Available online at: http://www.ijmtst.com/vol5issue02.html

International Journal for Modern Trends in Science and Technology

ISSN: 2455-3778 :: Volume: 05, Issue No: 02, February 2019

Fluoride Ions variation in Precambrian host rocks of Rarh region of West Bengal, India

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To Cite this Article

Dr. Sumana Bhattacharjee, "Fluoride Ions variation in Precambrian host rocks of Rarh region of West Bengal, India", *International Journal for Modern Trends in Science and Technology*, Vol. 05, Issue 02, February 2019, pp.-44-50.

Article Info

Received on 02-Jan-2019, Revised on 03-Feb-2019, Accepted on 12-Feb-2019.

ABSTRACT

Fluoride ions are significant micro element which is mainly found in the host rocks such as granite, gneiss and pegmatite of Precambrian Chhota Nagpur Gneissic Complex. This ion is very much crucial for brawny teeth and bones of humans. The scientific study attempts to find out the causes of regional concentration of fluoride ions particularly in the districts of Purulia, Bankura and Birbhum of Rarh Bengal. Total 105 water samples have been collected and three chemical parameters like (F^-), pH and iron (Fe) have been considered to study the relationship among these variables. Atomic Absorption Spectro-photometer device have been used to examine the level of fluoride content. Similarly, 11 rock chips have been brought from different sites of three districts of Rarh Bengal. PCI Geomatic V 9.1.0 software and Grapher 13 software have been applied to prepare the different thematic maps along with lineament density. The result shows that fluoride ions are mainly confined in the host rocks like granite gneiss and pegmatite. Fluoride bearing minerals are apatite, fluorite, mica, and hornblende etc. which are mainly confined in the districts such as Purulia, Bankura and Birbhum of Rarh Bengal. More than 300000 people are suffering due to fluorosis related health hazard and huge number of people compel to intake highly contaminated ground water.

Keywords: *Fluoride ions, Rarh Bengal, lineament density, fluorosis, health hazard*

I. INTRODUCTION

Fluoride ions are largely electronegative and reactive micro element which has belonged in halogen family and it has atomic number 9 and atomic weight 18.998 (Greenwood and Earnshaw, 2012; Gillespieet et al., 1989). In solution stage, fluoride stands no smell, colour and taste. Therefore, chemical examination is only measure to find out fluoride ions from the water sample. It is a vital micro element for making enamel of teeth and bones of humans. A range of 0.6 to 1.5mg/L (fluoride in drinking water) has been specified by World Health Organization (WHO, 1984) while Indian Council of Medical Research (ICMR) has recommended a range of fluoride from 0.5 to 1.5mg/L in drinking water. A scale 0.6 to 1.2 mg/L of fluoride is set by Bureau of Indian Standard (BIS, 1992) for the drinking water. Beyond the acceptable limit of fluoride in drinking water is detrimental for human health. According to World Health Organization (WHO, 1984) more than 260 million population are being consumed fluoride contaminated drinking water (above 1mg/L). Many

scientific studies have been reported that the people around 29 nations of the world are suffering due to excessive fluoride in ground water as well as fluorosis related health hazard (Basu&Bera., 2010). The moderate to severely affected countries are namely China, Pakistan, India, Japan, Sri Lanka, Iran, Turkey, Ghana, North Jordan, Kenya, Southern Algeria, Korea, Mexico, Ethiopia, Brazil, Italy, Canada, Norway (Young et al. 2011; Brindha and Elango, 2011, Phan et al. 2010). In India, nearly 95 million people with 6million children are affected by fluorosis related health hazard. Similarly, people of 23 states including 200 districts are highly affected by dental, skeletal and non-skeletal fluorosis for high intake of water (prevailing tropical climate).In West Bengal, around 7 districts including 43 blocks are affected by fluoride in ground water along with fluorosis related health hazard. The fluoride ions are found only in three districts (Birbhum, Bankura and Purulia) in Rarh Bengal. **The main objective of this scientific paper is to find out the causes behind the restricted (within three districts in Rarh Bengal) spatial distribution of fluoride in Western Bengal undulating upland or extended part of chhotanagpur gneissic complex.**

II. Area of Study

The study area is mainly confined on the western part of river Bhagirathi-Hoogli. It is bounded by 22°45´N to 23°43´N parallels of latitude and 85° 55´E to 88° 30´E meridians of longitude. Many experts opined that Rarh Bengal or Western Bengal undulating upland is the western side of river Bhagirathi-Hoogli where laterite or red soils are mostly accumulated. From geological view point, Rarh Bengal is the western most part of Medinipur-Farakka Fault (MFF).Geologically, Rarh Bengal (**Figure 1**) is the comprehensive part of Chhota Nagpur Gneissic Complex (CGC) which is located to the north of Singbhum Craton.

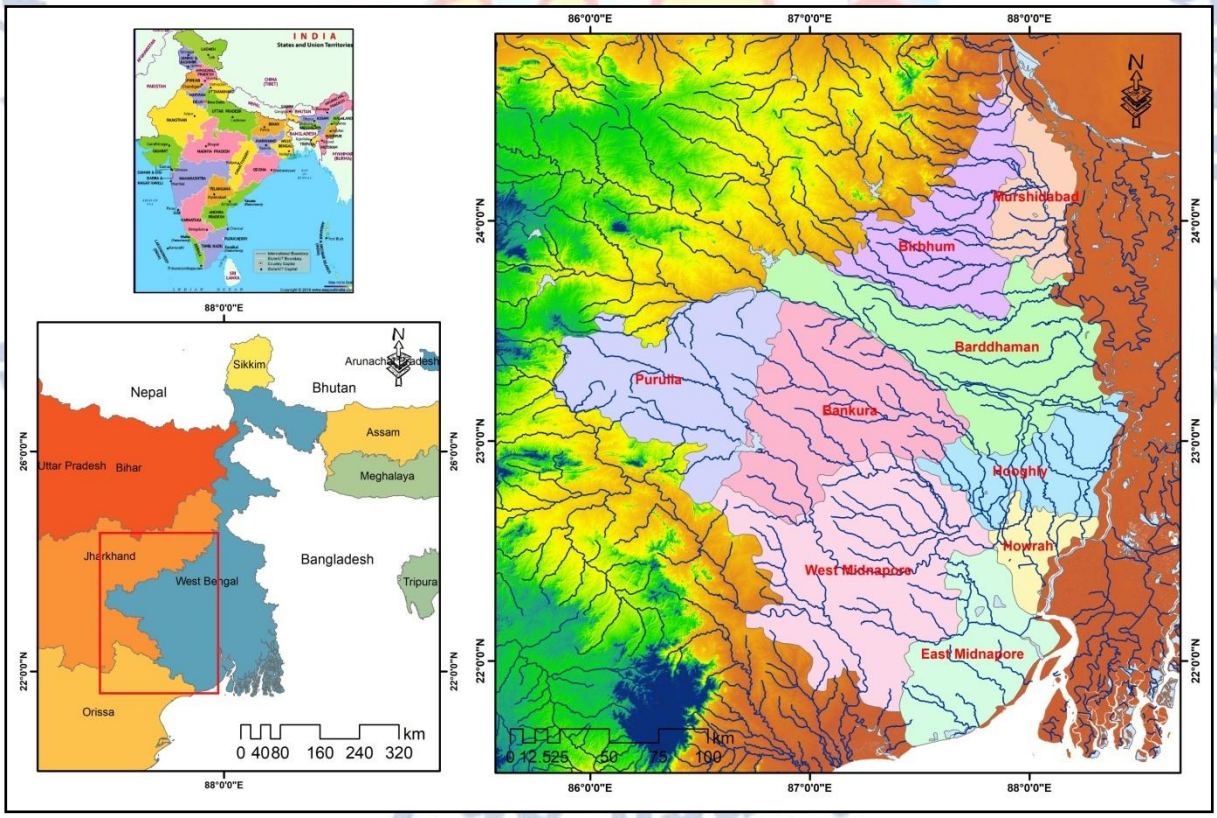

Figure 1: Location map showing Rarh Bengal Districts with drainage system

III. Methods and Materials

3.1 water sample and rock chip collection and tested in the laboratory

Total of 105 water samples have been collected from different sites of Birbhum, Bankura and Purulia districts of Rarh Bengal during the year 2018 to 2019. Following Bureau of Indian Standard (BIS), 100 ml plastic container has been used during water sample collection and within 24 hours water samples ultimately sent to the laboratory for testing. Three important parameters like fluoride (F^-), pH and iron (Fe) were tested to get correlation among these variables. Analytical

procedures are accurately maintained during the analysis of fluoride ions. Fluoride Meter (Atomic Absorption Spectro-photometer with furnace) has been applied to obtain good result. Total 11 rock chips have been collected from different sites where Precambrian rocks are exposed. These rock chips are analysed following BIS procedure (Bera, B., 2008b; Bera, B., 2009) in the laboratory of chemical engineering department of Jadavpur University.

3.2 Application of Remote Sensing and Geographical Information system (RS&GIS)

Different relevant digital maps and diagrams have been depicted using PCI Geomatic V 9.1.0 software and Grapher 13 software. The geological map has been obtained from Geological Survey of India (GSI) and it has been digitised on PCI Geomatic V 9.1.0 platform. The lineaments have been extracted from ETM and ASTER image applying module edge technique performed in PCI Geomatic V 9.1.0 software. ETM image is consisted of6 VNIR band with 30m resolution and 8 SWIR band with 15m resolution. Similarly, ASTER image is composed by 3 VNIR band of 30 m resolution and SWIR band with 15 m resolution. Lineament is simply defined as the linear imprints in a landscape and it is also manifestation of underlying basic geological structures (Bera, B., 2008a; Bera, B., 2010a). Similarly, it is also defined that the linear distinctive features which are exposed or under gone below the ground surface (Bera, B., 2010b). Ultimately, lineament density index (LDI) is calculated by considering the total length of lineament for every unit area (km/km^2) and it is articulated as –

$$LDI = \sum_{i=1}^{N} xi \text{ km/km}^2 \quad (1)$$

Where, LDI stands lineament density index (total length of lineament), N represents no. of lineament, and xi signifies for length of lineament no. i.

IV. Results

4.1 Spatial variation of fluoride in different districts of Rarh Bengal

In case of Rarh Bengal, people of three districts namely Purulia, Bankura and Birbhum are affected by fluorosis related problems. Out of 20 blocks of Purulia district, 18 blocks have crossed the permissible limit. Total 529 villages have been affected whereas the highest fluoride concentration (7.76 mg/L) is found at Rambani village under Kashipur block of Purulia following Daha village (Manbazar block, 6.87mg/L) and Bhangra village under Purulia-II block (5.45mg/L). Bankura has 20 affected villages while the maximum fluoride content (7.98 mg/L) is registered at bJasara village under Khatra block **(Table 1**). The severely affected villages are Kanchanpur (Bankura-II block, 7.56mg/L), Bhaduldoba village (Simlapal block, 7.10mg/L) and Kamlabad village (6.91mg/L) under Indpur block of Bankura district. Subsequently, around 18 villages are severely affected by fluoride in drinking water in Birbhum district of Rarh Bengal. The Kendgore village (Khoyrasole block) has highest concentration of fluoride (10.54mg/L) and following villages are namely Bhabanipur (Rajnagar block, 3.12mg/L), Sekhpur (Mayureswar I block, 2.56mg/L), Lakshminarayanpur (Nalhati I block, 2.34mg/L) and Dedaha (1.66mg/L) under Dubrajpur block. The petrological study of rock chips reveals that the maximum fluoride content around 12,500mg/Kg is found in Purulia district and followed by 9,500mg/Kg in Bankura and around 8,500mg/Kg in Birbhum districts of Rarh Bengal. People are also suffering due to various magnitude of dental, skeletal and non-skeletal fluorosis associated health hazard. Different degree of dental fluorosis includes small opaque, paper white of brown discoloration and discrete or confluent pitting, cavities, corroded-like appearance etc. while skeletal and non-skeletal fluorosis diseases are Knee joints pain, hip joints pain, neck joints pain, shoulder joints pain, can't do sit up, can't bent forward easily, unable to work, bow legs, lumber spines etc. The lineament density result shows that high lineament density (above 0.60 km/Km^2) is confined mainly under the blocks of Kashipur, Manbazar-I&II, Purulia-II and Raghunathpur-I of Purulia district followed by Khatra, Indpur, Bankura-II blocks of Bankura district and Khoyrasole, Rajnagar and Dubrajpur blocks of Birbhum district respectively. The low lineament density (0.0 to 0.30km/Km^2) is spread over the blocks of Hura, Barabazar, Joypur and Purulia-I under Purulia district followed by Mejhia, Taldangra and Ranibundh of Bankura district and Mayureswar I and Nalhati-I blocks of Birbhum district of Rarh Bengal.

Table 1 Highest fluoride concentration village, value and block-wise total number of affected villages in different districts of Rarh Bengal (2018 to 2019)

Districts	Blocks	Block- wise affected villages (Total no.)	Block-wise Average value of fluoride (mg/L)	Highest fluoride concentration village	Village-wise highest fluoride value (mg/L)
Purulia	Arsha	17	0.81	Kishanpur	1.80
	Balarampur	25	0.88	Biramdih	1.87
	Barabazar	21	0.59	Ladiha	2.21
	Hura	17	0.91	Palgan	1.91
	Jhalda I	18	0.78	Ichag	2.45
	Jhalda II	21	0.88	Sarjumatu	1.99
	Joypur	19	0.67	Karkara	2.21
	Kashipur	19	0.45	Rambani	7.76
	Manbazar I	45	1.45	Daha	6.87
	Manbazar II	21	0.56	Sankura	1.75
	Neturia	44	0.67	Gunyara	3.54
	Para	20	0.72	Kaluhar	1.95
	Puncha	48	1.54	Kenda	2.65
	Purulia I	43	1.00	Dimdiha&Bhul	2.00
	Purulia II	78	1.56	Bhangra	5.45
	Raghunathpur I	20	0.87	Shanka	2.32
	Raghunathpur II	35	0.97	Barrah	1.87
	Santuri	18	0.78	Talberya	1.96
Bankura	Bankura II	6	3.41	Kanchanpur	7.56
	Indpur	1	-	Kamlabad	6.91
	Khatra	3	4.87	Jasara	7.98
	Mejhia	3	1.96	Banjora	2.50
	Ranibundh	1	-	Suritari	2.70
	Simlapal	5	3.58	Bhaduldoba	7.10
	Taldangra	1	-	Kadamara	1.76
Birbhum	Dubrajpur	1	-	Dedaha	1.66
	Khoyrasole	6	4.55	Kendgore	10.54
	Mayureswar I	2	2.35	Sekhpur	2.56
	Nalhati I	2	2.38	Lakshminarayanpur	2.34
	Rajnagar	7	2.16	Bhabanipur	3.12

V. Discussions

Geologically, The Rarh Bengal plateau is inclusive part of Chhota Nagpur Gneissic Complex (CGC) and it is an extended part of Singbhum Craton (**Figure 2**). The region is characterised by undulating plateau with Precambrian metamorphic signature. The Chhota Nagpur Granite-Gneiss Complex is situated between Singhbhum Protocontinent in south and the Damodar Rift Valley in the north (Roy, 2012). The CGC is basically characterised by gneisses and granitoids of variable petrological composition. Small pockets of mafic gneissic rocks (also called diorite gneiss) have been exposed in different parts of the Birbhum, Bankura and Purulia districts of Rarh Bengal. The amphibolites (also designated as hornblende gneiss) are also found in scattered in nature mainly within gneiss-granite complex (Pascoe, 1973). The planner shaped fabric with normal layered little gneissic rocks (also termed as mylonite gneiss) has been occurred at the proximity of the outcrops of the Bengal Anorthosite (Roy et al., 2016). In Chhota Nagpur Gneissic Complex granites have isolated plutons which are mainly identified in different parts of Ranchi-Purulia Belt (**Figure 2).** The granites of the Chhota Nagpur Gneissic Complex have been categorised into pink and the grey granites while youngest pink is the intrusive type but grey granites are coarse grained type presenting like dome shaped mounds or tor like geomorphic features (Singh and Krishna, 2009; Saxena et al., 1992;Mahadevan, 1992; Mahadevan, 2002).The supracrustal metasedimentary and metavolcanic rocks have been exposed in different pockets of Purulia, Bankura and Birbhum districts of Rarh Bengal. These Precambrian rocks are mainly exposed by various primary and secondary geological structures.The host rocks are being weathered and gradually disintegrated due to high rate of weathering and erosionunder semi-arid climatic conditions. These above mentioned fluoride bearing minerals are released and mixed into the soils as well as ground water. In case of Rarh Bengal, Granite gneiss and pegmatite are the principal fluoride bearing host rocks while major fluoride bearing minerals are hornblende, biotite mica, apatite, fluorite etc. (Matthess, 1982; Pickering, 1985; Hem and Geological Survey (US), 1989; Handa, 1988; Haidouti, 1991; Gaumat et al., 1992; Gaciri and Davies, 1993; Datta et al., 1996; Apambire et al., 1997; Kundu et al., 2001; Mohapatra et al., 2009, Bera, 2018a;Bera, 2018b). The above-mentioned rocks with minerals are completely absent in other districts of Rarh Bengal that is why Purulia, Bankura and Birbhum of the Rarh Bengal districts are highly contaminated by fluoride ions in ground water.In case of Purulia, Bankura and Birbhum districts of Rarh Bengal, fluoride containing fertilizers are being extensively used in different blocks during monsoon and *rabi or kharif* seasons (Bera, 2018a).

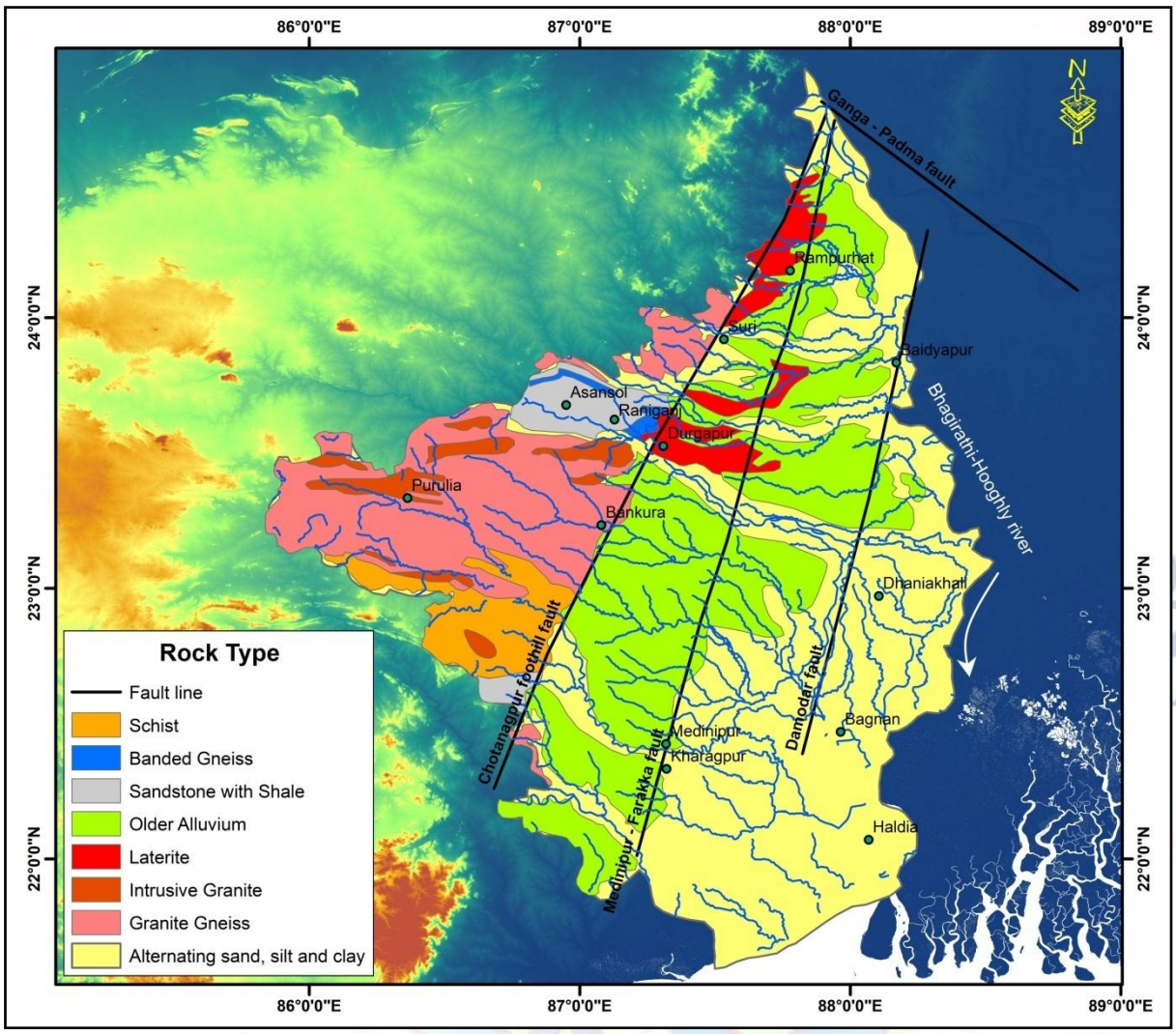

Figure 2: Hydro-geological attributes and fluoride bearing minerals of Rarh Bengal districts

VI. Conclusions

From the above scientific study, it is concluded that about 18 blocks of Purulia, 07 blocks of Bankura and 05 blocks of Birbhum districts are moderate to severely affected from dental, skeletal and non-skeletal fluorosis. Granitic gneiss and pegmatite are principal host rocks of Chhota Nagpur Gneissic Complex. The fluoride bearing minerals are apatite, biotite, hornblende, mica and fluorite which are released along the structural weakness from above mentioned rocks. Similarly,the semi-arid climatic conditions with geological structures are responsible for fluoride ions concentration in particularly Purulia, Bankura and Birbhum districts of Rarh Bengal. Subsequently, people of Rarh Bengal districts are applying various fluorides including chemical fertilizers like potash and superphosphate to improve agricultural productivity as well as maintaining food security (Bera, 2018a; Bera, 2018b).

Acknowledgement

Author extendsher sincere thanks to Public Health and Engineering, Govt. of West Bengal,Geological Survey of India and the people of Rarh Bengal for assistance, data, laboratory assistance and important information.

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