

Fluorosis-A Serious Health Problem Which Demands Sustainable Solution

Bihari Singh^{1*}, Jayant Kumar², Prashant Chandra³

Abstract

Two essential components of an Integrated Fluorosis Mitigation Program include provision for regular supply of fluoride-safe potable water to the fluorosis-affected areas, and nutritional supplementation of calcium, vitamins, iron, protein, and antioxidants to fluorosis patients. The present study reports the experience of the authors gathered during their study on fluorosis problems in different fluorosis-endemic areas of Bihar. They are fully convinced that of various methods available for providing fluoride-safe water to fluorosis-affected villages/habitations, the simple, sustainable, and easily acceptable by the beneficiary families – mostly rural poor families – may be either traditional surface water sources, rainwater harvesting techniques, or some safe groundwater source available in the nearby locality. Opting for a defluoridation technique should be the last choice. For nutritional supplementation, our experience is that sahjana (*Moringa oleifera*) – its leaves, seeds, and sticks – are rich in all the nutritional components (calcium, iron, vitamins, antioxidants, etc.) required for fluorosis patients. Its inclusion in the daily meal items of the fluorosis patients has been found to be highly effective in mitigating the suffering of fluorosis patients and promoting their health conditions.

Keywords: Fluoride safe water, traditional and sustainable methods, rainfed dam water, nutritional supplementation, *Moringa oleifera* body parts

INTRODUCTION

Fluorine is a trace element which, when it accumulates in the human body in the form of fluoride above the permissible limit, causes fluorosis. Fluorosis is a serious public health problem causing physical disorders like dental, skeletal, and non-skeletal fluorosis, besides inducing aging. Moreover, in recent years, from investigations on fluorosis patients, evidence is coming on the involvement of kidney, liver, adrenal gland, and reproductive organs as well [1, 2]. The rising prevalence of Autism Spectrum Disorders (ASD) in fluorosis-endemic areas of our country and elsewhere is another serious

concern [3]. Fluoride can reach the human body through natural sources – water and soil (via agricultural crops), and also ready-to-consume food items and industrial emissions from various industries with high fluoride content in them [4]. However, drinking water extracted from groundwater aquifers is the most common source of fluoride intake.

A total of 5485 habitations across 17 states of India are affected by fluoride contamination in drinking water across India (Government of India, 2022). Bihar is one among them; 3812 wards in 11 districts have been found to have a high level of fluoride in their drinking groundwater sources [5, 6].

*Author for Correspondence

Bihari Singh
E-mail: bihari_singh2001@yahoo.com

¹Centre In-charge, Centre for Fluorosis Research, A.N. College, Patna, Bihar, India

²Project Associate, Water Quality Monitoring & Surveillance, Centre for Fluorosis Research, A.N. College, Patna, Bihar, India

³Consultant, National Programme for Prevention and Control of Fluorosis, Centre for Fluorosis Research, A.N. College, Patna, Bihar, India

Received Date: June 21, 2025

Accepted Date: July 10, 2025

Published Date: November 18, 2025

Citation: Bihari Singh, Jayant Kumar, Prashant Chandra. Fluorosis-A Serious Health Problem Which Demands Sustainable Solution. Journal of Control & Instrumentation. 2025; 16(3): 26–33p.

Centre for Fluorosis Research (CFR) is a research wing of A.N. College, Patna, Bihar. Since its inception in 2006, CFR team members have been working regularly with its mission of service to fluorosis-affected people of Bihar.

In October 2017, a socio-scientific research-cum-fluorosis mitigation program titled “Integrated Fluorosis Mitigation (IFM) Program in Fluorosis-Endemic Selected Villages of Nawada District, Bihar” was undertaken by CFR with the financial and technical support of UNICEF, Bihar, Patna.

STUDY DESIGN AND METHODOLOGY

The present study has been designed to highlight the improvement in health conditions and related benefits of fluorosis patients from three severely fluorosis-endemic villages – Kachhariadih, Muslim Tola, and Hanuman Nagar – of Hardia Panchayat, Block Rajauli, District Nawada. The inhabitants of these villages had been using personal hand pumps for their drinking and other domestic needs until December 2019. All these water sources were found by our team to be highly fluoride-contaminated (fluoride levels were more than 2.0 ppm). However, after the inauguration of the supply of scientifically treated rainfed dam water from Phulwaria Dam by Honorable Chief Minister Shri Nitish Kumar under the Multi-Village Piped Water Supply (MVWS) Scheme, the villages under study have been using fluoride-safe dam water for their drinking and other domestic purposes. This change of potable water source together with the use of sahjana (*Moringa oleifera*) leaf powder in their daily meal items as a nutritional supplement has shown marked improvement in their health conditions.

The three villages selected for the present study – Kachhariadih, Muslim Tola, and Hanuman Nagar – are all rural, far from the township (Rajauli, Nawada), and are inhabited mostly by poor people belonging to the lower strata of society – economically and educationally.

The study has been designed to be conducted in two phases:

1. Phase I: From January 2018 to November 2019.
2. Phase II: From February 2020 to January 2022.

Phase I Studies

The study included:

- General survey on health status of inhabitants of the three villages selected for study.
- Water quality analysis of four drinking water sources from each of the selected villages before the supply of fluoride-safe water under the MVWS Scheme in December 2019.
- It is known that a decreasing pattern of fluoride concentration in the urine of fluorosis patients is an indicator that shows the positive effect of mitigation measures on fluorosis patients [7, 8]. Therefore, chemical analysis of urine samples from 4 selected fluorosis patients for fluoride concentration in their urine was done twice during the study period.
- Case studies of the four fluorosis patients selected for the study (their health complaints and other information) before intervention of supply of fluoride-safe dam water and provision for moringa leaf powder in their daily meal items as a nutritional supplement.

Phase II Studies

The study included:

- Water quality analysis of the treated dam water supplied under the MVWS Scheme since December 2019.
- Chemical analysis of urine samples from the selected fluorosis patients for fluoride concentration in their urine twice during the study period.
- Interaction of CFR team members with the selected fluorosis patients regarding improvement in their health condition after the interventions.

MATERIALS AND METHODS

For chemical analysis of water samples for different drinking water quality parameters, water samples were collected from different water sources in good quality screw-capped polyethylene bottles of 1-liter capacity. Some of the physicochemical parameters were determined on the site itself. For determination of the remaining parameters, the samples were labeled properly and analyzed in the laboratory of the Centre for Fluorosis Research, A.N. College, Patna.

Mostly A.R. grade Merck chemicals were used for analysis. All solutions were prepared in double-distilled water. Water samples were analyzed by methods recommended by APHA [9].

RESULTS AND DISCUSSION

Phase I Studies

1. Survey report on health status of the people inhabiting the study villages (Table 1).
 - Dental and skeletal fluorosis were found to be widely prevalent among children, adults, and elderly people of both sexes in the study villages. A few cases of non-skeletal fluorosis were also found.
 - Almost the entire population of the studied villages complained of pain in bones and other body parts.
 - A significant number of villagers complained of frequent indigestion and mild stomach pain.
2. Water Quality Analysis of 12 drinking water samples collected from 4 sources of each of the three selected villages.

Based on the results of analysis, the following observations were made:

- Fluoride concentration in all the water samples analyzed, except for one from the intake well of Phulwaria Dam, was higher than the maximum permissible limit of 1.5 ppm.
- Values of all the other physicochemical parameters – pH, turbidity, total dissolved solids, total hardness, total alkalinity, sulfate, chloride, nitrate, sodium, and potassium – in all the water samples were found within the permissible limits (Table 2).

Phase II Studies

Short Description of Interventions

As mentioned above, the supply of fluoride-safe potable water, together with nutritional supplementation of calcium, Vitamin C, Vitamin D3, antioxidants, etc., constitutes essential components of any fluorosis mitigation program. CFR team members have found that Sahjana (*Moringa oleifera*) – its leaves, sticks, and seedpods – are equally rich in all the essential nutrient components and have been found to be highly effective in lessening the suffering of patients in the villages under study.

Table 1. Description of selection sites.

S.N.	Sample code	Description of the location/house owner's Name	Source of water
1	S1	Hardia Primary School, Hanuman Nagar Hardia	Hand Pump
2	S2	Intake Well,(Dam), Hanuman Nagar Hardia	Rainfed Dam Water
3	S3	Dam Side, Hanuman Nagar, Rehabilitation Area	Hand Pump
4	S4	Road Side, Hanuman Nagar, Rehabilitation Area	Hand Pump
5	S5	Bhawan Bricks, Kachhariadih	Hand Pump
6	S6	Beside DilipRajbanshi House, Kachhariadih	Bore well
7	S7	KamtaRajbanshi, Kachhariadih	Hand Pump
8	S8	KaruYadav, Kachhariadih	Hand Pump
9	S9	Talab Mia (Neighbour of Ramjan Mia), Muslim Tola	Hand Pump
10	S10	RambalakYadav, Muslim Tola	Hand Pump
11	S11	Md. Ashgar, Muslim Tola	Hand Pump
12	S12	Md. JamirAnshari, Muslim Tola	Hand Pump

Table 2. Results of physico-chemical analysis.

S.N.	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)
	BI : 10500 – 2012	6.5-8.5	-	500– 2000	1 – 5	200 – 600	75 - 200	30 – 100	-	-	200 - 600	45	200 - 400	250 – 1000	1 – 1.5
	Desirable- Permissible limit														
1	S1	7.6	390	245	0.4	176	56.2	7.4	19.4	0.4	198	11.4	10.6	28	2.1
2	S2	7.2	176	108	0.6	70	20.4	4.2	8.2	1.8	72	2.2	5.4	26	0.5
3	S3	6.8	224	136	0.8	92	24.6	8.2	15.4	0.6	112	2.7	4.6	28	3.3
4	S4	6.4	262	146	0.5	88	26.4	4.8	30.6	0.7	102	1.8	0.4	32	3.9
5	S5	7.6	446	268	0.2	86	25.2	5.2	96	0.8	214	5.6	5.8	18	8.2
6	S6	7.4	482	291	0.7	124	36.6	6.2	85.2	0.4	196	8.8	6.2	27	4.2
7	S7	7.6	542	327	0.4	162	45.2	13.4	73.6	0.5	184	19.4	13.6	28	6.4
8	S8	7.8	916	548	0.6	176	44.8	15.6	144	0.6	415	27.6	14.3	31	3.5
9	S9	7.8	706	423	0.5	264	66	24.2	60.6	0.4	224	34.3	27.5	36	3.6
10	S10	7.2	346	208	0.4	134	46.2	4.4	19.4	0.3	146	3.98	6.2	24	4.2
11	S11	7.6	352	212	0.6	146	37.8	12.2	28.2	0.4	133	7.24	8.6	25	4.5
12	S12	7.4	418	250	0.3	175	61.2	4.6	12.8	0.6	172	11.6	9.2	28	3.6

Table 3. Physico-chemical parameters including fluoride concentration.

S.N.	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)	Chloride (mg/l, max)	Fluoride (mg/l, max)
	<i>BIS : 10500 – 2012 Desirable-Permissible limit</i>	6.5-8.5	-	500 – 2000	1 – 5	200 – 600	75 – 200	30 – 100	-	-	200 – 600	250 – 1000	1 – 1.5
1	T1	7.6	214	138	0.3	66	22.4	16.8	31.6	0.4	80	85	0.62
2	T2	7.4	218	142	0.4	42	18.2	7.6	23.4	0.6	82	86	0.66

Table 4. Data of patient 1 before interventions.

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
Ramavtar Rajbanshi	Male	46	Adult	Illiterate	Hanuman Nagar	4.1	6.9

Table 5. Data of patient 2 before interventions.

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	41	Adult	Illiterate	Kachhariadith	5.6	7.8

Extensive community mobilization programs have been organized through slogans, posters, booklets and through interaction meetings with the people in the study areas for use of the sahjana plant parts in their daily meal items.

A novel experiment has been conducted by C.F.R. team members to prepare powder of Sahjana leaves using sun dryers and grinders for free distribution to fluorosis-affected families of the study villages.

Physico-chemical Analysis of the Treated Dam Water

The water samples were collected from two outlet points of the Multi-Village Water Supply (MVWS) Sources located in PHED, Government of Bihar campus, Hanuman Nagar and were analyzed for their physicochemical parameters including fluoride concentration (Table 3).

Results

Physicochemical analysis of the treated dam water, which is now being supplied to the four study villages, showed that all the parameters were well within permissible limits. More importantly, the fluoride concentration was found to be well within the acceptable limit of 1.0 ppm.

Studies on Health Status, Educational Qualification, Etc., of Some Fluorosis Patients From the Study Areas (I) Before Interventions and (II) After Interventions.

[I]. Before Interventions:(Studies in Aug. – Oct. 2019) (Table 4)

Patient Number 1

Health Complains: Dental fluorosis: severe; Skeletal fluorosis: Knock knee; Constipation, Pain in backbone, hands and legs.

Patient Number 2

Health Complains: Dental fluorosis: mild, skeletal fluorosis: crippling, unable to walk without stick, pain in backbone and other body parts (Table 5).

Patient Number 3

Health Complains: Dental fluorosis: Severe; Skeletal fluorosis: Bowleg; Loss of appetite, Pain in backbone, wrists, etc. (Table 6).

Patient Number 4

Health Complains: Dental fluorosis: Brown color horizontal lines; Skeletal fluorosis: Knock knee, unable to walk freely, anemic look; Slow in responding to queries (Tables 7 and 8).

Table 6. Data of patient 1 before interventions.

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	51	Adult	Illiterate	Hanuman Nagar	3.5	7.4

Table 7. Data of patient 1 before interventions.

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	15	Child	High School student	Muslimtola	5.1	6.7

Table 8. Data of all patients after interventions.

S.N.	Name of patients	Fluoride level (ppm) in drinking water (treated dam water) of the patient	Fluoride level in urine of the patient
01.	Ramavtar Rajbanshi	0.65	4.7
Perceptible Health Recovery Status: Now can walk with ease; Does his daily work himself; Now feel more energetic than before			
02.	Sipiya Devi	0.65	6.9
Perceptible Health Recovery Status: Now can walk some steps without stick; No more pain in backbone and neck, feels good and fresh; Gas problem is almost gone.			
03.	Rajo Rajbanshi	0.65	6.1
Perceptible Health Recovery Status: Can attend to his daily routine work without the help of others; Sleep disorder is much less than before. Lesser gas problem in stomach, better appetite than before.			
04.	Reyaj Anshari	0.65	5.8
Perceptible Health Recovery Status: Now can walk and play, looks fit mentally and physically, Better appetite than before, Looks less anemic than before.			

CONCLUSION

Extensive study on some fluorosis patients of the three severely fluorosis-affected villages of Rajauli block, district, Nawada, Bihar, in two distinct phases – Phase-I before interventions and Phase-II after interventions – in the form of supply of fluoride-safe potable water from the rainfed Phulwaria dam, together with the use of Sahjana (*Moringa oleifera*) leaf powder in the daily meal items of fluorosis patients as a nutrient supplement, has shown convincing positive impact on the health status of the fluorosis patients of the study villages. A decrease in urinary fluoride of the fluorosis patients selected for regular monitoring also provides evidence of the success of the adopted fluorosis mitigation measures. The IFM program pursued by the C.F.R. team may be replicated in other fluorosis-affected villages/habitations of Bihar and elsewhere. These mitigation measures are certain to benefit the fluorosis patients and bring them back to the mainstream of social life.

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. Susheela AK. A Treatise on Fluorosis. New Delhi: Fluoride Research and Rural Development Foundation; 2018.
2. Chandrajit R, et al. Chronic kidney diseases of uncertain etiology in Sri Lanka: geographical distribution and environmental implications. *Environ Geochem.* 2013;33:267.
3. Strunecká A, Strunecký O. Neurotoxicity of fluoride: Autism Spectrum Disorders. In: 34th Conference of the International Society for Fluoride Research; 2018 Oct 18–20; Guiyang, P.R. China.
4. Ministry of Health & Family Welfare, Government of India. National Programme for Prevention and Control of Fluorosis (NPPCF), Revised Guidelines. New Delhi: 2014.
5. Panchayati Raj Department, Government of Bihar. List of districts and number of wards of Bihar, therein having fluorosis endemicity.
6. Singh Bihari, Singh KK. Integrated Fluorosis Mitigation Programme for abatement of fluorosis in selected fluorosis endemic villages of Nawada district, Bihar. *Fluoride.* 2019;2(1):82.
7. Chen et al. Change of urinary fluoride and bone metabolism indicators in the endemic fluorosis public water. *BMC Public Health.* 2013;13:156. Available from: <http://www.biomedcentral.com/1417-2548/13/156>

-
8. Srikanth R, Gautam A, Jaiswal SC, Singh P. 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. *Environ Monit Assess.* 2013;185(3):2343–50.
 9. American Public Health Association (APHA). *Standard Methods for the Examination of Water and Wastewater.* 23rd ed. Washington, DC: APHA; 2017.