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Fluoride Contamination of Ground Water at Jamda Village of Bankura District, West Bengal: A Geographical Analysis

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ABSTRACT

Groundwater of Bankura District is well known for its fluoride contamination in groundwater in recent time. People from many of the villages have been marked with fluorosis from consuming fluoride contaminated groundwater as only very small area are fed with pipe water supply scheme. People are compelled to use groundwater for drinking purpose as there is no other option available. Jamda village of Bankura district is highly affected by fluoride where highest level of fluoride contamination is 11.51mg/litre which is well ahead of the recommended limit and by drinking such contaminated water a sizable number of people are affected by dental, skeletal and non-skeletal fluorosis diseases. For the present study, household survey has been conducted to find out socioeconomic characteristics of the affected families and the nature of fluorosis diseases suffered by the people. The results found that 51.99% people are affected by fluorosis of different types among them skeletal and dental fluorosis are high which are 46.02% and 30.68% respectively. The significant non-skeletal fluorosis is gastrointestinal related, where about 5.68% patients are suffering from this type of fluorosis. Out of total fluorosis patients, 5.11% and 2.28% patients are suffering from body weakness and muscle-nervous fluorosis respectively. Removal of fluoride from drinking water and supply of clean fluoride free water is urgent necessity.

Introduction:

Groundwater is significant water source for domestic, agricultural and industrial purpose in India. More than 85% of rural and 50% of urban domestic water requirements are being met from groundwater resources, while irrigation accounts for around 92% of groundwater extraction (Jha et al, 2009). But, ever increasing population, urbanization, industrialization and demands for food production lead to unscientific and unsustainable groundwater development and management which in turn make deterioration of groundwater in terms of quality and quantity. Groundwater is now contaminated with various geochemical components like arsenic, fluoride, iron concentration etc. in various parts of India. Endemic fluorosis occurring due to consumption of groundwater contaminated with fluoride is threatening the health of millions of people in India and therefore is a challenging and extensively studied national health problem (Fawell et al. 2006). 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; Subba Rao 2011). Nearly 12 million out of the 85 million tons of fluoride deposits on the earth crust are found in India. At present, fluorosis is endemic in at least 20 states of India affecting more than 65 million people, including 6 million children. Estimation finds that 65% of Indian villages are exposed to fluoride risk (UNICEF, 1999). In West Bengal, excess fluoride in groundwater has been detected so far in 43 blocks

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spread over seven districts, viz. Purulia, Birbhum, Bankura, Malda, South Dinajpur, North Dinajpur and South 24-Parganas (www.wbphed.gov.in). Fluoride is important for tooth and bone formation. The main source of fluoride for human body is usually drinking water while, other sources are food and air. Research has shown that a concentration of 1.0 mg/litre of fluoride in drinking water reduces tooth decay. But oral intake of fluoride more than 1.5 mg/litre results in different types of diseases. According to BIS (Bureau of Indian Standards, 1991) and ICMR (Indian Council of Medical Research, 1975), the highest desirable limit of fluoride is specified at 1.0 mg/litre and the maximum permissible limit is 1.5 mg/litre. WHO (1999) also recommended maximum permissible limit of 1.5 mg/litre of fluoride contamination in drinking water for human consumption. Fluoride pollution in drinking water is a public health problem. Fluoride is known to cause diseases like dental fluorosis, skeletal fluorosis, Alzheimer's disease, dementia, abnormal thyroid function and other hormonal disturbances (Meenakshi and Maheshwari 2006). Bankura district has been experiencing a silent but inevitable natural disaster in the form of fluoride contamination in ground water.

Geological formation of groundwater in Bankura district is mainly responsible for groundwater contaminated with fluoride (Nag.et.al. 2013). In income sector, Bankura stands only second from the bottom in the state(Human Development Report, 2004), Purulia district having even lower income index. Access of modern facilities and social amenities to them are not sufficient. All these factors make the problem more acute. Due to this, the problem of fluoride pollution has been given emphasis in this study. It is earnest necessary to take some initiatives to alleviate this burning problem of fluoride pollution. From the geological and hydrological as well as climatological and water resource management point of view, the district Bankura faces the acute problem of drinking water scarcity. Due to low availability of fresh drinking water, the contamination of it with fluoride is very dangerous. People have no other option but to take such contaminated water for drinking purpose.

Jamda village of Laxmisagar Gram Panchayat of Simlapal CD Block is highly affected by fluoride contamination in drinking water in Bankura district. People use this contaminated water due to having no other options. So, large numbers of people are affected by dental, skeletal and different non-skeletal fluorosis diseases.

Objectives

The paper is to achieve the following objectives:

1) To identify nature, extent and spatial character in fluoride contamination of ground water and fluorosis disease of Jamda village of Laxmisagar G. P. atSimlapal block.

2) To identify relationship of fluoride contamination of groundwater with geological settings.

3) To find out some measures suitable for this area to alleviate the problems.

Location of the study area:

Bankura district with an area of 6,882 square km is a part of Burdwan division of West Bengal. It is situated between 22° 38´ and 23° 38´ North latitude and between 86° 36´ and 87° 46´ East longitude. The study area Jamda village is located at Laxmisagar GP (Gram Panchayat), one of seven GP of the Simlapal CD block (Community Development block) of Bankura district.

Geographically, the Bankura district is a part of the *Rarh* region of West Bengal. The entire area of this district is undulating in nature and general slope is from west towards east and southeast. Bankura is drained by *Damodar*, *Darkeswar* and *Kangsabati* rivers along with their tributaries of which *Gandeswari*, *Silai* and *Kumari* deserve separate mention (Human Development Report, 2004). Different types of soils are found in this district, but most of the area is covered by lateritic nodules. Old and younger alluvium soils are found in eastern and southern part of the district. Climate of this district is generally dry, mild and healthy. But western side is more dry and extreme than eastern region.

Simlapal Block of Bankura district has total population of 143,038 as per the Census 2011. Out of which 73,008 are males while 70,030 are females. The population density of this block is 460/km^2. In 2011, there were total 29,836 families residing in Simlapal Block. The Average Sex Ratio of Simlapal Block is 959. The average literacy rate in urban areas is 69.7% while that in the rural areas is 68.4%. Jamda village is located at 9.5km away from sub-district headquarter Simlapal. The total geographical area of village is 48.79 hectares with a total population of 681 peoples. There are about 137 houses in Jamda village. The total male and female populations are 365 and 316 respectively.

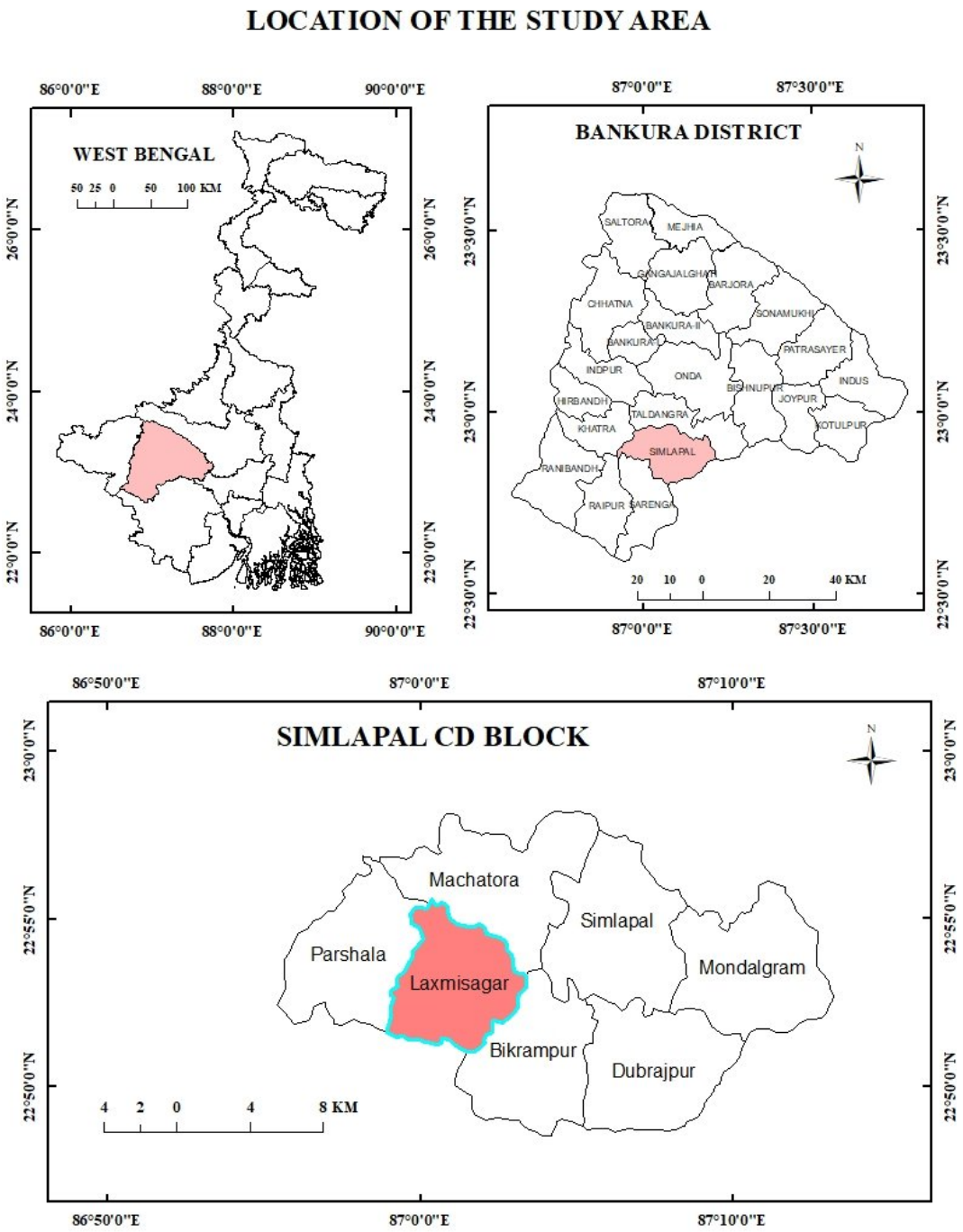

Fig. 1 : Location of the study area

Methodology and database:

The present paper has been prepared by both primary and secondary data. For secondary data, fluoride testing results of the tube wells of the Simlapal block have been collected from Public Health Engineering (PHE) Department, other information regarding fluoride contamination have been collected from various books, journals, websites, census report etc. The Jamda village has only four tube wells and one dug well for drinking water sources, water samples from these five sources are collected from the study area. Water samples are collected by plastic bottles having tight stopper after washing 2-3 times. Fluoride level are measured by using fluoride ion selective electrode Orion 9609 with expandable ion analyzer EA 940 in the water testing laboratory of Public Health Engineering Department, Bankura. Total ionic strength adjustment buffer (TISAB II) was added to the standards as well as to the samples before the measurement of fluoride. The instrument was calibrated with standard fluoride solutions (Fluoride electrode manual, 1991).

For primary data, fifty households from the Jamda village have been surveyed with well-defined schedules and questionnaires to understand the socio-economic conditions of the affected families of the villagers. With the help of local health workers, various types of fluorosis diseases are detected with their symptoms of field identification.

These collected data are then tabulated and analysed by choosing different variables and the relationships between different variables are found out. For mapping ArcGIS 10.1 software has been used.

Results and Discussion:

Geological relation of fluoride:

Fluoride contamination in groundwater is highly dependent on the geological structure and the mineral composition of rocks. From the geological point of view, the area is principally underlain by Pre-Cambrian Metamorphic rocks represented by granite gneiss (Chotanagpur granite gneiss), biotite granite gneiss, calc-granulites, and ultra-basic and meta-basic rocks, meta-sedimentary, including crystalline limestone, hornblende schist, biotite gneiss, pegmatite and quartz-vein (Bhattacharya et al. 2011).

Microscopic studies by drill cuttings of granite gneiss and pegmatite in the district have revealed fluoride bearing minerals, viz. apatite and fluorite (Chakraborty et.al. 2012). Two other fluoride-bearing minerals are biotite mica and hornblende which might have added fluoride into the groundwater. High level of fluoride is also observed within the pegmatite veins. These rocks and minerals are weathered and form calcium and magnesium carbonates, which serve as good sink for fluoride ions. Fluoride ions from these minerals leach into the groundwater and contribute to high fluoride concentrations. Therefore, hand pumps, dugs, and bore wells have been very much contaminated with fluoride. Due to excessive overdraft of groundwater for agriculture, it is falling very fast and long spell of drought in some years cause gradual leaching of fluoride into the circulating water.

Ground water condition in the area

The area under study belongs to the peripheral part of Chhotanagpur Plateau predominantly composed of granite gneiss (Precambrian). Here, groundwater, in general, occurs in the weathered zone within 8 m bgl (metre below ground level) and shallow fracture zones forming unconfined to semi- confined aquifers. The depth to water level varies from 3.5-9 m bgl in pre- monsoon and 2- 5 m bgl in post monsoon period (Nag.et.al. 2013). During lean period, most of the dug wells and the surface water bodies become dry.

Groundwater is being extracted through dug wells and shallow hand pumps fitted tube wells of 10 m bgl depth. Riverbed tube wells down to the depth of about 4 m in the beds of Shilabati at few places in the Laxmisagar G.P. are in use for meeting the domestic water requirement through a supply network.

Table 1. Four Ground water bearing layers in the area

Name of the Ground water bearing Layer	Depth mbgl (meter below ground level)
Weathered Layer	5.00-30.00
Semi-weathered Layer	7.00-60.00
Partially Weathered or partially Fractured rock	12.00-90.00
Fresh Rock Layer or Fractured Rock layer	15.00-110.00

Source : SWID Office, Bankura, 2016

Geophysical survey reveals that, in general, four sub-surface layers have been identified, namely weathered, semi-weathered, partially weathered and fresh rock layer (Table1). Weathering is varying within the depth range of 5.00 to 30.00 m bgl, semi-weathered rock occurs within the depth range of 7.00 to 60.00 m bgl and partially fractured rock is lying within the depth range between 12.00 to 90.00 m bgl. The fractures are identified to be within the depth range of 15.00 to 110.00 m bgl (Nag.et.al. 2013).

Scio-economic Conditions of the affected village:

Out of total fifty families and 227 persons within these families surveyed in the village,male and female population share was159 and 124 respectively. About 70% people belong to general category and remaining 30% people belong to SC (Scheduled Caste) category but there is no ST (Scheduled Tribe) population. Literacy rate is not poor and 76% people are literate (Field Survey, 2016).

Occupational structure and income level areimportant criteria for understanding the socio-economic condition of a region. From the field survey it is observed that only 2% population are engaged in Government service but 66% people are engaged in farming activities whereas 32% labourer in agricultural and non-agricultural sectors.

From the income analysis, it is calculated that 76% families belong to less than Rs.5,000 per month income category whereas 16% families are within Rs. 5,000 to Rs.10,000 and only 8% families belong in the category of more than Rs. 10,000 per month.

From the view point of land holding, 32% families have no land but 68% families have their own land. Among the land holder 10% families have more than 6 bigha of farming land and the remaining families have2 to 6 bigha of land. Agricultural lands are also fluoride affected due to irrigation with fluoride contaminated water and it is observed that 20.5 bigha of farmland out of total 156 bigha of land of the village dwellers are fluoride affected.

Nature and extent of fluoride contamination:

In Simlapal CD block all the seven gram panchayats are affected by fluoride contamination in drinking water sources. Among them, highest is found in Machatora gram panchayat where 12.69 mg/litre level of fluoride contamination is recorded (Table 2). Laxmisagar GP is also highly contaminated with fluoride, where 11.15 mg/litre fluoride is found in Jamda village.

In Jamda village, total four tube-wells and one well are found and all the sources of drinking water are fluoride contaminated above the level of 1.5mg/ litre. Other properties of drinking water of all sources like iron, pH and hardness of the water are given in the table 3.

Table 2. Maximum level of fluoride contamination in drinking water source

Name of the GP	Maximum Fluoride concentration (mg/litre)
Machatora	12.69
Laxmisagar	11.15
Parshala	6.81
Bikrampur	1.93
Mondalgram	1.92
Dubrajpur	1.96
Simlapal	1.96

Source : PHED, 2015

Table 3. Chemical Properties of the Water of the tube wells and well of Jamda village

Sample No	Fluoride (mg/litre)	Iron (mg/litre)	pH	Hardness (mg/litre)
Tubewell-1	11.15	1.30	6.68	440
Tubewell-2	6.83	5.23	7.15	286
Tubewell-3	1.78	0.98	6.65	310
Tubewell-4	1.52	0.64	7.08	196
Dug Well -1	2.16	1.21	7.80	420

Source : Field survey, 2015

Impact of Fluoride on Human Health:

Fluoride in drinking water has both beneficial and detrimental effects on human health. Small amounts of fluoride can have a positive effect on our health. WHO (2006) recommends that drinking water should ideally contain 0.5-1.0 mg/litre fluoride, as it helps to prevent dental caries. But, excess intake of fluoride has adverse effects on various parts of human body. Fluoride is a highly electronegative element and has a tendency to attract positively charged ions like calcium (Singh B, 2011). Hence, the effect of fluoride on mineralized tissues like bones and teeth leading to developmental changes. The bones and teeth have highest amount of calcium and thus attract the maximum amount of fluoride that gets deposited as calcium-flouro-apatite crystals (Meenakshi and Maheshwari, 2006). The intensity of fluorosis is not merely dependent on the fluoride content in water, the fluoride from other sources, physical activity and dietary habits are also responsible for fluorosis (Rudra S, 2016). Fluorosis diseases are categorised into three types i.e. Dental Fluorosis, Skeletal Fluorosis and Non-Skeletal Fluorosis.

Dental fluorosis:

In dental fluorosis, a dark brown mottling or spotting appear on the permanent teeth at the age of 8 or 9 years. Children are very much prone to dental fluorosis affecting on both the milk teeth and permanent teeth. First, the enamel of the teeth is eroded and the teeth become chalky white in appearance. Then, yellowish and white spots develop which then, transform into dark brown mottling or spotting of the permanent teeth. With due time, the spots become blank and cavities are formed which leads to breaking of teeth. In Jamda village,out of total fluorosis patients, 30.68% patients are suffering from dental fluorosis.

Skeletal fluorosis:

Skeletal fluorosis affects the bones or skeleton of the body and it can affect both young and old people. One can have aches and pain in the joints. The joints which are normally affected by skeletal fluorosis are neck, hip, shoulder and knee that makes it difficult to walk and movements, and painful rigidity or stiffness of joints also sets in. In Jamda village, large numbers of people are adversely affected by skeletal fluorosis disease. Out of total fluorosis patients, 46.02% patients are suffering from skeletal fluorosis in this village.

Table 4: Concentration of Fluoride in Drinking Water and its Effects on Human Health

Fluoride Concentration (mg/litre)	Effect
Nil	Limited growth and fertility
< 0.5	Dental caries
0.5 - 1.5	Promotes dental health, prevents tooth decay
1.5 - 4.0	Dental fluorosis (mottling and pitting of teeth)
4.0 - 10.0	Dental fluorosis, skeletal fluorosis (pain in neck bones and back
> 10.00	Crippling fluorosis

Source: International Drinking Water Standards (1971), WHO, Geneva.

Fig. 2: Some Dental Fluorosis Patients of Jamda Village

Fig. 3: Some skeletal fluorosis patients of Jamda village

Non -Skeletal Fluorosis:

One of the significant non-skeletal fluorosis diseases is related to gastrointestinal problem faced by the people of the fluoride endemic areas. Fluoride contaminated water effects adversely on stomach, liver and entire digestive systems and people face the problems of nausea, loss of appetite, pain in stomach, gas formation and blotted feeling, constipation and intermittent diarrhoea. The present study indicates about 5.68% patients are suffering from gastrointestinal problem in this village. Another important observation has been revealed in the present study that females are more prone to attack by gastro-fluorosis diseases than the male. This is due to the physiological and social factors. Time schedules for taking food is not regular and they belief in old customs and tradition and do unscientific fasting. (Rudra, 2016) These factors along with drinking of fluoride contaminated water induce gastro problem much in female than male.

Fluoride contaminated water reacts grievously to make the muscle pain, stiff and weakness which creates muscle pool and haemorrhage and ultimately reduces muscle workability and strength. Thus, a worker becomes dependent person. Out of total fluorosis patients, 5.11% and 2.28% patients are suffering from body weakness and muscle-nervous fluorosis respectively.

After consuming fluoride contaminated water, considerable numbers of people are also affected by allergic symptom, which creates skin eruptions and pain on the skin top. These are pinkish red or non-persistent oval shaped bluish red spots on the skin. These skin rashes are very painful and generally prevalent in women and children. This allergic fluorosis disease creates irritations and mental agony to the patients.

In the present study, there are some fluorosis patients who are suffering from shallow breath, tiredness and avulsion. In Jamda village 14.77% patients are suffering from these problems. Fluoride ingestion in excess have adverse effects on nervous system of human body and the patients face the problems of nervousness and depression, tingling sensation in fingers and toes.

The proportion of different types of fluorosis patients are given in the following table-5.

Table - 5: Percentage of different Fluorosis patients

Sl. No	Different Fluorosis Patients	Percentage of Patients
1	Dental fluorosis	30.68
2	Skeletal fluorosis	46.02
3	Gastrointestinal problem	5.68
4	Thyroid problem	0.57
5	Nerves Fluorosis	0.57
6	Muscle pain	1.71
7	Tiredness	7.95
8	Shallow breath	2.27
9	Avulsion	4.55

Source: Field survey, 2016

Conclusion

Out of fifty households in the fluoride affected village, major fluorosis diseases are dental and skeletal having 30.68% and 46.02% affected people respectively. Main two minerals which are responsible to cause fluoride contamination in the groundwater are identified are fluorite and apatite in the groundwater bearing rock structure. Other manifestation from fluoride toxicity are detected as gastrointestinal, muscle, renal and neurological problems etc.The situation of fluoride contamination of drinking water has already reached an alarming level and needs immediate intervention and attention of all people to mitigate the problem.

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