.000				
TH	-0.153	0.403	0.442	0.354	0.603	1.000			
Ca	-0.168	0.333	0.411	0.313	0.500	0.944	1.000		
Mg	-0.133	0.424	0.435	0.359	0.634	0.975	0.846	1.000	
Al	0.159	0.522	0.624	0.728	0.386	0.682	0.662	0.652	1.000

Number of observations : 46

Table - 2: Chemical analysis of groundwater of eastern zone (Nawa tehsil)

Site	Source	pH	TDS (mg l ⁻¹)	Electrical conductivity (µmho cm ⁻¹)	Fluoride (mg l ⁻¹)	Chloride (mg l ⁻¹)	Hardness (mg l ⁻¹ as CaCO ₃)	Calcium (mg l ⁻¹)	Magnesium (mg l ⁻¹)	Alkalinity (mg l ⁻¹ as CaCO ₃)
S1	OW	7.60	3018	3634	1.90	579.36	400	120.24	24.34	260
S2	OW	7.49	3304	3664	4.28	242.82	356	20.04	74.65	750
S3	PHED	7.32	2284	3064	1.52	82.36	84	20.84	7.80	320
S4	TW	7.86	2664	3508	4.69	366.36	1380	104.20	273.23	440
S5	OW	8.31	3296	3778	5.13	948.56	166	18.43	29.27	900
S6	TW	7.42	2578	3234	1.81	2073.20	680	88.97	111.71	330
S7	OW	8.42	3584	3976	3.31	874.72	440	65.73	67.31	650

OW = Open well, PHED = Public health engineering department, TW = Tube well, S1 = Manpura (Nolaji rad ki dhani), S2 = Kanpura, S3 = Kanpura (Water storage tank, near Rajikiya Prathmic Vidyalaya), S4 = Matasukha (near Kharda ki jamin), S5 = Shyamgarh (near pani ki sukhi nadi), S6 = Aabas (TW-16 near Hardarsi talai), S7 = Bijanio ki dhani (near Balaji temple)

Table - 3: Chemical analysis of groundwater of South Eastern zone (Nawa tehsil)

Site	Source	pH	TDS (mg l ⁻¹)	Electrical conductivity (µmho cm ⁻¹)	Fluoride (mg l ⁻¹)	Chloride (mg l ⁻¹)	Hardness (mg l ⁻¹ as CaCO ₃)	Calcium (mg l ⁻¹)	Magnesium (mg l ⁻¹)	(Alkalinity mg l ⁻¹ CaCO ₃)
S1	OW	8.34	6420	9760	14.62	4245.8	4560	769.53	643.79	3100
S2	OW	9.56	3544	3898	3.05	724.2	140	8.817	28.79	585
S3	OW	8.11	3624	3996	10.32	1895.7	512	32.06	105.39	950
S4	OW	7.83	3690	3780	2.56	2009.3	1360	52.90	299.61	570
S5	OW	7.96	3592	3926	2.80	852.0	434	27.25	89.29	480
S6	PHED	7.42	3520	3878	1.71	468.6	446	56.12	74.63	370
S7	OW	8.72	2958	3600	11.26	474.28	98	26.45	7.80	980
S8	OW	7.29	5820	8980	9.46	113.60	132	41.68	6.81	410
S9	OW	9.03	1372	3336	4.32	516.88	590	48.09	114.66	530
S10	OW	8.44	3546	5908	3.63	468.60	120	11.22	22.44	460
S11	OW	8.05	3490	3792	2.80	428.84	510	56.11	90.25	300
S12	OW	7.95	3390	3486	2.56	1897.12	492	65.73	80.00	210
S13	OW	7.70	3024	3638	7.36	3635.20	1204	156.3	198.54	480
S14	OW	8.15	3480	3890	9.46	167.56	364	33.66	68.31	630
S15	OW	9.23	2852	3486	12.28	164.72	80.00	8.016	14.64	920
S16	OW	7.44	2214	1430	1.74	1607.44	1940	352.70	258.47	300
S17	OW	8.87	3720	3982	6.72	201.64	70.00	13.62	8.78	650
S18	PHED	7.85	2688	3322	1.10	596.40	410.0	53.70	67.32	330
S19	OW	8.33	3506	3882	3.58	205.90	236.0	20.04	45.37	390
S20	PHED	8.12	1736	2578	1.90	220.10	572.0	126.65	62.40	480
S21	OW	9.29	1548	2356	1.90	102.24	20.00	3.20	2.93	360

OW = Open well, PHED = Public health engineering department

S1 = Govindi (Rulaniyo ki dhani) near Rajkiya Prathmic Vidhyalaya, Aadarsh Aagan Badi Kendra, S2 = Thikariya Kalan (Akhepura dhani) Nawa-Jaipur road, backside of Dabasi bridge, S3 = Chosla (Nawa- Jaipur road, near Peepal tree), S4 = Kuni (Hardly 2 km from Chosla Panchayat), S5 = Kuni (Balaji temple ke pass, near banyan tree, OW no.2), S6 = Kuni (water storage tank in the center of village), S7 = Lohrana (4 km from Lohrana bus stop), S8 = Piperali (On the way of Gaena ki dhani), S9 = Loonwa (7 km from lohrana bus stop OW no.1), S10 = Loonwa (meena mohalla, aagan bari, S.T), S11 = Loonwa (Balaji ki bagichi), S12 = Loonwa (Ragar S.C. ka mohalla), S13 = Loonwa (Kumawato ki dhani, near pond), S14 = Sirsi (Nethwalo ki dhani, Kaccha rasta), S15 = Sirsi (near Rajkiya Prathmic Vidhyalaya, near Balaji temple), S16 = Solaya, S17 = Varjan (Nawa - Minda road), S18 = Varjan (water storage tank near panchayat bhawan), S19 = Mundgosai (near Badhwa temple), S20 = Mundgosai (water storage tank near center of village), S21 = Shimbhupura (near Balaji temple)

eastern zone. It was recorded between 1.10 mg l⁻¹ (Varjan, Water easrem zone. It was recorded between 1.10 mg l⁻¹ (Varjan, Water storagetank near Panchayat bhawan) to 14.62 mg l⁻¹ (Govindi, Rulaniyo ki dhani). 21 ground water samples were collected from this zone (Table 3). In this zone 4.76% samples were found within permissible limit while 95.24% had fluoride concentration beyond permissible limit i.e. >1.5 mg l⁻¹. 7 ground water samples were collected from villages of eastern zone where fluoride concentration varied between 1.52 mg l⁻¹ (Kanpura, Water Storage Tank) to 5.13 mg l⁻¹ (Shyamgarh). (Table 2). All the villages had fluoride concentration more than the permissible limit. Total 18 samples were collected from 9 villages of southern zone. It was observed that many villages had more than one water source and fluoride content varied from source to source even in the same village. Table 4 reveals that majority of samples collected was found to contain fluoride content higher than the permissible limit. Fluoride content ranged between 0.64 mg l⁻¹ (Pachota, water storage tank and Ajitpura) to 3.63 mg l⁻¹ (Bhagwanpura, Khokhro ki dhani) among which 5 ground water samples had fluoride content within permissible limit whereas 13 samples had fluoride concentration beyond permissible limit.

Similar study was conducted in some districts of Rajasthan among which in more than 40% area in Nagaur district fluoride concentration varied between 1.5 to 13.5 mg l⁻¹ (Seth, 2005). Similarly acute toxicity of fluoride was observed in Didwana block of the nagaur district where among 152 surveyed villages it was found that 56% ground water had fluoride concentration in the range of 1.7 mg l⁻¹ and above (Viyas *et al.*, 2006). The results of the present study approved the earlier findings.

Other physico-chemical parameters such as pH, TDS, EC, Al, Cl, TH, C and Mg were also studied. pH recorded in ground water samples of eastern zone was 7.32 to 8.42, in south eastern zone 7.29 to 9.56 and in southern zone 7.28 to 9.78. A positive correlation (r= 0.893) has also been observed between fluoride and pH reported by Teotia *et al.* (1981) and Trivedi (1988). In the study area Electrical conductivity ranged between 3064 to 3976 µmho cm⁻¹ in eastern zone, 1430 to 9760 µmho cm⁻¹ in south eastern zone and 1596 to 3976 µmho cm⁻¹ in southern zone. All natural water contains varying concentrations of Total dissolved Salts as a result of the dissolution of minerals in rocks, soils and decomposing plant material. In the eastern zone Total Dissolved

Table - 4: Chemical analysis of groundwater of southern zone (Nawa Tehsil)

Site	Source	pH	TDS (mg l ⁻¹)	Electrical conductivity (µmho cm ⁻¹)	Fluoride (mg l ⁻¹)	Chloride (mg l ⁻¹)	Hardness (mg l ⁻¹ as CaCO ₃)	Calcium (mg l ⁻¹)	Magnesium (mg l ⁻¹)	Alkalinity (mg l ⁻¹ as CaCO ₃)
S1	HP	8.63	3496	3880	1.90	1388.76	616	101.80	88.28	270
S2	HP	8.76	3508	3886	3.05	3626.68	730	68.13	136.61	250
S3	HP	9.78	3542	3908	2.15	2374.24	436	11.22	99.54	465
S4	PHED	8.29	1508	2336	1.20	102.24	568	129.85	59.48	345
S5	TW	7.97	2860	3194	1.66	761.12	358	110.62	19.95	370
S6	PHED	7.96	1020	1596	0.64	96.56	548	126.65	56.55	310
S7	OW	9.23	2590	3242	1.52	360.68	128	33.66	10.72	475
S8	OW	8.45	3530	3920	2.35	1982.32	1360	252.50	178.00	190
S9	OW	8.60	3376	3680	3.63	142	46	7.21	6.83	385
S10	TW	8.91	2966	3606	2.56	462.92	142	40.08	10.23	520
S11	OW	8.07	3700	3976	2.28	248.50	410	54.50	66.83	430
S12	OW	7.92	2056	2860	2.08	181.76	254	63.32	23.40	270
S13	OW	7.46	2080	2856	2.73	156.20	266	60.12	28.27	260
S14	OW	7.76	1446	2232	0.64	76.68	156	38.47	14.62	350
S15	PHED	7.28	1330	2054	1.20	110.76	472	87.37	61.94	360
S16	TW	8.50	2164	2908	1.11	127.8	80	20.04	7.31	400
S17	OW	8.72	1628	2464	2.24	3578.4	126	8.016	25.86	500
S18	OW	8.08	3520	3896	2.44	1043.7	324	24.04	64.41	400

HP = Hand pump, TW = Tube well, OW = Open well, PHED = Public health engineering department,

S1 = Gudasalt (H.P. ward no. 7 main market), S2 = Gudasalt (S.C. Mohalla, ward no. 3), S3 = Gudasalt (H.P ward no. 2 near bank of Sambhar lake), S4 = Gudasalt (Water Storage Tank in the center of village), S5 = Pachota (Near Balaji Temple TW no.-4), S6 = Pachota (Water Storage Tank at house connection), S7 = Danpura (Near Rajkiya Prathmic Vidyalaya), S8 = Bhagwanpura (Punia ki Dhani, Kacchi Sadak ke Pass), S9 = Bhagwanpura (Khokhro ki Dhani, on main road), S10 = Bhagwanpura (Hema ki Dhani, TW no.14), S11 = Bijapura (Bajio ki Dhani), S12 = Bijapura, S13 = Bijapura (Rajputo ki Dhani), S14 = Ajitpura, S15 = Ajitpura (WST in the centre of Village), S16 = Nawa tehsil Office, S17 = Jabdinagar, S18 = Rajas (Nawa-Jaipur road)

Salts varied from 2284 to 3584 mg l⁻¹ while in south eastern zone it was recorded between 1372 to 6420 mg l⁻¹ and in southern zone it ranged from 1020 to 3700 mg l⁻¹. The principal ion contributing TDS are carbonate, bicarbonate, chlorides, fluorides, sulphates, nitrates, sodium, potassium, calcium and magnesium (EPA, 1976). Chloride varied between 82.36 to 2073.20 mg l⁻¹ in eastern zone, 102.24 to 4245.8 mg l⁻¹ in south eastern zone and 76.68 to 3626.68 mg l⁻¹ in southern zone.

If calcium is present in higher concentration it is most effective in reducing the fluoride concentration. A strong negative correlation between Ca and F in the ground waters that contain Ca in excess of that required for the solubility of fluoride minerals, has been observed by many researchers (Boyle, 1992; Janardhana *et al.*, 2009). Calcium content in the eastern zone ranged between 18.43 to 120.24 mg l⁻¹, in the south eastern zone 3.20 to 769.53 mg l⁻¹ and in the southern zone 7.21 to 252.50 mg l⁻¹ whereas magnesium content was recorded between 7.80 to 273.23 mg l⁻¹ in eastern zone, 2.93 to 643.79 mg l⁻¹ in south eastern zone and 6.83 to 178.00 mg l⁻¹ in southern zone of nawa tehsil.

Due to low fluoride solubility hardness showed negative correlation with fluoride content (Hem, 1991). In the present study it was observed that with the increasing concentration of fluoride in ground water hardness decreased while alkalinity

increased. In the eastern zone total hardness was recorded between 84 to 1380 mg l⁻¹, in south eastern zone it ranged between 20 to 4560 mg l⁻¹ and in southern zone it varied from 46 to 1360 mg l⁻¹ whereas alkalinity in the eastern zone varied from 260 to 900 mg l⁻¹, in south eastern zone it ranged from 210 to 3100 mg l⁻¹ and in southern zone it was recorded between 190 to 520 mg l⁻¹. Acceptable range of alkalinity as per guidelines suggested by BIS (1991) is 200 mg l⁻¹ (maximum), beyond this limit taste becomes unpleasant. 600 mg l⁻¹ (Permissible in the absence of alternate source). The results are in agreement with the findings of Susheela (1999), Sinha and Musturia (2004) and Saini and Bhardwaj (2006). Similar observations were reported earlier by many investigators (Kaushik *et al.* 2004; Sabal and Khan, 2008). After evaluating the data of the study it is concluded that the ground water of Nawa tehsil is degraded and deteriorated as it is polluted with high amount of fluoride and can result in dental and skeletal fluorosis.

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