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FLUORIDE CONTENT IN GROUNDWATER OF BAPOLI BLOCK OF PANIPAT (NCR) HARYANA, INDIA

Bhupinder Singh* and Anuradha

Department of Basic and Applied Sciences, Bhagat Phool Singh Mahila Vishwavidyalaya, Khanpur Kalan, Sonepat, Haryana, India

*Email: bsingh.bps@rediffmail.com

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ABSTRACT

In India more than 70% population relay on ground water for their daily needs. Ground water may be contaminated from natural contaminants e.g. fluoride, iron, arsenic and salinity etc. It has been proved that more than 21 states of Indian Republic are suffering from fluoride problem in their ground water. It is pertinent to mention here that fluoride in water and diet has both i.e. positive as well as negative effects on animals including humans. Haryana is one of the states facing the problem of fluorosis hence; the study under reference was carried out to monitor the level of fluoride in groundwater of Bapoli block of Panipat district of Haryana. In Bapoli block fluoride content varied between 0.24 - 1.76 mg/l and mean fluoride content was 0.99 mg/l. Out of 40 samples analyzed from Bapoli block, 34 samples had fluoride content within permissible limit and 06 samples had fluoride content above the permissible limit. The different studies carried out globally have shown that underground water includes larger amount of fluoride. It may be due to dissolution of fluoride minerals from rocks laden with fluoride minerals.

Keywords: Drinking Water, Fluoride, Fluorosis, Ion Selective Electrode, Quality

INTRODUCTION

It is well known fact that water is source of life on earth and its adequate availability in terms of both quantity and quality is essential for human survival. In recent times as a result of increasing urbanization, industrialization and agricultural activities, there has been an increasing threat to the quality of surface waters in rivers and lakes. Moreover, dependence on ground water has grown over the past few decades and the quantity and quality of groundwater is also under threat especially in tropical countries of the world (Ray *et al.,* 2017; Li *et al.,* 2017a; Adimalla and Venkatayogi 2018a; Adimalla and Li 2018). Groundwater quality throughout the world is deteriorated due to anthropogenic as well as natural geogenic contaminants. One of the most important geogenic contaminant in groundwater is fluoride and has serious health issue.

The studies from many regions of the world have shown that excess of fluoride intake through water has deleterious effects on humans (Emenike *et al.,* 2018; Adimalla 2018; Shaji *et al.,* 2007; Narsimha and Sudarshan 2018). The literature have shown that nearly 200 million humans from 25 countries are facing various health issues i.e. fluorosis due to excess fluoride in groundwater (Apambire *et al.,* 1997; Ayoob and Gupta 2006; Narsimha and Sudarshan 2017; Subbarao *et al.,* 2017).

It has been estimated that approximately 66 million people in India are suffering from noxious and incurable disease fluorosis (Adimalla and Venkatayogi 2017; Narsimha and Sudarshan 2017). Subsurface water is the main source of human consumption in different parts of India and it is heavily contaminated with fluoride (Ready, 2013; Sajit Kumar *et al.,* 2014). The unchecked extraction of groundwater for various purposes and weathering of rocks enriched the Indian groundwater with fluoride (SubbaRao *et al.,* 2016). During 1930 there were only four Indian states facing the issue of excess fluoride and now we have 21 states (Ayoob and Gupta 2006; Narsimha and Rajitha 2018; Adimalla *et al.,* 2018).

Subsurface water is the main source of humans consumption in Haryana State and studies have shown that in most of the districts groundwater is laden with fluoride (Mor et al 2003; Meenakshi *et al.,* 2004; Singh *et al.,* 2007; Khaiwal and Garg 2007; Garg *et al.,* 2008; Yadav and Lata 2009; Singh 2011; Singh and Garg 2012 and 2013; Haritash *et al.,* 2018). In spite of various studies there is lack of information regarding fluoride content of groundwater from Bapoli block of Panipat district of Haryana. Hence, in view of the above this study was carried out to estimate the fluoride content in groundwater of Bapoli block of Panipat district of Haryana. The study was carried out during April-May 2017.

MATERIALS AND METHODS

The state of Haryana is a major agricultural state of Indian Republic with an area of 44,212 Km2. The various districts of Haryana have fluoride issue in their groundwater (Haritash *et al.,* 2008). As there is no report on fluoride from Bapoli block so, it was decided to access the fluoride in groundwater of Bapoli block of Panipat district of Haryana. Panipat is lying in the east central part of Haryana State is located between $29^{0}09'15''$: $29^{o}27'25''$ north latitudes and $76^{o}38'30''$: $77^{o}09'15''$ east longitudes (figure 1).

A total of 40 water samples of ground water were collected from hand pumps and tube wells. The groundwater is not only used for irrigation purpose but also used for drinking also in the study area. The samples were collected in

Table 1 Detail of Parameters Analyzed along with Analytical Technique

Sr. No.	Parameter	Analytical Method
1	pH	pH meter (Systronics, 335)
2	Electrical Conductivity	Conductivity Meter (Systronic 304)
3	Total Dissolved Solids	United States Salinity Laboratory Staff (1954) Formula
4	Ca^{2+} , Mg^{2+} and Total Hardness	Ethylene diamine tetra acetic acid (EDTA) titration method
5	CO_3^{2-}, HCO_3^- and Total alkalinity	Sulphuric acid titration method
6	Chloride	Argentometric titration
7	Na^+ and K^+	Flame photometer
8	SO_4^{2}	Spectrophotometer
9	PO_4^{3}	Spectrophotometer
10	Fluoride	Fluoride ion specific electrode (Orion 96-09 BNWP)

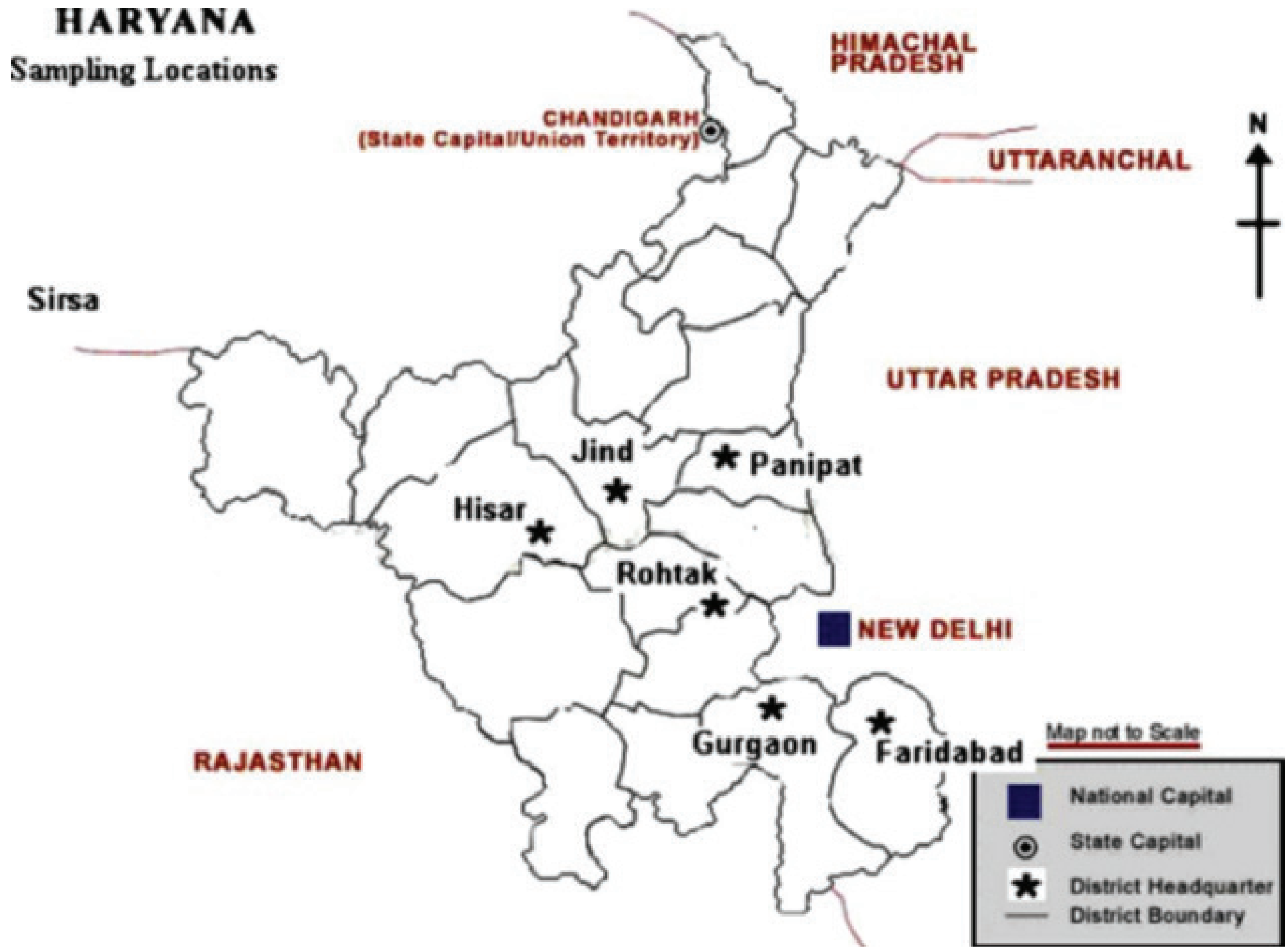

Figure 1: Location of Panipat Town in Haryana

sterilized polyethylene bottles of 500 ml capacity. Each sample's physical properties were measured in the field using portable meters (color, odor, taste, electrical conductivity and pH) at the time of sampling. The collected samples were kept in ice box and transported immediately to the laboratory for analysis by using methods as prescribed by APHA (1995). The detail of parameters analyzed along with method used to analyze is presented in table 1.

RESULT AND DISCUSSIONS

The table 2 shows the result of groundwater quality analysis of study area. All the studied samples had no color, odor and turbidity. The taste of studies samples was slightly saline at some of locations.

The pH value of groundwater in the study area varies from 7.00 to 8.20 with a mean of 7.58. It was observed that most of the analyzed water samples were alkaline in nature and pH of all the water samples was within the safe limits.

The electrical conductivity ranged from 0.49 to 4.4 mS with a mean of 1.99. The electrical conductivity test is carried out to measures the concentration of ions in a solution. In other words it is property of solution which indicates that how well the water conducts an electrical current and it is proportional to the concentration of ions in solution.

The total dissolved salts (TDS) content was 300-2800 mg/l with an average of1280 mg/l. The higher amount of TDS is may be due to the presence of higher concentration of

Table 2: Ground water quality at Bapoli block of district Panipat

S.N.	pH	EC	TDS	TH	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^{-}	TA	Cl^{-}	SO_4^{2-}	PO_4^{3-}	F^{-}
1	7.8	1.09	700	1596	180	13	87	28	0	1147	1215	75	893	0.24	1.76
2	7.9	1.09	700	1000	190	12	28	72	0	741	810	71	815	0.28	1.75
3	7.3	4.37	2800	356	230	13	28	66	0	908	1012	69	138	0.20	1.55
4	7.5	4.4	2800	376	250	12	28	65	0	215	285	112	176	0.05	1.60
5	7.3	0.62	400	420	100	21	31	68	0	526	615	639	216	0.19	0.86
6	7.3	2.81	1800	332	160	12	101	23	0	382	415	284	128	0.14	1.50
7	7.9	1.82	1200	368	260	11	71	40	0	119	195	80	8	0.13	0.37
8	8.0	1.82	1200	340	120	11	40	62	0	143	185	58	80	0.20	0.40
9	8.1	0.93	600	336	60	12	81	34	0	119	180	70	82	0.18	0.38
10	7.8	3.78	2400	356	190	12	36	68	0	143	159	70	87	0.14	0.30
11	8.0	2.5	1600	348	100	12	46	63	0	550	635	258	123	0.19	0.24
12	7.6	0.62	400	344	80	12	84	44	0	549	625	116	116	0.17	0.42
13	7.4	0.49	300	356	310	12	81	37	0	334	410	70	101	0.12	0.64
14	7.6	0.62	400	344	220	12	76	38	0	119	190	55	141	0.33	0.30
15	7.5	0.62	400	368	170	12	97	30	0	119	185	57	104	0.20	0.25
16	7.8	2.69	1700	98	120	12	95	28	0	119	180	62	81	0.18	0.25
17	7.9	1.4	900	392	210	13	80	37	0	119	175	52	73	0.14	0.35
18	7.8	1.09	700	356	250	10	140	32	0	717	815	97	115	0.11	0.32
19	7.6	0.62	400	348	210	11	42	33	0	715	810	98	91	0.11	0.33
20	7.8	0.62	400	368	210	10	39	36	0	454	510	172	91	0.33	0.34
21	7.9	1.25	800	356	210	10	56	52	0	645	715	706	173	0.19	1.50
22	8.2	1.09	700	120	150	10	43	15	0	536	685	302	337	0.09	1.20
23	7.9	1.09	700	160	180	11	65	19	0	529	615	71	106	0.09	1.35
24	8.0	1.25	800	740	270	10	35	15	0	480	550	64	136	0.16	1.35
25	7.5	3.43	2200	810	180	12	25	14	0	418	495	67	126	0.04	1.35
26	7.2	2.5	1600	850	170	20	31	18	0	419	490	135	185	0.07	1.40
27	7.2	2.34	1500	410	250	21	120	107	0	478	510	163	186	0.07	1.40
28	7.5	1.56	1000	400	320	11	232	62	0	478	505	165	195	0.01	1.20
29	7.2	2.81	1800	730	140	31	160	170	0	477	515	213	124	0.00	1.05
30	7.1	2.81	1800	393	690	13	105	36	0	479	515	220	196	0.00	1.20
31	7.2	1.25	800	310	120	12	105	75	0	540	612	199	193	0.11	1.20
32	7.4	1.25	800	280	230	13	200	49	0	635	712	156	88	0.09	1.20
33	7.9	3.43	2200	790	270	14	200	54	0	418	512	348	102	0.15	1.25
34	7.2	3.59	2300	770	140	11	95	18	0	539	610	327	318	0.18	1.20
35	7.1	3.12	2000	690	140	11	75	22	0	478	510	376	125	0.28	1.40
36	7	3.12	2000	690	330	21	78	145	0	536	610	309	308	0.14	1.25
37	7.2	3.28	2100	370	330	21	220	53	0	479	510	209	171	0.00	1.40
38	7.4	3.28	2100	390	320	21	230	28	0	477	510	202	191	0.13	1.35
39	7.6	1.71	1100	110	320	20	220	34	0	410	496	216	188	0.08	1.35
40	7.7	1.71	1100	230	370	20	105	26	0	479	515	245	186	0.07	1.35
Av.	7.58	1.99	1280	460.0	219	13.9	92.7	47.9	0	454.2	520	181.4	182.3	0.14	0.99
SD	0.32	1.15	737.3	281.9	108	4.64	61.9	32.8	0	225.7	235	148.0	170.1	0.08	0.50
Min	7.0	0.49	300	98	60	10	25	14	0	119	159	52	8	0.00	0.24
Max.	8.2	4.4	2800	1596	690	31	232	170	0	1147	1215	706	893	0.33	1.76
No. of samples having Fluoride (mg/l) below permissible limit														34	
No. of samples having Fluoride (mg/l) above permissible limit														06	

All parameters have been expressed as mg/L except pH and EC. The units of EC are mS.

salts of sodium, calcium, and magnesium. The drinking water has been classified by Rabinove *et al.,* (1958) on the basis of salinity contents and according to those18 samples were non saline while22 samples were slightly saline. The sources of dissolved salts in ground water may be natural (e.g. soil minerals) as well as anthropogenic (e.g. agrochemicals). The health risk due to consumption of drinking water with high dissolved salts reported from Haryana by Gupta and Misra (2018).

Hardness in groundwater is imparted by the sum of polyvalent metallic ions. Although different ions contribute to hardness but calcium and magnesium are the major components. Groundwater is naturally hard may be due to weathering and dissolution of limestone, dolomite and chalk etc. The hardness of studied samples varied between98 to 1596 mg/l with an average of 460 mg/l. The result reveals that only four water samples had hardness lesser than 180 mg/l. A perusal of data shows that groundwater from study area exhibits high alkalinity, chloride and sulphate content and it is well proved that these contributes to hardness (Thapliyal *et al.,* 2011).

Hardness of water has negative as well as positive impacts. Very hard water is not only suitable for drinking purpose but also has various drawbacks e.g. it consume more soap during leathering, form scale deposits on pipes, basins, pots and boilers. However, in certain conditions hardness may also be advantageous e.g. metal ions form a thin layer of scales in water supply pipes which prevents the corrosion and entry of heavy metals. This process is known as plumbosolvency. The calcium and magnesium content also showed variation.

Alkalinity is a property of water that helps to neutralize the acid impacts. In other words we can say that this is the property of water which resist or dampen changes in pH. The various compounds which impart alkalinity to water are bicarbonates, carbonates, and hydroxides etc. These anions help in removal of H+ ions and increase the pH of the water. Total alkalinity (TA as $CaCO_3$) varied from 159 to 1215 mg/l with a mean value of 520 mg/l. The literature shows that high alkalinity is may be due to intense chemical weathering of the parent rocks.

Sodium content of studied groundwater samples was between 60 to 690 mg/l and mean sodium content was219mg/l. The potassium content varied from 10 to 31 mg/l with a mean of 13.9 mg/l. However, these are obviously present in subsurface water but various anthropogenic activities e.g. domestic and industrial effluents and wastes may also contribute these ions to groundwater. Generally concentration of potassium ions is lesser than sodium ions in groundwater.

Chloride in groundwater may be originated from natural as well as manmade sources. The natural sources are chloride rich minerals while manmade sources may include septic tanks, fertilizers, industrial and domestic effluents etc. The chloride content of analyzed water samples was between52 to 706 mg/l and a mean of 181.4 mg/l. Presence of high chloride content in groundwater makes it salty and bitter i.e. unfit for drinking purpose. Moreover, excess chloride may cause economic loss due to corrosion of iron and steel.

The sulphate content of analyzed groundwater samples ranged from 08 to 893 mg/l with an average of 182.3 mg/l. It is a naturally occurring ion which contributes to total hardness in water.

The phosphate content ranged from 00 to 0.33 mg/l with an average of 0.14 mg/l. Generally groundwater consist of negligible concentration of phosphate however, different sources which may contribute phosphate to groundwater are domestic sewage, septic tanks leakage, indiscriminate use of fertilizers and animal excreta etc.

Fluoride has both beneficial and adverse effects on human health. Its deficiency i.e. consumption of less than 0.5 mg/l F enhance the formation of cavity in jaws; affect bone health (Jones *et al.,* 1997; Acharya *et al.,* 2008) while excess intake i.e. more than 1.5 mg/l may lead to dental fluorosis (WHO, 1996, 2008). Thus, less than 1.0 mg/l of fluoride content in drinking water is optimal for prevention of dental caries and bone mineralization especially in children (WHO 1997; Hussain *et al.,* 2010). However, Nawlakhe and Bulusu (1989) have reported that skeletal and crippling fluorosis may occur when drinking water has high F i.e. more than 3 mg/l and consumed for 8-10 years. The severity of fluorosis depends on the level of fluoride content and duration of its exposure (Gazzano *et al.,* 2010). Thus, excess intake of fluoride cause dental, skeletal and crippling fluorosis and non-skeletal fluorosis (Zhang *et al.,* 2003).

The fluoride level of studied samples was within the admissible limit for maximum samples and it was between 0.24 to 1.76 mg/l. The average fluoride content was 0.99 mg/l. Out of 40 samples analyzed from Bapoli block, 34 samples had fluoride content within permissible limit and 06 samples had fluoride content above the permissible limit. The frequency distribution of fluoride in groundwater of Bapoli showed that 15 samples had fluoride in the range of 0.0-1.0, 21 samples exhibited fluoride between 1.0-1.5 and 6 samples had showed fluoride in the range of 1.5-3.0 mg/l respectively.

CONCLUSION

The groundwater quality of Bapoli block of Panipat district of Haryana was assessed for various drinking water quality parameters along with fluoride. The research exhibits that groundwater was alkaline and fluoride content ranged from 0.24 to 1.76 mg/l. maximum of the studied water samples had fluoride content within safe range. According to Bureau of Indian Standards the desirable fluoride concentration in drinking water under Indian condition is 0.6 to 1.2 mg/l and it can be extended up to max. 1.5 mg/l in case of non-availability alternate source of water.

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REFERENCES

Acharya G.D., Hathi M.V, Patel AD, Parmar K.C (2008). Chemical properties of groundwater in BhilodaTaluka Region, North Gujarat, India. *E-J Chem* 5(4):792–796

Adimalla N. (2018). Groundwater quality for drinking and irrigation purposes and potential health risks assessment: a case study from semi-arid region of south India. *Expo Health.* https ://doi.org/10.1007/s1240 3-018-0288-8

Adimalla N. and Li P. (2018). Occurrence, health risks, and geochemical mechanisms of fluoride and nitrate in groundwater of the rock-dominant semi-arid region, Telangana State, India. *Hum Ecol Risk Assess* 1–23. doi:10.1080/10807039.2018.1480353.

Adimalla N, Li. P, and Venkatayogi S. (2018a).Hydrogeochemical evaluation of groundwater quality for drinking and irrigation purposes and integrated interpretation with water quality indexstudies. *Environ Process* 5(2):363–83. doi:10.1007/s40710-018-0297-4

Adimalla N, Vasa S.K, Li P. (2018). Evaluation of groundwater quality, Peddavagu in Central

Telangana (PCT), south India: an insight of controlling factors of fluoride enrichment. *Model Earth Syst Environ* 4(2):841–852. https //doi.org/10.1007/s4080 8-018-0443-z

Adimalla N, Venkatayogi S (2017). Mechanism of fluoride enrichment in groundwater of hard rock aquifers in Medak, Telangana state, south India. *Environ Earth Sci* 76:45. https ://doi. org/10.1007/s1266 5-016-6362-2 Vol:.(1234567890)

Apambire W.B, Boyle D.R, Michel F.A (1997). Geochemistry, genesis, and health implications of fluoriferous groundwater in the upper regions of Ghana. *Environ Geol* 33(1):13–24. https ://doi. org/10.1007/s0025

APHA, American Public Health Association (1995). Standard Methods for the Examination of Water and Waste Water. 19th Edition Washington, DC,

Ayoob S, Gupta A.K (2006). Fluoride in drinking water: a review on the status and stress effects. *Crit Rev Environ Sci Technol* 36:433–487

Emenike C.P, Tenebe I.T, Jarvis P (2018). Fluoride contamination in groundwater sources in southwestern Nigeria: assessment using multivariate statistical approach and human health risk. *Ecotoxicol Environ Saf* 156:391–402

Garg, V.K., Suthar,S., Singh, S., Sheoran, A., Garima, Meenakshi and Jain, S. (2008). Drinking water quality in villages of southwestern Haryana, India: assessing human health risks associated with hydrochemistry. *Environ Geol* DOI 10.1007/s00254-008-1636-y.

Gazzano E., Bergandi L., Reganti C., Aldieri E., Doublier S., Costamagna C., Bosia A., GhigoD. (2010). Fluoride effects: The two faces of Janus. *Curr. Med. Chem*. 17(22), 2431-2441.

Gupta, R. and A.K. Misra. 2018. Drinking water quality problem in Haryana, India: Prediction of human health risks, economic burden and assessment of possible intervention options. *Environ. Develop. Sustain.,*pp.1-15.

Haritash A.K, Kaushik C.P, Kaushik A, Kansal A, Yadav A.K (2008). Suitability assessment of groundwater in some villages of Rewari district in Haryana. *Environ Monit Assess* 145(1–3):397–406.

Haritash A.K, Aggarwal A, SoniJigyasa, Sharma Khyati, SapraMohnish and Singh Bhupinder (2018). Assessment of fluoride in groundwater and urine, and prevalence of fluorosis among school children in Haryana, India. *Appl Water Sci*. 8:52 https://doi.org/10.1007/s13201-018-0691-0

Hussain J, Hussain I, Sharma KC (2010). Fluoride and health hazards: community perception in afluorotic area of Central Rajasthan (India): an arid environment. *Environ Monit Assess* 162:1–14

Jones C.M, Taylor G.O, Whittle J.G, Evans D, Trotter D.P (1997). Water fluoridation, tooth decay in 5 year olds, and social deprivation measured by the Jarman score: analysis of data from British dental surveys. *BMJ* 315:514–517

Khaiwal R, Garg V.K (2007). Hydro-chemical survey of groundwater of Hisar city and assessment of defluoridation methods used in India. *Environ Monit Assess* 132(1–3):33–4.

Meenakshi, Garg V.K, Kavita, Renuka, Malik A (2004). Groundwater quality in some villages of Haryana, India: focus on fluoride and fluorosis. *J Hazard Mater* 106B: 85–97.

Mor S, Bishnoi M, Bishnoi N.R (2003). Assessment of groundwater quality of Jind city. *Indian J Environ Protection* 23:673–679.

Narsimha A, Rajitha S (2018). Spatial distribution and seasonal variation in fluoride enrichment in groundwater and its associated human health risk assessment in Telangana state, south India. *Hum Ecol Risk Assess Int J* 24(8):2119–2132. https ://doi. org/10.1080/10807 039.2018.14381 76

Narsimha A, Sudarshan V (2017). Assessment of fluoride contamination in groundwater from Basara, Adilabad district, Telangana state, India. *Appl Water Sci* 7(6):2717–2725. https ://doi. org/10.1007/s1320 1-016-0489-x

Narsimha A, Sudarshan V (2017). Contamination of fluoride in groundwater and its effect on human health: a case study in hard rock aquifers of Siddipet, Telangana state, India. *Appl Water Sci* 7(5):2501–2512. https ://doi.org/10.1007/s1320 1-016-0441-0

Narsimha A, Sudarshan V (2018). Drinking water pollution with respective of fluoride in the semi-arid region of Basara, Nirmal district, Telangana state, India. *Data Brief* 16:752–757. https :// doi.org/10.1016/j.dib.2017.11.087

Nawlakhe W.G and Bulusu K.R (1989).Nalgonda Technique: A Process for Removal of Excess Fluoride from waters, *Water Quality Bulletin*, Vol. 14, pp. 218-220.

Rabinove C.J, Long Ford R.H, Brook Hart J.W (1958). Saline water sources of north Dakota. *US Geological Survey Water Supply Paper* 1428, 72.

Ray R.K, Syed T.H, Saha D, *et al.,* (2017). Assessment of village-wise groundwater draft for irrigation: a field-based study in hard-rock aquifers of central India. *Hydrogeol J* 25(8):2513–25. doi: 10.1007/s10040-017-1625-x

Reddy A.G.S (2013). Geochemical evaluation of nitrate and fluoride contamination in varied hydrogeological environs of Prakasam district, southern India; *Environ. Earth Sci*. 71 4473–4495.

Sajil Kumar P. J, Jegathambal P and James E. J (2014). Factors influencing the high fluoride concentration in groundwater of Vellore district, South India; *Environ. Earth Sci.* 72(7) 2437–2446.

Shaji E, Viju B.J, Thambi D.S (2007). High fluoride in ground waters of Palghat district, Kerala. *Current Sci* 92(2):240–246

Singh, B., Gaur, S., &Garg, V. K. (2007). Fluoride in drinking water and human urine in southern Haryan, India. *Journal of Hazardous Material*, 144(1–2), 147–151.

Singh, B. and Garg, V. K. (2013).Fluoride Signatures in Groundwater and Dental Fluorosis in Permanent Teeth of School Children in Rural Areas of Haryana State, India. *International Journal of Occupational and Environmental Medicine* 4(2): 107-108.

Singh, Bhupinder (2011) Assessment of Groundwater Quality With Respect to Fluoride. *Universal Journal of Environmental Research and Technology* 1:45-50.

Singh, B. and Garg, V.K., 2012. Fluoride quantification in groundwater of rural habitations of Faridabad, Haryana, India. *Int. J. Environ. Protection*, **2**, 8-17.

SubbaRao N, Dinakar A, Surya Rao P, Rao P N, Madhnure P, Prasad K M and Sudarshan G (2016). Geochemical processes controlling fluoride bearing groundwater in the granite aquifer of a semi-arid region; *J. Geol. Soc. India* **88** 350–356.

SubbaRao N, Marghade D, Dinakar A, Chandana I, Sunitha B, Ravindra B, Balaji T (2017). Geochemical characteristics and controlling factors of chemical composition of groundwater in a part of Guntur district, Andhra Pradesh, India. *Environ Earth Sci* 76:747. https ://doi.org/10.1007/s1266 5-017-7093-8

Thapliyal, A., P. Vasudevan, M.G. Dastidar, M. Tandon and S. Mishra. 2011. Irrigation with domestic wastewater: Responses on growth and 1 yield of ladyfinger Abelmoschusesculentus and on soil nutrients. *J. Environ. Biol*., **32**, 645-651.

United States Salinity Laboratory (1954). Diagnosis and improvement of saline and alkaline soils United States Dept. of Agriculture. *Hand Book*, No. 60 (p. 160).

WHO (World Health Organization) (1996).Water and sanitation facts sheets. N112. http://www.who.int/inf-fs/en/fact112.html

WHO (World Health Organization) (1997). Guideline for drinking water quality health criteria and other supporting information, vol. 2, 2nd edn. Geneva.

WHO (World Health Organization). 2008. International standards for drinking water, 3rd edn, Geneva

Yadav J.P, Lata S, Kataria S.K, Kumar S (2009). Fluoride distribution in groundwater and survey of dental fluorosis among school-children in villages of Jhajjar District of Haryana, India. *Environ Geochem Health* 31:431–438

Zhang, B. Hong, M., Zhao, Y., Lin, X., Zhang, X., and Dong, J. (2003). Distribution and risk assessment of fluoride in drinking water in theWest Plain region of Jilin Province, China. *Environ. Geochem. Health* 25: 421–431.