Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2018, 7 (6): 1795-1804

(International Peer Reviewed Journal)

Effect of Fluorosis on Village Folks of Rajauli, Bihar

Ashok Kumar[1*], Vikas Kumar Singh[1] and Kamal Kishor Singh[2]

1. P. G. Dept. of Environmental Sciences A. N. College, Patna, **INDIA**
2. HOD, P.G. Department of Chemistry A.N. College, Patna, **INDIA**

Email: ashokkumarenv@gmail.com

Accepted on 15th November, 2018

ABSTRACT

Water is a prime natural resource, a basic human need and a precious national asset. Serious problems are faced in several parts of India due to the presence of high concentrations of fluoride in drinking water which causes dental and skeletal fluorosis to humans. The quality and availability of water depend on the way, we use and misuse this precious resource which is the most important life supporting substance. Hence the present study was undertaken for the determination of fluoride in ground water collected at random from 10 villages of Rajauli Sub-division Nawada, District of Bihar in India. It was observed that the fluoride annual average concentration values vary from 1.73 mgL^{-1} to 4.92 mgL^{-1}, Body Mass Index values ranged from adult female 14.7 to 18.6 and adult male 15.2 to 18.9, All of the adult people in each village were sampled for a total of about 1000 people in all 10 villages. On the basis of results obtained in the present study, it has been concluded that all physico-chemical parameters were within permissible limits whereas in case of fluoride, all samples exceeded permissible limit of the WHO and BIS for drinking water. Therefore, drinking water of study area is not suitable for the consumption without treatment. The ground water of ten villages was measured by the SPAND method.

Graphical Abstract

Photographs of skeletal deformed in Rajauli Sub- division of Bihar, India.

Keywords: Groundwater, Fluoride contamination, Dental fluorosis and BMI value, SPAND method, adult female and male, Rajauli Sub-division, Nawada District.

INTRODUCTION

Fluorine is the ninth element of the periodic table [1]. Nevertheless, its applications and biological significances were known only in the decade's of1920's. It is the lightest member of the halogen family and the most electronegative among all chemical elements (Hodge and Smith, 1965) [2]. Fluorine has both notable chemical qualities and physiological properties, which are of great interest and significance to human health. Fluorine is rarely or never found free in the nature in element form. It has strong affinity to combine chemically with other elements to form compound called 'fluoride'. Many reviewers used the word fluoride' to donate the ionized. WHO has considered fluoride as one of the very few chemicals that have been shown to cause significant effects in people. There is a narrow margin between the desired and harmful doses of fluoride [3]. Low concentration of fluoride in drinking water have been considered beneficial to prevent dental carries [4], but excessive exposure to fluoride can give rise to a number of adverse effects such as causing fluorosis [2, 5, 6]. WHO has set a limit value of 1.5 mg L^{-1} for fluoride in drinking water [7, 22]. 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. These effects are not apparent if the teeth were already fully grown prior to the fluoride overexposure; therefore, the fact that an adult may show no signs of dental fluorosis does not necessarily mean that his or her fluoride intake is within the safety limit. Chronic intake of excessive fluoride can lead to the severe and permanent bone and joint deformations of skeletal fluorosis. Early symptoms include sporadic pain and stiffness of joints: headache, stomach-ache and muscle weakness can also be warning signs. The next stage is osteosclerosis (hardening and calcifying of the bones), and finally the spine, major joints, muscles and nervous system are damaged. Whether dental or skeletal, fluorosis is irreversible and no treatment exists, the only remedy is prevention, by keeping fluoride intake within safe limits.

Skeletal Fluorosis: Excessive quantity of fluoride deposited in the skeleton, which is more in cancellous bone than cortical bone. Fluoride poisoning leads to severe pain associated with rigidity and restricted movements of cervical and lumber spine, knee and pelvic joints as well as shoulder joints. In severe cases of fluorosis, there is complete rigidity of joints.

Non–Skeletal Fluorosis: Fluoride when consumed in excess can cause several other kinds of manifestations; Nervousness, depression, tingling sensation of fingers and toes, excessive thirst and tendency to urinate more frequently.

Muscular: Muscle weakness, stiffness, pain in muscles and loss of muscle power.

Detection of fluorosis

1. Aches and pain in the joints, viz. neck, back, hip, shoulder and knee without visible signs of fluid accumulation, may be due to fluoride toxicity manifestations besides other reasons [8, 9].
2. Non-ulcer dyspepsia, viz. nausea, vomiting, pain in the stomach, bloated feeling/gas formation in the stomach, constipation followed by diarrhoea, may be due to fluoride toxicity manifestations besides other reasons [10-13].
3. Polyurea (tendency to urinate more frequently) and polydipsia (excessive thirst), if detected, may be due to fluoride toxicity manifestations besides diabetes and/or other diseases [14].
4. Muscle weakness, fatigue, anaemia with very low haemoglobin levels maybe due to fluoride toxicity besides other reasons [15, 16].
5. Complaints of repeated abortions/stillbirth and if the patient hails from an endemic area, one may suspect fluoride toxicity besides other reasons as fluoride is known to harden/calcify blood vessels and blood flow to the growing foetus is hampered [17].
6. Complaints of male infertility with abnormality in sperm morphology, oligospermia (deficiency of spermatozoa in the semen), azoospermia (absence of spermatozoa in the semen) and low testosterone levels and if the patient hails from an endemic area, one ought to suspect fluoride toxicity, besides other reasons[18–20].

Effect of Fluoride on Human Health: Fluoride contamination is a major health hazard in many parts of the world. Fluoride is considered beneficial to human health if taken in limited quantity (0.5 to 1.5 mg L^{-1}) [21]. Fluoride prevents tooth decay by enhancing the remineralization of enamel that is under attack, as well as inhibiting the production of acid by decay causing bacteria in dental plaque. Fluoride is also a normal constituent of the enamel itself, incorporated into the crystalline structure of the developing tooth and enhancing its resistance to acid dissolution.

Table 1. Concentration of fluoride and Biological effects

S No.	Fluoride in drinking water mg L^{-1}	Biological effects
1	0.002 mg L^{-1}in air	Injury to vegetation
2	1 mg L^{-1}in water	Dental caries reduction
3	2 mg L^{-1} or more in water	Mottled enamel
4	3.1 to 6.0 mg L^{-1}in water	Osteoporosis
5	8 mgL^{-1}in water	10%osteoporosis
6	20 – 80 mgday^{-1} or more in water or air	Crippling skeletal fluorosis
7	50 mg L^{-1} in food or water	Thyroid change
8	100 mg L^{-1}in food or water	Growth retardation
9	More than 125 mg L^{-1} in food or water	Kidney change
10	2.5 – 5.0 gm in actual dose	Death

Source: Public Health Engineering Department Rajasthan, (1991) and Hussain et al. (2002)

But it is also known to cause dental, skeletal fluorosis, osteosclerosis, thyroid, kidney changes and cardiovascular, gastrointestinal, endocrine, neurological, reproductive, developmental, molecular level, immunity effects. If concentration is higher than 1.5mg L^{-1} in drinking water (WHO, 1996) Smith and Hodge, (1959) [22, 23] have shown the correlation between fluoride and biological effect [24](Table 1).

MATERIALS AND METHODS

Study Area: The study area lies between Latitude: 24° 38' 59.99" N, Longitude: 85° 29' 59.99" E, in Rajauli is a Sub-division in Nawada district of Bihar state, India (contact Information Developer: David B. Zwiefelhofer Email:webmaster)

Sample Collection and Analysis: The samples were collected during winter, summer and monsoon season. Water samples from bore well were collected in glass containers. Before collecting samples, water from bore well was pumped out for about 5-10 min or until water temperature is stabilized. Samples were collected in different containers at each point to add necessary preservatives as per standard procedure. The samples were preserved in icebox and transported to laboratory. The samples were analysed as per Standard methods for the examination of water and waste water [25]. The results obtained were compared with the drinking water standards as specified by World Health Organisation (WHO) [26] and Bureau of Indian Standards (BIS) [27].

This study was conducted between October 2015 to March 2016 in 10 villages in Rajauli Sub-division, on basis of yearly and quarterly study. The Climate is hot and dry in summer and mild in winter. Except for some small villages 10 villages in that area was selected for study, rely for their drinking water on local groundwater sources with varying concentration of fluoride (F^-) level. The selection of these villages was done in such a way that all of them have essentially the same socio-economic standards and nutritional conditions. Most of villages have the similar public health and dental care. All the adult people in each village were examined. Included in total of 1000 adult people were 500 female and 500 male. For the Fluoride (F^-) analysis standard SPAND method was used with a Systronic company spectrophotometer. The dental fluorosis of the adult people in each village were

determined according to the WHO standard [22] by two dentists from Patna using a sharp dental probe and mouth mirror under good natural light. The samples collected from the 10 villages are shown in the figure 1 and 2.

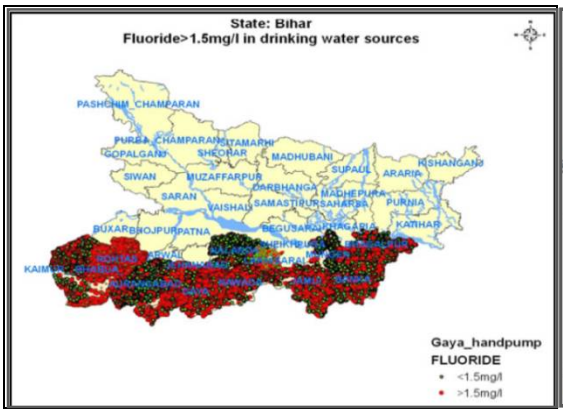

Figure 1

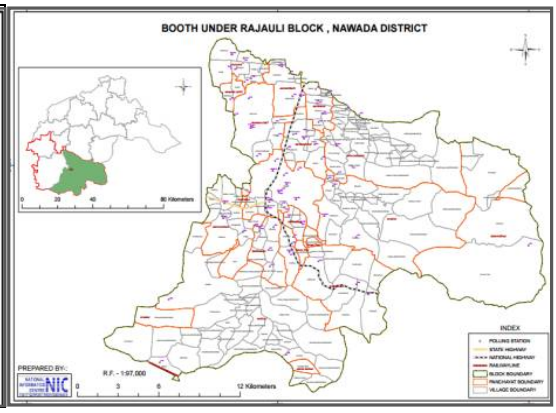

Figure 2

Figure 1 and 2. Location of Nawada district in Bihar

[Note: Map curtsey of http://phed.bih.nic.in/WaterQuality.htm figure 1], **[**Note:Map curtsey of website National Informatics Centre figure 2**]**

Sampling location: 1. Kachahariyadih, 2. Mushlim Tola, 3. Haldia (Hardiya) Sector-I, 4. Haldia (Hardiya)Sector- II, 5. Takauatand, 6. Dhamni, 7. Rajauli Mohalla Near (PS), 8. Rajauli Mohalla (SDM office), 9. Garh dibaur, 10. Choutha,

Procedure: Intermediate fluoride solution of 2, 4, 6, 8, and 10 mL was taken and then diluted to 50 mL with distilled water. After dilution added 10mL acid zirconyl SPADNS reagent and allowed to stand the standard solution for 10 min for completing the reaction between fluoride and acid zirconyl SPADNS reagent. After 10 min we saw the sample on the spectrophotometer at the wavelength 570 nm, and draw the calibration graph, absorbance against concentration of the standard sample. From this calibration graph we found out the concentration of unknown sample of water. Reference solution was considered as blank for fluoride detection.

50 mL sample of waste water or sampled water was taken and added few drop of sodium arsenite solution to reduce the interference of chloride, then added 10 mL acid zirconyl SPADNS reagent allowed to stand for 10 min for completing the reaction. Then saw the sample on the Systronics company spectrophotometer at wavelength 570 nm and note down the absorbance of the sample, and found out the value of fluoride from the calibration graph prepared by standard fluoride solution.

Calculation:

$$F^{-}(mg\ L^{-1}) = (A / mL\ sample) \times (B/C)$$

Where A = µg F^{-} determined spectrophotometrically. The ratio B/C applies only when a sample is diluted to a volume B, and portion C was taken from it for colour development [25].

Data were computerized and analyzed using the statistical package for social science. Linear regression analysis was used to examine the relationship between the F^{-}concentration in the drinking water dental caries, skeletal deformation and their BMI Value.

BMI Weighing Scale: WHO defines as the weight in kilos divided by the square of the height in meter or kg meter $square^{-1}$. For examples an adult weighing 70 kg and whose height in 1.75 meter will have a BMI of 22.88

$$BMI = 70kg/ (1.75\ m)^2 \text{ or } 70/ 3.06= 22.88$$

The BMI was invented by Adolphe Quetelet between 1830 and 1850 [28]. A scientist named Ansel Keys first used the term *body mass index* in 1972 [29]. He wrote that governments should measure the BMI of adults to find out whether they are too fat or too thin (Table 2).

Overweight or Not: Health organizations, including the World Health Organization (WHO), use the BMI to help in deciding whether people are too fat or too thin. The WHO uses these numbers for adults [30]

Table 2. International Classification According to BMI

Underweight	up to 18.5
Severe thinness	up to 16
Moderate thinness	16 to 16.99
Mild thinness	17 to 18.49
Normal	18.5 to 24.99
Overweight	25 to above
Pre obese	25 to 29.99
Obese	30 above
Obese class I	30 to 34.99
Obese class ii	35 to 39.99
Obese class iii	40 to 45
Super obese	45 and above

Figure 3. Photographs of skeletal deformed in Rajauli Sub- division of Bihar, India.

Moderate Severe Very severe

Figure 4. Photographs of dental fluorosis in Rajauli Sub- Division of Bihar, India.

RESULTS AND DISCUSSION

The population and the number of adult people female and male examined in each village are shown in table 3. The concentration of F^- level in all 10 villages groundwater was found to vary widely from 1.73 to 4.96 mg L^{-1}. However, in Kachahariyadih, Mushlim tola, Chautha and Garh dibaur villages the F^- concentration was found 4.92, 4.86, 3.92 and 3.79 mg L^{-1} shown in the figure 5. The adult female

dental fluorosis values of above four villages was reported as 19, 16, 14,13, skeletal deformation values were found 10, 8, 7, 5 and non-skeletal deformation values were found 24, 21, 19 and 17. It seems that the dental fluorosis, skeletal deformation and non-skeletal deformation values have linear regression between increasing the (Fluoride) F^- level content of the groundwater and increasing trend of dental fluorosis, skeletal deformation and non-skeletal deformation.

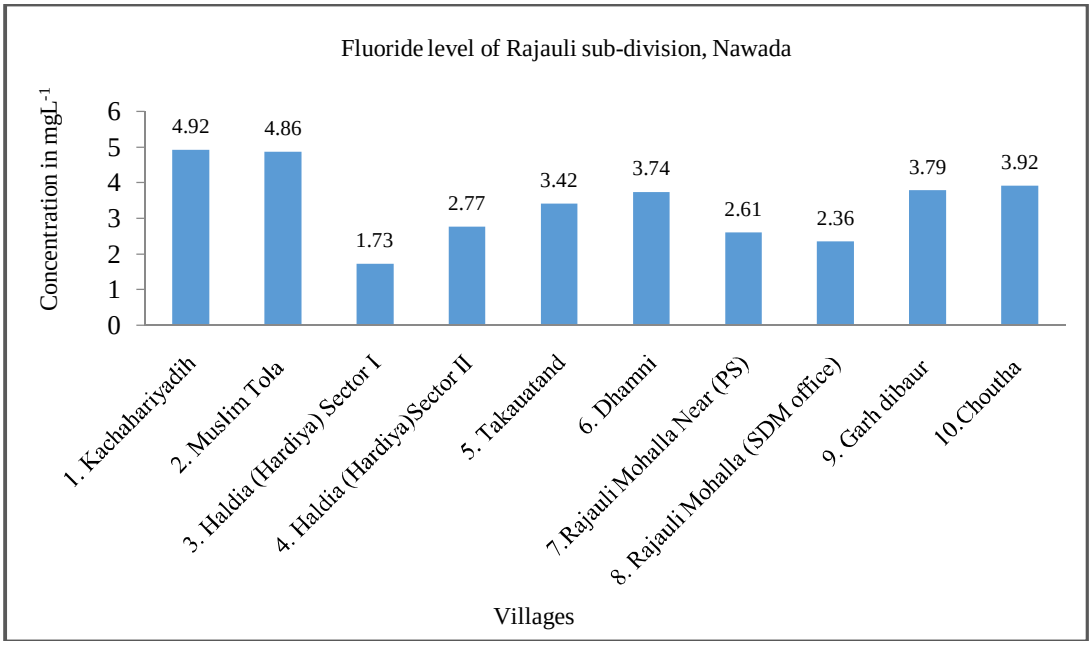

Figure 5. Fluoride concentration in 10 villages of Rajauli Sub-division Nawada, Bihar, India

The adult male dental fluorosis values of above four villages was reported as 17, 14, 14, 12 skeletal deformation values were found 9, 7, 5, 4 and non- skeletal deformation values were found 21, 20, 17 and 16. It seems that the dental fluorosis, skeletal deformation and non- skeletal deformation values have linear regression among increasing F^- level content of the groundwater and increasing trend of dental fluorosis and non- skeletal deformation. For both female and male of different age groups in the remaining villages, as it is shown female and male people in figure 7, 8 and 9 shows the relationship between dental fluorosis, skeletal deformation and non-skeletal deformation values of Kachahariyadih, Mushlim tola, Chautha and Garh dibaur villages. Higher F^- concentration is also found in these villages as found 4.92, 4.86, 3.92 and 3.79 mg L^{-1}.

Thus, we see that both male and female are affected, but comparatively female are affected more than male counterpart as it is evident from table 3, figure 7, 8 and 9. Linear regression is shown above the data base, it seems that male and female health is decreasing day by day.

The BMI values shows of female and male was found inversely proportional to the concentration of F^- level that is BMI values of Hardiya Sector-I is highest as 18.6 and BMI values of female in Kachahariyadih, Mushlim tola, Chautha and Garh dibaur villages is lowest as 14.7, 15.1, 15.3 and15.7. This data indicates that major part of female population of these villages have poor health and anaemic as shown the figure 6 to10.

The adult male minimum BMI value 15.2 is found in Kachahariyadih and highest BMI value 18.9 in Hardiya sector-I as shown in table 3. Therefore it reveals that the people of Kachahariyadih, Mushlim tola, Chautha and Garh dibaur possess very poor health as their BMI value is lower. But the people of Hardiya sector-I posses good health. The BMI value of Hardiya Sector-II 18.4, Rajauli

mohalla near (PS) 18.5 and Rajauli mohalla (SDM) office is 18.6, so we can say that people of these sector possess better health.

Table 3. Yearly determination of BMI value and adult female/male health survey in Rajauli Sub-division during 2015-2016

S. No.	Name of the villages	Population in Rajauli Sub-division	Number of Examined People	Yearly Determination of BMI value and adult Female/ Male health survey during 2015-2016								
				Dental Fluorosis		Skeletal deformation		Non Skeletal deformation		BMI Mean Value		Mean F^- level in (mg L^{-1})
			Female + Male	Female	Male	Female	Male	Female	Male	Female	Male	
1	Kachahariyadih	280	50+50	19	17	10	9	24	21	14.7	15.2	**4.92**
2	Muslim Tola	430	50+50	16	14	8	7	21	20	15.1	15.8	**4.86**
3	Haldia (Hardiya) Sector I	4000	50+50	6	4	2	1	8	5	18.6	18.9	**1.73**
4	Haldia (Hardiya) Sector II	3900	50+50	9	8	3	2	12	9	17.2	18.4	**2.77**
5	Takauatand	2500	50+50	13	9	3	2	14	14	16.5	17.7	**3.42**
6	Dhamni	2815	50+50	13	10	4	3	16	14	15.9	17.3	**3.74**
7	Rajauli Mohalla Near (PS)	1500	50+50	8	6	3	3	12	9	17.7	18.5	**2.61**
8	Rajauli Mohalla (SDM office)	1300	50+50	7	4	2	2	9	7	18.3	18.6	**2.36**
9	Garh dibaur	1717	50+50	13	12	5	4	17	16	15.7	16.8	**3.79**
10	Choutha	2075	50+50	14	14	7	5	19	17	15.3	16.2	**3.92**
	Total	**20,517**	**1000**	**118**	**98**	**47**	**38**	**152**	**132**	**Avg16.5**	**17.3**	**3.41**
		Min		**6**	**4**	**2**	**1**	**8**	**5**	**Min 4.7**	**15.2**	**1.73**
		Max		**19**	**17**	**10**	**9**	**24**	**21**	**Max 8.6**	**18.9**	**4.92**

When our team visited Haldiya Sector-I and Hardiya Sector-II villages, it was found that in some areas drinking water is being supplied water by PHED, Government of Bihar and this water has fluoride concentration between 0.5 to 1.5 mg L^{-1} which is within permissible limit as WHO and Bureau of Indian Standards.

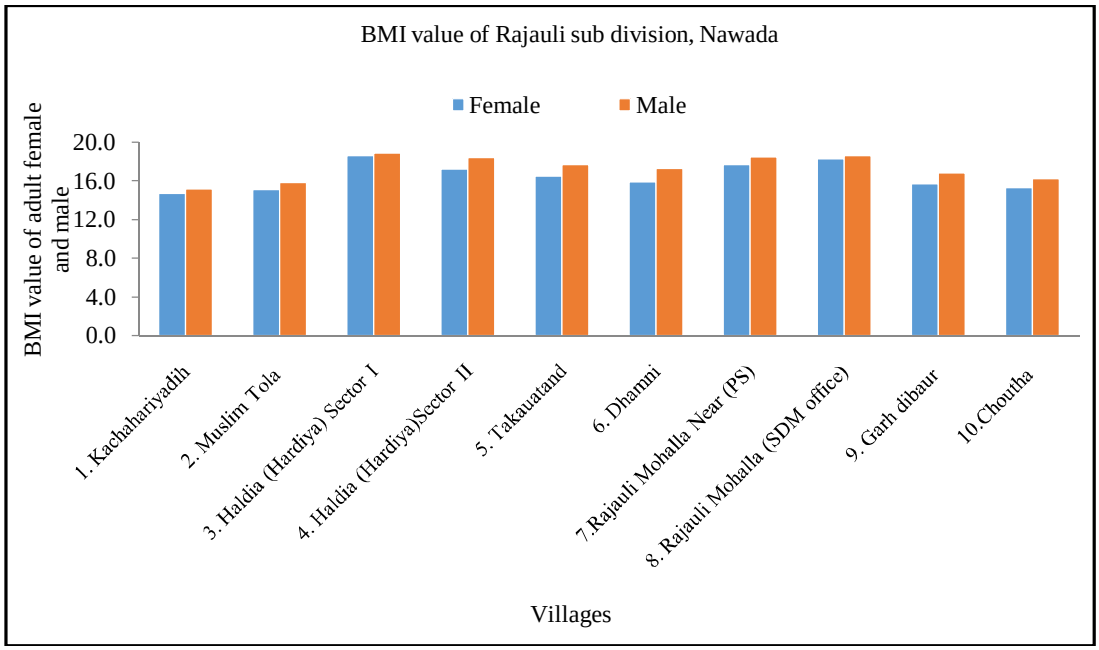

Figure 6. Relationship between fluoride content and mean of BMI value of adult female, male.

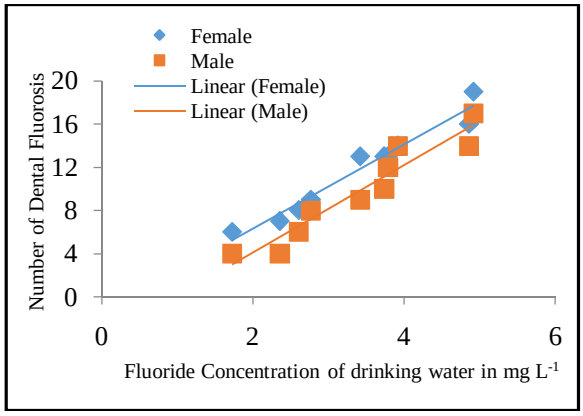

Figure 7. Relationship between fluoride content and mean of dental fluorosis value of adult female, male.

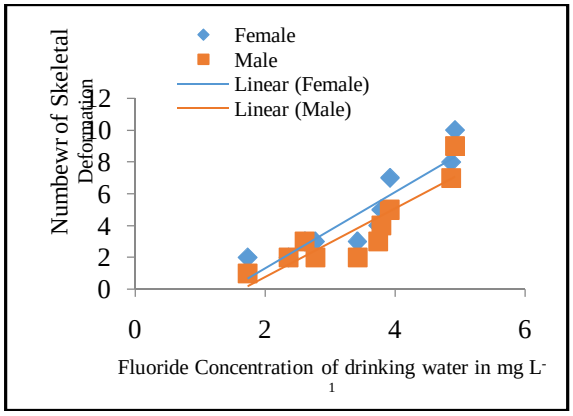

Figure 8. Relationship between fluoride content and mean of skeletal deformation value of adult female, male.

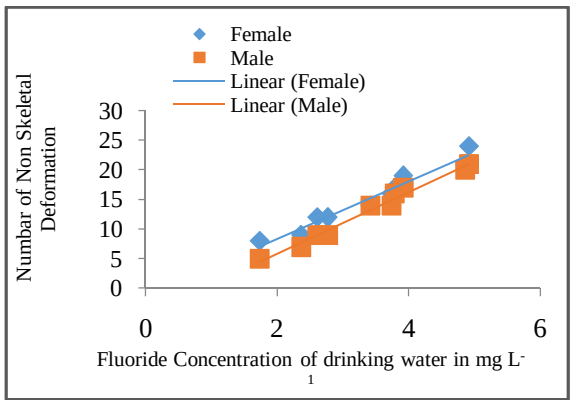

Figure 9. Relationship between fluoride content and mean of non skeletal deformation value of adult female, male.

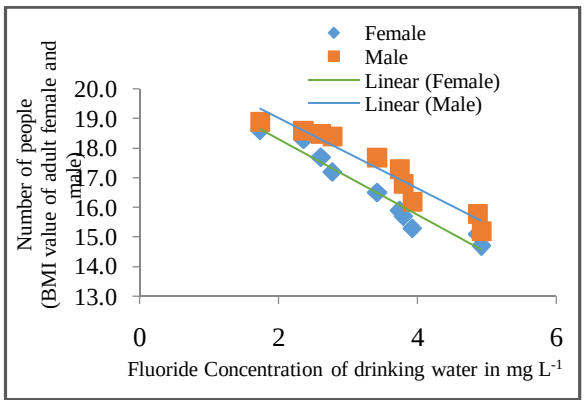

Figure 10. Relationship between fluoride content and mean of BMI value of adult female, male.

APPLICATION

Nutritional intervention is also practiced simultaneously. This requires counselling of the patients and educating those who cook and serve food for the family. The importance of choosing crops which are rich in calcium, vitamin C, E and anti-oxidants for consumption on a daily basis is emphasized. This needs to be monitored initially at intervals of short duration, viz. 3 to 4 weeks to reveal to the members of the family the benefits they accrue from such an approach. A desk review on the impact of nutrition on fluorosis has been brought out by UNICEF [31]. The fluoride levels in blood, urine and drinking water are also monitored for a period of 3–6 months; the complaints gradually disappear with decline in fluoride levels providing great relief to the individual. They would then continue the dietary regime and consumes of water. Government of Bihar also installed FRC(Fluoride Removal Centre) unit in some villages of Rajauli Sub-division, district Nawada Bihar but Fluoride free drinking water is being misused and no one to care that.

CONCLUSION

Physico-chemical analysis of groundwater sources (drinking water sources) of the 10 villages Rajauli Sub-division district Nawada state Bihar, suggest that all the physico-chemical parameters are within safe limits except that of fluoride which is above permissible limit as prescribed by WHO/BIS for drinking water. The excess fluoride concentration in the study area (Rajauli Sub-division in ten villages) may be attributed to the geological formation in the area. The weathering of rocks and leaching of fluoride bearing minerals might be the major reasons which may have contributed to the

elevated concentration of fluoride in groundwater sources of the study area. Therefore, the present study indicates that groundwater sources in Rajauli Sub-division in ten villages are not fit for drinking purpose. Elevated levels of fluoride in groundwater sources might be possibly responsible for reported cases of dental fluorosis, skeletal fluorosis and non- skeletal fluorosis in the residents of investigated area. The study was conducted to generate baseline data on fluoride concentration in groundwater sources of Rajauli Sub-division in ten villages. Further study is required to estimate fluoride concentration both in pre- and post-monsoon period and associated health risk because of intake of water with elevated level of fluoride. The amount of fluoride in food, vegetables and dental products used in the locality also needs to be measured.

REFERENCES

[1]. Periodic Table of the Elements. National Institute of Standards and Technology, U.S. Department of Commerce.
[2]. D. A .Wright - 1975 - Cited by 62-Related articles Hodge and Smith, **1965**. H.C. Hodge, F.A. Smith Biological effects of inorganic fluorides. J.H. Simons (Ed.), Fluorine chemistry, 4, Academic Press, New York.
[3]. M. Agarwal, K. Rai, S. Dass, Defluoridation of water using amended clay, *J.Cleaner Prod*, **2003**, 11, 439-444.
[4]. A.P.H.A, A.W. W.A, W.P.C.F, Standard methods of examination of water and wastewater. 14th ed, **1975**
[5]. E. Bellack, P. J. Schouboe, Rapid photometric determination of fluoride in water, *Anal. Chem.* **1958**, 30, 2032-2034.
[6]. P. L. Bishop, G. Sancoucy, Fluoride removal from drinking water by ftuid izcd activated alumina adsorption, *J.Amer. Water Works Asso,* **1978**, 70, 554-559.
[7]. J. S Jacobson, L. H. Weinstein, Sampling and analysis of fluoride: Methods for ambient air, plant and animal tissues, water, soil and foods, J. *Occ. Mad*., **1977**, 19, 79 -87
[8]. M. J. Larsen, E. 1. F. Pwce, S.J Jcriscn, Defluoridation of water at high pH with use of brushite, calcium hydroxide and bone charcoal, *J. Dent. Rcs.*, **1993**, 72, 15-19.
[9]. A. K. Susheela, K. Majumdar, Proc. 18th WEDC Conference, Kathmandu, Nepal, **1992**, 229–231.
[10]. A. K. Susheela, , Proceedings of the 1st International Specialized Conference on Water Quality and its Management, New Delhi, **1998**, 292–300.
[11]. A. K. Susheela, Das, K. Taposh, I. P. Gupta, R. K. Tandon, S. K. Kacker, P. Ghosh, R. C.Deka, *Fluoride,* **1992**, 25, 5–22.
[12]. I. P. Gupta, T. K. Das, A. K. Susheela, S. Dasrathy, R. K. AndmTandon, *J. Gastroenterol. Hepatol.*, **1992**, 7, 355–359.
[13]. T. K., Das, A. K. Susheela, I. P. Gupta, S. Dasarathy, R. K. Tandon, *J. Clin. Gastroenterol.*, **1994**, 18, 194–199.
[14]. S. Dasarathy, Das, K. Taposh, I. P Gupta, A. K. Susheela, R. K. Tandon, *J. Gastroenterol.*, **1996**, 31, 333–337.
[15]. A. K. Susheela, Proceedings of the National Workshop on Water Quality Monitoring andSurveillance in Rural Areas, Rajiv Gandhi National Drinking Water Mission, August, **1997**.
[16]. A. K. Susheela, S. K. Jain, Proceedings of the 14th Conference of the InternationalSociety for Fluoride Research, Japan, Elsevier Publishing House, Amsterdam, **1986,** 231–239.
[17]. R. D. Kaul, A. K. Susheela, , Symposium on Non-skeletal Manifestations of Chronic Toxicity–The Muscle, Fluoride, **1976**, 9, 9.
[18]. A. K. Susheela, P. Kharb, *Exp. Mol. Pathol.*, **1990**, 53, 72–80 and A. K. Susheela, P. Jethnandani, *Clin. Toxicol.*, **1996**, 34, 183–189.
[19]. Sundaram, M. D. Chanemouga, Thesis, Department of Obstertics and Gynaecology, All India, Institute of Medical Sciences, New Delhi, **1998**.
[20]. Mehta, R., Rajvi and Anand Kumar, T. C. (unpublished observation).
[21]. J. Hussain, K. C. Sharma, I. Hussain, *Ind. J. Environ.Health*, (**2004**).

[22]. WHO: *Guideline for drinking water quality*, second edition, vol. 2, Health criteria and other supporting information,WorldHealth Organization, Geneva (**1996**).
[23]. F. A. Smith, H. C. Hodge,In: *Fluorine and dental Health*, (T. C. Muhler, M. K. Hne, eds.) Bloomington, Indian University Press, pp. 11-37 (**1959**).
[24]. I. Hussain, J. Hussain, K.C. Sharma, K .G. Ojha, In: *Environmental Scenario of 21st Centaury*, APH Pub.Co., New Delhi, pp. 355 –374 (**2002**).
[25]. Standard Methods for the Examination of Water and Wastewater; APHA (American Public Health Association), AWWA and WEF, 21st Edition, **2005**.
[26]. WHO, Guidelines of drinking water quality Recommendation: the 3rd edition. Geneva: World Health Organization, **2006**2nd Ed. In article.
[27]. Bureau of Indian Standards,. Drinking Water-Specification IS 10500:2012, Second Revision, Government of India, New Delhi, **2012**.
[28]. Eknoyan, Garabed. "Adolphe Quetelet (17961874)-the average man and indices of obesity", *Nephrol. Dial. Transplant*, **2008**, 23 (1): 47– 51.doi:10.1093/ndt/gfm517 .PMID17890752.
[29]. Keys, Ance, Fidanza, F, Karvonen, M. J.Kimura, N. Taylor, HL , Indices of relative weight and obesity, *J Chronic Dis.*, 1972, 125(6), 329– 43, .doi:10.1016/00219681(72) 900276. PMID 4650929
[30]. "BMI Classification". World Health Organization.
[31]. UNICEF, Desk Review: *Impact of Nutrition on Fluorosis*, Industrial Toxicology Research Centre, Lucknow, **1998**.