RESEARCH ARTICLE OPEN ACCESS

A Review of Groundwater Quality Issue in Jharkhand Due to Fluoride

Neeta Kumari[1], Gopal Pathak[2]
[1]Associate Lecturer, Environmental Science & Engineering Group
[2]Professor, Environmental Science & Engineering Group Birla Institute of Technology, Mesra, Ranchi, PIN – 835215

Abstract
Water is elixir of life. Water resources are categorized as surface sources and Groundwater sources. The groundwater have certain dissolved ions , among which presence of fluoride has got significance as it is required by the human body for mineralization of bones and formation of enamel. As per the WHO standard prescribe maximum level for fluoride in drinking water, is 1.5 mg/l, and IS : 10500 specifies required desirable limit of fluoride concentration in drinking water as 0.6-1.0 mg/L, maximum limit is extended to 1.5 mg/l. In the study area, Jharkhand, Palamu, Garhwa, Giridih, Bokaro, Gumla, Godda, Ranchi are the districts where fluoride pollution in water is prevalent. The Daltonganj block in Palamu district is severely affected by this problem. The fluoride problem in the area is mainly geogenic. Other factors like pH, climatic conditions also play a major role.
This review paper focuses on the fluoride sources , its distribution and current status of fluoride occurrence in groundwater of different districts of Jharkhand .The factors which are mainly responsible for the occurrence of high fluorides in groundwater & fluoride associated diseases among the residents of the affected area are also analysed. The solution of this problem is either look for the alternative sources of water supply or defluoridation strategy should be suggested.
Key words : Groundwater, Fluoride, Defluoridation

I. Introduction

Water in the saturated zone is called Groundwater. It caters to 80% of the total drinking water requirement and 50% of the agricultural requirement in rural India[1].

Though fluoride enters the body through food, water, industrial exposure, drugs, cosmetics, etc., drinking water is the major contributor (75-90% of daily intake)[2]. It is 17th in the frequency of occurrence and represents about 0.06%-0.09% of the earth's crust[3]. Fluoride in small amounts is an essential component for normal mineralization of bones and formation of dental enamel[4]. The composition of foods (in respect to Ca, Mg, P and Al), age, sex, occupation, growth and remodelling of bone are other factors, which influence the toxic effects of fluoride[5]. Fluoride endemic areas have high concentration of fluoride in vegetable and foods like sorghum, Ragi, Bajra which aggravate the condition[6].

Fluoride concentration in mg/l	Effects
1.0	Safe limit
1.0 – 3.0	Dental Fluorosis (discolouration, mottling, and pitting of teeth)
3.0 – 4.0	Stiffened and brittle bones and joints
4-6 and above	Deformities in knee and hip bones, and finally paralysis, making the person unable to walk or stand in straight posture, crippling fluorosis.

Table: 1 - Effect of Fluoride on human health[1]

The cause of presence of high fluoride in groundwater is the aridity of climate, dissolution of fluoride bearing minerals and rocks such as fluorspar, cryolite, fluorite, fluorapatite, and hydroxyapatite[10] , ion exchange , velocity of flowing water , temperature, pH, concentration of calcium and bicarbonate ions in water and evaporative concentration can locally account for high fluoride concentration in groundwater.[7,8,9,10,11,12,13,14,15]

Mineral	Composition
Fluorite (Fluorspar	CaF_2
Fluorapatite	$Ca_5(F,Cl)PO_4$
Micas Biotite Muscovite Lepidolite	$K(Mg\ Fe^{+2})_3(AlSi_3)O_{10}(OHF)_2$ $KAl_2(AlSi_3\ O_{10})(OHF)_2$ $K_2(LiAl)_5(Si_6\ Al_2)O_{20}\ (OHF)_4$
Amphiboles Hornblende Tremolite Actinolite	$NaCa_2(MgFe^{+2})_4$ $(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$ $Ca_2(Mg\ Fe^{+2})_5(Si_8O_{22})\ (OHF)_2$
Topaz	$Al_2SiO_4(OHF)_2$
Rock Phosphate	$NaCa_2(MgFe^{+2})_4(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$

Table - 2 showing the source of Fluoride in Groundwater[16]

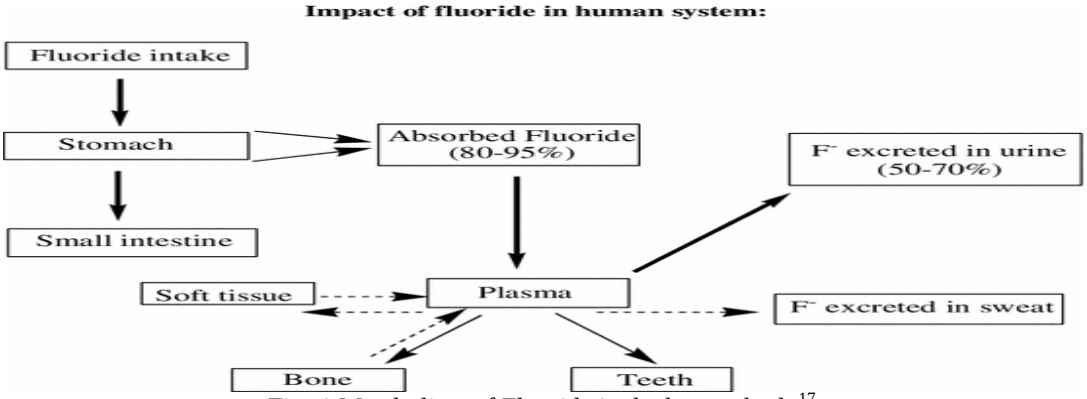
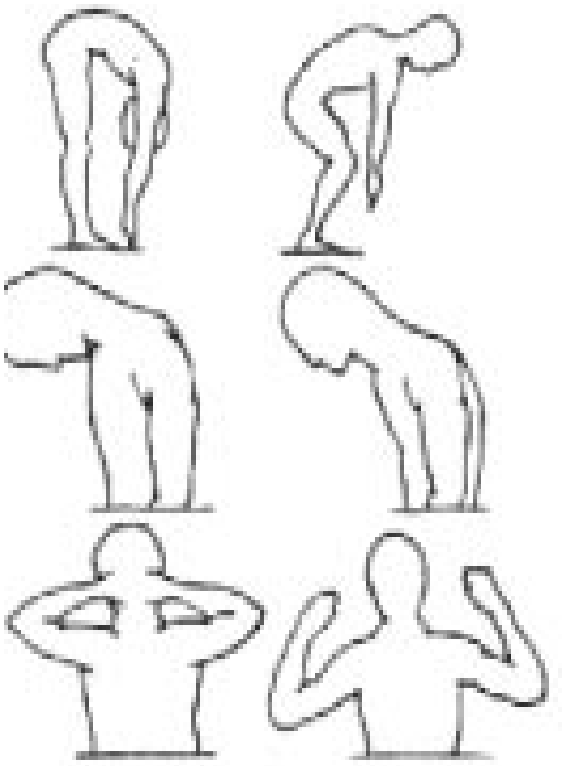


Fig -1 Metabolism of Fluoride in the human body[17]

In endemic fluorosis zones, establishment of the relationship between various chemical characteristics like pH, total alkalinity, total hardness, Carbonate hardness, Non-Carbonate hardness, and excess alkalinity , with the Fluoride enrichment condition is an important aspect and can be used as indicators in delineation of fluorosis zones.[18]

II. Dental and Skeletal fluorosis

Dental fluorosis, which is characterized by discolored, blackened, mottled or chalky white teeth, is a clear indication of overexposure to fluoride during childhood when the teeth were developing. Chronic intake of excessive fluoride can lead to the severe and permanent bone and joint deformations termed as skeletal fluorosis. UNICEF[19] has published a simple guide to identify a fluorosis diseased person for they can not perform some basic exercise related to body posture.



Left Column: Normal capacity person, Right Column: Fluorosis diseased person, Top – the person is unable to bend completely from the waist. ,Middle

– unable to bend the neck to touch the chin on the chest and, Bottom – unable to bend arms to touch the back of head.

Figure-2 showing. A simple guide to identify a fluorosis diseased person from body posture (UNICEF, 1996)

There are different indices for dental fluorosis, which are illustrated in the following table

Indices	Developed by	Weight	Classification
Dean's Index [20,21]	H.T.Dean, 1934, 1942)	0-4 (0,0.5,1,2,3,4)	Normal, questionable, very mild, Mild, Moderate, Moderately severe, severe
Thylstrup and Fejerskov Index (TFI) [22]	Thylstrup and Fejerskov (1978)	10 point ordinal scale (0 to 9)	Based on histological changes that occur in dental fluorosis and increasing fluoride exposure
Tooth surface index of fluorosis (TSIF) [23]	Horowitz et.al. (1984)	8 point scale (0 to 7)	Area of the teeth surface affected
Fluorosis risk index (FRI) [24]	Pendrys (1990)	6 point scale (0,1,2,3,7,9)	Each tooth is divided into zones that correspond to the age at which they begin development.

Table -3 Comparative chart of four indices for assessment of severity of Dental fluorosis

III. International scenario for fluoride in their groundwater

In 1984, WHO estimated that more than 260 million people living all over the world consume water with fluoride concentration above 1mg/l.[25]

UNICEF estimates that " fluorosis is endemic in at least 25 countries" and Around 200 million people from 25 nations have health risks because of high fluoride in groundwater[26] & in India , around 25 million people of 150 Districts are affected by fluorosis disease.[27]

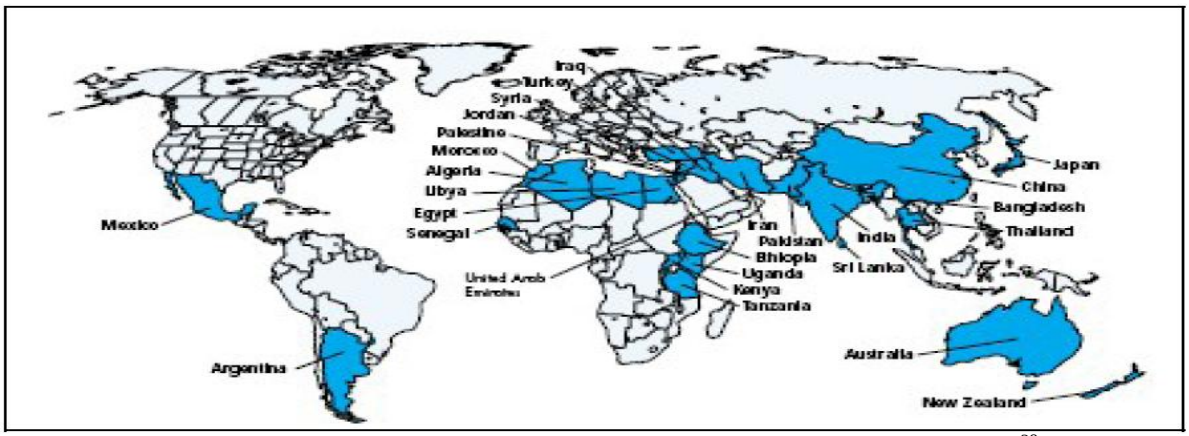


Fig:3 Countries with endemic fluorosis because of high fluoride in drinking water[28]

IV. National scenario for fluoride in their groundwater

In India In 2002, 17 states were affected by severe fluorosis[29] and now the problem exist in 20 states indicating that endemic fluorosis has emerged as one of the most alarming public health problems of the country[5]. In most part of the country , however , the water supplied through groundwater is beset with problems of quality[30]. In some parts of india , the fluoride levels are below 0.5 mg/l, while at certain other places, fluoride levels are as high as 30 mg/l have been reported[7]. World Bank , on 7th January 2014 ,Approved $500 Million to improve rural water supply and sanitation services in four indian states ,

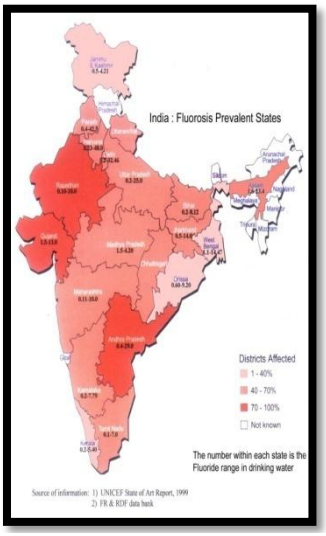
which includes Assam, Bihar, Jharkhand and Uttar Pradesh. About 7.8 million rural people are expected to directly benefit from the project. In India, about 62 million people are suffering from various levels of fluorosis , of which 6 million are children below the age of 14 years; they suffer from dental, skeletal, and/or non-skeletal fluorosis[31]**.** Dental fluorosis is endemic in 14 states and 150,000 villages in india with the problem most pronounced in the states of Andhra Pradesh, Bihar, Gujarat,Madhya Pradesh, Punjab, Rajasthan,Tamil Nadu and Utter Pradesh[32]. According to the Drinking Water Supply department, out of 593 districts , of whose data is available, groundwater in 203 districts has shown high fluoride[33].

Region/State	Fluoride concentration (mg per liter)	Maximum severity of fluorosis observed
North-West India	0.4 – 19	Severe
Central India	0.2 – 10	Moderate
South India	0.2 – 20	Severe
Deccan Province	0.4 – 8	Moderate

Table – 4 The distribution of fluoride in Indian groundwaters is shown in Table[10, 34]

Categories	Percentage	Name of States
I	30% of the Districts Affected	Jammu and Kashmir, Delhi, Kerala and Orissa
II	30-50% of the Districts Affected	Maharashtra, Karnataka and Bihar
III	50-100% of the Districts Affected	Uttar Pradesh, Rajasthan, Gujurat, Andhra Pradesh and Tamilnadu

Table-5 Percentage Categories of Fluoride in Various States of India[35,36,37,38]



Source : UNICEF state of art report, 1999[28].

State in alphabetical order	Source	General range of Fluoride concentration in Groundwater	Reference
Central Rajasthan [40]	Geological, Fluorine rich minerals and rock	0.5 – 5.8 mg/l	J.Hussain et.al. (2013)
Bassi tahsil of district Jaipur of Rajasthan [16]	Geological, Fluorine rich minerals and rock	0.1 – 12.5 mg/l	S.Saxena & saxena, (2013)
Faridabad , Haryana [41]	weathering of rocks and anthropogenic activities	1.0 – 40 mg/l	Garg & Singh; (2013)

Wailpalli watershed, Nalgonda district Andhra Pradesh [42]	Geological and climatic conditions	0.97- 5.83 mg/l	A.G.S.Reddy et.al (2010)
Parts of Nalgonda district , Andhra Pradesh [43]	Weathering of rocks & evaporation of Groundwater , Irrigation	0.1 – 8.8mg/l with a mean of 1.3 mg/l	K.Brindha et.al. (2010)
Ajmer (NW India) [44]	Geological and climatic conditions	0.12 – 16.9 mg/l	C.Vikas et.al. (2009)
Mudhol Taluk , Karnataka [45]	Less fluoride in water As per required prescribed limit because of more hardness in water.	0.06 - 0.573 mg/l	P.D.Pol et.al. (2012)
Patripal panchayat of Balasore , Odisha [35]	Geological and climatic conditions	0.6 – 5.83 mg/l	Kaushik kumar Das et.al. (2012)
Karera block in Shivpuri district, Madhya Pradesh [46]	Geological and climatic conditions	1.65 – 3.91 mg/l	D.N.Saksena & Y.S.Narwaria (2012)
Mathura district, Uttar Pradesh [47]	Geological & anthropogenic	3.4 – 4.6 mg/l	K.S.Rawat et.al. (2012)
Anantapur District, Andhra Pradesh [48]	Geological	1.8 – 5.2 mg/l	V.Sunitha et.al. (2012)
Talupula , Andhra Pradesh [49]	Geological	0.78 – 6.10 mg/l	Arveti Nagaraju et.al. (2010)
Dindigul town, Tamilnadu [50]	Geological and Anthropogenic	2.47 – 5.26 mg/l	Mohamed Hanipha M. & Zahir Hussain A.(2013)
Kommala area of Warangal district Andhra Pradesh [51]	Geological	1.1 – 5.8 mg/l	Veerati Radhika & G.V.Praveen (2012)
Ottapidaram block Tamilnadu [52]	Geological	0.936 – 4.34 mg/l	V.Veeraputhiran & G.Alagumuthu (2010)
Sonitpur District, Assam [53]	Geological	0.17 – 5.602 mg/l	Joydev Datta et.al. (2010)
Guntur district, Andhra Pradesh [54]	Hydro geochemical	0.3 – 1.8 mg/l	N.Subba Rao (2010)
Malpura Tehsil, Tonk, Rajasthan, India [55]	Hydro geochemical	0.08 – 11.30 mg/l	Girja Shankar Tailor & C.P.Singh Chandel (2010)
Erode district, Tamilnadu [56]	Geological and climatic condition	0.5 – 8.2 mg/l	K.Karthikeyan et.al. (2010)
Kadiri,Mudigubba & Nallamada mandals of Anantapur District, Andhra Pradesh [57]	Geological and Climatic conditions	0.1 – 7.0 mg/l	B.Muralidhara Reddy (2013)
Dungarpur district of Rajasthan [58]	Geological and Climatic conditions	1.5-4.4 mg/l	S.L.Choubisa (2012)
Rural habitations of central Rajasthan [59]	Geological and Climatic conditions	>1.5 – 5.91mg/l	I.Hussain ,M.Arif & J.Hussain (2012)
Kadayam block of Tirunelveli district [60]	Geological, environmental & human activities	0.73 – 3.02 mg/l	G.Alagumuthu & M.Rajan (2008)
Rameswaram Area Tamilnadu, Southern India [61]	Geological and Climatic conditions	1.5-2.5 mg/l	V.Sivasankar & T Ramachandramoorthy. (2011)

Mettur taluk of Salem District, Tamilnadu [62]	Water-rock interaction	0.1-2.8 mg/l (pre-monsoon) 0.4-4.0 mg/l (Post-monsoon)	K.Srinivasamoorthy et.al. (2010)
Villages of Jind District, Haryana (India) [63]	Water-rock interaction	0.2-2.0 mg/l	Singh et.al. (2013)
Deoli Tehsil (Tonk District) Rajasthan [64]	Geological and Climatic conditions	0.3-9.6 mg/l	Meena et.al. (2011)

Table 7. Concentration of fluoride in groundwater and its sources in those states of India where fluoride problem is prevalent as per based on literature in last five years (2008-2013) apart from Jharkhand.

Groundwater Scenario in the Study Area : Jharkhand Location of study area

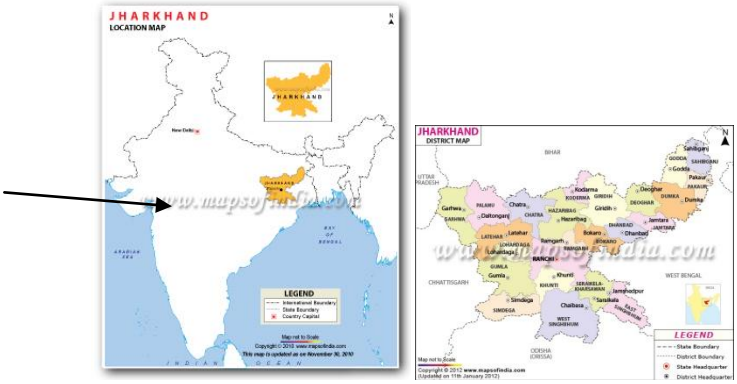


Fig : 3 Map Of Jharkhand [www.mapsofindia.com]

Jharkhand means 'The Forest Area',nearly 29% of the total geographical area is under forest foliage. Jharkhand is the 28th state in India having 13th rank as per the population and 15th rank considering the geographical area having 30% of the total population as tribal. The population of Jharkhand is 32,966,238 (2011 census) and covers an area of 79,714 km sq.

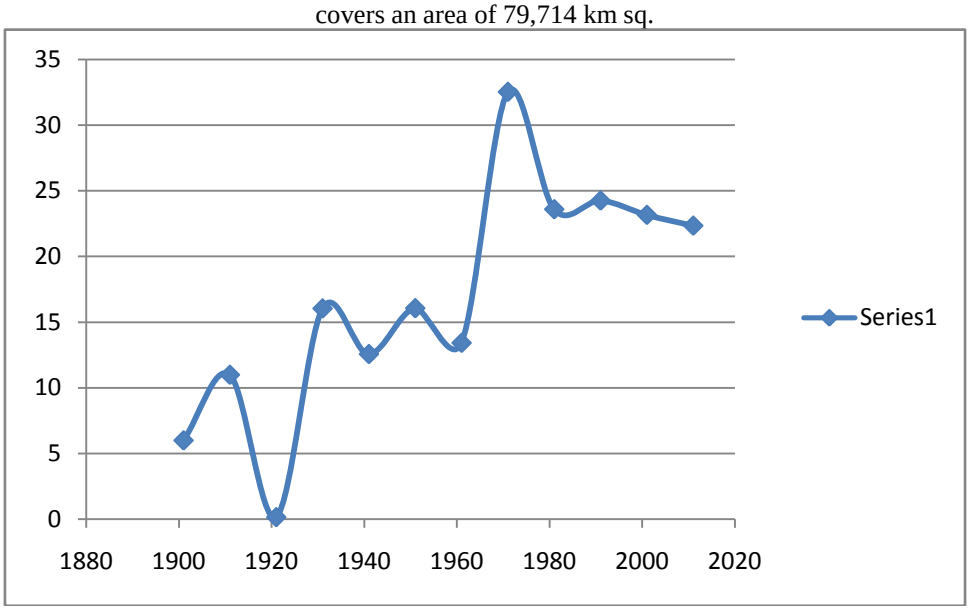


Fig-4 showing percentage growth in population after each decade starting from 1901.(data obtained from Census 2011). On X-axis – Year, On Y-axis – Percentage growth. From this figure it is evident that the percentage growth was maximum in the year 1971.

The Jharkhand ,mostly occupied by hard rocks (90% of the geographical area) where groundwater occurs in the irregularly distributed secondary porosities – the fractures. Groundwater occurrence and movement , the two cardinal parameters of water bearing zones , vary considerably in the state. The stage of groundwater development is less than 10% in the state & stress on

groundwater regime is visible in some urban agglomerates like Ranchi.

Hydrogeological set-up of the area

Serial Number	Geological Framework Or Formations	District
1	Archean-Proterozoic schists, Phyllites, Granites , amphibolites, basic and ultra basic lavas	Gumla, Ranchi, Lohardaga, Singhbhum, Hazaribagh, Deoghar, Giridih, Dumka
2	Vindhyans	Garhwa and Palamu
3	Gondwanas	Parts of Hazaribagh, Giridih, Dhanbad, Deoghar, Dumka, Palamu and Sahebganj, Pakur and Godda.
4	Rajmahal Trap	Sahebganj, Pakur, Dumka and Godda
5	Tertiary deposits	East Singhbhum
6	Quarternary Deposits	Godda, Palamu, Sahebganj,and Pakur.

Table-8 showing geological framework of the state / District wise distribution of different rock types.[65]

The state preserves the geological history ranging from Archean age (3300 million years) to recent deposits along the course of the major rivers like Subarnrekha, N & S Koel, Damodar etc. The major hydrogeological units are (i) Semi – consolidated formation ; where groundwater present in both primary and secondary porosities e.g. Gondwana sediments, with yield within 50 m^3 /hr and (ii) Porous formations represented by an array of soft rocks. The Tertiary beds of singhbhum district and alluvium deposits along the northern or eastern borders of the state forms the major part of this unit having a yield potential up to 80 m^3/hr.

Serial Number	District	Latitude	Longitude	Population As per 2011 census	Population As per 2001 census	Groundwater Quality problems as per CGWB
1	Ranchi	$23^0 20' 55''$	$85^0 18' 45''$	2914253	2785064	Sporadic fluoride contamination in Ormanjhi, Ranchi sadar and Silli blocks
2	Hazaribag	$23^0 58' 02''$	$85^0 20' 52''$	1734495	2277475	Nil
3	Lohardaga	$23^0 28' 00''$	$84^0 42' 00''$	461790	364521	NA
4	Palamu	23.4^0 – 24.6^0 N	84.0^0 – 84.9^0 E	1939869	1537465	Fluoride and Nitrate
5	Garhwa	$24^0 08' 30''$	$83^0 48' 30''$	1322784	1035464	Fluoride
6	Chatra	$24^0 12' 00''$	$84^0 52' 30''$	1042886	791434	NA
7	Bokaro	23.4^0 – 23.9^0 N	85.6^0 – 86.4^0 E	2,062,330	1777662	Fluoride, Iron, Mn, Zn,
8	Latehar	23° 44.4' north	84° 31' East	725673	560894	NA
9	Simdega	22°37' N & 22.62° N	84°31' E & 84.52°E	599813	514320	NA

10	Koderma	24.2^0 – 24.8^0 N	85.2^0 – 85.9^0 E	716259	540901	Fluoride
11	Giridih	24^0 10′ 00″	86^0 18′ 30″	2445474	1904430	Fluoride
12	Dhanbad	23^0 49′ 30″	86^0 31′ 40″	2684487	2397102	Fluoride and Nitrate at few places
13	Deoghar	24^0 29′ 10″	86^0 42′ 36″	1492073	1165390	Iron
14	Jamtara	23°10′ and 24°05′ north	86°30′ and 87°15′ east	790207	653081	NA
15	Dumka	24^0 16′ 00″	87^0 15′ 00″	1321096	1106521	NA
16	Godda	24^0 50′ 12″	87^0 14′ 20″	1313551	1047939	Fluoride and Nitrate
17	Pakur	24^0 38′ 02″	87^0 52′ 42″	900422	701664	Fluoride
18	Sahibganj	25^0 14′ 00″	87^0 38′ 20″	1150038	927770	Arsenic
19	Ramgarh	23^0 38′ 34″	85^0 29′ 10″	949159	Did not exist as district	NA
20	West Singhbhum	22.0^0 – 23.1^0 N	85.1^0 – 86.2^0 E	1502338	1233945	NA
21	East Singhbhum	22.2^0 – 23.0^0 N	85.9^0 – 86.9^0 E	2293919	1982988	NA
22	Saraikela-Kharsawan	22^0 42′ 15″	85^0 55′ 15″	1065056	848850	NA
23	Khunti	23^0 04′ 00″	85^0 16′ 24″	531885	Did not exist as district	NA
24	Gumla	23^0 02′ 38″	84^0 33′ 12″	1025656	832447	NA

Table-9 showing Locality index, Population and quality problem in different Districts of Jharkhand. NA = Not available.

As per CGWB survey report in 2010 In Jharkhand , following districts had Flouride in their groundwater more than permissible limit

Table-10: Jharkhand districts showing fluoride > 1.5 mg/l				
1	Bokaro	Chas	Chas	2.50 mg/l
2	Giridih	Khijri	Khijri	1.60 mg/l
3	Giridih	Tisri	Tisri	1.80 mg/l
4	Godda	Boarijor	Lalmatia	1.81 mg/l
5	Godda	Godda	Godda	1.77 mg/l
6	Palamu	Chainpur	Chainpur	2.18 mg/l
7	Palamu	Bishrampur	Bishrampur	2.46 mg/l
8	Ranchi	Ormanjhi	Chutupalu	2.60 mg/l
9	Ranchi	Silli	Silli	2.20 mg/l

Table-11 showing the data collected for the fluoride level in different districts, from Drinking water and sanitation department (DW&SD) of Jharkhand for the year 2000.
The major problem in terms of water collection is that 90-95 % of the rainfall is wasted as untapped runoff and so the groundwater level is depleting day by day as the demand is more and recharge is comparatively at slow rate , Therefore at the end the quality of water get worsely affected.

Districts in Jharkhand	Source	General range of Fluoride concentration in Groundwater	Prevalence of Dental fluorosis & Skeletal fluorosis	Reference
Palamu	Geological	0.5 - 4.2mg/l		A.C.Pandey et.al. (2012)[66]
		0.1- 12mg/l	83% children with dental fluorosis & 47% adults with skeletal fluorosis	R.Srikanth et.al. (2008)[67]
Garhwa	Geological	0.018- 2.4mg/l		K.avishek et.al. (2010)[68]
		0.018-5.92mg/l		Shekhar et.al (2012)[69]
		0.52.7.62mg/l		S.C.Samad et.al (2013)[70]
Hazaribag	Geological	1.89-3.84mg/l	Dental fluorosis among children has been observed	Rajendra Kumar & D.N.Sadhu (2013)[71]
Barhait block of Sahibganj	Geological	0.75-.88mg/l(children) 0.331-10.36mg/l(adult)	Dental and skeletal fluorosis both.	Nayak et.al. (2009)[72]
Jharkhand	Geological		Dental fluorosis among children has been observed	L.H.McDonald et.al (2011)[73]
Garhwa	Geological	3.5 mg/l	Dental and Skeletal fluorosis cases in Garhwa district	The Telegraph, (6th April, 2013)[74]
Garhwa	Geological	1.83-3.15 mg/l		Hindustan Times (October,15, 2011)[75]
Hazaribag (Keredari, Barkagaon, Barhi, Vishnugarh, Katkamsandi, Churchu.)	Geological & Anthropogenic	Samples with fluoride level more than prescribed limit		Prabhat Khabar (1st July, 2009)[76]

Table-12 Fluoride in groundwater as per reported in literatures for Jharkhand only

In the List of Districts Showing Localized Occurrence of Fluoride (>1.5mg/litre) in Ground Water in India[39,] Jharkhand has Bokaro, Giridih, Godda, Gumla, Palamu, Ranchi districts where fluoride in groundwater was found beyond permissible limit. Studies pertaining to fluoride concentration in groundwater of Jharkhand have been conducted by various researcher[67,77,73,66,69,68,71,78,79,80]. In these work, water is sampled , then lab tested for fluoride. All have suggested fluoride pollution in the area is due to rock-water interaction & more exploitation of groundwater resources . Defluoridation is also suggested by eating some herbs which have medicinal value[77].

R.Srikanth (2008) have also reported that in Palamu district ,where groundwater is the only source of drinking water , Ganke, Mukhiya Tola, Satyari Tola, Chukru, and Bakhari , these five villages have severe fluoride problem in their groundwater. On Socioeconomic front the inhabitants of these villages are very poor, depend entirely on agriculture and casual labor for their livelihood, rarely have proper food, suffer from various degree of malnutrition. In this study The highest F concentration found was 12 mg/L , detected in five water sources of Chukru and Andharbagh villages

Sadhu et.al. have collected data on seasonal basis of three seasons (rainy, winter, summer) of the year July 2011 to June 2012 of Hazaribag district and calculated the percentage of children affected with dental fluorosis.L.H. McDonald paper have discussed the fluoride problem in Jharkhand (Palamu and Garhwa district) , defluoridation technique using fluoride removing material made by locally available material and the fluoride management on the community scale.

A.C.Pandey(2012) and Shekhar, et.al.(2012) analysed a set of data of Palamu and Garhwa district to show the severity of problem. B.S. Thakur (2013)

& V. Pandey (2013) found the reason of the problem is geogenic .

K.avishek et.al used the data for Majhiaon block of Garhwa for mapping of fluoride quantity in different water sources likh public handpump, public well, private well, private handpump, school and health center.

According to N.Priyadarshi, Bakhari village in Daltonganj where most of the people have problems like deformed limbs, cataract, or premature ageing, if people continuous consume significant amount of of Chakwad (ring worm plant) plant then they get less affected of fluoride toxicity. The presence of high calcium in this plant which binds fluorine –helps in safe excretion of fluorine, and also helping replenish body calcium depleted by fluorine. Jharkhand Government should promote these types of plants in Fluoride affected areas.

As per 2011 census, Urban area of Ranchi has population of about 12, 57, 340 persons. Taking 135 litres daily consumption per person, the total water requirement of the Ranchi urban area comes out to be 1169.7 lakh litres /day (61.95 mcm/ annum). Due to excess withdrawal of groundwater, there is urgent need for recharging deeper aquifers in those areas where number of apartments are more. (Thakur,B.S.,2013).

For the fluoride management in the groundwater following options can be taken with reference to the study area:

Effective monitoring of drinking water sources should be made mandatory and Water with high fluoride concentration should be abandoned by regulation.

Food items rich in Ca and P should be consumed because it reduces fluoride retention capacity of human body. The places where fluoride levels are in the range of 1.5-2mg/l, some nutritional additives like food that are rich in iron, Ca and vitamin C is advised to consume. The black salt or the products containing black salt and fluoridated toothpaste consumption must be avoided in these places.

Defluoridation techniques suitable to the area is to be adopted

Rain water harvesting and artificial recharge of aquifer results in reduction of fluoride in groundwater.

Environmental awareness and full community participation can ensure safe water supply in the area.

References:-

[1] Meenakshi and Maheshwari R.C.,2006, Fluoride in drinking water and its removal, Journal of Hazardous Matter, 137(1), pp 456-463.

[2] Sarala K. and P.R. Rao., 1993, Endemic fluorosis in the village Ralla Anantapuram in Andhra Pradesh: An Epidemiological Study, Fluoride, 26, pp 177-180.

[3] Ibrahim M.et.al., 2011, Flouride contents in groundwater: a review, International Journal.of Pharmaceutical applications ISSN 0976-2639, Vol 2 (2), pp 128-134.

[4] Wood J.M., 1974, Biological Cycle for toxic elements in the environment, Science, 183, pp 1049-1052.

[5] Teotia S.P.S. and Teotia. M., 1984, Endemic fluorosis in India: challenging national health problem, J.Assoc.Phys.India, , 32, pp 347-352.

[6] Krishna Kodalirama.& SasiKiran NOA.,2013, Fluorosis – An Update, Int.J.Research in Pharmaceutical and Biomedical sciences, Vol 4(4) . pp 1084-1088.

[7] Handa BK., 1975, Geochemistry and genesis of fluoride-containing ground waters in India. Ground Water ,13, pp 275–281.

[8] Apambire W. M.et.al.,1997, Geochemistry, genesis, and health implications of fluoriferous groundwater in the upper regions of Ghana, Environmental Geology , 35(1), pp 13-24.

[9] Jacks, G. et. al., 1993, Genesis of high F groundwater, Southern India, Applied geochemistry, Vol 2 , pp - 3.

[10] Agrawal V.et.al.,1997, Groundwater quality: Focus on fluoride and fluorosis in Rajasthan. Curr Sci ,73, pp 743–746.

[11] Saxena V. K. & Ahmed, S., 2003, Inferring the chemical parameters for the dissolution of fluoride in groundwater, Environ. Geol., 43, pp 731–736.

[12] Ramesam V & Rajagopalan K ,1985, Fluoride ingestion into the natural waters of hard-rock areas, Peninsular India, J Geol Soc India, 26, pp 125–132.

[13] Sivashankar V & Ramachandramoorthy T.,2011, Fluoride in groundwater and Dental fluorosis in Rameswaram Area, Tamil Nadu, Southern India., Journal of Environment Analytic Toxicol, 1(3), pp 1-6.

[14] Chandra et. al., 1981, Water Quality and Dental fluorosis., Ind. J.Pub.Hlth.,25,pp 47-51.

[15] Largent E.J.,1961, The Health aspects of fluoride compounds, Ohio State University press, Columbus,O.H.

[16] Saxena,S.& Saxena, U.,2013, Study of Fluoride contamination status of groundwater in Bassi Tehsil of district Jaipur, Rajasthan, India., Int.J. of

Environmental Sciences, Vol 3(6), pp 2251-2260, 2013.ISSN 0976-4402.

[17] Aniruddha Ghosh et.al., 2013, Sources and toxicity of fluoride in the environment, Research on chemical intermediates ,Vol 39(7) , pp 2881 – 2915, 01/2013; DOI:10.1007/s11164-012-0841-1.

[18] Subba Rao,N.,2011, High Fluoride groundwater , Environ Monit Assess, Vol 176 , pp 637-645, DOI 10.1007/s10661-010-1609-y.

[19] UNICEF ,1996, Plan of action of UNICEF assisted pilot projects of Fluorosis control in Dungarpur District, Rajsthan"

[20] Dean H.T.,1934, Classification of mottled enamel diagnosis, J.Am.Dent.Assoc 21, pp 1421-1426.

[21] Dean H.T.,1942, The investigation of physiological effects by the epidemiological method. In: Moulton FR, editor. Fluorine and Dental health. Pub. No. 19. Washington (DC); American Association for the advancement of science, pp 23-31.

[22] Thylstrup A. and Fejerskov O., 1978, Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes, Community Dentistry and Oral Epidemiology, 6, pp 315–328

[23] Horowitz, H.S.et.al., 1984, A new method for assessing the prevalence of dental fluorosis – the Tooth Surface Index of fluorosis., Journal of the American Dental Association, 109, pp 37

[24] Pendrys D.G.,1990, The fluorosis risk index: a method for investigating risk factors, J Publ Hlth Dent, 50, pp 291-298.

[25] WHO,1984, Guidelines for Drinking Water Quality. In: Health Criteria and Other Supporting Information , second ed., vol. 2. World Health Organization, Geneva

[26] Ayoob S., & Gupta A. K., 2006, Fluoride in drinking water: A review on the status and stress effects . Critical Reviews in Environmental Science and Technology , 36, pp 433–487.

[27] Rajiv Gandhi National Drinking Water Mission, 1986 & 1993, Prevention and control of Fluorosis in India , pp 8 - 9.

[28] UNICEF ,1999, State of the art report on the extent of fluoride in drinking water and the resulting endemicity in India., Report by Fluorosis Research & Rural Development Foundation for UNICEF, New Delhi.

[29] Choubisa, S.L., 2001,.Endemic fluorosis in Southern Rajasthan, India., Fluoride, 34, pp 61-70.

[30] Central Ground Water Board of India, 2002, Technical Report, pp - 38.

[31] Susheela, A.K. and Majumdar, K., 1992, Fluorosis control programme in India., Water Environment and Management, 18th WEDC Conference, Kathmandu, Nepal, pp. 229-233.

[32] Subba Rao,N., 1992, Factors affecting optimum development of groundwaters in crystalline terrain of the eastern ghats, Vishakhapatnam area, Andhra Pradesh, India., Jour. Geol.Soc.India., 40(5), pp 462-467.

[33] Susheela AK.,2001, Fluorosis: Indian scienario: A treatise on fluorosis. Fluorosis Research and Rural Development Foundation; New Delhi, India.

[34] Yadav, S., et.al., 1999, Fluorosis in India with special reference to Rajasthan. In: Proceedings of the International Conference on Water, Environment, Ecology, Socioeconomics and Health Engineering (WEESHE), Seoul National University, 18–21st October, pp 3–10

[35] Das,K.K. et.al.,2012, Occurrence of fluoride in groundwater of Patripal Panchayat in Balasore District, Odisha, India., Journal of Environment, 01(2), pp 33-39.

[36] Susheela, A.K.,1987, Fluorosis in India, the magnitude and severity of the problem, Sci. Dev. Env., pp. 147-157.

[37] Susheela, A.K.,1999, Fluorosis management programme in India, Curr. Sci., 77, pp. 1250-1256.

[38] Susheela, A.K. , 2007, Fluorosis management programme in India. Curr. Sci., 77, pp. 1250-1256.

[39] CGWB, 2010, Groundwater quality in shallow aquifers of India, pp 9.

[40] Hussain J.et.al.,2013, Fluoride contamination in groundwater of Central Rajasthan, India and its toxicity in rural habitants". Toxicological & Environmental Chemistry, Vol 95(6), pp – 1048 – 1055.

[41] Garg K. & Singh B.,2013, Fluoride signatures in groundwater and dental fluorosis in permanent teeth of school children in rural areas of Haryana state, India., Int. J. Occup Environ Med ,Vol 4(2), Pp 107-108

[42] Reddy, A.G.S.et.al., 2010, Hydrogeochemical characterization of fluoride rich groundwater of Wailpalli watershed , Nalgonda District, Andhra Pradesh, India, Environ. Monit. Assess. Vol 171, pp 561-577. DOI 10.1007/s10661-009-1300-3.

[43] Brindha,K.,et.al., 2010, Fluoride contamination in groundwater in parts of Nalgonda District, Andhra Pradesh India, Environ Monit assess, DOI 10.1007/s10661-010-1348-0.

[44] Vikas,C.et.al.,2009, Hydrochemical status of groundwater in District Ajmer (NW India) with reference to fluoride distribution, Journal geological society of India, Vol. 73 pp 773-784.

[45] Pol,P.D.et.al.,2012, Fluoride contamination status of groundwater in Mudhol taluk, Karnataka, India: Correlation of fluoride with other physic-chemical parameters, Rasayan J.Chem., 5(2), pp 186-193.

[46] Saksena D.N. & Narwaria Y.S.,2012, Incidence of fluoride in groundwater and its potential health effects in ten villages of Karera block in Shivpuri District, Madhya Pradesh, India, International Journal of Environmental Sciences, 3(3) , pp 1141-1149.

[47] Rawat , K.S.et.al.,2012, Identification of geospatial variability of fluoride contamination in groundwater of Mathura District, Uttar Pradesh. Journal of Applied and Natural Science. , 4(1) pp 117-122.

[48] V.,Sunitha.et.al.,2012, Variation of fluoride and correlation with alkalinity in groundwater of shallow and deep aquifers – A case study in and around Anantapur district, Andhra Pradesh., Int.J. of applied sciences and Engineering research, 1(4). pp 569-575.

[49] Arveti nagaraju.,2011, Fluoride incidence in groundwater: a case study from Talupula, Andhra Pradesh, India., Environmental monitoring assessment, 172. pp 427-443.

[50] Mohamed Hanipha M. & Zahir Hussain A.,2013, Study of groundwater quality at Dindigul Town, Tamilnadu, India., Int. Res.J.Environment Sciences.,2(1), pp 68-73.

[51] Radhika,veerati & Praveen G.V., 2012, Determination of fluoride status in groundwater of Kommala area of District Warangal, Andhra Pradesh, India. : A case study, Advances in applied science research, 3 (4), pp 2523-2528.

[52] Veeraputhiran.V, & Alagumuthu.G., 2010, A report on fluoride distribution in drinking water, International Journal of Environmental Sciences, 1(4) pp 558-566.

[53] Dutta,J.et.al., 2010, Monitoring of Fluoride concentration in groundwater of small tea gardens in Sonitpur District, Assam,India: correlation with physic-chemical parameters, Internatonal J. of chemtech Research, 2(2), pp 1199-1208.

[54] Subba Rao, N.,2010, Groundwater quality : focus on fluoride concentration in rural parts of Guntur district, Andhra Pradesh, India., Hydrogeological Sciences Journal, Vol 48(5), 835-847.

[55] Tailor,G.S. & Singh Chandel, C.P., 2010, To assess the quality of groundwater in Malpura Tehsil (Tonk, Rajasthan, India) with emphasis to fluoride concentration, Nature and Science , 8 (11), pp 20-26.

[56] Karthikeyan K.et.al. , 2010, Prevalence of certain inorganic constituents in groundwater samples of Erode district Tamilnadu, India, with special emphasis on fluoride , fluorosis and its remedial measures., Environmental Monitoring Assessment, 160(1-4), pp 141-155.

[57] Reddy,B.M.et.al.,2013, Fluoride and Nitrate geochemistry of Groundwater from Kadiri, Mudigubba, and Nallamada Mandals of Anantapur District, Andhra Pradesh, India. Journal of Agricultural engineering and biotechnology, 1(2) pp 37-42.

[58] Choubisa. S.L., 2012, Fluoride in drinking water and its toxicosis in tribals of Rajasthan, Proceedings of the National academy of sciences, India section B:Biological sciences., 82 (2) pp 325-330

[59] Hussain, I. et.al., 2012, Fluoride contamination in drinking water in rural habitations of Central Rajasthan, India. , Environmental monitoring and assessment, 184(8) pp 5151-8

[60] Alagumuthu, G. & Rajan, M.. ,2008, Monitoring of fluoride concentration in groundwater of Kadayam block of Tirunelveli District, India : Correlation with physic chemical parameters., Rasayan.J.Chem. ,1(4). ,pp 757-765.

[61] Sivasankar V. & Ramachandramoorthy T, 2011, Fluoride in groundwater and Dental Fluorosis in Rameswaram area, Tamilnadu, Southern India., J. Environmental & analytical toxicology, 1(3) .Doi : 10.4172/2161-0525.1000110.

[62] Srinivasamoorthy,K.et.al., Assessment of groundwater quality with special emphasis on fluoride contamination in crystalline bed rock aquifer of Mettur region, Tamilnadu,India., Arab J. Geosciences, DOI 10.1007/s12517-010-0162-x

[63] Singh,A.et.al., 2013, Fluoride distribution in groundwater and prevalence of Dental fluorosis among school children in villages of Jind District, Haryana (India).,

International Journal of current research, Vol 5(4), pp-998-1002.

[64] Meena,K.S.et.al., 2011, Fluoride contaminated ground water and its implications on human health in Deoli Tehsil (Tonk District) in Rajasthan., Journal of Chemical, Biological, and Physical Sciences, Vol 1(2),pp 275-282.

[65] CGWB ,2007 , A report on Hydrogeological framework and groundwater development prospects of Jharkhand state.

[66] Pandey, A.C.et.al., 2012, Evaluation of Fluoride in Groundwater sources in Palamu district of Jharkhand . Journal of Applied Sciences 12(9). 882-887.

[67] Srikanth, R..,2008, Endemic fluorosis in five villages of the Palamau district, Jharkhand, India. Fluoride, 41(3), pp 206–211

[68] Avishek, K.et.al., 2010, Water quality assessment of Majhiaon block of Garhwa District in Jharkhand with special focus on fluoride analysis, Environmental Monitoring assessment ,167: 617-623.

[69] Shekhar,S.et.al.,2012, Evaluation of fluoride contamination in groundwater sources in hard rock terrain in Garhwa district, Jharkhand,India.,.International Journal of Environmental Sciences, Vol 3(3), pp-1022-1030. DOI:10.6088/ijes.2012 0301330 10.

[70] Samad, S. C. et. al.,2013, Fluoride geochemistry and assessment of the exposure dose of fluoride from drinking water in Garhwa district of Jharkhand, India., Advances in applied science research (Pelagia research library), Vol 4(5), pp 325-329.

[71] Kumar & Sadhu.,2013, Assessment of Drinking water quality in tribal dominated villages of Barkagaon, Hazaribag, Jharkhand, India". European Scintific Journal , Vol 9(35), pp 331-338.

[72] Nayak,B.et.al.,2009, Health effects of groundwater fluoride contamination., Clinical toxicology (Phila.), 47(4), pp 292-295.

[73] MacDonald et.al.,2011, An integrated approach to address endemic fluorosis in Jharkhand, India . Journal of water resource and protection, 3 ,pp 457-472

[74] The Telegraph ,2013, Fluoride in the groundwater of Garhwa district specially in three villages Pratappur, Darmi and Parsi. , dated 6th April, 2013.

[75] Hindustan Times , dated 15th October,2011, Central team confirms high fluoride in Garhwa water, page – 1

[76] Prabhat Khabar (hindi), dated 1st July, 2009. , Jile ke bhumigat jal main fluoride ki matra badhi (increase of fluoride in the groundwater of district) was in reference of Hazaribag district.

[77] Priyadarshi,N.,2012, Fluoride toxicity in Jharkhand state of India http://fluoridealert.org/news, fluoride action network..

[78] Thakur,B.S.,2013, Sustainable management of deeper aquifers in hard rock areas of Ranchi urban area, Proceeding of National Conference on Earth Sciences in India : Challenges and Emerging trends (ESICET-2013) 7-9 November, 2013.

[79] Pandey,V.,2013, Impact of fluoride rich water on human health – A case study of Palamau district, Jharkhand, India., Proceeding of National Conference on Earth Sciences in India : Challenges and Emerging trends (ESICET-2013) 7-9 November, 2013.

[80] Thakur,B.S.,2013, Urgent need for Sustainable management of Ground water in fractured Aquifers in hard rock terrains of Ranchi urban area,Jharkhand., Proceeding of National Conference on Earth Sciences in India : Challenges and Emerging trends (ESICET-2013) 7-9 November, 2013. www.mapsofindia.com Census-2001 & Census – 2011.