Fluoride Distribution in Villages of Jhajjar District of Haryana, India

Mohammed Arif
Department of Chemistry
Banasthali University Niwai, District-Niwai – 304 022, Rajasthan, India

Jakir Hussain
National River Water Quality Laboratory
Central Water Commission,
New Delhi – 110 016, India

Ikbal Husain
Public Health Engineering Department
(PHED) District Laboratory,
Bhilwara – 311 001, Rajasthan, India

***Abstract*—Deficiency or excess of fluoride in the environment is closely associated with human health. It is estimated that around 200 million people of 25 nations all over the world, are under the dreadful fate of fluorosis. India and China, the two most populous countries of the world, are the worst affected. Nearly 12 million of the 85 million tons of fluoride deposits on the earths crust are found in India. It is not surprising; therefore, the fluorosis is endemic in 17 states of India. The most seriously effected areas are Andhra Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Tamil Nadu and Utter Pradesh. Present study was carried out to assess the fluoride concentration in groundwater of some villages of Jhajjar district in Haryana, where groundwater is the main source of drinking water. One hundred and forty nine water samples were collected from hand-pumps and analyzed for fluoride content. Fluoride concentration in five tehsil ranges from 0.10 (Jhamri village) to 4.30 mg/l (Bhadani village) of Matanhail Tehsil of Jhajjar district respectively.**

Ninety one villages / towns in which fluoride concentration is below 1.0 mg/l, maximum desirable limit of standards for drinking water recommended by Bureau of Indian Standard (IS: 10500, 2012) and 26 villages/ towns have fluoride concentration above 1.0 mg/l and below or equal to 1.5 mg/l. 32 villages/ towns have fluoride concentration above the permissible limit and found unfit for drinking purposes. Moreover, dental and skeletal fluorosis is at alarming stage in local resident of these areas. Presence of fluoride bearing minerals in the host rock, the chemical properties like decomposition, dissociation and dissolution and their interaction with water is considered to be the main cause for fluoride in groundwater. The suggested remedial measures to reduce fluoride pollution in groundwater include dilution by blending, artificial recharge, efficient irrigation practices and well construction.

Keywords*— *Ground water, Fluoride, Fluorosis, Jhajjar District, Haryana)

I. INTRODUCTION

It is well established that India has two acute public-health problems induced by utilization of groundwater as a source of drinking water having excess fluoride and arsenic. Fluorine is the most electronegative of all chemical and is therefore never found in nature in elemental form. Combined chemically in the form of fluorides, it ranks 17th in abundance of elements in the earth's crust representing about 0.06–0.09% of the earth's crust (WHO, 1994). Fluoride is one of important life elements to human health. It is essential for normal mineralization of bones and formation of dental enamel with presence in small quantity (Chouhan and Flora, 2010). When fluoride is taken up more then permissible limit, it become toxic and causes clinical and metabolic disturbance in animals and human being such as dental and skeletal Fluorosis (Arif et al., 2011, 2012 a, b, 2013 a, b, c, 2014; Hussain et al., 2002, 2004a, 2010, 2011; Singh et al., 2007).

Owing to the universal presence of fluorides in earth's crust, all water contains fluorides in varying concentrations ranging from trace levels to several milligrams per litre (WHO, 1994). In surface water such as rivers and lakes, fluoride concentrations are usually low, ranging from 0.01 to 0.3 mg/l (Murray, 1986). However, exceptionally high values can be found such that some lakes in Kenya have fluoride content >2000 mg/l. For example, Lake Nakuru, which is situated in the rift valley in Kenya, has a fluoride concentration of 2800 mg/l and it is reported that this is the highest natural fluoride concentration ever found in water (Murray, 1986). Generally most groundwater sources have higher fluoride concentrations than surface water. As groundwater percolates through the weathered rock in the aquifers, it dissolves fluoride bearing minerals hence releasing fluoride into solution (Cairncross and Feachem, 1991; Falvey, 1999). The main source of fluoride in groundwater is basically from the rocks minerals shown in table 1.

Table 1 Source of Fluoride in Groundwater

Minerals	Chemical Composition
1. Fluorite (Fluorspar)	CaF_2
2.Fluorapatite (Apatite)	$Ca_5(F,Cl)PO_4$
3.Micas	
a. Biotite	$K(MgFe^{+2})_3(AlSi_3)O_{10}(OHF)_2$
b. Muscovite	$KAl_2(AlSi_3O_{10})(OHF)_2$
c. Lepidolite	$K_2(Li,Al)_5(Si_6Al_2)O_{20}(OHF)_4$
4. Amphiboles	
a. Hornblende	$NaCa_2(MgFe^{+2})_4(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$
b.Tremolite Actinolite	$Ca_2(MgFe^{+2})_5(Si_8O_{22})(OHF)_2$
5. Topaz	$Al_2SiO_4(OH.F)_2$
6. .Rock Phosphate	$NaCa_2(MgFe^{+2})_4(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$

These minerals are commonly associated with the country rocks through which the ground water percolates under variable temperature conditions. Besides these minerals, alkali rocks, hydrothermal solutions may also contribute to higher concentration of fluoride in groundwater. Robinson and Edington (1946) reported that the main source of fluoride in ordinary soil consists of clay minerals. The weathering and leaching process, mainly by moving and percolating water, play an important role in the incidence of fluoride in groundwater. When fluoride rich minerals, which are present in rocks and soil, come in contact with water of high alkalinity; they release fluoride into groundwater through hydrolysis replacing hydroxyl (OH) ion. The degree of wreathing and leachable fluoride in a terrain is more important in deciding the fluoride bearing minerals in the bulk rocks or soil. Due to weathering of rocks the Ca-Mg / carbonate concentration which form in arid and semi arid areas appears to be good sink for the fluoride ion (Jacks et al., 2005). While fluoride is present in air, water and food, the most common way it enters the food chain is via drinking water.

High groundwater fluoride concentrations associated with soil and rock minerals have been reported from India, Pakistan, West Africa, Thailand, China, Sri Lanka, and Southern Africa (Hussain et al., 2012,2013; Ayoob et al., 2006). The problems are most pronounced in Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh (Hussain 2001; Hussain et al. 2000, 2003, 2004a, 2004b, 2005a, 2005b, 2007; Godfrey et al. 2006; Ayoob and Gupta 2006; Sharma et al. 2007; Khaiwal and Garg 2007). Groundwater is the major source of drinking in the villages of Haryana State. Few studies have been carried out in Haryana with regard to fluoride distribution, endemic fluorosis (Garg et al. 1998; Dahiya et al. 2000, 2001. Thus the objective of this study was to investigate the quality of drinking water (ground water) with special reference to the concentration of fluoride in most rural sites of Haryana, India.

A. *Hydrogeology of Jhajjar District*

Figure 1 represents the hydrogeology of the district. The ground water in the area occurs in the alluvium of Quaternary age. The permeable granular zones comprising fine to medium sand and occasionally coarse grained sand and gravel. Their lateral as well as vertical extent is limited.

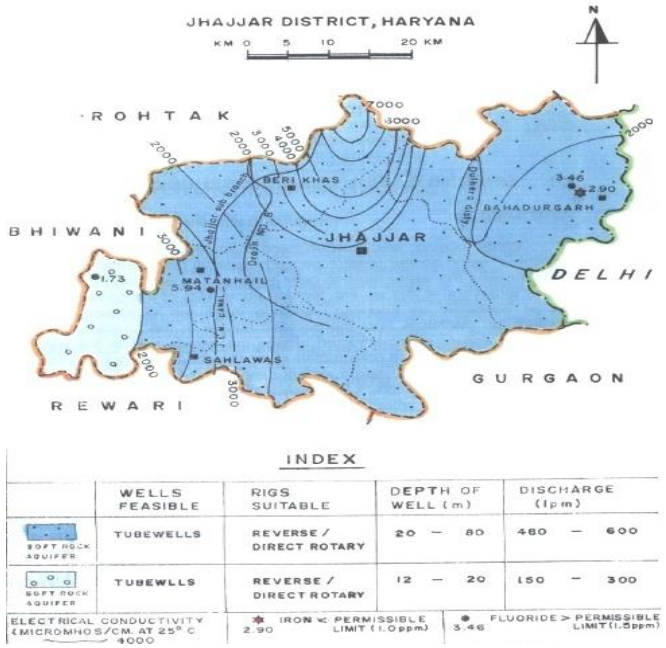

Fig. 1 Hydrogeology of Jhajjar district

The study of borehole data generated by the ETO/CGWB indicates that clay group of formations dominate over the sand group in the district. The lithological correlation clearly indicates the presence of clay layer at the top of the surface. In general, source of ground water in the area is rainfall, sub-surface inflow, seepage from canal and return seepage from irrigation. The natural discharge includes sub-surface out flow and evapo transpiration. The artificial discharge includes utilization of groundwater for irrigation, domestic and industrial purposes. Granular zones that occur are inter bedded with clays in alluvial formations, form the principal ground water reservoir. The upper surface of zone of saturation is represented by water levels in dug wells. Groundwater in the area occurs under water table and semi-confined or confined conditions. The basement also encountered at a depth of 315.5om near Jhajjar. Two to four permeable granular zones with an aggregate thickness varying between 23m and 50m have been encountered down to the depth of bed rock. The boreholes drilled at 9 sites 8 were abandoned due to bad quality of water or inadequate discharge and one was proved to be successful. At Bahu site in depth range of 74m to 116m Transmissivity value 124m^2 /day and lateral Hydraulic Conductivity 731m/day were determined (CGWB, 2007).

B. *Guidelines and Standards*

According to WHO's guidelines for drinking water, a fluoride level of 1.5 mg/L is the Permissible limit. India reduced the upper limit of fluoride in drinking water from 1.5 to 1.0 mg/L with a rider that "less is better" (BIS 10500, 2012). This is due to the extremes in climatic conditions and the diet being deficient in essential nutrients (calcium, vitamins C, E and antioxidants) in the rural communities of India. So, the Indian standard for the maximum desirable limit of fluoride in drinking water is 1.0 mg/L and the maximum permissible limit is 1.5 mg/L. As the amount of water consumed and consequently the amount of fluoride ingested is influenced primarily by air temperature, USPHS (1962) has set a range of concentrations for maximum allowable fluoride in drinking water for communities based on the climatic conditions, as shown in Table 2.

Table 2 USPHS recommendation for maximum allowed fluoride in drinking water

Annual average maximum daily air temperature (°C)	Recommended fluoride concentration (mg/L)			Maximum allowable fluoride concentration (mg/L)
	Lower	Optimum	Upper	
10–12	0.9	1.2	1.7	2.4
12.1–14.6	0.8	1.1	1.5	2.2
14.7–17.7	0.8	1	1.3	2
17.8–21.4	0.7	0.9	1.2	1.8
21.5–26.2	0.7	0.8	1	1.6
26.3–32.5	0.6	0.7	0.8	1.4

C. *Health Effects*

Fluorides in drinking water may be beneficial or detrimental depending on their concentration and the total amount ingested. Fluoride is beneficial especially to young children (below eight years of age) for calcification of dental enamel, when present within allowable /desirable limits (1.0 mg/L).

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Fluoride, being a highly electronegative ion, has an extraordinary tendency to get attracted by positively charged ions like calcium. Hence, the effect of fluoride in mineralized tissues like bone and teeth is of clinical significance as they have the highest amount of calcium and thus attract the maximum amount of fluoride which is deposited as calcium fluorapatite crystals. Tooth enamel is composed principally of crystalline hydroxyapatite. Under normal conditions, when fluoride is present in the water supply, most of the ingested fluoride ions are incorporated into the apatite crystal lattice of millions of calciferous enamel tissue during its formation. The hydroxyl ion is substituted by the fluoride ion because fluorapatite is more stable than hydroxyapatite. The most common health problems associated with excess fluoride in drinking water are dental and skeletal fluorosis. Endemic fluorosis is known to be global in scope, occurring in all continents and affecting many people. Dental fluorosis leads to pitting, perforation and chipping of the teeth, whereas skeletal fluorosis causes severe pains in joints followed by stiffness, which ultimately leads to paralysis. However, recent studies have proved that the health effects of fluoride are not only restricted to dental or skeletal fluorosis but also cause other ailments such as neurological disorders, muscular and allergic manifestations, and gastrointestinal problems, and may also cause lethal diseases like cancer.

D. Social and Economic Implications of Fluorosis

The social and economic implications for those people living in endemic areas are enormous. Affected people lead a very "Poor Quality of Life" that often borders on a vegetative sate owing to a deteriorating health condition. They present psycho sociological for themselves and their families. These problems are further compounded by economic stress.

Dental fluorosis is a health problem but it is as much an aesthetic and social problem for those affected discoloured teeth and mouth odour are the bane for a number of individuals in endemic areas. School children who suffer from dental fluorosis are often taunted by their mates. As a result they withdraw into a shell and are barely able to continue their education. With some, the prospect of meeting people from outside is a nightmare.

Children suffering from skeletal fluorosis are deprived of Childhood joys. They are unable to more, run and play like other children. Some parents who are affected by fluorosis are unable to continue working with the same capacity as they did earlier. Unfortunately in such a situation education of children takes a backseat. In most situations of dental fluorosis affected person, particularly the younger lot, withdraw into a shell and refuse to talk to anybody. They often find themselves alone with litter or no interaction with their peer group.

A major source of worry for the youth is their poor matrimonial prospects. In the case of girls the condition of their teeth is often a serious impediment in matrimonial propositions. They worry about the way they would be treated by the groom's family. Even after getting married they avoid revealing their condition for as long as possible. Marriage is as much a source of worry for men. Those with visible signs of skeletal fluorosis know that the chances of finding a bride are rather dim. Some decide not to marry at all. The issue of marriage weighs heavy in the minds of girls parents in rural areas. There are economic and social concern related to the event. But a daughter with fluorosis appears to be a problem with little solution. If they do manager to get her married, sometimes by hiding facts, they are serious consequences. The girl is mostly treated badly by the boy's family.

For the younger lot a debilitating illness such as fluorosis can bring disappointments and a loss of hope in terms of work and a bright future.

E. Study Area

Jhajjar district of Haryana lies between 28^o 22': 28^o 49' north latitudes, and 76^0 18': 76^{0}59' east longitudes. Total geographical area of the district is 1834 sq.km. Administratively, the district is controlled by Rohtak division. The district consists of 262 villages, which are distributed in the five blocks of Jhajjar district: Jhajjar, Bahadurgarh, Beri, Matanhail, and Sahalawas. In most of the villages, groundwater is the only source of drinking water. The groundwater source is drawn by hand pumps, tube wells, and open wells. The district area falls in Yamuna sub-basin of Ganga basin, and is mainly drained by the artificial drain NO.8 flows from north to south. Jawahar Lal Nehru feeder and Bhalaut sub Branch are main canals of the district. Area under Canal irrigation is about 690 sq. km. in the district. The CGWB has carried out ground water exploration besides other hydro geological and geophysical studies in the district.

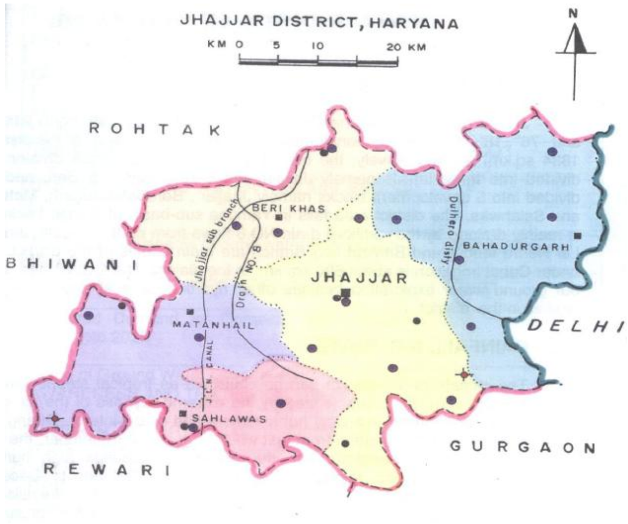

Fig. 2 Study area

II. MATERIAL AND METHODS

Groundwater samples of a total of 149 villages / towns located in Jhajjar district in Haryana state of India were collected in pre cleaned polythene bottles with necessary precautions (Brown et al. 1974).

The fluoride concentration in water was determined electrochemically, using fluoride ion selective electrode (APHA, 2012). This method is applicable to the measurement of fluoride in drinking water in the concentration range of 0.01–1,000 mg/l. The electrode used was an Orion fluoride electrode, coupled to an Orion electrometer. Standards fluoride solutions (0.1–10 mg/l) were prepared from a stock solution (100 mg/l) of sodium fluoride. As per experimental requirement, 1 ml of Total Ionic Strength Adjusting Buffer Grade III (TISAB III) was added in 10 ml of sample. The ion meter was calibrated for a slop of −59.2 ±2 (APHA, 2012). The composition of TISAB solution was as 385.4 gm ammonium acetate, 17.3 gm of cyclohexylene diamine tetraacetic acid and 234 ml of concentrate hydrochloric acid per liter. All the experiments were carried out in triplicate, and the results were found reproducible with ± 2% error.

III. RESULTS AND DISCUSSION

A. *Fluoride Distribution in Jhajjar District:*

Fluoride concentrations in groundwater of 149 villages / towns of Jhajjar district of Haryana were examined. The abstract of fluoride distribution in five tehsils, Beri Khas, Jhajjar, Matanhail, Bahadurgarh and Salhawas of Jhajjar district is shown in table 3.

Fluoride concentration in five tehsil ranges from 0.10 (Jhamri village) to 4.30 mg/l (Bhadani village) of Matanhail and Jhajjar Tehsil respectively.

The present survey reveals that out of 149 villages / towns of Jhajjar district, ninety one villages / towns in which fluoride concentration is below 1.0 mg/l, maximum desirable limit of standards for drinking water recommended by Bureau of Indian Standard (IS: 10500, 2012) and 26 villages/ towns have fluoride concentration above 1.0 mg/l and below or equal to 1.5 mg/l. As per the desirable and maximum permissible limit for fluoride in drinking water determined by WHO (1996) or by Bureau of Indian Standards (2012), groundwater at 32 sampling stations (21%) was found unfit for drinking purposes. According to Whiteford (1997) the 75–90% of ingested fluoride is absorbed. In an acidic stomach fluoride in converted into hydrogen fluoride (HF) and here up to 40% of the ingested in stomach and remaining in intestine. Once absorbed into blood, fluoride readily distributes throughout the body, with approximately 99% of the body burden of fluoride retained in calcium rich areas such as bones and teeth (dentine and enamel) (WHO 1997). However, in plasma, fluoride is transported as ionic fluoride and non-ionic fluoride. Ionic fluoride does not bind to plasma proteins, and is easily excreted with the urine. However, in the form of HF, about 35–45% is reabsorbed and returned to the systemic circulation. pH of tubular fluid and urinary flow are the main factors which influence reabsorption (Whitford et al. 1976).

The amount of urinary fluoride excreted from the body reflects the amount of fluoride ingested. Brouwer et al. (1988) stated that fluoride (F^-) is attracted by positively charged calcium ions, due to its strong electronegative charges, in teeth and bones and therefore excessive intake of fluoride cause pathological changes in teeth and bones. The tehsil wise fluoride concentration of Jhajjar District of Haryana is given in Table 4 and distribution is described below-

A. Beri Khas Tehsil

The minimum concentration 0.23 mg/l was recorded in Chimi villages while maximum concentration was recorded from village Chaman pura (3.37 mg/l). Five villages namely Chamanpura (3.37), Dharana (2.12), Dighal (1.56), Beri (2.1) and Madana Kalan (3.1) have fluoride concentration above the MPL.

B. *Jhajjar Tehsil*

The minimum concentration 0.20 mg/l was recorded in Dadri Toe and Luhari villages while maximum concentration was recorded from village Bhadani (4.30 mg/l).

C. *Matanhail Tehsil*

The minimum concentration 0.10 mg/l was recorded in Jhamri villages while maximum concentration was recorded from village Ladain (4.23 mg/l). Seven villages namely Akehri Madanpur (2.45) Amdalshahpur (1.56) Birohar (2.22) Jhanswa (2.22) Khanpur Khurd (2.78) Khaparwas (2.67) Ladain (4.23) have fluoride concentration above the MPL prescribed by BIS.

D. *Bahadurgarh Tehsil*

The minimum concentration 0.22 mg/l was recorded in Badsa village while maximum concentration was recorded from village Asanda Sewan (4.22 mg/l). Ten villages namely Asauda Sewan (4.22), Bamnoli (2.76) Dulhera (1.89) Isherheri (1.85) Kanonda (3.87) Ladrawan (3.33) Lowa Kalan (3.89) Mehandipur(1.75) Munda Khera(3.10) Shidipur(3.89) have fluoride the fluoride concentration above the MPL.

E. *Salhawas Tehsil*

The minimum concentration 0.37 mg/l was recorded in Kunjia village while maximum concentration was recorded from villages Babepur (3.89). Five villages namely Babepur (3.89), Dhakla (2.76), Kasni (1.57), Khudan (3.76) and Salhawas (1.55) have the fluoride concentration above the MPL.

Table 3: Abstract of Fluoride Distribution of Jhajjar District of Haryana

Name of Tehsil	Beri Khas	Jhajjar	Matanhail	Bahadurgarh	Salhawas
No of Samples Analyzed	09	50	32	34	24
F^- Concentration- Minimum (mg/l)	0.23	0.20	0.10	0.22	0.37
F^- Concentration- Maximum (mg/l)	3.37	4.30	4.23	4.22	3.89
% of samples with in MDL	2 (22%)	36 (72%)	21 (66%)	16 (47%)	16 (67%)
% of samples Between MDL - MPL	2 (22%)	9 (18%)	4 (12%)	8 (24%)	3 (12%)
% of samples with in MPL	4 (44%)	45 (90%)	25 (78%)	24 (71%)	19 (79%)
% of samples above MPL	5 (56%)	5 (10%)	7 (22%)	10 (29%)	5 (21%)

Table 4: Fluoride Distribution of Jhajjar District of Haryana

Tehsil	Villages / Towns
Beri Khas	Siwana (0.88), *Chimi (0.23)*, **Chamanpura (3.37)**, Wazirpur (1.23), Dharana (2.12), Dighal (1.56), Beri (2.1), Madana Kalan (3.1), Seria (1.1)
Jhajjar	Amadalpur (0.67), Babra (3.87), Batehra (0.23), **Bhadani (4.30)**, Bir Sunarwala (1.20), Birdhana (0.85), Boria (0.78), Chhabili (0.56), *Dadri Toe (0.20)*, Dawla (0.34), Dhor (1.20), Dujana (0.76), Fatehpur (3.60), Fortpura (0.22), Gijarod (0.34), Girawar (1.67), Hassanpur (0.67), Jahangirpur (1.21), Jondhi (1.11), Kahari (0.23), Kaimalgarh (0.67), Kaloi (0.67), Khajpur (1.21), Khakhana (0.54), Kheri Taluka Patoda (0.87), Khungai (1.34), Kilrod (0.67), Kukrola Munimpur (0.65), Kutani (0.23), Ladpur (0.45), *Luhari (0.20)*, Machhrauli (0.75), Mehrana (0.22), Nangla (0.35), Patoda (1.19), Pelpa (3.78), Raipur (0.45), Raiya (1.29), Rankhanda (0.48), Saloda (0.64) Sekhupur Jat (0.56), Silana (0.22), Silani Pana Keso (0.48), Sondhi (0.56), Surha (1.35), Tamaspura (0.45), Ukhalchana (0.45), Untloda (0.78), Yaqubpur (0.23), Zahidpur (0.54)
Matanhail	Akehri Madanpur (2.45), Amdalshahpur (1.56), Azad Nagar (0.45), Bahu (0.54), Bambulia (0.67), Belochpura (0.87), Bhindawas (0.49), Birohar (2.22), Chadhwana (0.45), Dhalanwas (0.90), Gawalison (0.34), Jamalpur (0.68), *Jhamri (0.10)*, Jhanswa (2.22), Jharli (0.67), Kaliawas (0.12), Karoda (0.49), Khanpur Khurd (2.78), Khaparwas (2.67), Kheri Hosdarpur (0.78), Khetawas (1.44), Koyalpuri (1.23), **Ladain (4.23)**, Maliawas (1.34), Marot (0.34), Mundsa (0.78), Noganwa (0.76), Redhuwas (0.68), Sasroli (0.22), Selanga (0.65), Shahjahanpur (1.45), Sundrehti (0.86),
Bahadurgarh	**Asauda Sewan (4.22)**, Asauda Todran (0.23), Badli (0.56), *Badsa (0.22)*, Ballour (1.45), Bamnoli (2.76), Bhaproda (0.67), Bupania (1.30), Chhara (0.45), Chhudani (0.83), Daboda Khurd (1.14), Daryapur (1.48), Dulhera (1.89), Gangarwa (0.67), Isherheri (1.85), Kanonda (3.87), Kassar (0.45), Khairpur (0.66), Kharhar (1.47), Kharman (0.67), Ladrawan (3.33), Lagarpur (0.56), Lowa Kalan (3.89), Mahmood Pur Majra (0.84), Mandothi (0.90), Mattan (0.38), Mehandipur(1.75), Munda Khera(3.10), Rohad(0.87), Sankhol(1.11), Shidipur(3.89), Silothi(1.10), Soldha(1.40), Tandaheri (0.29)
Salhawas	Amboli (1.11), **Babepur (3.89)**, Bithla (1.39), Chandpur (0.55), Chhapar (0.49), Dadanpur (0.55), Dhakla (2.76), Dhana (0.47), Fatehpuri (0.39), Girdharpur (0.77), Jaitpur (0.76), Jatwara (0.67), Kanwah (0.98), Kasni (1.57), Khudan (3.76), Kohandrali (0.66), *Kunjia (0.37)*, Niwada (0.87), Patasani 0.66), Salhawas (1.55), Samaspur Majra (0.56) ,Sarola (0.46), Subana (1.44), Surehti (0.76)
	Bold value denotes maximum and *Italic* value denotes minimum

IV. PREVENTION

Fluorosis is not only affects older persons but there is ample evidence that even newborn baby and children of younger age have also been its victims. It not only affects the body of a person but also renders them socially and culturally crippled. There is a need development a well through out strategy to attack this problem which requires an urgent attention from both medical as well as of social workers.

Considerable work has been done all over the word on treatment of fluorosis. Unfortunately the results indicated that the effects of fluorosis are irreversible. So, "Prevention is better than cure", many potential problems can be prevented by safe guarding the integrity of a drinking water sources. So, fluoride poisoning can be prevented or minimized by –

- ❖ Providing defluoridation water for drinking purposes
- ❖ Creation of awareness of hazards of high fluoride contamination and the need for restricting the consumption of water and produce having high fluoride concentration.

A. Changing of dietary habits

Defluoridation of drinking water alone shall not bring the fluoride level to a safe limit. It would be necessary to overcome the toxic effects of the remaining fluoride ingested through other sources. This can be done by effecting minor changes in

the diet and dietary habits of the population compatible with social system and available resources. The main aim should be to

- ✓ Restrict use of fluoride rich food
- ✓ Avoiding use of fluoride rich cosmetics
- ✓ Use of food rich in calcium, vitamin C and proteins. Clinical data indicate that adequate calcium intake is clearly associated with a reduced risk of dental fluorosis (Teotia et al. 1987; Pius et al. 1999). Vitamin C may also act as a safeguard against the risk. Hence, measures to improve the nutritional status of an affected population—particularly children— appear to be an effective supplement for antidote against fluorosis.

B. Water harvesting (alternative water source)

Fluoride not only affects the people but it also affects the animals. Therefore, it is desirable that the animals should also be provided with fluoride free water for maintaining their longevity. Defluoridation of drinking water for animals will be too costly and not feasible and therefore the only solution of this problem is water harvesting. The water harvesting technologies should be aimed not only to provide fluoride free water to human beings but also to animals. Rain water storage can be a major source of fluoride free drinking water for the animals.

C. Artificial recharge

Any quality improvement right at the source would therefore reduce hassles and provide a better alternative for the end users. Considering the geographic and climatic factors, artificial recharge through recycling the rainwater back into the aquifer appears to be the most suitable technique for water quality improvement. The fluoride levels in groundwater can be brought down by the artificial recharge of groundwater. Borewell water with low concentration (<0.5 mg/L) of fluoride can be blended with high fluoride waters before being supplied for domestic purpose. In areas of high fluoride concentration, easily available local raw materials such as clay, serpentine, and marble can be used to reduce fluoride content.

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