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Fluoride concentration in ground water of Kalahandi and Nuapada District, Odisha, India

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ABSTRACT

The present study deals with ground water quality with respect to the fluoride content in water resources of Kalahandi and Nuapada districts of Odisha, India. Water samples were collected in different locations covering tap water, open wells, tube wells and river waters. Ground waters of tube wells are highly polluted with fluoride in comparison to open wells. In Nuapada district out of 4920 tube wells 399 contains 1.5-3.0 (mg/L) and 114 are from 3-5(mg/L) and 22 are from 5-6.5> (mg/L). A survey report shows 22557 people are affected with fluorosis and nearly 2 lakh people are in risk. In Kalahandi district Karalkot, Kerijhola and Binapur water supply contains objectionable fluoride content i.e. 3.88 mg/L. Dental fluorosis was observed among school children in Boden and Sonapalli blocks. In view of the severity of the problem the defluoridation techniques need to be evolved to reduce or minimize the fluoride concentration in drinking water.

Keywords: Ground water, Fluoride, Kalahandi, Nuapada, Odisha

INTRODUCTION

The crucial role groundwater plays as a decentralized source of drinking water for millions rural and urban families cannot be overstated. According to some estimates, it accounts for nearly 80 per cent of the rural domestic water needs, and 50 per cent of the urban water needs in India.

Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. Also, the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata. But, In India, where groundwater is used intensively for irrigation and industrial purposes, a variety of land and water-based human activities are causing pollution of this precious resource. Its over-exploitation is causing aquifer contamination in certain instances, while in certain others its unscientific development with insufficient knowledge of groundwater flow dynamic and geo-hydrochemical processes has led to its mineralization[1,2]. Fluoride content in groundwater is mainly due to natural contamination, but the process of dissolution is still not well understood[3,4]. Fluoride, an electronegative element, is highly reactive, therefore, almost never occurs in elemental state in natural water. It combines with most of the elements to form ionic or

covalent fluorides. Areas with semi-arid climate, crystalline igneous rocks and alkaline soils are mostly affected[3]. The origin of fluoride in groundwater is through weathering of alkali, igneous and sedimentary rocks. The common fluoride bearing minerals are Fluorspar (CaF_2), Cryolite (Na_3AlF_6), Fluor-apatite (Ca_3 $(PO_4)_2$ Ca (FCl_2). Fluorite (CaF_2) is the principle bearer of fluoride and is found in granite, granite gneisses and pegmatite[5,6]. Apart from natural sources, a considerable amount of fluoride may be contributed due to anthropogenic activities. Burning of coal, manufacturing process of aluminium, steel, bricks, Phosphatic fertilizers industries, often contain fluoride as an impurity and are being leached down to the ground water[5,7,8,9]. The high level of fluoride in drinking water beyond the permissible limit[2] has toxic effects, while its optimum level shows beneficial effects in reducing dental carries. The severity depends upon the amount ingested and the duration of intake[10].

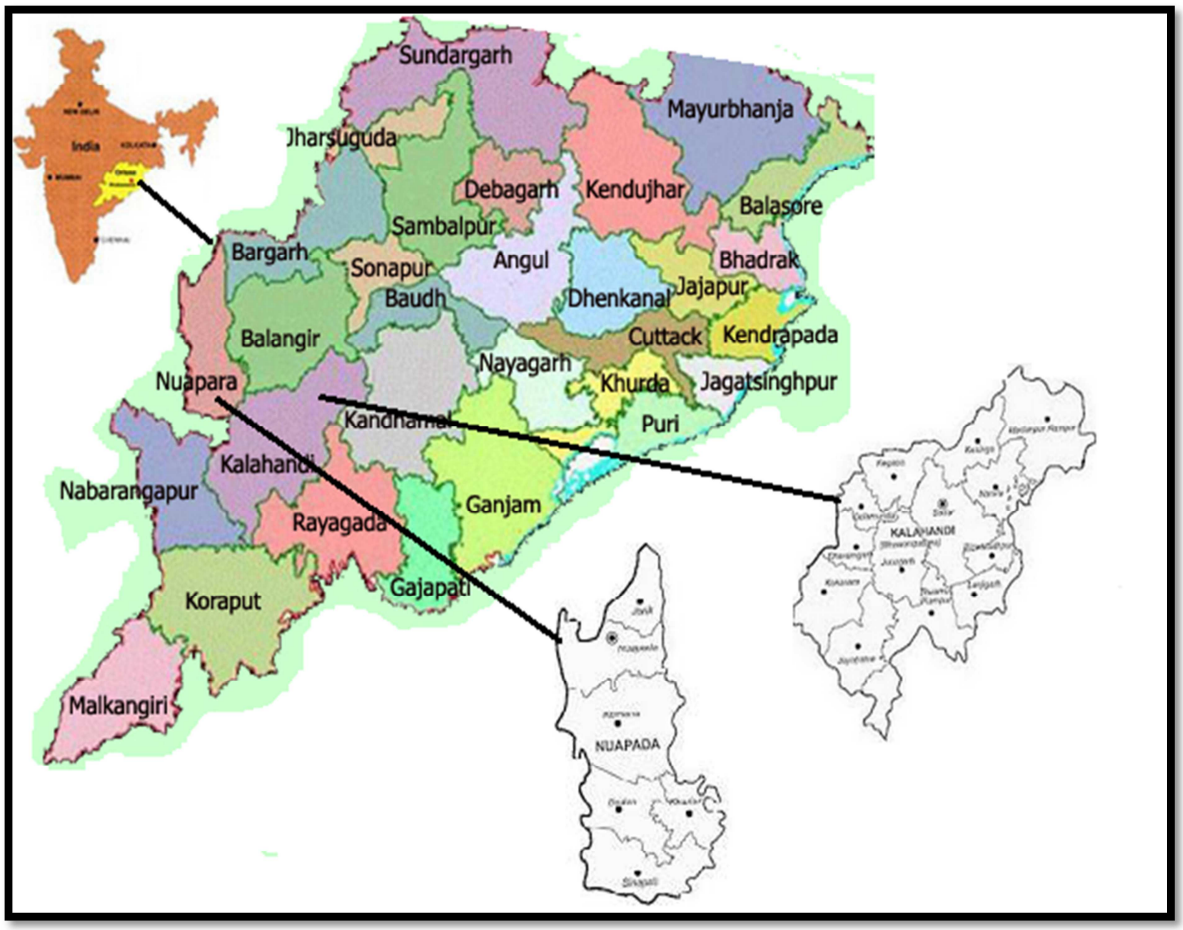

Fig-1: Kalahandi and Nuapada Districts of Odisha

Fluoride contamination of groundwater is a growing problem in many parts of the world. High concentration of fluoride is reported both from hard rock (granites & gneisses) as well as alluvial aquifers[11]. In India more than 66million people are at risk of developing fluorosis and high fluoride concentration in groundwater (greater than 1 mg/l) is widespread in the arid to semi-arid western states of Rajasthan and Gujarat and in the southern states of Andhra Pradesh, Karnataka and Tamil Nadu[12,13,14,15]. People living in such areas were drinking high fluoride water without realizing its presence, which caused various bone diseases. The cause of high fluoride in ground water is geogenic being a result of the dissolution of fluoride bearing minerals. Fluoride in ground water is mainly influenced by the local and regional geological setting and hydro geological condition. However, soil consisting of clay minerals[16,17], the influence of local lithology, aided by other factors like semi-arid climate of the region may be responsible for higher concentration of fluoride in the groundwater of the region. In sea area, fluoride containing chemical components of Ca, Mg, Na, Cl, SO_4, bicarbonate, Bromide, Phosphate, Iron, Aluminium etc., Locally used agricultural pesticides and anthropogenic contamination of surface water due to many rivers carry on particulate

matter on rainy seasons. Fluoride problems are wide spread in nine states of India covering almost the entire country. Nearly 66million of people face the risk of which an estimated 6million are children. In view to look into the aspects of water quality and related health problems, the water quality date of Kalahandi and Nuapada districts of Odisha, India, are highly fluoride effected villages has been studied.

MATERIALS AND METHODS

2.1 Study area

The study was undertaken in Kalahandi and Nuapada districts of Odisha. Initially, Nuapada District was a part of Kalahandi District till early March 1993, but for the administrative convenience, Kalahandi District was divided into two parts - Kalahandi and Nuapada under the state government Notification on 27th March, 1993.

The district of Kalahandi is located in south-west region of the state of Orissa. As regards geographical region, the district is situated between $19^{o}3'$N and $20^{o}18'$N latitude and $82^{o}20'$E and 83^{o} 47'E longitudes. The district headquarter town Bhawanipatna is situated at a distance of 418 kms from State Capital Bhubaneswar. The district is bounded on the north by Nuapada and Balangir districts, on the east by Kandhamal and Rayagada, on the south by Nabarangapur and Koraput districts, on the west by Raipur (Chhatisgarh) and Nabarangapur districts. Total geographical area of this district as supplied by the Surveyor General of India is 7,920 sq kms. The district ranked seven in this state of Orissa in comparison to other districts in terms of area.

Nuapada is a district of Orissa, India. Naupada district located in western part of Orissa, lies between 20° 0' N and 21° 5' No latitudes and between 82° 20' E and 82° 40' E longitudes. Its boundaries extend in the north, west and south to Raipur district in Madhya Pradesh and in the east to Bargarh, Balangir and Kalahandi districts. Its boundaries extend in the north, west and south to Raipur District in Chhattisgarh and in the east to Barhgarh District, Balangir District and Kalahandi district. This district is spread over in an area of 3407.5 sq kms. Generally, climate of Nuapada District is hot and dry; humidity is negligible with scanty rainfall.

2.2 Sampling

Drinking water samples were taken from different villages of Kalahandi and Nuapada districts (Fig-1). After the water samples were transported to the laboratory, fluoride analyses were performed immediately.

2.3 Determination of Fluoride

A combination fluoride electrode was used to determine the fluoride concentrations in drinking water, juice and bottled water samples. The samples and fluoride standard solutions were diluted 1:1 with the TISAB, The solutions, which contained 25ml of the sample and 25mL of TISAB solutions, were mixed with a magnetic stirrer for 3mins. The electrode potentials of the sample solutions were directly compared with those of fluoride standard solutions.

RESULTS AND DISCUSSION

Environmental pollution due to fluoride contamination has serious consequences. Besides the immediately visible syndromes, the effect of this environmental problem can be a syndromes astheria, muscular atrophy, heartburn, joint pain, disfigured teeth, skeletal deformation, osteosclerosis and calcification of ligaments leading to such as hyphosis, stiffness of the spine and bony exostosis (Fig-2a,2b).

Dental fluorosis was observed in 76% out of the 622 children surveyed in the 9 selected villages. More than half the children (325) were suffering from mild dental fluorosis, while 132 were moderately afflicted and 15 were diagnosed with severe dental fluorosis. Skeletal fluorosis was observed in Bastipada and Khandhapada hamlets of Nuamalpada village and in Sukalpur village (Table-1).

Table-2 reveals fluoride concentrations greater than the accepted level of 1.5 mg/l in most of these sources. The highest fluoride concentration found in these sources is 4.0 mg/l in Nuamalpada village. The fluoride content varied from source to source in each village. It was much higher in groundwater sources (hand pumps and open wells) as compared to surface water sources. The high fluoride content in groundwater is probably due to the presence of underground fluoride bearing rocks. Seven villages, namely, Bakalikhuti, Tetelpada, Binapurpada, Putupada, Pharsera, Malpada and Jharbandh have higher concentrations of fluoride in handpumps compared to the open wells. The remaining 4 villages Sukalpur, Amguda, Numalpada and Belgaon have similar ranges of fluoride concentrations

in the hand pumps and open wells. This indicates that the former villages contain fluoride in the upper strata rather than the deeper strata of underground rocks. Most of the open wells in these villages exhibited fluoride content below 1mg/L. It was interesting to note that most of these open wells were not used for drinking.

Fig-2(a): Skeletal Fluorosis

Fig-2(b): Dental Fluorosis

Four grab samples were collected from tap water in Karalkot, Kerijhola, Binapur and Boden villages which were supplied with piped water by government agencies. The analysis revealed that three of the four samples had fluoride contents around 3mg/L or more. Three out of the four samples were from supplies withdrawn from deep bore wells. These points out that supplying water from deep bore wells may not be a viable solution to the problem. Fluoride concentrations were also monitored in Sundher, Indra and Patal Ganga rivers. All of them had fluoride content below 1mg /L. Hence, these surface water sources can be used for supplying drinking water, after treating them to remove bacteriological contamination (Table-3,4).

Fluorosis has spread its tentacles to 283 Villages in 65 Gram Panchayats under Golamunda, Bhawanipatna, Narla and Kesinga blocks during the last few years. Among 10,235 school children in the age group of five to fourteen years surveyed in these villages, 4984 were found to be affected by Dental Fluorosis of different degrees. While 2,966 were found to be suffering from Mild Fluorosis, 1,526 were in moderate category and 492 having severe

problems (Table-5). According to the study, some of the severely affected villages are Dhamanpur, Khaliapali, Limser, Chahaka and Golamunda under Golamunda block, Suknabhata, Ghugurpala, Sargiguda, Ratanpur and Kamegaon villages under Narla block and Sagda, Deypur, Pokharighat, Gohirapadar and Gudialipadar villages under Bhawanipatna block.

Table-1: Dental Fluorosis Status among the Children (from 7 to 16 years age) in Villages Surveyed

S. No.	Name of Gram Panchayat	Name of Village	Total Children Surveyed	Status of Different degree fluorosis				
				Mild	Moderate	+++	Total	
							Nos.	%
Block – Boden								
1	Pharsara	Baklikhunti	105	50	35	1	88	82
		Amguda	158	80	38	5	122	78
		Tentelpada	48	26	7	0	30	71
		Pharsara	90	56	20	1	80	93
		Putupada	63	33	8	0	44	71
2	Khaira	Sukalpur	24	18	4	2	22	75
Block – Senapali								
1	Jharbandh	Jharbandh	27	10	0	0	12	46
		Malpada	77	36	4	0	40	53
2	Nangalbod	Nuamalpada	43	14	22	7	41	96
Total	**4**	**9**	**635**	**323**	**138**	**16**	**479**	**76**

Table 2: Fluoride Concentration in Village Drinking Water Sources

S. No	Villages	Hamlet (Pada)	Range of Fluoride Concentration (mg/I)	No. of Water Sources				
				W	Hp	Pond	Total	
							No.	%
1	Sukalpur	Sukalpur						
			< 1.0	1	*	*	1	7
			1.0 – 1.5	1	*	*	1	7
			1.6 – 3.0	4	2	1	7	50
			3.0 – 4.0	2	*	*	2	14
			>4.0	2	1	*	3	21
2	Bakalikhuti	Bakalikhuti						
			< 1.0	2	*	*	2	15
			1.0 – 1.5	4	2	*	6	46
			1.6 – 3.0	3	2	*	5	39
		Sargiguda						
			< 1.0	2	*	*	2	18
			1.0 – 1.5	3	1	*	4	36
			1.6 – 3.0	2	3	*	5	45
		Madhupur						
			< 1.0	2	*	1	3	60
			1.0 – 1.5	*	2	*	2	40
3	Amguda	Bodlapada						
			1.0 – 1.5	*	4	*	4	57
			1.6 – 3.0	1	2	*	3	43
		Padarpada						
			1.6 – 3.0	1	1	*	2	100
		Jhakarpada						
			1.6 – 3.0	*	1	*	1	100
		Amguda- Bastipada						
			< 1.0	3	2	*	5	45
			1.0 – 1.5	1	3	1	5	45
			1.6 – 3.0	*	1	*	1	10
		Jhulapada						
			1.0 – 1.5	*	2	*	2	100
		Bandhpada						
			1.6 – 3.0	3	2	*	5	100
4	Tetelpada	Tetelpada						
			< 1.0	*	1	*	1	17
			1.0 – 1.5	2	2	*	4	67
			1.6 – 3.0	*	1	*	1	17
5	Binapur	Binapurpada						
			1.0 – 1.5	*	1	*	1	100

6	Putupada	Putupada						
			< 1.0	*	2	*	2	17
			1.0 – 1.5	1	7	*	8	67
			1.6 – 3.0	1	*	*	1	8
			3.0 – 4.0	1	*	*	1	8
		Arjuna						
			< 1.0	1	2	1	4	80
			1.0 – 1.5	*	1	*	1	20
		Mahulpada						
			< 1.0	1	*	*	1	33
			1.0 – 1.5	1	1	*	2	67
7	Pharsara	Pharsara						
			< 1.0	2	3	*	5	56
			1.0 – 1.5	*	3	*	3	33
			1.6 – 3.0	*	1	*	1	1
		Kanakpur						
			< 1.0	1	*	*	1	25
			1.0 – 1.5	*	3	*	3	75
8	Malpada	Bastipada						
			< 1.0	1	*	*	1	20
			1.0 – 1.5	*	2	*	2	40
			1.6 – 3.0	*	2	*	2	40
		Routpada						
			< 1.0	*	1	*	1	25
			1.0 – 1.5	*	2	*	2	50
			1.6 – 3.0	*	1	*	1	25
9	Jharbandh	Vanpada						
			1.6 – 3.0	*	1	*	1	100
		Bastipada						
			< 1.0	*	1	*	1	11
			1.0 – 1.5	*	5	*	5	56
			1.6 – 3.0	*	3	*	3	33
10	Nuamalpada	Bastipada						
			1.6 – 3.0	*	1	*	1	9
			3.0 – 4.0	*	1	*	1	9
			>4.0	5	3			
		Hanspada				1	9	82
			1.6 – 3.0	*	1	*	1	100
		Khandhapada						
			1.0 – 1.5	*	*	1	1	12
			1.6 – 3.0	*	1	*	1	12
			3.0 – 4.0	1	2	*	3	37
			>4.0	1	2	*	3	37
		Portipada						
			1.6 – 3.0	*	2	*	2	67
			3.0 – 4.0	*	1	*	1	33
		Kachharpada						
			>4.0	1	2	*	3	100
		Podhpada						
			1.6 – 3.0	1	1	*	2	67
			3.0 – 4.0	1	*	*	1	33
11	Belgoan	Belgoan						
			< 1.0	*	2	*	1	7
			1.0 – 3.0	1	2	*	1	7
			3.0 – 4.0	*	3	*	7	50
			> 4.0	*	1	*	2	14

**Not found or monitored, W- Open well, Hp = Handpump*

When fluoride is naturally present in drinking water, the concentration should not average more than 1.0mg/L. The Indian Council of Medical Research[18] has given the highest desirable limit of fluoride as 1.0mg/L and maximum permissible limit as 1.5mg/L. the Bureau of Indian Standards has recommended the limit of 1.5mg/L.[19] Manufacturers of products for internal consumption generally restrict the F concentration of water to about 1.0mg/L. the effect of F on livestock is same as in the case human beings and should not exceed 2.0mg/L, since excess concentration affects animal breeding and causes mottled teeth of the young animals (Table-6).

Traditionally the people in Nuapada district had been using the water from open wells, tanks, riverbeds and hilly steams. Water borne diseases were very common in all the villages till very recent time. With the spread of deep tube wells, in many villages water related diseases have been very much under control. However, to the misfortune of the people in many villages even the tube well waters have been found to be contaminated with several minerals which are harmful to human health. Among such minerals iron contamination is very common. But presence of high quantities of fluoride in some tube well water has posed a very serious problem in this district.

The water quality was classified into 6 categories depending upon its fluoride concentration. The categories are as follows:

A total number of 4702 tube wells and 218 open wells were covered under the survey in all the 5 blocks of Nuapada district. The following table gives the block-wise distribution of wells. The above table shows that out of the 4920 wells and tube wells that were tested for the amount of fluoride contamination, 907 wells (both tube wells/open wells) were found to be having more than the permissible limit. The wells that contained higher quantity of fluoride were declared as very dangerous and it was resolved that the people will not drink water from these wells.

Table-3: Fluoride Concentrations in Tap Water Supply

S.No.	Description	Fluoride Concentration (mg/I)
1	Karalkot water Supply	0.26
2	Kerijhola Water Supply	4.18
3	Binapur Water Supply	3.38
4	Boden Water Supply	2.98

Table-4: Fluoride Concentrations in rivers

S. No.	Description	Fluoride Concentration (mg/I)
1	River – Indra near Rajna Village	0.45
2	River- Sundar near Konabeer Village	0.50
3	Patal Ganga, Natural Stream	0.42

Table-5: Dental Fluorosis Facts in Kalahandi
(Report by Sahabhagi Vikash Abhiyan as on 18.11.09)

S. No.	Name of the block	No. of G.P.	No. of villages	Total school children	Status of Different degree of Fluorosis			Total	
					Mild	Moderate	Severe	No.	Percentage
1	Bhawanipatna	29	145	4355	865	134	19	1018	23.37%
2	Kesinga	2	4	81	30	12	0	42	51.85%
3	Narla	11	52	983	135	32	8	175	17.80%
4	Golamunda	23	82	4816	1936	1348	465	3749	77.84%
TOTAL		65	283	10235	2966	1526	492	4984	

Table-6: Relationship between fluoride concentrations in drinking water and severity of fluorosis

Severity of fluorosis	Number of cases	Average fluoride conc. in drinking water (mg/1)
Non affected	17	1.5
Mild dental fluorosis	109	2.1
Moderate dental fluorosis	61	4.2
Severe dental fluorosis	13	3.7
Skeletal fluorosis	30	5.0

Table-7: Affected Villages selected for studies

Name of the blocks	No. of GPs	No. of affected villages
Nuapada	29	24
Komna	27	93
Boden	14	53
Khariar	18	24
Sinapai	21	20
Total	109	214

Table-8: Blocks showing the tube wells with fluoride contents

Sr. no.	Name of the block	No of tube wells/wells covered	Volume of fluoride found 535				
			1-1.5	1.5-3	3-5	5-6.5	>6.5
1	Nuapada	1700	25	33	9	1	-
2	Komna	1241	200	190	47	5	3
3	Boden	794	102	128	40	5	-
4	Khariar	525	27	17	7	2	2
5	sinapali	660	18	31	11	4	0
District total		4920	372	399	114	17	5

Table-9: Affected villages and Gram panchayat of Kalahandi district

Name of the blocks	Total no. of tube wells surveyed	Affected wells	Affected GP	Affected villages	Population having high risk	Population already affected		
						Male	Female	Total
Nuapada	1700	68	15	24	20819	642	635	1275
Komna	1241	445	24	93	84870	6562	5303	11865
Boden	794	275	14	53	49921	347	2728	6201
Khariar	525	55	10	24	22566	668	477	1145
Sinapai	660	64	10	20	13150	1158	913	2071
Total	4920	907	73	214	191326	12503	10054	22557

Table-10: Fluoride Concentration and its effects

Category	Quantity(mg/liter)	Remarks
1	<1	Acceptable
2	1-1.7	Minor risk
3	1.5-4	Risky
4	3-6	Risky
5	5-6.7	Highly risky
6	>6.6	Very dangerous

A survey was undertaken in all the blocks to ascertain the spread and intensity of fluorosis. It also intended to find out the socio-economic condition of the affected people, their loss of income and assets and their current coping mechanisms. For this purpose all the villages in the 5 blocks of Nuapada district were covered.

Table-7 shows the total 109 G.Ps, 214 Villages were affected with fluoride. Out of which 93 from Komna block and 53 from Boden block were severely affected. Tubewells from Nuapada (1700), Komna (1241), Boden (794), Khariar (525) and Sinapali (660) were investigated for fluoride concentration. Out of 4920 tubewells 372 are in the safe range (1-1.5). 399 are moderately toxic (1.5-3.0), 114 tube wells are with high concentration (3.0-5.0) and 22 tubewells are with very high fluoride content (5-6.5>). On the whole 907 villages from 5 blocks were affected with fluoride in different concentrations (Table-8).

In another survey it was observed that male persons were prone to fluorosis in comparison to female. Nuapada district only 22557 are already affected and 191326 population having high risk of fluoride contamination (Table-9).

Traces of fluorides are present in many waters; higher concentrations are often associated with underground sources. In seawater, a total fluoride concentration of 1.3mg/L has been reported[20]. In areas rich in fluoride-containing minerals, well water may contain up to about 10 mg of fluoride per litre. The highest natural level reported is 2800 mg/L. Fluorides may also enter a river as a result of industrial discharges[20]. In groundwater, fluoride concentrations vary with the type of rock the water flows through but do not usually exceed 10 mg/L (Table-10).[21]

The environmental protection Agency[22] recommended a limit of 1.0mg/L of fluoride in irrigation water for continuous use, but up to 1.5mg/L of fluoride for short term use of fine soils. In Orissa ground water is generally quite safe for irrigation purposes and as such no care is required for use of phosphatic fertilizers except in few cases. The defluoridation process includes costly techniques like reverse osmosis and electro dialysis, and also the hit and trial method like deep bore wells, which are not suitable in rural areas. The Nalgonda technique is an economical way for defluoridation[23]. The Nalgonda technique using alum and lime is easily applicable at both the domestic and community levels provided the TDS of water below 1500mg/L and hardness below 250mg/L. Prescribed

quantities of alum and lime are added to raw water and vigorously stirred when fluorides settle as floes. The treated water contains permissible amounts of fluoride.

CONCLUSION

High fluoride in ground water cause health hazard. In Odisha incidence of high fluoride content ground water (>1.5mg/L) is not uncommon in both shallow and deeper water bearing zones. Fluoride data analysis of tube wells, open wells and river water of villages blocks and gram panchayats ranges from 1-6 (mg/L). In majority of the cases 1-1.5 (mg/L) was prevalent. However large number of cases starting from school children to old age people affected with dental and skeletal fluorosis. Most of the ground water samples in study area were found within the drinking water quality standard. The study revealed that rock-water interaction is the major source of fluoride in ground water and very much influenced by local lithology.

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