

Positive impact of consumption of fluoride safe potable water together with moringa leaf powder on fluorosis patients of some habitations of Rajauli block, Nawada, Bihar

Bihari Singh¹, Rajesh Kumar², Tripti Gangwar³, Anil Kumar Singh⁴, Prashant Chandra⁵, Vishal Patel⁶ and Jayant Kumar⁷

¹Centre-Incharge, Centre for Fluorosis Research, A. N. college, Patna

²Project supervisor, Centre for Fluorosis Research, A. N. college, Patna

³Head, Dept. of Chemistry-cum-coordinator, Centre for Fluorosis Research, A. N. College, Patna

⁴Dept. of chemistry-cum-member Centre for Fluorosis Research, A. N. College, Patna

^{5&7}Project Associate, Centre for Fluorosis Research, A. N. College, Patna

⁶District Mission Manager, Jal-Jeevan-Hariyali Mission, Rural Dev.Dept., Govt. of Bihar

Email : bihari_singh2001@yahoo.com, rajeshkumar1952@gmail.com, triptigangwar312@gmail.com, anilkrishna11@gmail.com, chandraprashant999@gmail.com, vshlpt145@gmail.com, jayant.992@gmail.com

Manuscript received online 05 January 2023, accepted on 06 March 2023

Abstract: Present study reports survey on health status of fluorosis patients from fluorosis endemic three neighbouring habitations - Kachhariadih, Muslimtola and Hanumannagar of Hardiya Panchayat, Rajauli, Nawada, Bihar. The study has been conducted in two phases. First phase study was conducted from November 2017 to December 2019 when the people from these fluorosis endemic habitations consumed fluoride contaminated groundwater for drinking and cooking purpose. Second phase study covers the period from January 2020 onwards till the date of submitting this research paper. On 18.12.2019 fluoride safe treated dam water was started from rainfed Phulwariadam under Multiple Village Piped Water Supply (MVWS) scheme conducted from PHED, Govt. of Bihar campus, Hanumannagar, Hardia. Under this scheme fluorosis endemic 100 habitations of Rajauli Block covering a population of over 85,000 are being supplied fluoride safe potable water. Our study habitations are covered under this scheme. Supply of fluoride safewater is coupled with use of moringa leaf powder as nutritional supplement to the fluorosis patients of the study area. The first phase study revealed that all the three types of fluorosis – dental, skeletal and non-skeletal-were widely prevalent in the people of study area. Analysis of all their drinking water sources showed fluoride concentration from 1.8 ppm to 8.7 ppm being higher than maximum permissible limits of 1.5 ppm. In rainfed dam water it was 0.6 ppm. During second

phase study which is still going on fluorosis patients have expressed gradual relief in body pain and stiffness of body parts, improved digestion system etc. Decreasing fluoride concentration in their urine sample after interventions is also an indicator of success of the mitigation measures.

(Key words : Fluorosis patients, Fluoride safe potable water, Moringa leaf powder, Improved health status)

Introduction

Fluorine is a trace element which when accumulates in human body in the form of fluoride above permissible limit causes fluorosis. Fluorosis is a serious public health problem causing health disorders like Dental fluorosis, Skeletal fluorosis and Non-skeletal fluorosis, besides inducing ageing. Moreover, in recent years investigation on fluorosis patients evidences are coming on involvement of Kidney, Liver, Adrenal gland and Reproductive organ as well(Ref.1,2,3). The rising prevalence of Autism Spectrum Disorders (ADS) in fluorosis endemic areas of our country and elsewhere is another concern of serious nature (Ref. 4). Fluoride can reach human body through natural sources- water

and soil (via agricultural crops) and also through ready to consume food items and industrial emission from various industries with high fluoride content in them. Several of the ready to serve foods, beverages, snacks etc. have high content of black rock salt (CaF_2) which is as high as 157ppm fluoride(Ref.5). However, drinking water extracted from ground water aquifers is the most common source of fluoride intake.

In some region of the world including our country and the state of Bihar, the geographical crust is heavily loaded with fluoride bearing minerals due to which ground water is naturally fluoridated. The occurrence of fluoride in ground water in higher concentrations is attributed to the leaching of fluoride from its minerals. Intake of fluoride contaminated drinking water for a prolong period causes fluorosis. It is detrimental to the health of an individual and the community which in turn has adverse effects on growth, development and economy of a state and the country.

In our country as per Bureau of Indian Standards (BIS), the “Acceptable limit (maximum)” of fluoride in drinking water and the “Permissible limit (maximum) in the Absence of Alternative source” are 1.0 mg per litre (1.0ppm) and 1.5mg per litre (1.5ppm) respectively with a rider. “Lesser the fluoride the better (Ref. 6)”.

Fluorosis: Indian scenario

As per the Ministry of Water Resources, Govt. of India, New Delhi out of 639 districts in India, 267 districts were the fluoride affected in the year 2012. UNICEF estimated about 66.62 million people to be at risk due to fluoride contaminated water in 19 states of India including 6 million children below the age of 14 years (Ref.7).

As per the latest data presented in the Lok Sabha in September 2020, a total of 5,485 habitations across 17 states are affected by

fluoride contamination in drinking water across India.

Fluoride affected areas of Bihar

Bihar is one among the 17 states of India where fluoride endemicity has been reported in 11 out of 38 districts of Bihar due to high level of fluoride in their drinking ground water sources (Ref.8, 9).

As the damage/change in skeletal system and teeth due to prolonged exposure to high fluoride levels is irreversible, the focus of management of fluorosis is on prevention, health promotion, deformity correction and rehabilitation. In order to address the problem of fluorosis in the country, Govt. of India started 100% centrally approved “National Programme for Prevention and Control of Fluorosis (NPPCF)” as a new health initiative during 11th five year plan in a phased manner (Ref.5)

Centre for Fluorosis Research and Integrated Fluorosis Mitigation (IFM) Programme.

Centre for Fluorosis Research (CFR) is a research wing of A. N. College, Patna, Bihar (India). It provides a platform to scientists, researchers, medical professionals, philanthropic organizations and individuals who are genuinely working for or wish to be associated with the noble cause of fight against fluorosis. This conglomeration of sensible persons work together to lesser the suffering of fluorosis patients and to bring them back to main stream of social life.

In October 2017, a Socio-Scientific Research-cum-Fluorosis Mitigation Programme entitled “Integrated Fluorosis Mitigation (IFM) Programme in Fluorosis endemic selected villages of Nawada Districts, Bihar” was undertaken. The IFM Programme is being implemented with the financial and technical support of UNICEF, Bihar and is being conducted by Centre for Fluorosis Research, A.

N College, Patna in collaboration with CSIR-NEERI, Nagpur, ICMR-NIRTH, Jabalpur and PHED, Government of Bihar.

METHODOLOGY & STUDY DESIGN

The three habitations selected for the present study are all rural far from the township and inhabited mostly by poor people belonging to the lowest strata of the society-economically, socially and educationally.

Study Design:

As has been mentioned above the study has been designed to be conducted in two phases:

PHASE I:

Phase I study covered the study period from November 2017 to December 2019.

It included:

[A]. Survey on health status and food habits of the people:

(i). Survey on health status of individual members of each and every family of the fluorosis endemic study habitations was conducted through a Health Survey Booklet designed specifically for recording the survey report.

It contained a set of questionnaires designed to record the type and severity level of fluorosis of the fluorosis affected members of each family individually.

(ii) Common food items and food habits of common people of the study habitations were recorded in the Health Survey Booklet. Such records are helpful in understanding the nutritional status of the fluorosis patients and help in planning for food/nutritional supplements to fluorosis patients in particular and to malnourished people in general.

[B]. Water quality analysis of all the 32 drinking water sources: [27 hand pumps, 3 bore wells, 1 dug well and 1 Intake well (dam)]

These were the only source of drinking and cooking water in the study areas before the supply of fluoride safe water under MVWS Scheme in December, 2019.

The water quality analysis and survey on the health status of the people in the study habitations were conducted from March 2018 to October 2019. First water quality analysis of all the 32 drinking water sources was conducted in March 2018 and the second Water quality analysis was conducted in October 2019, just before the supply of fluoride safe water were undertaken in these habitations under MVWS scheme from 18th December, 2019 onwards.

It is known that decreasing pattern of fluoride concentration in urine of fluorosis patients is an indicator which shows the positive effect of mitigation measures on the fluorosis patients. Therefore, periodic chemical analysis of urine sample of some selected fluorosis patients for fluoride concentration in their urine was done (Ref 17,18,19).

[C]. Case studies of some fluorosis patients (their health complaints, educational status etc.) from the study villages before interventions of supply of fluoride safe water and provision for moringa leaf powder in their daily meal items as nutritional supplement were undertaken.

PHASE II:

Phase II Study covered the period after the supply of fluoride safe water under MVWS scheme was undertaken on 18.12.2019. The study covered the period from January 2020 to October 2022.

The study included:

[A]. Water quality analysis of the fluoride safe water supplied under MVWS Scheme. The water quality analysis was conducted twice—first in the month of May, 2020 and second in the month of September-October, 2022.

[B] Periodic chemical analysis of urine sample of the selected fluorosis patients for fluoride concentration in their urine was done along with the water quality analysis.

[C] Interaction of CFR team members with some severely affected fluorosis patients from the study have been habitations undertaken and their health status (including improvement in their health conditions) recorded after they have been consuming fluoride safe water being supplied under MVWS Scheme for drinking and cooking purpose together with specified quantity of moringa leaf powder in their daily meal items made available to them by the CFR team members free of cost.

Materials and Methods

For chemical analysis of water samples for different drinking water quality parameters including fluoride concentration, water samples were collected from different water sources in good quality screw capped polythene bottles of one litre capacity. Some of the physico-chemical parameters were determined on the site itself. For determination of the remaining parameters the samples were labelled properly and analysed in the laboratory of Centre for Fluorosis Research A. N. College, Patna.

For determination of fluoride concentration in water samples as well as in urine samples of the fluorosis patients the instrument used was ORION STAR A214 ION SELECTIVE ELECTRODE.

Mostly A.R grade Merck chemicals were used for analysis. All the solutions were prepared in double distilled water. Water samples were analysed by methods. (recommended by APHA (Ref.13).

Results and Discussion PHASE I STUDIES

[A]. Summarised Report on health status and food habits of the people from the habitations under study (survey conducted from August to October, 2018 and recorded in detail in the Health Survey Booklet).

[I]. Health Status of the People

(a). Kachhariadih Habitation

It is inhabited mostly by poor people belonging to the lowest state of the society-economically, socially and educationally.

- (i) Total number of families residing permanently in this habitation: 74
- (ii) Total number of people residing permanently in the habitation and surveyed: 401
- (iii) Number of inhabitants-mostly young boys and girls below 16 years of age having dental fluorosis: 137
- (iv) Number of people having skeletal fluorosis of serious nature: 24
- (v) Number of people with cases of mild skeletal fluorosis: 40
- (vi) Number of people with non - skeletal fluorosis and were found confined partially/fully to bed: 14
- (vii) Number of people having complains of gastrointestinal disturbance, loss of appetite, pain in stomach, chronic constipation etc. : 104

(b) Muslimtola Habitation

It is inhabited mostly by poor Muslim families

- (i) Total number families residing permanently in the habitation: 35
- (ii) Total number people residing permanently in the habitation and surveyed: 215

- (iii) Number of inhabitants - mostly young boys and girls below 16 years of age having dental fluorosis: 71
- (iv) Number of people having skeletal fluorosis of serious nature: 14
- (v) Number of people with cases of mild skeletal fluorosis: 20
- (vi) Number of people with non-skeletal fluorosis and were found confined partially/fully to bed: 02
- (vii) Number of people having complains of gastrointestinal disturbance-loss of appetite, pain in stomach, chronic constipation etc.: 62
- (c). **Hanuman Nagar Habitation**
It is inhabited mostly by poor people of schedule caste category (Rajbanshi Community).
 - (i) Total number families residing permanently in the habitation: 23
 - (ii) Total number people residing permanently in the habitation and surveyed: 116
 - (iii) Number of inhabitants'- mostly young boys and girls below 16 years of age having dental fluorosis: 49
 - (iv) Number of people having skeletal fluorosis of serious nature: 07
 - (v) Number of people with cases of mild skeletal fluorosis: 05
 - (vi) Number of people with non-skeletal fluorosis and were found confined partially/fully to bed: 02
 - (vii) Number of people having complains of gastrointestinal disturbance-loss of appetite, pain in stomach, chronic constipation etc. : 36

[III]. Food habits of common people in the study areas:

(a). Food habits of majority of the people of Kachhariadih and Hanuman Nagar habitations were recorded as given below:

- * Main food items (grains): Rice and Wheat
- * Pulses : 2 – 3 times a week
- * Main vegetable items which are cooked almost daily: Potato, Brinjal, Pumpkin etc.
- * Leafy green vegetables: 1 – 2 times a week.
- * Non vegetarian items - Egg, Fish, Poultry, Meat etc: Usually once in a month.
- * Main oil medium for cooking vegetables and other food items: Mustard oil.
- * Milk : Once/ twice in a week
- * Curd : Usually once in a week
- * Fruits: Rarely taken; mostly during festivals.

(b). Food habits of majority of the people of Muslim tola habitation:

Food habits of majority of the people are similar to those of the neighbouring Kachhariadih and Hanuman Nagar habitations. One difference in food habit of inhabitants of Muslim tola as found was that they have non-vegetarian items in their meals almost thrice in a week.

[B]. Water Quality Analysis of all the 32 drinking water sources collected from the study areas

(a). Description of sampling sites

Details of all the 32 drinking water sources in the habitations under study from where water samples were collected for their physico-chemical analysis are as tabulated below :

Panchayat :-Hardiya, Block :- Rajauli, District :- Nawada, Bihar, India

S. No	Sample code	Description of the Location/House owner's Name	Source of water
1	C ₁	Hardia Primary School, Hardia	Hand Pump
2	C ₂	Intake Well,(Dam), Hardia	Rainfed Dam Water
3	C ₃	Dam Side, Hanuman Nagar, Rehabilitation Area	Hand Pump
4	C ₄	Road Side, Hanuman Nagar, Rehabilitation Area	Hand Pump
5	C ₅	NareshRajbanshi, Hanuman Nagar, Rehabilitation Area	Hand Pump
6	C ₆	AmeriJadav (Brother of IshwariJadav), Kachhariadih	Bore well
7	C ₇	Fluride Removal Centre (FRC), Kachhariadih	Bore well
8	C ₈	Bhawan Bricks, Kachhariadih	Hand Pump
9	C ₉	Beside DilipRajbanshi House, Kachhariadih	Bore well
10	C ₁₀	Jaiprakash Saw (First source) , Kachhariadih	Hand Pump
11	C ₁₁	Jaiprakash Saw (Second source) , Kachhariadih	Hand Pump
12	C ₁₂	Satish Mishra, Kachhariadih	Hand Pump
13	C ₁₃	KamtaRajbanshi, Kachhariadih	Hand Pump
14	C ₁₄	TulshiRajbanshi, Kachhariadih	Hand Pump
15	C ₁₅	PintuRajbanshi, Kachhariadih	Hand Pump
16	C ₁₆	KaruYadav, Kachhariadih	Hand Pump
17	C ₁₇	Jainath Saw, Kachhariadih	Hand Pump
18	C ₁₈	Krishna Yadav, Kachhariadih	Hand Pump
19	C ₁₉	Kameshwar Saw,Kachhariadih	Hand Pump
20	C ₂₀	Dilip Saw(Sarpanch), Kachhariadih	Hand Pump
21	C ₂₁	Dug Well, Kachhariadih	Dug Well
22	C ₂₂	YaloRajbanshi , Kachhariadih	Hand Pump
23	C ₂₃	Mushari Mia, Muslim Tola	Hand Pump
24	C ₂₄	Gauri Devi (NareshMistri), Muslim Tola	Hand Pump
25	C ₂₅	Ramjan Mia, Muslim Tola	Hand Pump
26	C ₂₆	Talab Mia (Neighbour of Ramjan Mia), Muslim Tola	Hand Pump
27	C ₂₇	Mustakin Mia, Muslim Tola	Hand Pump
28	C ₂₈	RambalakYadav, Muslim Tola	Hand Pump
29	C ₂₉	Ekbal Mia, Muslim Tola	Hand Pump
30	C ₃₀	Md. NasimAnshari, Muslim Tola	Hand Pump
31	C ₃₁	Md. Ashgar, Muslim Tola	Hand Pump
32	C ₃₂	Md. JamirAnshari, Muslim Tola	Hand Pump

Based on the results of analysis of water samples from different sources in the study area, following observations have been made:

- (1). Value of pH, Turbidity, Total alkalinity, Total dissolved solids; Sulphate and Chloride in all the water samples were found to be within the permissible limits.
- (2). Fluoride concentration in all the water sources except one from the Intake well, Phulwaria dam were higher than the maximum permissible limit of 1.5 ppm. The value ranged from 1.8 ppm in sample C₁₉ to as high as 8.7 ppm in sample C₈. As expected, in the water sample collected from Intake well of the rainfedPhulwaria dam water fluoride concentration was found to be 0.6 ppm which is well below the acceptable limit of 1.0 ppm.
- (3). Total hardness as CaCO₃ (in ppm), Calcium hardness as Ca⁺⁺ (ppm) and Magnesium hardness as Mg⁺⁺ (ppm) were found to be within permissible limits.

[b]. Results of First Study
Sample Collection date: -14.03.2018 – 16.03.2018 Sample analysis date: -20.03.2018 – 23.03.2018

Sl. N	Sample code	pH	EC (µS/cm)	TDS (mg/l, max)	Transparency (NTU Max)	Total Hardness As CaCO ₃ (mg/l, max)	Calcium as Ca ²⁺ (mg/l, max)	Magnesium as Mg ²⁺ (mg/l, max)	Sodium (mg/l)	Potassium (mg/l)	Total alkalinity as CaCO ₃ (mg/l, max)	Nitrate NO ₃ ⁻ (mg/l, max)	Sulphate (mg/l, max)	Chloride (mg/l, max)	Fluoride (mg/l, max)
		6.5 - 8.5	-	500 - 2000	1 - 5	200 - 600	75 - 200	30 - 100	-	-	200 - 600	45	200 - 400	250 - 1000	1 - 1.5
1	C1	7.4	388	241	0.5	180	54.4	8.6	20.9	0.6	202	10.3	11.4	25	1.9
2	C2	7.9	180	110	0.4	74	22.6	3.8	8.6	2.1	69	1.6	5.8	25	0.6
3	C3	6.6	220	133	0.7	88	22.4	7.8	14.7	0.3	100	2.8	4.8	25	3.4
4	C4	6.6	265	150	0.7	92	27.2	5.7	31.5	0.8	108	2.4	0.9	20	4.1
5	C5	6.6	282	169	0.6	138	38	9.7	36.9	0.5	142	10.5	4.2	20	2.4
6	C6	7.5	521	320	0.2	124	38.4	6.7	92.6	0.6	210	10.2	6.2	30	6.4
7	C7	7.6	402	240	0.3	132	43.2	5.8	66.6	0.6	172	5.8	5.6	25	5.4
8	C8	7.4	443	267	0.4	83	24	4.8	94	0.6	210	5.2	5.7	15	8.7
9	C9	7.6	483	293	0.4	122	36.9	6.7	86.7	0.7	192	9.2	6.1	25	4.4
10	C10	7.4	431	258	0.5	160	46.4	10.6	43.7	0.5	200	9.7	6.0	26	3.2
11	C11	7.6	515	306	0.2	144	44.8	7.7	77.6	0.6	210	21.0	9.6	22	4.6
12	C12	7.6	416	248	0.5	130	40	7.7	60.4	0.5	172	5.5	6.6	20	3.7
13	C13	7.7	545	329	0.3	167	48	13.5	72.1	0.6	187	18.2	14.3	29	6.6
14	C14	7.6	309	167	0.6	89	25.6	3.8	108	0.6	170	13.2	10.6	25	6.5
15	C15	7.8	796	478	0.5	180	51.2	12.5	132	0.7	324	15.8	16.4	20	3.6
16	C16	8.2	920	551	0.4	181	44.9	16.3	149	0.7	421	27.2	14.4	34	3.6
17	C17	8.0	960	582	0.5	205	44.8	25.0	158	0.7	420	44.3	15.1	50	2.8
18	C18	7.9	1041	629	0.4	226	60.7	19.2	151	1	550	45.3	25.8	61	3.6
19	C19	7.7	427	256	0.4	167	44.8	13.4	43.8	0.7	219	11.8	5.3	30	1.8
20	C20	7.9	366	220	0.7	164	41.6	13.4	37.9	0.7	140	7.73	6.8	25	3.0
21	C21	8.1	842	509	0.8	120	32	9.6	143	12.8	362	7.31	8.1	39	3.4
22	C22	7.7	491	295	0.4	142	36.9	11.5	65.8	0.5	230	7.60	8.6	25	3.3
23	C23	7.6	526	306	0.3	220	36	19.2	25.1	0.6	182	17.5	15.3	36	3.7
24	C24	7.7	482	256	0.4	192	48	17.3	20.7	0.4	222	5.17	6.2	20	3.6
25	C25	7.8	982	589	0.3	336	92.8	25.0	90.1	0.4	308	46.7	35.6	66	2.8
26	C26	7.6	704	422	0.4	261	64	24.0	60.3	0.5	220	34.1	27.4	35	3.7
27	C27	7.6	710	425	0.4	109	27.2	7.9	13.8	0.4	82	3.6	61.4	15	5.0
28	C28	7.4	349	210	0.3	136	46.4	4.8	20.2	0.5	150	4.65	6.6	20	4.3
29	C29	7.5	321	192	0.5	121	38.4	5.7	22.0	0.4	140	5.98	8.1	16	5.0
30	C30	7.3	266	159	0.6	115	22.4	14.4	8.6	0.4	79	4.3	7.9	20	3.5
31	C31	7.5	350	210	0.8	144	38.4	11.5	28.6	0.5	130	8.54	8.1	20	4.3
32	C32	7.2	415	247	0.4	172	60.8	4.9	13.3	0.4	170	12.0	9.6	26	3.7

[c]. Results of Second Study

Sample Collection date:-20.10.2019-23.10.2019

Sample analysis date:-25.10.2019-28.10.2019

SLW	Sample code	pH	EC ($\mu\text{S}/\text{cm}$)	TDS (mg/l, max)	Turbidity (NTU, Max)	Total Hardness As CaCO_3 (mg/l, max)	Calcium as Ca^{2+} (mg/l, max)	Magnesium Mg^{2+} (mg/l, max)	Sodium (mg/l)	Potassium (mg/l)	Total alkalinity as CaCO_3 (mg/l, max)	Nitrate NO_3^- (mg/l, max)	Sulphate (mg/l, max)	Chloride (mg/l, max)	Fluoride (mg/l, max)
BIS: 10530-2012	Desirable-Permissible limit	6.5-8.5	-	500-2000	1-5	200-600	75-200	30-100	-	-	200-600	45	200-400	250-1000	1-1.5
1	C1	7.5	396	243	0.4	183	54.6	8.7	20.7	0.7	220	10.3	16.7	25	1.9
2	C2	7.9	180	110	0.4	78	23.1	3.8	8.6	2.1	69	1.6	5.8	26	0.6
3	C3	6.5	220	132	0.7	88	22.4	7.8	14.2	0.3	100	2.7	4.8	25	3.4
4	C4	6.6	260	150	0.7	92	27.0	5.8	31.5	0.7	108	2.3	1.1	20	4.2
5	C5	6.6	282	169	0.6	138	38	9.7	36.9	0.5	139	10.5	4.2	21	2.5
6	C6	7.5	521	320	0.3	124	38.4	6.7	92.5	0.5	210	10.2	6.4	30	6.2
7	C7	7.6	402	238	0.3	132	42.9	5.8	66.6	0.7	172	5.9	5.7	25	5.4
8	C8	7.3	443	267	0.5	82	24	4.8	94.0	0.5	210	5.2	5.7	16	8.4
9	C9	7.6	483	293	0.2	122	36.9	6.2	85.9	0.7	193	9.2	6.1	25	4.4
10	C10	7.4	439	261	0.4	160	45.2	10.6	43.7	0.5	200	9.7	6.2	26	3.2
11	C11	7.6	517	306	0.2	144	44.8	7.7	77.6	0.5	213	21.4	9.6	22	4.7
12	C12	7.6	416	248	0.5	139	40	7.7	59.2	0.7	172	5.5	6.6	20	3.9
13	C13	7.7	545	331	0.3	184	48	12.9	72.1	0.5	185	18.0	13.9	29	6.4
14	C14	7.6	309	187	0.6	89	25.6	3.8	107.9	0.5	170	13.2	10.6	25	6.5
15	C15	7.8	706	478	0.5	180	50.7	12.5	132.1	0.7	320	15.8	16.4	20	3.6
16	C16	8.2	919	551	0.4	181	44.9	16.3	150.2	0.7	421	27.1	14.4	34	3.6
17	C17	8.0	960	579	0.4	205	44.8	22.8	158.2	0.7	420	44.3	15.1	49	3.0
18	C18	8.1	1050	627	0.4	229	60.7	19.2	151	1.0	549	44.2	25.6	60	3.6
19	C19	7.7	427	257	0.4	167	45.1	12.7	43.8	0.7	219	11.8	5.3	29	1.9
20	C20	7.8	366	220	0.7	164	41.6	13.4	37.9	0.5	142	7.73	6.7	25	3.0
21	C21	7.9	848	509	0.9	122	31.9	9.7	143	12.7	365	7.51	8.1	40	3.6
22	C22	7.8	491	297	0.4	142	36.9	11.5	65.6	0.5	231	7.60	6.6	25	3.3
23	C23	7.6	527	309	0.4	220	56	19.2	20.5	0.5	182	17.5	15.3	36	3.7
24	C24	7.7	448	256	0.4	195	48	17.3	20.5	0.4	222	5.17	6.2	20	3.7
25	C25	7.8	984	592	0.3	336	93.1	25.0	90.1	0.4	308	46.7	35.2	65	2.8
26	C26	7.7	704	422	0.4	261	64	24.0	60.3	0.5	222	34.1	27.4	35	3.7
27	C27	7.6	710	421	0.5	109	27.2	8.1	13.8	0.5	82	3.6	61.4	15	5.2
28	C28	7.4	351	210	0.3	140	46.4	4.8	20.1	0.5	150	4.65	6.6	20	4.3
29	C29	7.5	321	192	0.5	121	39.0	5.6	22.0	0.4	144	5.98	8.1	17	5.2
30	C30	7.2	266	159	0.6	115	22.4	14.4	8.6	0.4	79	4.3	8.0	20	3.5
31	C31	7.5	350	212	0.9	145	38.4	11.5	28.6	0.5	130	8.54	8.1	21	4.3
32	C32	7.7	415	242	0.4	170	61.2	4.7	13.2	0.5	169	12.0	9.7	26	3.7

- (4). Electrical conductivity value ranged from the lowest value of $180\mu\text{cm}$ in sample C_2 to the highest value of $1041\mu\text{S/cm}$ in sample C_{18} . For a few water samples— C_{16} , C_{17} , C_{21} and C_{25} the values were on higher side.
- (5). Nitrate concentration in all the analysed water samples were well within the permissible limit except in samples C_{18} (45.3 ppm) and C_{25} (46.7 ppm) which were higher than the permissible limit of 45 ppm.

Study on health status of 10 selected fluorosis patients before interventions :

i.	Normal	The enamel surface is smooth, glossy, translucent, creamy-white in colour.	0
ii.	Mild	Enamel surface showing extensive chalky white opaque areas in two or more teeth.	1
iii.	Moderate	Enamel surface showing brownish yellow or brown colour horizontal lines.	2
iv.	Severe	Enamel surface showing brown colour with pitted, discrete or confluent, eroded or destroyed structure on two or more teeth.	3

Numeral notation for Status of Skeletal Fluorosis:

i.	Knock knee/Bow leg	Present= 1, Absent= 2
ii.	Crippling	Present= 1, Absent= 2
iii.	Touching chest with chin	Yes= 1, No= 2
iv.	Bending forward	Yes= 1, No= 2
v.	Touching Back of Head by both arms with extended shoulder	Yes= 1, No= 2

Numeral notation for Status of Non-Skeletal Fluorosis :

i.	Loss of appetite	Yes= 1, No= 2
ii.	Constipation	Yes= 1, No= 2
iii.	Pain in stomach	Yes= 1, No= 2
iv.	Frequent tendency to Urinate	Yes= 1, No= 2
v.	Extreme weakness	Yes= 1, No= 2
vi.	Lack of sleep	Yes= 1, No= 2
vii.	Mental retardation	Yes= 1, No= 2

Numeral notation for Educational Status :

i.	Illiterate	0
ii.	Can sign only	1
iii.	Can read and write	2
iv.	Primary (Upto 5 th class)	3
v.	5 th – 8 th class	4
vi.	Upto 10 th class	5
vii.	Secondary	6
viii.	Graduate	7
ix.	Post Graduate	8

Health Status Report

Patient Number 1

Patient's details:

Name	Sex	Age (yrs)	Child / Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Pankaj Kumar	Male	18	Adult	2	Kachhariadih	i	23.03.2018	5.4	i	23.03.2018	8.9
						ii	28.10.2019	5.4	ii	28.10.2019	9.0

Health Complains:

1.	Dental fluorosis changes – (iv) 3
2.	Skeletal fluorosis changes – (i) 1 (ii) 2 (iii) 1 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes - (i) 2 (ii) 2 (iii) 1 (iv) 2 (v) 1 (vi) 2 (vii) 2
4.	Any other observation – Pain in Backbone, Gas in stomach

Patient Number 2 Patient's details:

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
RamavtarRaj banshi	Male	44	Adult	0	Hanuman Nagar	i	23.03.2018	3.4	i	23.03.2018	4.6
						ii	28.10.2019	3.5	ii	28.10.2019	4.6

Health Complains:

1.	Dental fluorosis changes – (iv) 2
2.	Skeletal fluorosis changes – (i) 1 (ii) 2 (iii) 2 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes – (i) 1 (ii) 1 (iii) 2 (iv) 1 (v) 1 (vi) 1 (vii) 1
4.	Any other observation – Pain in Backbone, hands and legs; Bed ridden, Always feels restlessness.

Patient Number 3**Patient's details:**

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
IshwariRajbanshi	Male	38	Adult	0	Kachhariadih	i	23.03.2018	5.4	i	23.03.2018	7.3
						ii	28.10.2019	5.4	ii	28.10.2019	7.4

Health Complains:

1.	Dental fluorosis changes – (iv) 3
2.	Skeletal fluorosis changes – (i) 2 (ii) 2 (iii) 2 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes – (i) 1 (ii) 1 (iii) 1 (iv) 1 (v) 1 (vi) 1 (vii) 1
4.	Any other observation –Pain in Backbone, Wrists.etc

Patient Number 4**Patient's details:**

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Rajo Rajbanshi	Male	49	Adult	0	Hanuman Nagar	i	23.03.2018	2.4	i	23.03.2018	7.7
						ii	28.10.2019	2.5	ii	28.10.2019	7.8

Health Complains:

1.	Dental fluorosis changes – (iv) 3
2.	Skeletal fluorosis changes – (i) 1 (ii) 2 (iii) 2 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes – (i) 1 (ii) 1 (iii) 1 (iv) 1 (v) 1 (vi) 1 (vii) 2
4.	Any other observation – Bed ridden, Always feels vibration in hands and legs

Patient Number 5**Patient's details:**

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l) In Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Sipiya Devi	Female	39	Adult	0	Kachhariadih	i	23.03.2018	5.4	i	23.03.2018	7.9
						ii	28.10.2019	5.4	ii	28.10.2019	8.0

Health Complains:

1.	Dental fluorosis changes – (iii) 2
2.	Skeletal fluorosis changes - (i) 2 (ii) 1 (iii) 2 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes - (i) 1 (ii) 1 (iii) 1 (iv) 1 (v) 1 (vi) 1 (vii) 1
4.	Any other observation – Unable to walk without stick or walker; Pain in Backbone, Headache etc.

Patient Number 6**Patient's details:**

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Pato Devi	Female	46	Adult	0	Kachhariadih	i	23.03.2018	8.5	i	23.03.2018	8.6
						ii	28.10.2019	8.4	ii	28.10.2019	8.6

Health Complains:

1.	Dental fluorosis changes – (iii) 2
2.	Skeletal fluorosis changes - (i) 2 (ii) 2 (iii) 2 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes - (i) 1 (ii) 1 (iii) 2 (iv) 1 (v) 1 (vi) 2 (vii) 2
4.	Any other observation – Pain in Backbone, Knee etc; Stiffness of Neck

Patient Number 7

Patient's details:

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Reshmi Devi	Female	60	Adult	1	Kachhariadih	i	23.03.2018	6.5	i	23.03.2018	7.1
						ii	28.10.2019	6.5	ii	28.10.3019	7.3

Health Complains:

1.	Dental fluorosis changes – (iii) 2
2.	Skeletal fluorosis changes – (i) 2 (ii) 2 (iii) 2 (iv) 1 (v) 2
3.	Non- Skeletal fluorosis changes - (i) 1 (ii) 2 (iii) 2 (iv) 1 (v) 1 (vi) 2 (vii) 2
4.	Any other observation – Gas in Stomach; Pain in Backbone, Knee etc.

Patient Number 8

Patient's details:

Name	Sex	Age (yrs)	Child /Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Rajesh Kumar	Male	10	Child	3	Kachhariadih	i	23.03.2018	8.5	i	23.03.2018	6.9
						ii	28.10.2019	8.4	ii	28.10.3019	6.6

Health Complains:

1.	Dental fluorosis changes – (iv) 3
2.	Skeletal fluorosis changes – (i) 2 (ii) 2 (iii) 1 (iv) 1 (v) 1
3.	Non- Skeletal fluorosis changes - (i) 1 (ii) 1 (iii) 1 (iv) 1 (v) 2 (vi) 2 (vii) 2
4.	Any other observation – Always feels weakness and tiredness.

Patient Number 9

Patient's details:

Name	Sex	Age (yrs)	Child/ Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Reyaj Anshari	Male	10	Child	3	Muslimtola	i	23.03.2018	5.0	i	23.03.2018	6.3
						ii	28.10.2019	5.2	ii	28.10.3019	6.8

Health Complains:

1.	Dental fluorosis changes – (iii) 2
2.	Skeletal fluorosis changes - (i) 1 (ii) 2 (iii) 2 (iv) 2 (v) 2
3.	Non- Skeletal fluorosis changes – (i) 1 (ii) 1 (iii) 1 (iv) 1 (v) 1 (vi) 2 (vii) 2
4.	Any other observation – Unable to walk freely, cannot run; Anaemic, Slow in understanding and responding to the queries etc.

Patient Number 10**Patient's details:**

Name	Sex	Age (yrs)	Child /Adult	Education	Habitation	Source of Fluoride ingestion: Mainly Ground Water					
						Fluoride Conc.(mg/l)in Drinking water of the Patient			Fluoride Conc.(mg/l) in Urine of the Patient		
Swastik Kumari	Female	8	Child	3	Kachhariadih	i	23.03.2018	8.5	i	23.03.2018	7.3
						ii	28.10.2019	8.4	ii	28.10.2019	7.2

Health Complains:

1.	Dental fluorosis changes – (iv) 3										
2.	Skeletal fluorosis changes - (i) 2 (ii) 2 (iii) 1 (iv) 1 (v) 1										
3.	Non- Skeletal fluorosis changes - (i) 2 (ii) 2 (iii) 1 (iv) 1 (v) 1 (vi) 2 (vii) 1										
4.	Any other observation – Looks Anaemic, Slow in understanding and responding the queries etc.										

PHASE II STUDIES:

Phase II studies covered the study period from January, 2020 to October, 2022.

(A). Health Promotion through Provision for nutritional supplement:

It is universally accepted that supply of fluoride safe drinking and cooking water coupled with nutritional supplementation of Calcium, Vitamin C, Vitamin D₃ and Antioxidants are essential component of any fluorosis mitigation programme. Nutritional supplements in pharmaceutically prepared tablets, capsules, syrup etc. are suggested for consumption by fluorosis patients. However, C.F.R. A.N. College, Patna team members have found that Sahjana (Drum stick i.e. *Moringa oleifera*)- its leaves, sticks, and seedpod are equally rich in all the nutrient components (Calcium, Iron, Vitamins, Antioxidants etc.) and have been found to be highly effective in lessening the suffering of fluorosis patients of the habitations under study.

The activities included the following steps:

* Extensive community mobilization programmes have been organised through slogans, posters, booklets, leaflets and through interaction meeting with the people in the study areas for use of these plant parts in their meals items.

* The affected families have been helped to develop small garden nearer to their dwelling places with plants of Sahjana, and also Lemon, Gooseberry (Amla) and Curry leaves which too have been found to be beneficial to fluorosis patients.

* A novel experiment has been initiated by CFR team members to prepare powder of sahjana leaves using sun dryers and grinders set up for free distribution to fluorosis affected families of the study habitations.

(B). Extensive awareness-cum-interaction programmes have been organised regularly in the community through posters, booklets, leaflets, slogan writings etc. by IFM team members to educate the affected community about the causes and ill effects of fluorosis disease and importance of IFM programme in prevention, control and mitigation of fluorosis.

Physico-chemical analysis of the treated dam water

The water samples were collected from the outlet point of the Multi-Village Water Supply (MVWS) sources located in PHED, Govt. of Bihar campus, Hanuman Nagar, and were analyzed twice during the study period.

Sample analysis date: -06.05.2022 – 08.05.2020

		Sample Collection date: - 04.05.2020				Sample analysis date: -06.05.2022 - 08.05.2020							
Sl. No	Sample code	pH	EC (μ S/cm)	TDS (mg/l, max)	Turbidity (NTU)max	Total Hardness As CaCO_3 (mg/l, max)	Calcium as Ca^{2+} (mg/l, max)	Magnesium Mg^{2+} (mg/l, max)	Sodium (mg/l)	Potassium (mg/l)	Total alkalinity as CaCO_3 (mg/l, max)	Chloride (mg/l, max)	Fluoride (mg/l, max)
	BIS : 10500 – 2012 Desirable-Permissible limit	6.5 – 8.5	-	500 – 2000	1 – 5	200 – 600	75 – 200	30 – 100	-	-	200 – 600	250 – 1000	1 – 1.5
1	T ₁	7.8	219	142	0.4	62	20.8	17.5	32.7	0.5	84	89	0.65

Sample analysis date: 30.09.2022 – 02.10.2022

Sl. No	Sample code	pH	EC ($\mu\text{S}/\text{cm}$)	TDS (mg/l , max)	Turbidity (NTU) _{max}	Total Hardness As CaCO_3 (mg/l , max)	Calcium as Ca^{2+} (mg/l , max)	Magnesium as Mg^{2+} (mg/l , max)	Sodium (mg/l)	Potassium (mg/l)	Total alkalinity as CaCO_3 (mg/l , max)	Chloride (mg/l , max)	Fluoride (mg/l , max)
BIS : 10500 – 2012 Desirable-Permissible limit		6.5 - 8.5	-	500 – 2000	1 - 5	200 – 600	75 – 200	30 – 100	-	-	200 – 600	250 – 1000	1 – 1.5
1	T ₂	7.5	224	146	0.3	38	17.6	7.8	24.1	0.7	80	83	0.62

Results

Physico-chemical analysis of the treated water being supplied to the inhabitants of the study areas showed that all the analysed physico-chemical parameters were well within permissible limit. More importantly the fluoride concentrations found in both the studies were well within the Acceptable limit of 1.0 ppm.

The physico-chemical analysis of the treated water now being used by the entire population of the fluorosis endemic habitations under study are good quality fluoride safe water. The treated dam water is being supply not only for drinking and cooking purpose but also for all

domestic purpose under Functional Household Tap Connection (FHTC) Programme, Department of Drinking Water and Sanitation, Ministry of Jal Shakti, Government of India.

[D]. Studies on health status of the same fluorosis patients selected for study during the first phase of study; Study was done to record changes/improvement in their health conditions after the interventions – Supply of fluoride safe potable water and provision for use of moringa leaf powder in their daily meal items as nutritional supplement were introduced.

Health status report after intervention :

Patient Number 1

Patient's details:

Name	Habitation	Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
		Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Pankaj Kumar	Kachhariadih	i	06.05.2020	0.65	i	06.05.2020	9.0	i. Now can walk freely; Does his daily routine work himself. ii.No more pain and gas problem in stomach. iii. Now feels more energetic than before.

Patient Number 2

Patient's details:

Name	Habitation	Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
		Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Ramavtar Rajbanshi	Hanuman Nagar	i	06.05.2020	0.65	i	06.05.2020	4.6	i. Can freely move the neck. ii. Now feels lesser pain in backbone. iii. Gas problem in stomach is much less than before.
		ii	30.09.2022	0.62	ii	30.09.2022	4.2	iv. Feels good at the time of morning wake up. v. Does his daily routine work himself without other help.

Patient Number 3
Patient's details:

Patient's details.		Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
Name	Habitation	Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Ishwari Rajbanshi	Kachhariadih	i	06.05.2020	0.65	i	06.05.2020	7.5	i. Now can easily touch chest with chin. ii. Can bend forward with much ease than before. iii. Now can stretch the hands, fold the arms and can almost touch the back of the head.
		ii	30.09.2022	0.62	ii	30.09.2022	7.0	iv. Now feels lesser pain in backbone, wrist and other body parts. v. Felling of restlessness and tiredness is now no more.

Patient Number 4
Patient's details:

Patient's details:								
Name	Habitation	Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
		Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Rajo Rajbanshi	Hanuman Nagar	i	06.05.2020	0.65	i	06.05.2020	7.8	i. Can comfortably attend to his daily routine work without the help of others. ii. Sleep disorder as felt earlier is much less than before. iii. Feeling of restlessness and tiredness is much less than before.
		ii	30.09.2022	0.62	ii	30.09.2022	7.7	iv. Vibrational feeling in legs and hands is almost gone. v. Lesser gas problem in stomach, better appetite than before.

Patient Number 5
Patient's details:

Patient's details:								
Name	Habitation	Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
		Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Sipiya Devi	Kachhariadih	i	06.05.2020	0.65	I	06.05.2020	7.5	i. Previously bedridden, now can walk slowly with the help of stick. ii. Now can rotate the neck more than before.
		ii	30.09.2022	0.62	ii	30.09.2022	6.9	iii. No more pain in back and knee, feels good and fresh. iv. Gas problem in stomach is almost gone. v. Frequent urination problem is no more now. vi. Feeling of tiredness and wekness is much less than before.

Patient Number 6**Patient's details:**

		Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
Name	Habitation	Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Pato Devi	Kachhariadih	i	06.05.2020	0.65	i	06.05.2020	8.3	i. Now can easily move the neck and can bend forward with much ease. ii. No more gas problem in stomach. iii. Frequency of urination is much less than before. iv. Pain problems in backbone and other parts of the body is much less than before. v. Better appetite than before.
		ii	30.09.2022	0.62	ii	30.09.2022	7.6	

Patient Number 7**Patient's details:**

		Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
Name	Habitation	Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Reshmi Devi	Kachhariadih	i	06.05.2020	0.65	i	06.05.2020	7.0	i. Gas problem in stomach is almost over. ii. No backbone pain and pain in other parts of the body. Iii. Frequent urination and weakness problems are much less than before. iv. Feeling of restlessness is almost over; feels better and energetic.
		ii	30.09.2022	0.62	ii	30.09.2022	6.2	

Patient Number 8**Patient's details:**

Patient's details:								
Name	Habitation	Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
		Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Rajesh Kumar	Kacchhariadih	i	06.05.2020	0.65	i	06.05.2020	6.3	i. Constipation problem is much less than before. ii. Better appetite than before. iii. No pain in stomach. iv. Frequency of urination is less than before. v. Looks less anaemic than before.
		ii	30.09.2022	0.62	ii	30.09.2022	5.4	

Patient Number 9**Patient's details:**

Name	Habitation	Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
		Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Reyaj Anshari	Muslimtola	i	06.05.2020	0.65	i	06.05.2020	6.6	i. Now can walk and play without difficulty. ii. Looks fit-mentally and physically. iii. No Pain in stomach. iv. Better appetite than before. v. Frequency of urination is much reduced than before. vi. Looks less anaemic than before. vii. No constipation
		ii	30.09.2022	0.62	ii	30.09.2022	5.4	

Patient Number 10
Patient's details:

		Source of fluoride safe water: Treated Dam water under MVWS Scheme						Perceptible Health Recovery Status
Name	Habitation	Fluoride conc.(mg/l)in Drinking water of the patient			Fluoride conc. (mg/l)in urine of the patient			
Swastik Kumari	Kachhariadih	i	06.05.2020	0.65	i	06.05.2020	7.2	i. Looks mentally and physically fit.
		ii	30.09.2022	0.62	ii	30.09.2022	6.6	ii. No pain in stomach. iii. Improved appetite. iv. Less anaemic look than before.

Conclusion:

Extensive study on fluoride patients of inhabitants of the three severely fluorosis affected habitations of Rajauli block, district, Nawada, Bihar in two distinct phases: one before interventions and the other after interventions in the form of supply of fluoride safe potable water together with provision for moringa leaf powder in the daily meal items of fluorosis patients as nutrient supplement have shown convincing positive impact on health status of the fluorosis patients. Narration of gradual relief in body pain, improved appetite, mentally and physically better look than before and walking of some bed ridden fluorosis patients with the help of sticks are some convincing evidences of positive impact of interventions coupled with extensive awareness-cum-interaction programmes to educate inhabitants of the study areas about the ill effects of indigestion of fluoride contaminated potable water and the benefits of Integrated Fluorosis Mitigation Programme conducted in the study habitations.

Gradual decrease in urinary fluoride of the fluorosis patients selected for regular

monitoring also provide a convincing evidence of the gradual success of the fluorosis mitigation measures.

Bihar is one among the 17 states of India where fluoride endemicity has been reported in 11 out of 38 districts of Bihar. As the interventions introduced by C.F.R. A.N .College, Patna, Bihar has been found to have perceptible positive impact on fluorosis patients of the study habitations, IFM programme perused by our team may be replicated/extended to all other fluorosis endemic habitations of Bihar and elsewhere. These mitigation measures are sure to benefit the fluorosis patients and bring them back to the mainstream of social life, contributing their share in nation building.

Acknowledgement: Authors are thankful to UNICEF, Bihar, Patna for providing financial support.

Conflict of Interest: The authors declare that they have no conflict of interest.

References

1. R.Chandrajith et. at. Chronic kidney diseases of uncertain etiology in Sri Lanka: geographical distribution and environmental implications *Environ. Geochem* **33**, 267 (2013)
2. T.Chakma. Health Effects and ways to Mitigate the Fluorosis: Workshop on naturally occurring pollutants affecting water quality in India (June 20-21, 2018), Devesha Centre for Climate Change IISC, Bangalore. (2018)

3. A.K Susheela. A Treatise on Fluorosis 4th Edition. Published by Fluorosis Foundation of India, New Delhi, India. (2018)
4. A. Struncka and O. Strunecky. Neurotoxicity of fluoride: Autism Spectrum disorders; 34th International Conference of the International Society for Fluoride Research (October 18-20, 2018), Guiyang, People Republic of China. 2 (2018)
5. National Programme for Prevention and Control of Fluorosis (NPPCF). Revised Guidelines, Ministry of Health & Family Welfare, Government of India. 5 (2014)
6. Bureau of Indian Standards (BIS) : New Delhi; IS 10500 (2012).
7. UNICEF State of Art Report.. Fluoride Contamination in drinking water and Resulting endemicity in India. (1999)
8. Panchayati Raj Department, Government of Bihar. List of districts and number of wards of Bihar, there in having fluorosis endemicity. (2018)
9. Bihari Singh; K.K Singh. Integrated Fluorosis Mitigation Programme for abatement of fluorosis in selected fluorosis endemic villages of Nawada districts, Bihar, FLUORIDE, International society for fluoride Research; 02(01)82 (2019)
10. Chen et.al. Change of urinary fluoride and bone metabolism indicators in the endemic fluorosis areas of southern china after supplying low fluoride public water; BMC Public Health; 13:156 <http://www.biomedcentral.com/1417-2458/13/156> (2013)
11. R.Srikanth; A.Gautam; S.C Jaiswal; P.Singh. : Urinary fluoride as a monitoring tool for assessing successful intervention in the provision of safe drinking water supply in five fluoride affected villages in Dhar district, Madhya Pradesh, India. Springer link (Full Text Article); Environ Monit Assess, 185(3), 2343-50. (2013)
12. A.K Susheela; N.K Mondal; N.Tripathi; R.Gupta. Early Diagnosis and complete Recovery from fluorosis through practice of Interventions; *Journal of the Association of physicians of India*, **62**, 572 (2014)
13. APHA: Standard Methods for the Examination of Water and Wastewater, Washington DC, USA (23rd Edition). (2017)