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IMPACT OF FLUORIDE CONTAMINATION ON HUMAN HEALTH: A CASE STUDY OF KHARAI VILLAGE OF PURULIA DISTRICT

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ABSTRACT

Fluoride mixing with the ground water contaminates it and by drinking the fluoride contaminated water large number of people are affected by different types of fluorosis diseases. According to World Health Organisation, maximum permissible limit of fluoride in water is 1.5 mg/litre.



Kharai village of Purulia district is highly affected by fluoride where 8.28 mg/litre level of fluoride contaminated tube well is found 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 out of total fluorosis patients, dental and skeletal fluorosis are high which are 55% and 38% respectively. Statistical analysis shows that people of less than 20 years age are more affected by dental fluorosis and people above 20 years age group are more affected by skeletal and different non skeletal fluorosis diseases.

KEYWORDS : Fluoride, ground water, dental fluorosis, skeletal fluorosis, non-skeletal fluorosis,

INTRODUCTION:

Water is very important for our existence. But, this water becomes contaminated with various elements and by using this contaminated water, considerable damages occur on human health. Fluoride is one of the elements, which contaminate water and human health hazards occur. Fluoride is the compound form of fluorine. Fluoride is a common element and exists in a number of minerals, like fluorspar, cryolite, apatite, mica and fluorapatite (Agarwal et.al.1997). Fluoride ions from

these minerals leach into the groundwater and contribute to high fluoride concentrations. Therefore, hand pumps, dug and borewells have been very much contaminated with fluoride. Though fluoride enters the body through food, water, industrial exposure, drugs, cosmetics, etc., drinking water is the major contributor (75–90% of daily intake) (Sarala and Rao 1993). More than 90% of the rural population use ground water for domestic purposes. Fluoride in drinking water can be a blessing or a hazard depending on the concentration levels. Fluoride is important for tooth and bone formation. Deficit of fluoride in human body causes dental caries. But if the concentration of fluoride in water exceeds the limit then many problems are created in our health.

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. According to WHO (1997), the permissible limit for fluoride is 1.5 mg/litre.

Contamination of drinking water with fluoride is a public health problem in many parts of the world as well as in 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 2008). At present, fluorosis is endemic in at least 20 states in India, affecting more than 65 million people, including 6 million children (Gupta et al. 2006). In West Bengal, fluoride was first detected at Bhuvanandapur in Nalhati-I Block in Birbhum District in 1996. In 2005, 729 sources were found contaminated with fluoride above 1.5ppm in 43 blocks of seven districts viz. Purulia, Birbhum, Bankura, Malda, South Dinajpur, North Dinajpur and South 24-Parganas.

Kharai village of Beko Gram Panchayat of Kashipur CD Block is highly affected by fluoride contamination in drinking water in Purulia district. Economically the affected people are most backward. Access of modern facilities and social amenities to them are not sufficient. All these factors make the problem more acute. 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. So, large numbers of people are affected by dental, skeletal and different non skeletal fluorosis diseases.

OBJECTIVE:

The study has been done to achieve the following objectives:

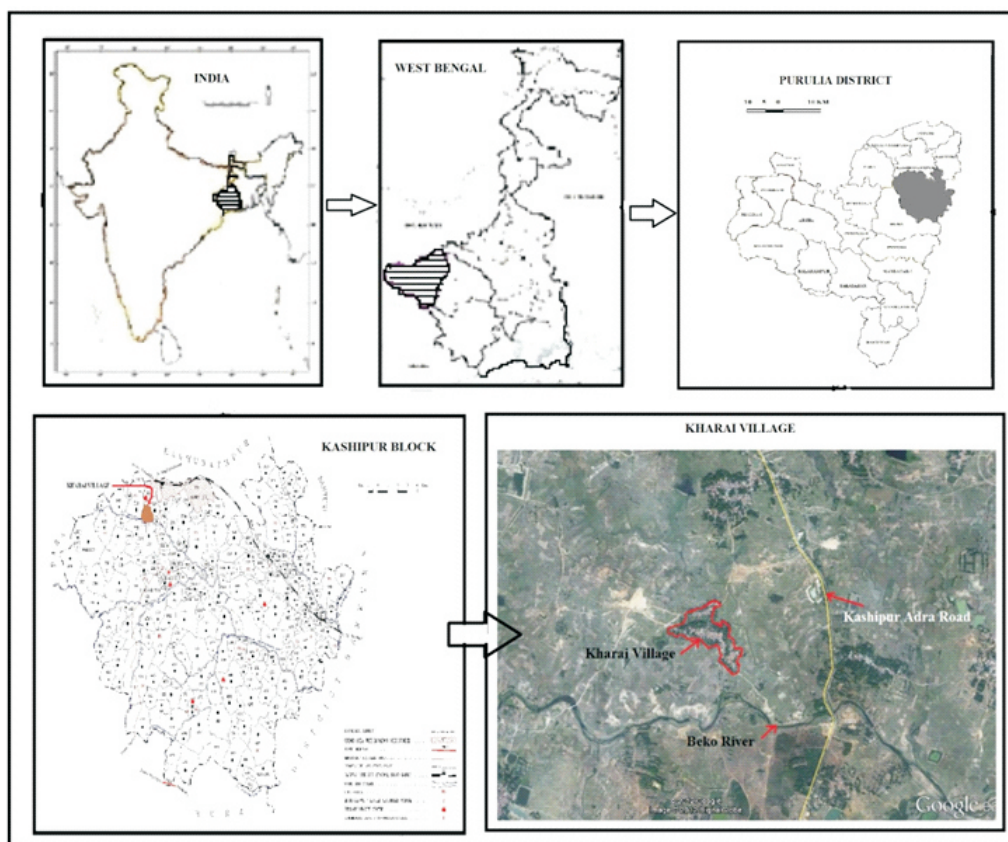
- 1) To identify the nature and extent of fluorosis diseases suffered by the people through the drinking of fluoride contaminated water
- 2) To analyse statistically the relation between fluorosis patients and other socio economic and demographic factors
- 3) To find out some measures suitable for this area to alleviate the problems

STUDY AREA:

For present study, Kharai village of Beko gram panchayat of Kashipur block of Purulia district has been selected where the level of fluoride content in the water is 8.28mg/litre. Purulia is the westernmost district of West Bengal. This district is located in between 22°42'35"N and 23°42'00"N latitude and 85°49'25"E and 86°54'37"E longitude. Kharai is a small village located at the western side of Kashipur-Adra main road of Beko gram panchayat of Kashipur block. Area of the Kharai mouza is 27.9

hectare. Special feature of the village is that, the village is fully resided by scheduled caste population. Out of total population, 55.09% population is literate and male and female literacy rates are 65.83% and 41.67% respectively. Fluoride level of this village is highest in the district which is 8.28 mg/liter. People of the village take the contaminated water for drinking and cooking purposes and the villagers face acute problems of fluorosis diseases.

Fig. 1: Location Map of Kharai Village



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 have been collected from PHE office, other information regarding fluoride contamination have been collected from books, journals, websites, census report etc. For primary data household survey has been conducted with well defined schedules and questionnaires. The questionnaire has two sets of questions. The first set of questionnaire includes the questions on the socio-economic conditions of the affected families of the villagers. The second set includes the questions on the different fluorosis diseases suffered by the people. Nine types of fluorosis diseases are selected with their symptoms of field identification. These collected data are then tabulated and statistically analysed by choosing different variables and the relationships between different variables are found out.

RESULTS AND DISCUSSION:

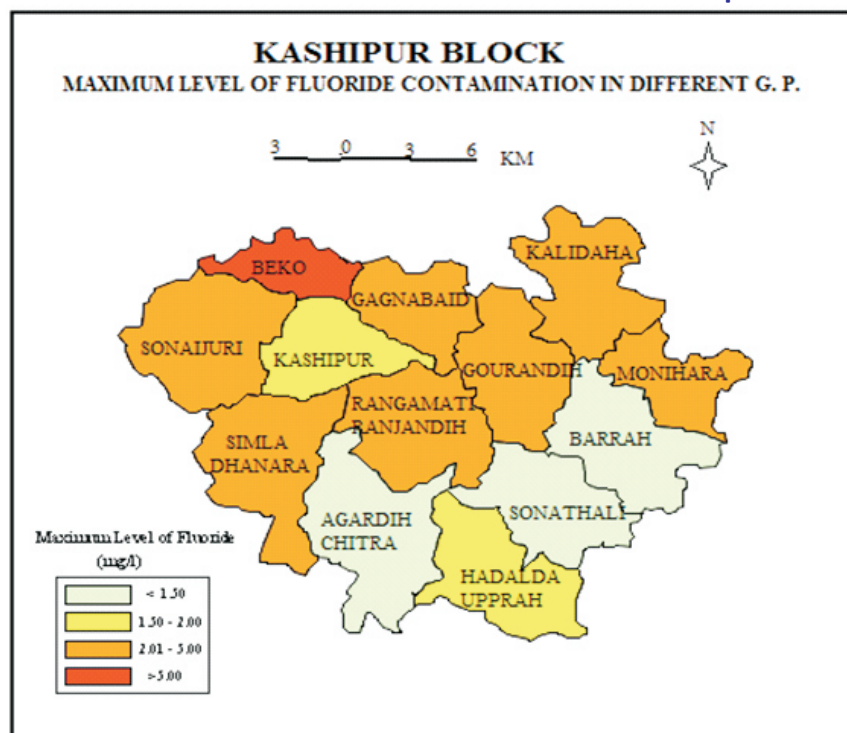
In Kashipur CD block, Boko G.P. is highly contaminated with fluoride, where 8.28 mg/litre fluoride is found in Kharai village. Lower level of fluoride is found in the tube wells of Barrah, Agardih

Chitra and Sonathali G.P., where fluoride levels are less than 1.5 mg/litre. The results are shown in the following table.

Table 1: Fluoride Contamination Level

Sl. No.	Gram Panchayat	Percentage of Tube wells of different Fluoride Level (mg/litre)			Maximum Fluoride (mg/litre)
		<1.0	1.0 - 1.5	>1.5	
1	Agardih Chitra	97.10	2.90	0.00	1.19
2	Barrah	91.11	8.89	0.00	1.13
3	Beko	87.88	3.03	9.09	8.28
4	Gagnabaid	96.77	1.08	2.15	3.12
5	Gourandih	84.00	12.00	4.00	2.89
6	Hadalda Upprah	85.48	9.68	4.84	1.88
7	Kalidaha	85.71	10.00	4.29	2.56
8	Kashipur	91.75	7.22	1.03	1.64
9	Monihara	86.15	12.31	1.54	2.39
10	Rangamati Ranjandih	94.59	4.05	1.35	2.04
11	Simla Dhanara	83.51	13.40	3.09	2.39
12	Sonaijuri	90.48	6.35	3.17	2.25
13	Sonathali	96.10	3.90	2.51	1.14

Fig. 2: Maximum Level of Fluoride Contamination in Kashipur CD block



In Beko GP, more than 9% tube wells are found to be fluoride contaminated above the level of 1.5 mg/litre. Out of 9 villages in this gram panchayat, tube wells of 44.44% villages namely Kharai, Beko,

Palaskola and Rugri are fluoride contaminated. In Kharai village, total four tubewells are found and all the tubewells are fluoride contaminated above the level of 1.5mg/ litre. Other properties of drinking water of the tube wells like iron, pH and hardness of the water are given in the table below.

Table 2: Chemical Properties of the Water of the Tube wells of Kharai village

Sample No	pH	Iron	Fluoride (mg/l)	Hardness
1	8.50	0.8	2.22	228
2	9.00	0.4	8.28	64
3	7.20	0.3	3.23	180
4	6.90	0.2	1.58	220

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 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. 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-fluoro-apatite crystals. Thus, a large amount of fluoride gets bound in these tissues and only a small amount is excreted through sweat, urine and stool. The intensity of fluorosis is not merely dependent on the fluoride content in water, but also on the fluoride from other sources, physical activity and dietary habits.

Excessive intake of fluoride may also lead to muscle fibre degeneration, low haemoglobin levels, deformities in RBCs, skin rashes, depression, gastrointestinal problems, urinary tract malfunctioning, nausea, abdominal pain, tingling sensation in fingers and toes, reduced immunity, repeated abortions, male sterility etc. All these diseases are categorised into three types i.e. Dental Fluorosis, Skeletal Fluorosis and Non-skeletal Fluorosis. The crippling and painful malady has become one of the most serious public health problems in Purulia district.

Table 3: Concentration of Fluoride in Drinking Water and its Effects on Human Health

Fluoride Concentration (mg/liter)	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.

In the Kharai village, percentage of fluorosis patients per family ranges between 11%-100%.

These families have been categorized into three groups e.g., highly affected families where nearly 30% to 100% family members are fluorosis affected, least affected families where 11% to 20 % members are affected and moderately affected families where 20% to 30 % members are fluorosis affected.

Table 4: Fluorosis Patient of Kharai Village

% of Fluoride affected people per family	Fluorosis Patient (% to total Person)		
	Male	Female	Total
11.00- 20.00	14.00	14.29	14.13
20.00-30.00	22.50	25.71	24.00
30.00-100.00	66.67	45.28	56.64

Dental fluorosis is the most important disease where above 55% patients suffer from this disease followed by skeletal fluorosis for adult persons. Patients suffering from neurological problem and still birth and abortion are least in number where nearly 1% patients are affected by these diseases. In between these, the moderate proportion of diseases by which people are suffering, are gastrointestinal and muscular problems, polyurea and polydipsia, skeletal fluorosis for children and allergy. The proportion of different types of fluorosis patients are given in the following table.

Table 5: Percentage of different Fluorosis patients

Sl. No.	Patients	Percentage of Patients
1	% of dental fluorosis patients to total patients	54.70
2	% of skeletal fluorosis for children to total patients	3.16
3	% of skeletal fluorosis adult patients to total patients	38.14
4	% of patients with gastrointestinal problem to total patients	8.25
5	% of fluorosis patients with muscular problem to total patients	5.05
6	% of patients with neurological problem to total patients	1.03
7	% of patients with polyurea & polydipsia problem to total patients	3.09
8	% of patients with allergy problem to total patients	2.06
9	% of patients with problem of still birth & repeated abortion to total patients	0.79

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 Kharai village, out of total fluorosis patients, 54.70% patients are suffering from dental fluorosis where proportion of male dental fluorosis patients is 55.26% and female proportion is 53.49%.

Table 6: Dental Fluorosis of Kharai Village

% of Fluoride affected people per family	Fluorosis Patient		
	Total	Male	Female
11.00- 20.00	10	50.00%	50.00%
20.00-30.00	10	50.00%	50.00%
30.00-100.00	32	31.25%	68.75%

Skeletal fluorosis affects the bones or skeleton of the body. 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 Kharai village, large numbers of people are adversely affected by skeletal fluorosis disease. Here, total, male and female proportion of skeletal fluorosis patients to total fluorosis patients are 38.14%, 35.19% and 41.86% respectively. As far the child skeletal fluorosis is concerned, three children are suffering from skeletal fluorosis.

Table 7: Skeletal Fluorosis of Kharai village

% of Fluoride affected people per family	Child Fluorosis Patient			Adult Fluorosis Patient		
	Total	Male	Female	Total	Male	Female
11.11- 20.00	0	0.00%	0.00%	3	33.33%	66.67%
20.00-29.88	0	0.00%	0.00%	4	50.00%	50.00%
29.88-100.00	3	66.67%	33.33%	29	58.62%	41.38%

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 bloated feeling, constipation and intermittent diarrhea. The present study indicates that the proportion of gastro-fluorosis patients to total fluorosis patients is nearly 1/10th in the villages. 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. The health awareness among female are less than male. Time schedules for taking food is not regular and they belief in old customs and tradition and do unscientific fasting. 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 hamorage and ultimately reduces muscle workability and strength. Thus, a worker becomes dependent person.

After consuming fluoride contaminated water, considerable numbers of people are affected by allergic fluorosis, 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. Only 2.06% patients are suffering from allergic problem.

The renal system is responsible for excreting most of the body's excess fluoride and is exposed to higher concentrations of fluoride than other organs. Due to fluoride pollution, renal impairment may

also cause. Urine may be much less in volume, yellow red in colour and itching in the region of axilla may be the symptoms. It can also lead to polyurea and polydipsia. Polyurea is a disease in which patients have tendency to urinate more frequently though urine volume may be less and in polydipsia patients feel excessive thirst.

In the present study, there are small proportion of fluorosis patients who are suffering from polyurea and polydipsia. In Kharai village 3.09% patients are suffering from this disease. 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. In this village, only 1% people are suffering from this disease that is only female.

Excess intake of fluoride contaminated drinking water has possible adverse effects on pregnancy outcome. Fluoride is known to cause calcification in the blood vessels or arteries. Repeated abortion and still birth have been reported in the study areas of fluorosis because due to fluorosis, fetal blood vessels calcification takes place which arrest the growth of the fetus. In Kharai, only 0.79% female patients have been found who have this kind of problem.

STATISTICAL ANALYSIS:

Several statistical methods have also been applied such as correlation, regression, chi-square, correlation matrix etc to find out the accurate results. Correlation coefficients have been computed between number of dental fluorosis patients and the number of male, female and total family members of below 20 years age. The result shows the positive relationship between the variables that means the higher the number of people of below 20 years age higher is the proportion of dental fluorosis patients in the family. Correlation coefficients between percentage of fluorosis patients per family and number of male, female and total family member of more than 20 years age indicates positive correlation that means the skeletal and non skeletal fluorosis patients are largely found in the people of above 20 years age.

Fig. 3: Relationship between number of dental fluorosis patients and family member of below 20 years age

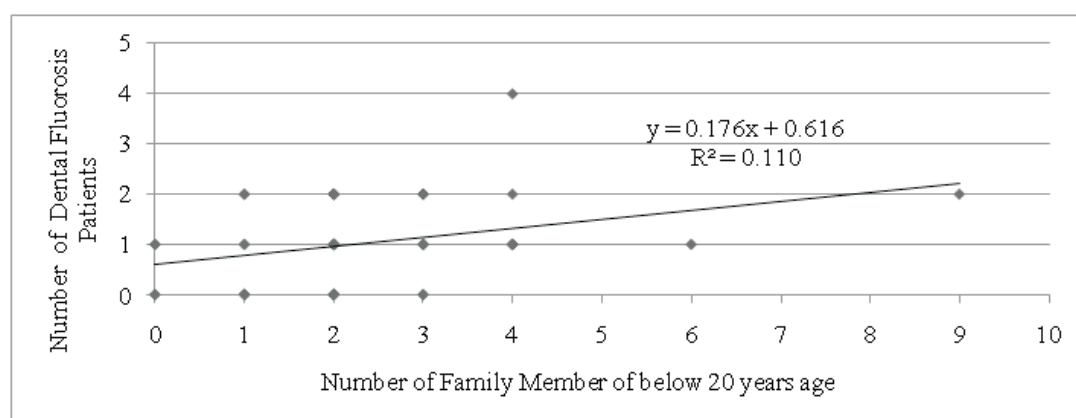
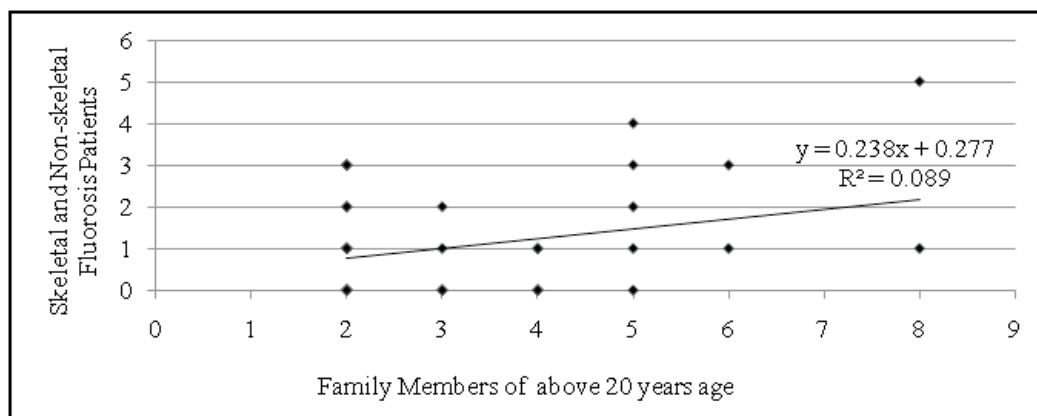


Fig. 4: Relationship between number of skeletal and non-skeletal fluorosis patients and family member of above 20 years age



An attempt has been made to find out correlation coefficients between percentage of fluorosis patients per family and number of male and female illiterate persons of family. These variables are chosen because illiteracy indicates ignorance and unawareness about the problems and it is very difficult to motivate, inspire and mobilise the illiterate people against the attack of fluorosis. It is believed that illiterate people are basically poor, who have very small amount of purchasing capacity to resist, protect and prevent from fluorosis. That is why, these illiterate people should be severely attacked by fluorosis.

The higher educated persons are very much aware of contamination effects of fluoride on their health. Besides, they can be motivated, mobilised and inspired about the resistance, preventive and protective measures of fluorosis diseases. Therefore, it is found that the households where large numbers of members have obtained higher education degrees have small proportion of fluorosis patients.

Correlation matrix has been computed to find out the clustering of different fluorosis diseases. In this village, considerable numbers of dental fluorosis patients are found. In those households where dental fluorosis patients are found, there large numbers of skeletal fluorosis of adult persons are also observed. But, this is observed in the sample households only and is not found in the entire village because the correlation coefficient is insignificant.

It can be said that skeletal fluorosis, fluorosis causing polyurea, polydipsia and allergy patients have clustered in the same household which is observed in the entire village as the correlation coefficient among them are significant at 5% level of significance.

Table 8: Correlation Matrix of Fluorosis Diseases of Kharai Village

DISEASES	Dental Fluorosis	Children Skeletal Fluorosis	Adult Skeletal Fluorosis	Muscular Problem	Neurological Problem	Gastrointestinal Problem	Polyurea & Polydypsia	Allergy Problem	Still Birth & Abortion
Dental Fluorosis	1.00								
Children Skeletal Fluorosis	-0.12	1.00							
Adult Skeletal Fluorosis	0.22	0.15	1.00						
Muscular Problem	-0.18	-0.04	-0.11	1.00					
Neurological Problem	-0.18	-0.04	0.04	-0.02	1.00				
Gastrointestinal Problem	-0.06	-0.12	0.17	-0.07	0.33*	1.00			
Polyurea & Polydypsia	-0.12	0.05	0.29*	-0.04	-0.04	0.34*	1.00		
Allergy Problem	-0.14	0.05	0.38*	-0.03	-0.03	-0.10	-0.05	1.00	
Still Birth & Abortion	-0.18	-0.04	0.04	-0.02	-0.02	-0.07	-0.04	-0.03	1.00

Note: ** means significance at 1% level, * means significance at 5% level, No * means insignificance

Chi square (χ^2) test has been attempted to find out the association between percentage of fluorosis patients per family (row) and average age of the family members, level of education of the family members and main occupation (column).

The computed χ^2 values between the above mentioned variables are 0.23, 21.92 and 3.97 in Kharai and computed χ^2 values between percentage of fluorosis patients per family and education status of the family members are larger than the tabulated χ^2 values at 5% levels of significance. Therefore, Null Hypothesis is rejected and alternative hypothesis is accepted that means there is association between percentage of fluorosis patients to total family member and education status of the family members. But, the computed χ^2 values between percentage of fluorosis patients per family and average age of the family members and main occupation are smaller than the tabulated χ^2 values. Therefore, Null Hypothesis is accepted, indicating no association between percentage of fluorosis patients per family and average age of the family members and main occupation at the household level study. The results of χ^2 test are shown in the following tables.

Table 9: Chi Square (χ^2) Test Results of Kharai Village

Column Variable	Raw Variables	χ^2 Value	Tabulated χ^2 values at levels of significance		Significant/ Insignificance
			1%	5%	
% of fluorosis patients to total family member	Average age of the family member	0.23	13.28	9.49	Insignificant
	Level of Education	21.92	23.21	18.31	Significant at 5% level
	Main Occupation	3.97	13.28	9.49	Insignificant

REMEDIAL MEASURES:

Large numbers of people of Kharai village are affected by fluoride contamination and have been suffering from different types of fluorosis diseases due to drinking of that fluoride contaminated water since long time. Therefore, people face several problems relating to their health and socio-economic conditions of their families. To solve the burning problems, several programmes have been initiated in this village. These are as follows:

1. Water from the tube wells are tested regularly for detection of fluoride, Iron, pH, Hardness and Bacteria.
2. Dental screening of the students of Primary school has been done by a team of UNICEF along with PHE department, Purulia.
3. Contaminated tube wells have been detected and Red colour has been labeled indicating dangerous water.
4. Fluoride free pipe water supply has been established with 5 taps at different parts of the village since last five years.
5. One water filtration plant programme was initiated but due to location dispute it was not materialized.
6. But no medical measures have been started to treat the patients and no awareness programme has been organized at the village.

But, there are some problems that stand in the way of the programme. These are:

1. Supply water line is not sufficient to provide fluoride free water for whole villagers.
2. Water is available only two hours a day which is not sufficient for whole day utilization for cooking and drinking.
3. Water is not available equally from all the taps.
4. No tap has stopper to control the wastage of water. So, the water is flowing out all through the supply time and the other taps which are located at the other end of the village are not getting sufficient flow of water.
5. Only two out of five water taps work properly which supply water to the people of less than half of the village. Remaining three taps have water only 15-30 minutes and water flow is very thin. So, the villagers of that part of the village where supply water is not sufficient are compelled to drink the contaminated water from red marked tube wells.

6. In the Kharai primary school, mid day meal is cooked with the fluoride contaminated water of 8.28 mg/liter because during mid day time, water supply is not available. Water is available only 30 minutes during morning which is also not regular.

7. Level of education, economic condition, level of consciousness of the people of Namo para are very bleak, at the same time, supply of water in this part is not sufficient. That is why, the people are not gaining any advantage of the management programme.

8. In Namo para of Kharai village almost all the household and almost all children in between of 8-18 years of age are suffering from dental fluorosis with whitish to brown pitted teeth.

To solve the problems of the people and to get full benefit of the management programme, following programme should be implemented urgently.

1. Fluoride free safe drinking water supply should be sufficient in the all corners of the village.
2. Pipeline should be checked up regularly, so that, the flow of water would be enough to provide water upto the end of the village.
3. Number of water taps should be at least 10 to avoid long line, waiting and quarrelling for taking water.
4. All the water taps should have stoppers to avoid wastage of water.
5. Water should be supplied twice daily, in morning and afternoon.
6. Primary Schools should have water storage tanks to store water for mid day meal and to provide fluoride free water to the children throughout the school time.
7. A medical team should be formed to regular check up the patients and supply proper medicine and regular monitoring the progress of health status.
8. Fluoride filter should be made up by local sanitary marts and should be distributed to the affected households.
9. Proper training should be given to the people to use and maintenance of the filters.
10. Emphasis should be given to the people having low income and low education level.
11. Awareness programme should be performed to aware the people about the source of their problems, personal remedial measures, changing of bad habits and food habits.

CONCLUSION:

So, it can be concluded that the source of fluoride in drinking water is natural i.e. from fluoride bearing minerals. As the main source of drinking water is the groundwater based tube wells, by drinking this fluoride contaminated water, large number of people have been suffering from different types of fluorosis diseases like dental, skeletal and non-skeletal fluorosis. People being economically backward, illiterate, having poor access to modern infrastructure, facilities and amenities and suffering from malnutrition are mostly attacked by fluorosis disease. Fluorosis disease not only affects badly on the health of the people, but also it adversely affects the economy of the family and society. Several social, economic, cultural, infrastructural, political as well as administrative problems are also emerging out from fluorosis. Several remedial measures are suggested and action programmes have been chalked out to get rid of these problems.

But, some problems may stand in the way of these remedial measures. These problems can be social, economic, infrastructural, political and administrative. Due to the presence of all these socio-cultural, economical, infrastructural and politico-administrative obstacles, these remedial measures either can't be implemented or will be rejected by the village society. If, all these remedial measures are implemented after removing all these obstacles, then the people of the district will recover from the adverse effects of fluoride contamination of drinking water.

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