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RESEARCH ARTICLE

ASSESSMENT OF FLUORIDE CONTAMINATION SCENARIO OF GROUNDWATER: A STUDY ON PURULIA-I AND PURULIA-II BLOCK, PURULIA DISTRICT, WEST BENGAL

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ABSTRACT

In recent time, Purulia district of the West Bengal faces a problem of occurrence of fluoride in groundwater and it gradually the scenario become serious. People of the many villages in Purulia-I and Purulia-II blocks have been marked with fluorosis after consuming fluoride contaminated water. Geologically, this study area is underlain by pre- cambrian metamorphic rocks like granite and gneiss etc. and have the semi- arid climatic condition. In present study a high fluoride concentration in groundwater is identified in a number of villages like Pattamputra, Bhul, in Purulia-I block and Hutmura, Chirumacha in Purulia-II blocks in Both post- monsoon and pre- monsoon season. In some of the village fluoride level have identified below the detection level. The average fluoride concentration of the study area in post monsoon and pre – monsoon season is 0.7215 mg/l and 0.8215mg/l respectively. The other water parameters such as pH, iron, and total hardness were also measured to find out the find out the hydro chemical relationship fluoride and other parameters. The groundwater of the study area is found acidic in nature but a positive relationship has been observed among the fluoride concentration and p^H. Fluoride concentration has negative relation with iron and total hardness. The hydro - geological condition of the study area is a key factor for the occurrence of fluoride concentration in groundwater.

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INTRODUCTION

The major part of the rural population in developing country like India, depend on groundwater for their daily use of drinking purpose. On the other hand groundwater quality has been ditoriated gradually day by day due to natural and anthropogenic activities. Fluoride contamination in groundwater is a problem in many parts of the world as well as India and West Bengal. Fluoride compounds are states that form when the element, fluorine, combines with minerals in soils or rocks. Fluoride exists as a minor trace element in water and has profound toxic effects if present beyond the permissible limit. These effects come in subtle insidious ways that are difficult to detect, particularly when the fluoride content is unusually low in natural water system (Chakrabarti *et al*., 2013). Factors like temperature, p^H, solubility of fluorine bearing minerals, anion exchange capacity of aquifer bering minerals and the nature of geological formations drained by water and contact time of water with a particular formation are depending variables of fluoride contamination of natural water (Raju *et al*., 2009). Fluoride in minute quality is an essential element which is good for mineralisation of bones formation of teeth enamel and helps to prevent dental caries. World Health Organisation (WHO) recommended that 0.5 mg/ litre is ideal as prevent dental fluorosis. Excessive ingestion of fluoride in human body my causes different diseases, are called fluorosis, such as dental fluorosis, skeletal fluorosis, non skeletal fluorosis (WHO, 2006). According to BIS (Bureau of Indian Standard) and ICMR the desirable limit of fluoride is specified at 1.00 mg/ litter and maximum permissible limit at 1.50 mg / litter[4]. High fluoride concentrations and fluorosis in the country are commonly associated with rural areas, arid and semi arid climate, granites and gneisses and advanced stage of groundwater development (Handa 1988). Several districts of the states of Andhra Pradesh, Kerala, Gujrat, Haryana, Punjab, Rajasthan Tamil Nadu, Uttar Pradesh, Jharkhand, and West Bengal are facing the problem of fluoride hazard. In West Bengal, excess fluoride in groundwater has been found as far in 43 blocks spread over 7 (seven) districts viz. Purulia, Birbhum, Bankura, Maldah, North and South Dinajpur, and south 24 Parganas (Bhattyacharya, 2009; Raju *et al*., 2009).

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Study area

Present study is conducted in the Purulia –I and Purulia –II block of Purulia district, West Bengal, India. 26 villages have been randomly selected from these two blocks (13 from each block) for the purpose of this study. Purulia district is a part of Chotanagpur plateau region. The district is characterized by undulating topography with rugged hilly terrain in the western and southern part. General elevation ranges from 100 to 300 meters. Master slope ranges between 10 to 20 m/ km. climatologically, Purulia district falls under semi-arid and drought-prone region. The monthly temperature varies between 7.8 ^{o}C to 46.8 ^{o}C from winter to summer. Average rainfall recorded during last fifty years is 1375.2mm. The main rivers are Kangsabati and Kumari and their tributaries and they are flowing from northwest to south east direction. From geological point of view, the district is underlying by rocks of Precambrian and Archean ages represented by granite, gneiss, calgranulite, ultrabasic and metamorphic rocks, including crystalline lime stone, hornblend schist, biotic gneiss, pegmatite vein. The groundwater in the district occurs in the weathered zone within 10 mbgl and or shallow fracture zones forming unconfined to semi confined aquifers. The depth of the water level varies from 3.63- 9.76 mbgl in pre-monsoon and1.32 – 7.3 mbgl in post monsoon period (Saha, 2015).

Objectives

The objectives of the present study are as follows:

- To assess the occurrence and spatial variation of fluoride contamination in groundwater during pre and post-monsoon situation.
- To study the nature of the concentration of fluoride and hydro-chemical impact.
- To find out the impact on the human health due to intake of fluoride contaminated water.

Methodological issues

In order to assess the fluoride contamination in groundwater, total 45 water samples have been collected from 26 villages of Purulia-I and Purulia-II blocks during both post-monsoon season (December, 2014) and pre-monsoon season (April and May, 2015). Water samples were collected from those tube wells which have been presently used for drinking purposes. The water samples collected in the field were tested in the laboratory using the Standard Methods given by American Public Health Association. The results were evaluated in accordance with drinking water quality standards given by the WHO (World Health Organisation.

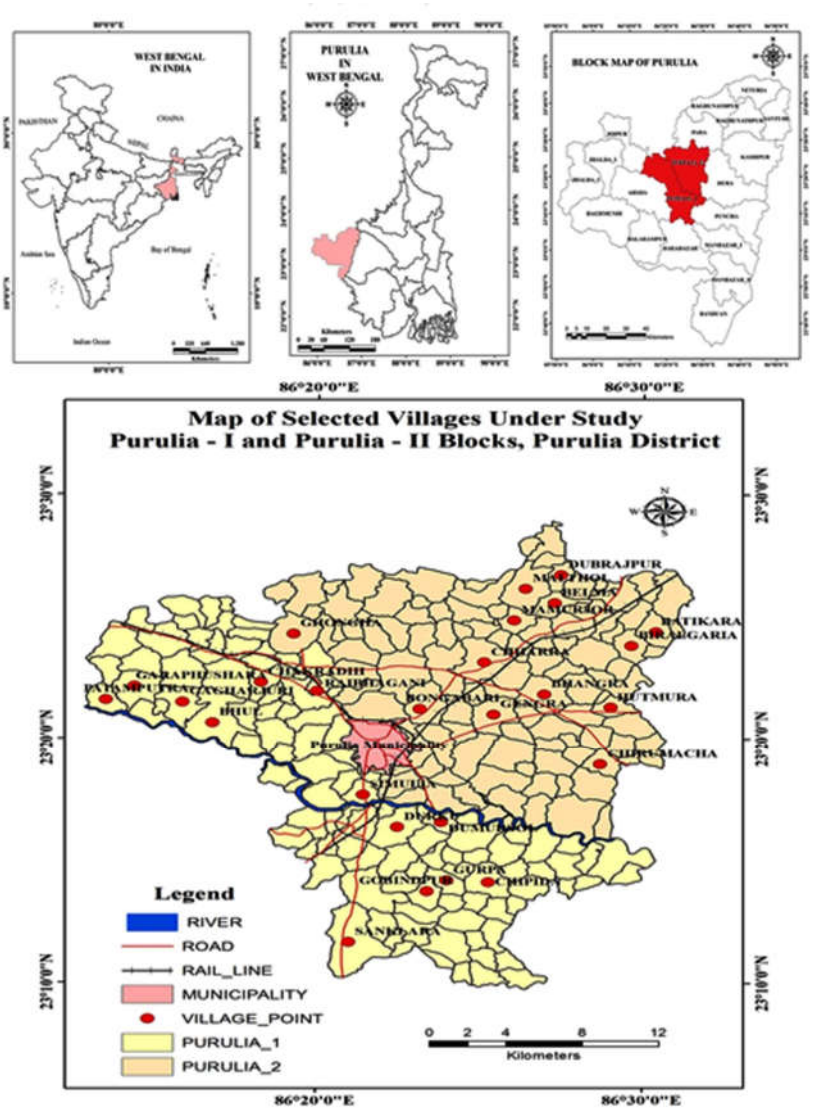

Fig. 1. Location of the Study Area

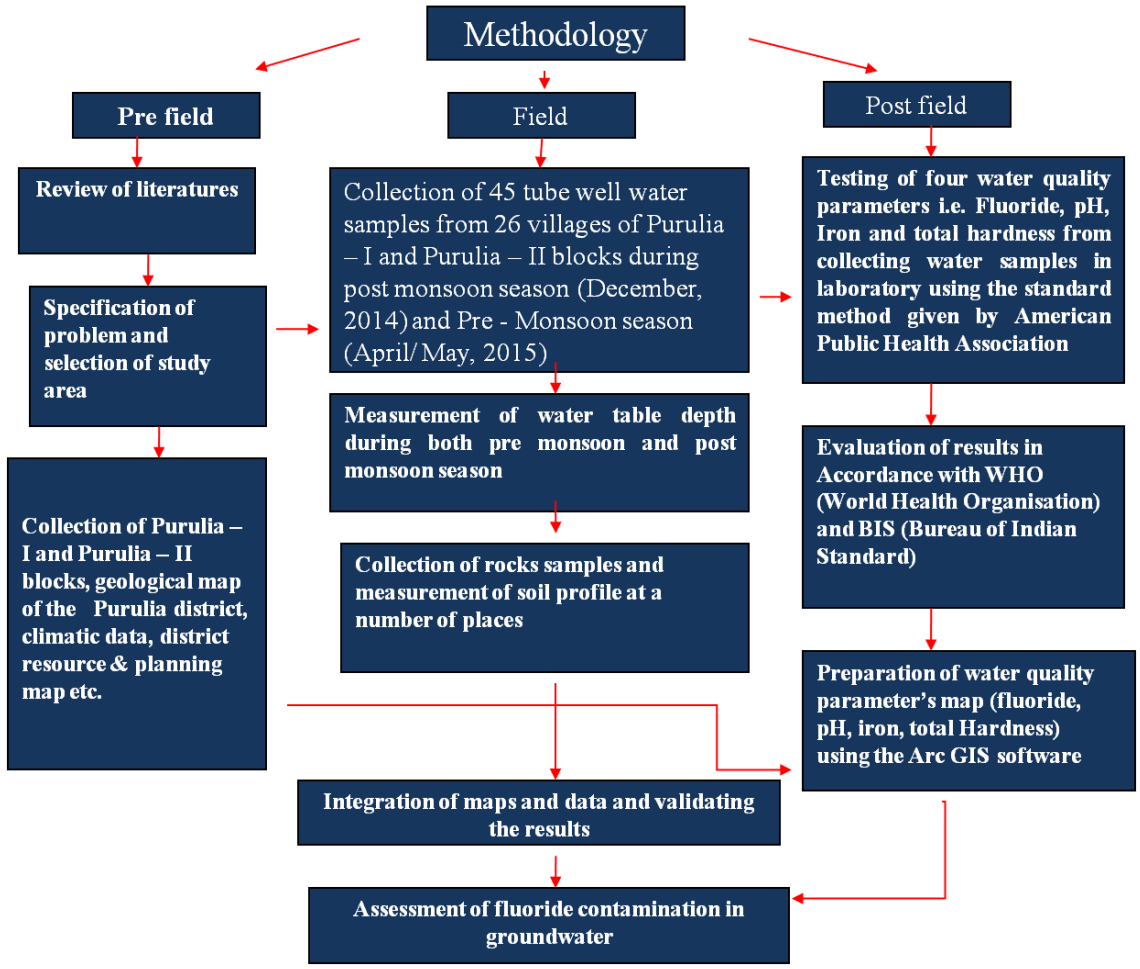

Fig.2. Methodology of the study in Flowchart

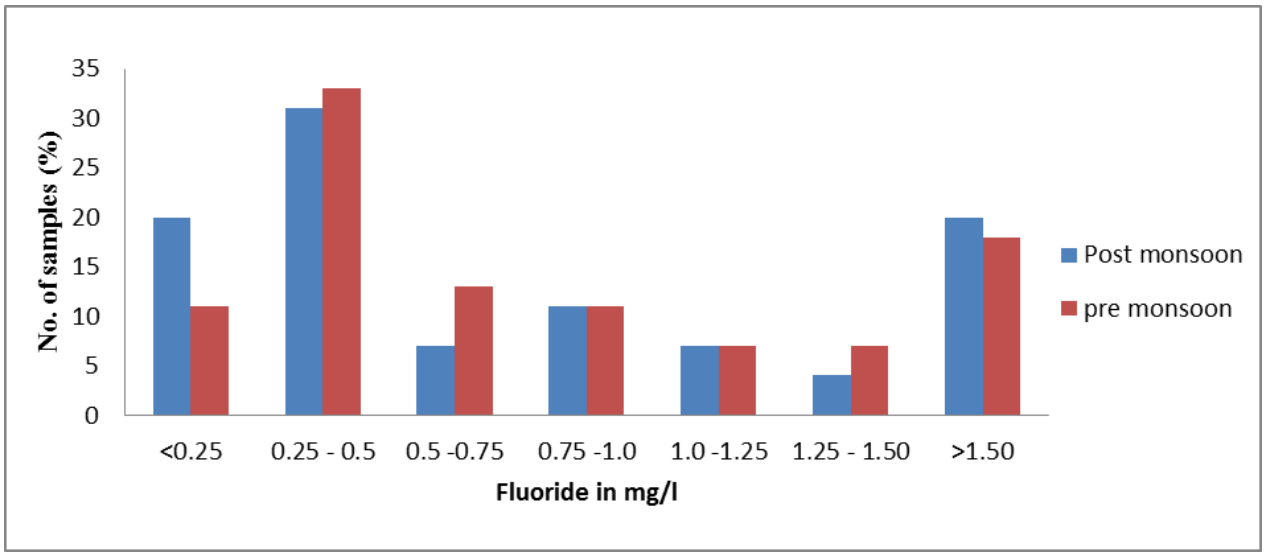

Figure 3. Frequency distribution of fluoride during post-monsoon season (December, 2014) and pre-monsoon season (April/May, 2015)

RESULTS AND DISCUSSION

The four water quality parameter namely fluoride, p^H, Iron (Fe) and hardness have been studied. In the Table.1 the summarised mean values of fluoride (F), p^H, iron (Fe) and total hardness (TH) have given. The data show s significant variations in the water samples.

Distribution of fluoride in groundwater of the study area

The distribution of fluoride during both the pre-monsoon season and post monsoon season are presented in table-1.a and 1.b. During post monsoon season (month of December) the mean fluoride value in groundwater varies from 0.13 mg/l to 1.76 mg/l and in case of both blocks, Purulia-I and Purulia–II

the average mean value of fluoride is 0.722 mg/l. The maximum fluoride concentration has been found at Pattamputra Village of Purulia – I block i.e. 2.23 mg/l. During pre-monsoon season (month of April and May) the mean fluoride value in groundwater varies from 0.104 mg/l to 2.16 mg/l and in case of both blocks, Purulia-I and Purulia –II the average mean value of fluoride is 0.8025 mg/l. In this season, the maximum fluoride concentration of 3.42 mg/l has been found at Pattamputra village of purulia –I block.

The frequency distribution and range of occurrence of fluoride during post monsoon and pre-monsoon season are presented in the table- 1 and 2. Fluoride varied from a minimum level of 'below detectable limit' to 2.23 mg/l and 3.42 mg/l subsequently during post-monsoon season and pre-monsoon season. To show the frequency distribution all the samples are categorized into 7 classes. There are 20 % samples during post monsoon season and 11% samples during pre- monsoon season have the fluoride value below the detection level (< 0.25 mg/l) and 20 % samples have found under the > 1.5 mg/l during post- monsoon season which is reduced in 18 % during

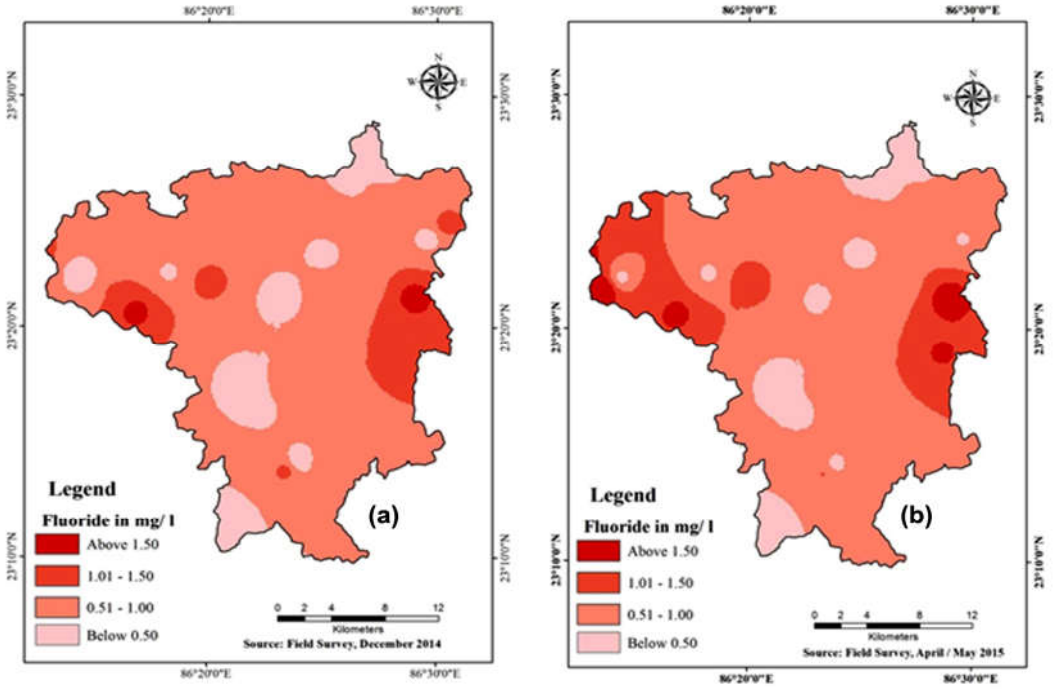

Figure 4. a-Spatial distribution of fluoride in groundwater during post-monsoon season (December, 2014) and b-Spatial distribution of fluoride in groundwater during pre-monsoon season (April/may, 2015)

Table 1. Availability of Fluoride (mg/l), pH, Iron (mg/l) and Hardness (mg/l) in Study Villages in Pre-Monsoonal Time

Block	Villages	No. of Sample	Fluoride mg/l		pH		Iron mg/l		Hardness mg/l	
			Max	Mean	Max	Mean	Max	Mean	Max	Mean
Purulia- I	Gobindpur	3	1.30	1.01	6.51	6.38	3.00	1.50	330	250
	Gurpa	2	0.38	0.38	6.24	6.11	0.50	0.50	380	330
	Raibaghini	2	1.59	1.33	6.29	6.21	0.30	0.25	180	170
	Bhul	2	1.82	1.70	6.97	6.74	0.50	0.30	360	300
	Ghagarjhury	2	1.31	1.23	6.86	6.71	0.30	0.18	320	280
	Pattamputra	3	3.42	2.16	6.66	6.60	0.20	0.17	400	327
	Garafushra	1	0.36	0.36	5.86	5.86	1.00	1.00	520	520
	Snklara	1	0.28	0.28	5.91	5.91	0.20	0.20	180	180
	Durku	2	0.35	0.35	5.85	5.85	0.50	0.50	400	245
	Simulia	1	0.33	0.33	5.71	5.71	0.10	0.10	140	140
	Chipida	1	0.83	0.83	6.00	6.00	0.40	0.40	160	160
	Chakradih	1	0.40	0.40	5.81	5.81	0.30	0.30	420	420
	Dumursole	1	0.86	0.86	6.14	6.14	0.70	0.70	140	140
	Charrah	2	0.46	0.38	6.74	6.54	0.30	0.20	520	440
	ghonga	2	0.68	0.61	6.57	6.43	0.10	0.06	440	420
	Bongabari	2	0.46	0.43	6.32	6.15	0.40	0.30	420	325
	Chirumacha	1	1.56	1.56	6.36	6.36	0.20	0.20	180	180
	Hutmura	1	1.94	1.94	6.40	6.40	0.20	0.20	180	180
Purulia- II	Biralgoria	2	0.25	0.46	6.39	6.38	0.40	0.35	200	170
	Batikara	2	0.80	0.75	6.58	6.28	0.50	0.30	480	360
	Belma	3	1.67	0.86	6.40	6.32	3.00	1.50	580	373
	Dubrajpur	2	0.39	0.38	6.44	6.23	0.30	0.20	480	240
	Malthore	2	1.06	0.66	7.11	6.79	0.50	0.28	480	350
	Mamurjhore	2	0.21	0.10	6.45	6.26	0.50	0.25	480	350
	Gengara	1	0.67	0.67	6.12	6.12	0.30	0.30	300	300
	Bhangra	1	0.83	0.83	6.39	6.39	0.10	0.10	160	160
		45		0.80		6.26		0.40		281.154

Source: Primary Survey

Table 1. Availability of Fluoride (mg/l), pH, Iron (mg/l) and Hardness (mg/l) in Study Villages in Post Monsoon Time

Block	Villages	No. of Sample	Fluoride mg/l		pH		Iron mg/l		Hardness mg/l	
			Max	Mean	Max	Mean	Max	Mean	Max	Mean
Purulia- I	Gobindpur	3	2.00	1.14	6.99	6.38	1.20	0.57	340	267
	Gurpa	2	0.18	0.13	6.51	6.11	0.80	0.65	760	590
	Raibaghini	2	1.61	1.21	6.58	6.21	0.50	0.28	360	300
	Bhul	2	1.77	1.73	6.74	6.74	0.50	0.30	240	220
	Ghagarjhury	2	1.33	1.03	6.95	6.71	0.50	0.48	360	290
	Pattamputra	3	2.23	1.73	6.78	6.60	1.20	0.33	480	360
	Garafushra	1	0.13	0.13	6.01	5.86	0.50	0.50	800	800
	Snklara	1	0.28	0.28	6.02	5.91	0.20	0.20	180	180
	Durku	2	0.35	0.30	6.09	5.85	0.40	0.30	400	245
	Simulia	1	0.33	0.33	5.85	5.71	0.50	0.50	160	160
	Chipida	1	0.85	0.85	6.25	6.00	0.40	0.40	160	160
	Chakradih	1	0.83	0.83	6.25	5.81	0.50	0.50	160	160
	Dumursole	1	0.44	0.42	6.24	6.14	3.00	2.10	780	550
	Charrah	2	0.54	0.38	6.78	6.54	0.40	0.30	580	430
	ghonga	2	0.79	0.54	6.61	6.43	0.40	0.20	500	450
	Bongabari	2	0.32	0.28	6.46	6.15	1.00	0.85	460	350
	Chirumacha	1	1.48	1.48	6.39	6.36	0.20	0.20	100	100
	Hutmura	1	1.76	1.76	6.53	6.40	0.30	0.30	260	260
	Biralgoria	2	0.32	0.28	6.50	6.38	0.50	0.35	160	160
	Batikara	2	1.59	1.20	6.49	6.28	0.30	0.30	500	400
	Belma	3	1.92	0.92	6.67	6.32	2.00	1.03	720	487
	Dubrajpur	2	0.24	0.23	6.46	6.23	0.30	0.20	400	330
Purulia- II	Malthore	2	0.23	0.23	6.79	6.20	0.30	0.30	260	260
	Mamurjhore	2	0.84	0.84	6.97	6.26	0.30	0.30	180	180
	Gengara	1	0.27	0.27	6.31	6.12	2.00	2.00	340	340
	Bhangra	1	0.25	0.25	6.67	6.39	0.02	0.20	140	140
		45		0.72		6.23		0.52		314.192

Source: Primary Survey

pre-monsoon season. So these two categories have a negative change in fluoride concentration i.e. the fluoride concentration decreases in pre- monsoon season. There are no changes in sample percentages under two categories i.e. 0.75 mg/l – 1.00 mg/l and 1.00 mg/l - 1.25 mg/l during both pre- monsoon and post- monsoon season. During post - monsoon season 31% samples contained fluoride 0.25mg/l to 5.0 mg/l, 7 % contained 0.5mg /l to 0.75 mg/l, 4 % contained 1.25 mg/l to 1.50 mg/l. But during pre–monsoon season, positive changes have been found under these categories for example, 33% of samples recorded a concentration of 0.25 mg/l to 0.5 mg/l, 13% of samples contained 0.5 mg/l to 0.75 mg/l and 7 % of samples contained 1.25 mg/l to 1.50 mg/l during pre- monsoon season (fig.-3). Fluoride concentration above the 1.5 mg/l, results in severe problems large part of the country. There are five isolated pockets with concentration ranging from 1.00 mg/l to 1.5 mg/l and two isolated pockets with fluoride concentration more than 1.5 mg/l were observed in post monsoon season (fig.4,a). where as in pre- monsoon season, there are three isolated pockets with concentration ranging from 1.00 mg/l to 1.5 mg/l and four isolated pockets with fluoride concentration more than 1.5 mg/l were observed (fig.4,b).

In the villages like Gobindpur, Bhul, Pattamputra in Purulia –I block and Hutmura, Chirumacha in Purulia –II block the samples contained 1.5 mg/l fluoride concentration have been recorded in both post-monsoon and Pre-monsoon season and have the mean fluoride concentration above 1.00mg/l.

Fluoride concentration and hydro-chemical environment of the study area

In this communication the relationship between fluoride concentration and the hydro chemical environment of groundwater in the study are have been analysed. In the figure-5, the relation of fluoride concentration with p^H, Iron, Total Hardness has been shown through scatter diagram. Plots of correlation between fluoride and other parameters indicate that fluoride concentration in the analysed water samples is governed by ph, iron and TH. There is positive correlation found between fluoride concentration and the pH values. Fluoride leaching is found to be best favoured under slightly alkaline condition (Chakrabarti and Bhattacharya, 2013)[5]. In acidic medium (acidic p^H), fluoride is absorbed in clay; however in alkaline medium, it is desorbed, and thus alkaline p^H is more favourable for fluoride dissolution activity (Saxena and Ahmed, 2001). The average p^H of the study area i.e. Purulia-I and II blocks in both season have been observed 6.25 and the mean p^H value ranges from 5.71 to 6.79 in both season which indicates the groundwater is mainly acidic in nature. From the fig.-5, it can be seen that fluoride concentration in the study area shows slightly positive correlation with p^H. It can also be observed from the table-1and 2 that the villages like Gobindpur, Pattamputra, Bhul, Ghagarjhuri which have the mean fluoride concentration above the 1.00 mg/l, have the mean pH value 6.5 though there have some exceptional cases. Total hardness (TH) is expressed in terms of amount of calcium carbonate. A strong negative correlation between Ca and F in the groundwater that contain Ca in excess of that required for the solubility of fluoride minerals has been observed by many researchers (Edmonds and Boyel, 1992). The average TH of the study area has been observed 314.19 mg/l in Post–monsoon season and 281.15 mg/l in pre-monsoon season. The average iron concentration of the study area is 0.525 mg/l in post-monsoon season and 0.3975 mg/l in pre-monsoon season. The negative correlation has been found between fluoride concentration and total hardness (TH) in the study area (fig.5).

Fluoride concentration and hydrogeology of the study area

Fluoride content in groundwater is mainly due to natural contamination but the process of dissolution is still not well understood (Handa, 1975; Saxena and Ahmed, 2001).

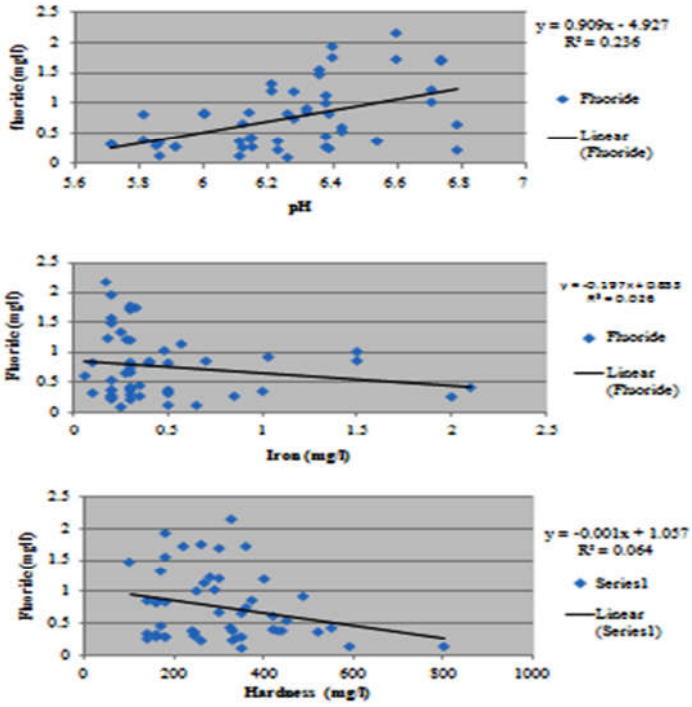

Fig. 5. Scatter diagrams showing the relationship of fluoride and pH, iron and total hardness

Figure 6. a, geological map of Purulia-I and II blocks, b showing some geological evidences at different places in study area

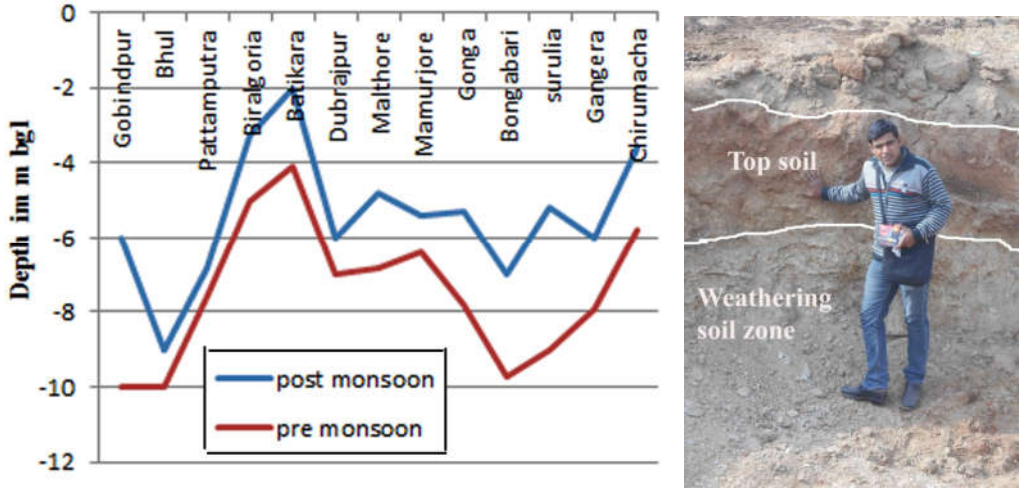

Figure 7. a, showing the fluctuation groundwater table at number of villages under study; b, showing the subsurface soil layers near Batikara village, Purulia-II block

Fluorite is the principle bearer of fluoride and found in granite, gneisses and Pegmatite (Deshmukh and others, 1995, Rao, 1982). Fluoride occurs in various rock types such as granite, gneisses, basalts, dolerites, quatzites, pegmatites, hornblende, syenites, biotite, muscovite, fluorite, fluoromica,, cryolite, villanite, etc. (Saxena and Ahmed, 2002). Generally, high fluoride contamination in hardrock terrain is common due to water quality variation and changes in shallow and deep aquifers zones. But in alluvial plain groundwater the variation and changes in fluoride levels are usually rare (Raju *et al*., 2009). Sinha (1986) and Narasayya (1970) report that the fluoride content varies from 0.8 to 3.6 % in apatite rocks of Singbhum district of Bihar (presently Jharkhand), the Vizianagaram district of Andhra Pradesh and Purulia district of West Bengal. As mention earlier, the study area is underlain by the rocks of granite, gneiss, Calgranulite, ultra basic and metamorphic rocks, including crystalline lime stone hornblend schist, biotite gneiss, pegmatite and quartz vein (Fig.6.a,&b). Review of geological literature in Purulia has reveal that fluoride exists as a complex ion in a naturally occurring mineral called 'apatite' which is a fluorinated calcium Phosphatic compound (Dasgupta and Bhattachaya, 1992). The mineralization of apatite has taken place along two prominent linear zones- one located in the North Purulia region and referred as ' North Purulia Shear Zone' 9 covering the areas of Jhaldha- Jaipur-Raghunathpur) and the other located in south of the district reffered as 'South Purulia Shear Zone (covering the areas of Balarampur-Beldih-Barabhum) (Bhattachaya and Chakrabarti, 2011).

There are four sub- surface layers have been identified in Purulia district (a) weathered mentle,(b) saprolitic zone, (c) fractured zones of hard rocks, (d) narrow zone of unconsolidated sediments along with river valley. The groundwater in the study area generally occurs in weathered zones within 10 mbgl and or shallow fracture zones forming unconfined to semi confined aquifers. For understanding the groundwater variation of the study area, the water table have been measured in the wells of number of villages in both post monsoon season (December, 2014) and pre-monsoon season (April/ may, 2015) and this survey reveals that the water table of the study area varies from 5 to 10 mbgl in pre - monsoon and 2 to 9 mbgl in post- monsoon season (Fig.-7, a). During the pre-monsoon season most of the dug wells and sub-surface water bodies become dry. These rock water interaction with the change of seasons seems to play a major role behind enrichment process, fast recession of the water table (due to excessive groundwater withdrawal) and long spells of drought (as fallout of climate change) have triggered the gradual leaching of fluoride into circulating water (CSME report, 1997; Bhattacharya and Chakrabarti, 2011).

Health Effects

The main source of fluoride intake is usually from the drinking water, which supplies 75 -95% of daily intake. Preliminary health survey, in the study area has revealed that dental and skeletal fluorosis is prevalent in the study area. The rural people of the study area depend on groundwater for drinking purpose. Except one or two village there is no centralised water supply. As the result using the groundwater where fluoride concentration is very high like Pattamputra, Gobindpur, Bhul, Hutmura, Chirumach Gharjhuri villages poor villagers and school students have been victimized and suffers from dental fluorosis with discolouration of teeth, pitting of teeth, joint pains, crippled limbs quick aging etc. Mainly the children belonging to the age group of above 8 years to 15 years have been suffering from dental fluorosis and the people above the age of 30 years are found to be victimized. In purulia – I block, 47358 people of 24 Mouzas and in Purulia –II block, 53961 people of 27 Mouzas were facing health problems due to fluoride contamination (Battacharya, 2009).

Conclusion

Occurrence of fluoride in groundwater in the study area is mainly from the natural sources. Fluoride concentration in almost water samples in pre-monsoon season is greater than

post-monsoon season. The geo-hydrological conditions like presence and weathering of fluoride bearing rocks, high fluctuations of water table conditions etc. play an important role for the occurrence of fluoride content in groundwater. The fluoride concentration is also found to be controlled by the geo-chemical environment of the groundwater in study area. It seems to be a threat to the people of many villages in study area where high fluoride concentration occurs. Due to lack of water treatment schemes, rural people have no other alternatives of drinking water except the contaminated groundwater. So, it may be concluded that the occurrence of fluoride in groundwater has been gradually becoming a serious alarming issue and it seems to be a threat to the people of the study area where many villages are totally devoid of centralised water supply.

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REFERENCES

Bhattacharya, H.N. and Chakrabarti, S. 2011. Incidence of fluoride in groundwater of Purulia District, West Bengal: a geo-environmental appraisal, *Current Science*, 101(2), pp. 152 -155.

Bhattyacharya, D. 2009. Pachimbanger bhugarvastha jole fluoride sankraman o tar pratikar, Amit Bari, 5, pp.8-11.

BIS 1991. Bureau of Indian Standards, Drinking water specification, (first Revision) IS 10500.

Boyle, D. R. 1992. Effects of base exchange softening on fluoride uptake in groundwaters of the Monckton Sub-Basin, New Brunk- swick, Canada. In *Water–Rock Interaction* (eds Kharaka, Y. K. and Maest, A. S.), Proceedings of the 7th International Sympo- sium on Water–Rock Interaction. A.A. Balkema, Rotterdam.

Chakrabarti, S. and Bhattacharya, H.N. 2013. Inferring the Hydro-Geochemistry of Fluoride contamination in Bankura District, West Bengal: A case Study, Journal Geological Society of India, 82, pp.379-391.

CSME Report, submitted to NRDMS, DST, GOI, Centre for Study of Man and Environment, 1997; http://nrdms.gov.in/ assesment.groundwater.asp.

Dasgupta, S. and Bhattacharya, D.K. 1992. Indian Miner, 46(2), pp.- 123 - 132.

Deshmukh, A.N. and Chakravarti, P.K. 1995. Hydro-Chemical and hydrological impact of natural aquifer recharge of selected Fluorosis endemic areas of Chandrapura district, Gondwana Geol. Mag.,9, pp.169-184.

Edmonds, W. M. Hydro-geochemistry of ground waters in the Derbyshire Dome with special reference to trace constituents. Report 71/7, Inst. Geol. Sci., Great Britain.

Handa, B.K. 1975. Geo-chemiastry and genesis of fluoride containing groundwater in India, groundwater, 13,pp.275-281.

Handa, B.K. 1988. Fluoride occurrence in Natural waters in India and its significance, Bhu Jal News 3(2), pp.31-37.

Narasayya, B.L. 1970. Mineralogy of Cromite, Magnetite and apatite deposits of the parts of Easternghats, Andhra Pradesh, India, phD thesis, Andhra University, Andhra Pradesh, India.

PHED report, 2009, http://www.wbphed.gov.in/saticpages/ fluoride.html.

Raju,N. J., Dey S. and Das, K. 2009. Fluoride contamination in groundwaters of Sonbhadra District, Uttar Pradesh, India, *Current Science*, 96(7), pp.979-984.

Rama Rao, N.V. 1982. Geo chemical factors influencing the distribution of fluoride in rocks, soils, and water sources of Nalgonda district. Doctoral Thesis, Osmania University, India, pp.320.

Ramesh, K. and soorta, V. 2012. Fluoride Contamination in Drinking Water in Palacode Region, Tamil Nadu, *International Journal of Research in Chemistry and Environment*, 2(1), pp.-116-123, www.ijrce.org .

Rao, N.S. 1997. The occurrence and beviour of fluoride in the groundwater of the Lower Vamsadhara river basin, India, Hydrological Science Journal,42(6), pp.877-892, http://www.tandfonline.com/loi/thsj20.

Saha, J. 2015. Groundwater quality of Purulia District- a micro level study on Purulia-I block, Purulia district, West Bengal, *International Journal of Human Resources and Social Sciences*, 2(7), pp.40-48, https://www.aarf.asia/ download.php

Saxena, V.K. and Ahmed, S. 2001. Dissolution of fluoride in groundwater: a water-rock iteraction study. *Enviro. Geol*., (40), pp.-1084-108.

Sinha, R.K. 1986. Industrial Minarals (2nd edn), 379, Oxford & FBH New Delhi.

WHO 2006. Guidelines for drinking water quality, third edition, incorporating first and second addenda. Water Sanitation and Health 9WSH), World Health Organization, Geneva.

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