FLUORIDE TESTING AND FLUOROSIS MITIGATION IN SONEBHADRA DISTRICT

1. INTRODUCTION

About 62 million people in India suffer from dental, skeletal and or non-skeletal fluorosis.(1) Of these, 6 million are children below the age of 14. Fluorosis is a crippling disease caused by fluoride concentrations above 1.5 mg/L in drinking water. In India about 20 states have been identified with a problem of excess fluoride in groundwater. Rural populations who are mainly dependent on groundwater for drinking purposes, are the worst affected. Since the late 1980s, government and non-government agencies have launched efforts to control the spread of fluorosis. Despite these efforts, reports continue to appear indicating an increasing spread of fluorosis. This can either be due to identification of an existing problem in a new area, or a fresh incidence striking a hitherto unaffected population due to local environmental changes.

Sonebhadra district lies in the eastern panhandle of Uttar Pradesh. Most of the well-known "Singrauli industrial area" falls in it. Several industries like thermal power plants and Hindalco, situated in this area, are also potential sources of fluorides in water and air. Banwasi Seva Ashram (BSA), a local voluntary organization (VO), has identified many cases of fluorosis in dozens of villages of Chopan and Myorpur blocks. Tribal communities dominate these blocks. Drinking water quality tests for fluoride content done by BSA in 1999 showed fluoride concentrations between 1.1 – 5.4 mg/L in surface water and 0.5 – 5.9 mg/L in groundwater.

With the help of BSA, Peoples' Science Institute (PSI) began a programme of fluoride testing and fluorosis mitigation in Sonebhadra district in September 2004. This report presents the results of the water quality tests and the accompanying health surveys. It also describes in a summary fashion proposals by village communities for fluorosis mitigation.

II. METHODOLOGY

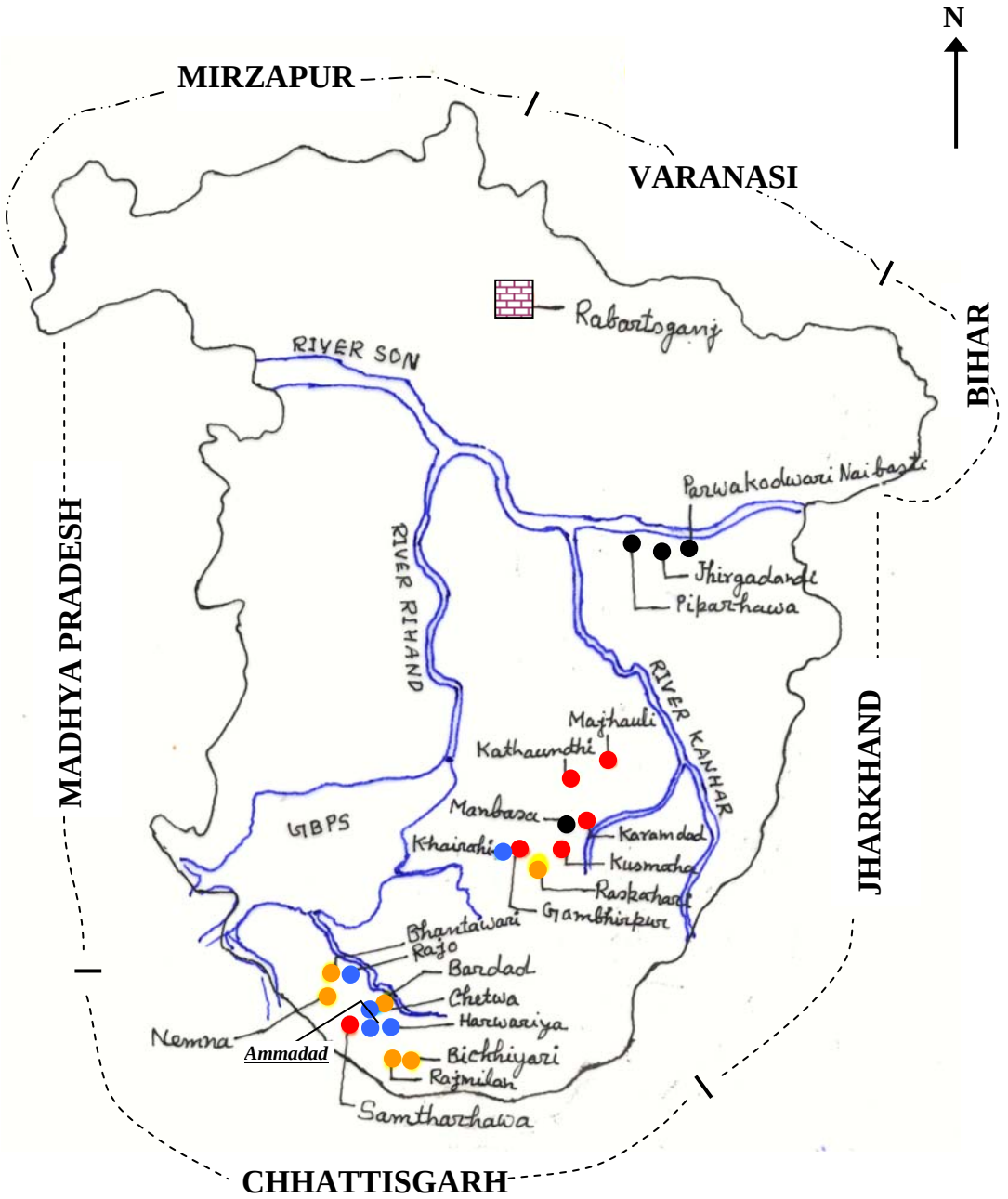
Health Survey

The staff and field workers of BSA helped identify villages where fluorosis cases had been reported. Medical professionals from BSA and PSI's research scientists carried out a dental fluorosis survey of children (ages 6 to 16 years) in 41 schools in the targeted area during October-November 2004. Children from all the schools filled out survey questionnaires.

Water Quality Monitoring

Data gathered from the health survey of school children were summarized village-wise. Villages that had severe dental fluorosis in more than 50% children were selected for water quality monitoring. One hundred per cent monitoring of drinking water sources was done in these villages between December 2004 and March 2005. The sources included open concrete and dug wells, hand pumps, natural streams, rivers and ponds (bandha). The water quality of 1477 water sources in 21 villages was monitored. Water quality parameters like pH, electrical conductivity, alkalinity, total hardness, calcium hardness, calcium, and fluoride were determined. Due to

Fig.1 : Location (along with fluoride concentration) of villages studied in Sonebhadra



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- > 80% water sources containing > 2 mg/l fluoride concentrations
- 60– 80% water sources containing > 2 mg/l fluoride concentrations
- 40– 60% water sources containing > 2 mg/l fluoride concentrations
- 20– 40% water sources containing > 2 mg/l fluoride concentrations

logistical constraints, only fluoride was monitored in the water sources of two villages, i.e., Chetwa and Ammadad.

Sample Collection and Analysis

Three temporary field laboratories were set up in the target area. Samples were collected in polyethylene bottles, which were vigorously washed with detergents and rinsed with distilled water. As a precaution, all the sample bottles were again washed vigorously with the water to be tested. These samples were analyzed within 24 hours of collection in the field laboratories.

Battery-operated handheld pH and EC meters were used to measure the pH and the electrical conductivity of the samples. Alkalinity, total hardness, calcium hardness and calcium were analyzed by titrimetric methods. A fluoride ion meter (Model 290A+ Orion, USA) was used to analyze fluoride concentrations in the water samples. The standard methods of water analysis prescribed by the APHA were followed in analysis of all the parameters.[2]

Community-Based Fluorosis Mitigation Planning

A specially organized team of community workers, scientists and folk artists carried out a Sandesh Yatra for mobilizing the affected villages communities over three weeks in January '05 and February'05, covering all the targeted 21 village. They informed the communities about the levels of fluoride contamination in the domestic water sources of their villages, the nature of fluorosis and possible measures for mitigation of the problem. Activities like puppet shows, street plays, dialogues with the villagers, posters pasting and distribution of pamphlets on fluorosis were carried out in each targeted village. Mapping of the fluoride content in the different drinking water sources and the affected households was also done in each village.

Once the water quality monitoring and Sandesh Yatra were over, a series of community meetings were held in each village to discuss plans for accessing safe water. The issues discussed at these meetings included options for mitigation, costs and management systems. Each village finally prepared detailed mitigation plans using this information.

III. RESULTS AND DISCUSSION

Health Survey

A total of 3588 children participated in the dental fluorosis survey carried out in 41 primary, junior and higher secondary schools in the Chopan, Dudhi, Myorpur and Babhani blocks of Sonebhadra district. The survey results are summarized in Table 1.

Water Quality of Village Water Sources

Table 2 shows a wide spatial variation in the values of all the water quality parameters analyzed. This variation indicates a varied geochemistry in the area. Parameters like pH, EC, alkalinity, hardness and calcium were found to be within the prescribed limits for most of the water sources. Calcium concentration was low in the water sources of most of the villages monitored. Fluoride concentrations were higher than the prescribed limit of 1.5-mg/l. in drinking water sources in most of the villages. In addition to high fluoride content in ground water sources, it was also high in the surface water sources of Parwakodwari–Naibasti, Piparhawa, Kathaundi,

Kusmaha, Raspahari, Bhantawari, Rajo and Nemna villages. Fluoride concentrations were generally found to be high in water sources that had low calcium and high alkalinity.

Table: 1. Results of the Dental Fluorosis Survey

S.No.	Description	Values
1.	No. of schools surveyed	41
2	No. of villages students are resident in	207
3	No. of villages with very high prevalence of fluorosis	18
4	No. of villages with moderate prevalence of fluorosis	82
5	No. of villages with mild prevalence of fluorosis	36
6	Total no of villages with fluorosis cases	136
7	Total no. of children surveyed	3588
8	No. of children affected by mild dental fluorosis	1300 (36%)
9	No. of children affected by moderate dental fluorosis	447 (12 %)
10	No. children affected by severe dental fluorosis	49 (1.2 %)
11	Total no. of children affected by dental fluorosis	1796 (50%)
12	No. of children with suspected dental fluorosis	424 (12%)
13	Total no. of children affected or suspected	2219 (62%)

Fluoride Concentration in Drinking Water Sources

Table 3 shows that fluoride concentrations varied between 0.2 –15.5 mg/l in all of the 1477 water sources monitored. The concentrations were observed to vary with the sources and the location in each village. Fluoride concentrations were much higher in ground water sources than the surface water sources. High fluoride concentration in the ground water is most likely due to fluoride bearing underground rock. Villages located near Beejpur and Renukoot may also be affected by fluoride emissions from the Rihand Super Thermal Power Plant and Hindalco respectively.

Villages with high fluoride concentrations sources included Parwakodwari – Naibasti, Kusmaha and Bhantawari (with sources containing >15 mg/l), Samtharhawa. ($\leq$14 mg/l), Manbasa and Karamdad (both with sources above 12 mg/l), in Piparhawa ($\leq$ 9 mg/l) and Kathauthi, Raspahari , Bardad, Nemna, Rajmilan and Bichhiyari (all with with sources containing $\leq$8 mg/l).

In general, fluoride concentrations were in a similar range in hand pumps, pucca wells and dug wells. In Chetwa, Ammadad, Harwariya, Bardad and Rajo Bhantawari and Nemna, however, fluoride concentrations were higher in hand pumps than the open wells. It seems that the upper rocks strata contain lower amounts of fluoride as compared to the deeper strata. Due to the undulating topography of the area, however, it is not possible to make any generalization about the depth to which safe water can be found.

Table: 2. Water Quality Profile of the Different Sources of Drinking Water

S. No.	Village	Kind of source	No. of Sources	Water Quality Parameters						
				pH	EC (µmho/cm)	Total Alkalinity as CaCO3 (mg/l)	Total Hardness as CaCO3 (mg/l)	Calcium Hardness as CaCO3 (mg/l)	Calcium as CaCO3 (mg/l)	Fluoride (mg/l)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Parwa	HP	13	6.9-7.8	448-1379	200-536	140-324	18-242	10.2-97.0	3.5-11.8
	kudwari-	PW	14	7.4-8.4	474-1378	192-628	124-266	24-174	9.6-69.8	1.7-15.5
	Nai basti	DW	21	7.2-8.6	508-1173	180-784	78-388	36-176	14.4-70.6	1.2-12.3
		Nala	2	8.0-8.4	655-778	296-374	226-254	104-116	41.7-46.5	2.5-4.2
2	Jhirgadandi	HP	7	7.1-7.4	579-790	244-376	196-308	112-164	44.9-65.8	2.8-6.3
		PW	9	7.3-7.8	404-997	180-418	140-388	110-176	44.1-70.6	2.5-6.7
		DW	1	7.7	790	358	222	80	32.1	5.0
		River	1	8.1	197	84	70	70	28.1	0.40
3	Piparhawa	HP	9	6.6-7.7	293-1055	128-570	214-428	46-210	18.4-84.2	0.2-5.50
		PW	11	7.3-8.0	618-958	304-468	132-258	42-174	16.8-69.8	0.7-8.10
		DW	65	7.6-8.0	569-1065	264-544	188-288	100-164	40.1-65.8	1.3-4.5
		River	1	8.3	240	102	84	60	24.1	0.40
		Nala	1	8.2	830	426	254	160	64.2	4.45
4	Kusmaha	HP	24	7.1-7.7	537-986	176-426	102-280	76-190	30.5-76.2	0.9-9.8
		PW	24	7.3-8.1	406-1076	158-522	88-466	58-264	23.8-105.9	1.0-14.8
		DW	7	7.8-8.5	748-995	276-424	148-354	104-220	41.7-88.2	2.9-6.3
		Bandha	2	8.2-10.1	355-526	172-284	84-102	30-100	13.6-40.1	1.3-2.0
5	Gambhirpur	HP	10	7.1-7.5	540-1008	170-422	140-308	76-214	30.5-85.8	1.59-4.4
		PW	5	7.2-8.0	626-889	282-344	164-346	100-188	40.1-75.4	1.4-3.5
		DW	6	7.3-7.8	662-1224	166-354	228-528	174-212	69.8-85.0	0.9-3.2
		Bandha	2	8.1-9.7	559-730	234-316	96-150	40-84	26-33.7	2.3-3.4
6	Khairahi	HP	26	6.6 – 7.6	375-1 223	80 – 398	114 – 422	34 – 186	13.6 – 75.6	0.2 –2.5
		PW	18	7.2 – 8.4	456 -1414	180-582	104-328	34-146	13.6- 58.5	0.6-4.0
		DW	16	7.1- 8.3	423- 1132	160- 526	64-348	24-92	9.6-36.9	0.5-2.2
7	Raspahari	HP	41	6.8-7.9	447-1411	120-430	102-524	78-320	31.3-128.2	0.4-7.3
		PW	58	7.2- 8.3	393-1254	130-676	104-494	48-310	19.3-124.3	0.4-7.3
		DW	101	7.2-8.5	340-1359	104- 622	84-564	40-356	16.0-142.7	0.5-7.9
		Bauli	2	8.1-9.0	744	312-344	194-254	80-90	32.1-36.1	6.1-7.2
		Bandha	3	8.9-9.6	516-793	214-334	116-130	56-66	22.5-26.5	2.4-3.2
		Nala	1	8.8	883	428	212	60	24.1	2.0
8	Karamdad	HP	9	6.8-7.4	534-1037	223-476	140-288	80-168	32.1-67.4	0.5-6.7
		PW	9	6..8-8.0	296-1138	142-616	78-266	52-238	20.8-95.4	1.0-5.61
		DW	9	7.0-8.1	329-1166	144-522	126-286	56-198	22.5-79.4	0.6-11.9
		Bandha	1	8.9	384	232	88	60	24.1	1.8
9	Manbasa	HP	30	6.5-7.6	351-1172	110-682	122-512	62-190	24.8-76.2	1.2-7.5
		PW	22	7.0-8.3	426-1158	182-596	156-470	60-214	24.1-85.8	0.8-11.7
		DW	33	7.1-8.3	445-1646	188-982	66-406	34-198	13.6-79.4	0.8-8.7
		Bauli	4	7.6-7.7	641-915	308-406	208-322	80-120	32.1-48.12	3.0-6.5
		Nala	2	7.8	770-917	364-468	258-288	92-100	36.9-40.1	2.4-3.6
10	Kathaundhi	HP	31	7.0-8.0	362-1314-	240-370	102-344	20-136	8.2-54.5	0.7-7.8
		PW	16	7.7-8.7	488-1358	336-702	168-356	14-152	5.6-60.9	0.9-7.9
		DW	72	7.6-8.4	495-1825	214-486	60-392	8-138	3.1-55.3	0.4-7.4
		Bandha	2	8.1-8.4	484-634	-	126-196	64-48	27.3-15.2	1.6-1.9
		Nala	1	8.3	791	-	178	24	9.62	5.29
11	Majhauli	HP	37	7.1-8.0	549-1152	238-478	138-388	22-256.0	8.8-102.6	0.9-5.8
		PW	46	7.6-8.4	305-1248	112-442	108-394	10-154.0	4.0-61.6	0.9-5.4
		DW	118	7.2-8.6	520-1154	218-548	140-388	14-240	5.6-96.2	0.9-6.1
		Bauli	3	7.5-8.4	542-743	226-314	110-234	14-196	5.6-76.2	3.9-4.0
		River	2	8.2-8.4	653-707	312-352	192-200	38-84	15.2-33.7	72.3-2.7
		Bandha	1	9.3	593	276	154	28	11.2	3.8
12	Harwariya	HP	5	6.8-7.4	292-637	-	-	-	-	1.4-4.9
		PW	9	7.5-8.3	282-893	-	-	-	-	0.7-3.7
		DW	12	6.8-7.8	324-637	-	-	-	-	0.6-2.9

13	Bardad	HP	10	6.2-7.5	171-803	16-328	32-224	18-148	7.2-59.3	1.1-8.6
		PW	22	6.4-7.5	143-1277	16-316	40-330	14-238	5.6-95.4	0.5-6.9
		DW	48	6.2-7.9	142-1130	12-434	24-374	22-338	8.8-135.5	0.2-7.9
		Bauli	1	7.0	126	24	44	34	13.6	2,6
14	Rajo	HP	9	6.9-7.9	364-602	164-322	150-310	90-202	36.1-81.0	1.2-2.9
		PW	4	7.0-7.7	269-335	86-190	92-240	56-118	22.5-47.3	0.9-2.4
		DW.	33	6.8-7.9	215-608	52-374	104-268	50-150	20.0-60.1	0.3-3.9
		Bauli	4	7.0-7.9	209-413	100-234	142-206	34-86	13.6-34.5	0.9-3.0
		Nala	1	8.1	425	210	180	104	41.7	2.0
15	Bhantawari	HP	8	7.0-9.0	208-812.	96-880	66-372	28-168	11.2-67.4	2.4-4.8
		PW	19	6.5-9.0	222-1461	78-668	54-286	36-260	5.0-104.3	0.4-14.8
		DW	50	6.5-9.5	153-1156	36-506	52-378	28-242	14.4-97.0	0.4-9.8
		Bauli	4	6.8-8.0	186-596	100-310	100-174	46-106	18.4-42.5	0.9-4.2
		Nala	1	8.3	372	152	X	74	29.7	1.96
16	Nemna	HP	18	6.4-8.4	156-1065	50-484	62-486	42-186	16.8-74.6	1.2-4.1
		PW	22	6.8-9.9	364-1275	56-334	114-324	32-220	12.8-88.2	0.2-3.6
		DW	50	6.6-8.2	315-1520	80-606	80-370	4-240	1.6-96.2	0.3-91
		Bauli	6	7.2-8.3	515-860	180-304	128-214	24-122	9.6-48.9	1.7-4.3
		Chaurha	3	7.7-8.4	491-570	292-220	96-204	96-124	38.5-49.7	1.2-2.1
		Nala	1	8.3	535	206	106	48	19.2	2.4
17	Samtharhawa	HP	5	7.0-8.0	579-829	196-406	146-218	80-126	32.1-50.5	1.8-4.6
		PW	8	7.0-8.0	544-1186	128-294	86-254	44-176	17.6-70.7	2.0-11.1
		DW	42	6.0-8.0	157-1076	40-574	54-256	30-186	12.0-74.6	0.3-14.0
		Bandha	2	6.0-7.0	184-285	52-122	44-70	34-62	13.6-24.9	0.2-0.7
		Nala	2	7.0	422-425	182-190	78-84	60-68	24.1-27.3	1.8-2.4
18	Rajmilan	HP	23	6.8-8.0	393-857	84-378	116-378	56-176	22.4-70.6	0.7-6.5
		PW	4	7.2-7.9	468-634	104-284	190-386	78-146	31.3-58.5	0.4-1.8
		DW	27	6.5-8.8	303-1203	54-730	74-462	44-250	17.6-100.2	0.4-7.8
		Bauli	6	7.0-9.6	309-684	122-254	82-174	56-114	22.4-45.7	0.4-4.1
		Bandha	1	9.1	118	254	64	30	12.0	0.5
19	Bichhiyari	HP	3	7.1-7.2	575-1083	258-462	158-374	118-232	47.3-93.1	1.9-3.3
		PW	9	7.0-8.3	422-1080	96-488	116-390	50-262	20.0-105-1	1.0-6.5
		DW	20	6.8-7.9	191-852	76-336	106-300	280-152	160-60.9	0.7-7.5
		Bauli	1	8.4	708	322	138	70	28.0	3.2
		Bandha	1	8.1	311	120	100	60	24.1	0.9
		River	2	7.6-8.6	459-698	208-254	154-182	84-86	33.7-34.5	1.9-2.1

HP – Handpump; PW – Pucca well; DW – Dug well

Relationship Between Severity of Fluorosis and Fluoride Concentrations

Data showing the relationship between the severity of fluorosis and fluoride concentrations was extracted from the fluorosis mapping exercises and the water quality monitoring exercises. It is summarized in Table 4. The average fluoride concentrations in drinking water corresponding to different degrees of severity of fluorosis were also calculated and shown in Table 5 and Fig. 2.

Table 3: Fluoride Concentrations in Different Sources of Drinking Water

S. No.	Range of Fluoride (mg/l)	Number of Drinking Water Sources							Total	
		HP	PW	DW	Bauli	Bandha	River	Nala		
1	2	3	4	5	6	7	8	9	(10)No.	(11)%
1.	Parwakodwari – Naibasti									
	1.2 – 2.0	-	1	4	-	-	-	-	5	10
	2.1 – 6.0	9	9	14	-	-	-	2	34	70
	6.1 – 10.0	1	2	2	-	-	-	-	5	10
	>10	2	2	1	-	-	-	-	5	10
2.	Jhirgadandi									
	0.4 – 2.0	-	1	-	-	-	1	-	2	11
	2.1 – 6.0	6	7	1	-	-	-	-	14	78
	6.1 – 10.0	1	1	-	-	-	-	-	2	11
3.	Piprahawa									
	0.2 – 2.0	2	1	1	-	-	1	-	5	19
	2.1 – 6.0	7	8	4	-	-	-	1	20	74
	6.1 – 10.0	-	2	-	-	-	-	-	2	7
4.	Kushmaha									
	0.9 – 2.0	6	9	-	-	1	-	-	16	28
	2.1 – 6.0	16	12	6	-	1	-	-	36	63
	6.1 – 10.0	2	1	1	-	-	-	-	4	7
	>10	-	1	-	-	-	-	-	1	2
5.	Gambhirpur									
	0.9 – 2.0	2	2	4	-	-	-	-	8	35
	2.1 – 6.0	8	3	2	-	2	-	-	15	65
6.	Khairahi									
	0.2 – 2.0	20	10	10	-	-	-	-	40	67
	2.1 – 6.0	6	8	6	-	-	-	-	20	33
7.	Raspahari									
	0.4 – 2.0	20	27	44	-	-	1	1	93	45
	2.1 – 6.0	20	30	55	-	2	-	-	107	52
	6.1 – 10	1	1	2	2	-	-	-	6	3
8.	Karamdad									
	0.5 – 2.0	6	1	2	-	1	-	-	10	36
	2.1 – 6.0	2	8	6	-	-	-	-	16	58
	6.1 – 10.0	1	-	-	-	-	-	-	1	3
	>10	-	-	1	-	-	-	-	1	3
9.	Manbasa									
	0.8 – 2.0	6	4	8	-	-	-	-	18	20
	2.1 – 6.0	21	15	21	3	-	1	-	61	67
	6.1 – 10.0	3	2	5	1	-	-	-	11	12
	>10	-	1	-	-	-	-	-	1	1
10.	Kathaundhi									
	0.4 – 2.0	10	7	25	-	2	-	-	44	36
	2.1 – 6.0	20	7	40	-	-	1	-	68	56
	6.1 – 10.0	1	2	7	-	-	-	-	10	7

11.	Majhauli									
	0.9 – 2.0	11	17	38	1	-	-	-	67	32.5
	2.1 – 6.0	26	29	79	2	1	2	-	139	67
	6.1 – 10.0	-	-	1	-	-	-	-	1	0.5
12.	Chetwa									
	0.1 – 2.0	20	11	20	-	-	-	-	51	82
	2.1 – 6.0	7	2	2	-	-	-	-	11	18
13.	Ammadad									
	0.3 – 2.0	2	2	15	-	-	-	-	19	65
	2.1 – 6.0	2	1	7	-	-	-	-	10	35
14.	Harwariya									
	0.6 – 2.0	4	4	9	-	-	-	-	17	65
	2.1 – 6.0	1	5	3	-	-	-	-	9	35
15.	Bardad									
	0.2 – 2.0	3	6	26	-	-	-	-	35	43
	2.1 – 6.0	6	15	21	1	-	-	-	43	53
	6.1 – 10.0	1	1	1	-	-	-	-	3	4
16.	Rajo									
	0.3 – 2.0	4	3	22	3	-	-	1	33	65
	2.1 – 6.0	5	1	11	1	-	-	-	18	35
17.	Bhantawari									
	0.4 – 2.0	4	8	33	3	-	-	1	49	58
	2.1 – 6.0	4	8	14	1	-	-	2	29	35
	6.1 – 10.0	-	2	3	-	-	-	-	5	6
	>10	-	1	-	-	-	-	-	1	1
18.	Nemna									
	0.2 – 2.0	7	14	22	2	-	-	-	45	45
	2.1 – 6.0	11	8	27	4	-	-	1	51	51
	6.1 – 10	-	-	4	-	-	-	-	4	4
19.	Samtharahawa									
	0.2 – 2.0	2	1	14	-	2	-	1	20	34
	2.1 – 6.0	3	6	23	-	-	-	1	33	56
	6.1 – 10	-	-	4	-	-	-	-	4	7
	>10	-	1	1	-	-	-	-	2	3
20.	Rajmilan									
	0.4 – 2.0	8	4	15	3	1	-	-	31	51
	2.1 – 6.0	14	-	10	3	-	-	-	27	44
	6.1 – 10	1	-	2	-	-	-	-	3	5
21.	Bichhiyari									
	0.7 – 2.0	1	3	14	-	1	-	1	20	55
	2.1 – 6.0	2	5	5	1	-	-	1	14	38
	6.1 – 10	-	1	1	-	-	-	-	2	7

Total Monitored Sources – 1477, (-) Not found
Index ; HP – Hand pump, PW – Pucca well, DW – Dug well
Fluoride: < 2 mg/l – Acceptable, 2.1 – 6.0 – Harmful, 6.1 – 10 – Dangerous >10.0 – Very Dangerous

The ill-effects of fluorides in drinking water depend upon several factors, e.g., nutrition of the person at risk, the exposure period, etc.[1] Hence the same level of exposure to fluorides can have different effects on different people. Varying concentrations of fluoride in drinking water

cause different degrees of fluorosis in Sonebhadra district. Table 4 shows that cases of mild dental fluorosis (discolouration of teeth) occur at fluoride concentrations as low as 2 mg/l. About 80% of the moderate dental fluorosis (appearance of striations on teeth) cases are associated with sources containing >3 mg/l. The average fluoride concentration for severe dental fluorosis (loss of teeth) is about 5 mg/l. While three persons using water containing above 3 mg/l reported mild skeletal fluorosis (aching joints but no visible stiffening), the average for the remaining 30 cases was above 7 mg/l. Crippling skeletal fluorosis (inability to walk without support) on the other hand most likely sets in due to exposure to fluoride concentration of more than 9.5 mg/l.

Table 4: Fluoride Concentrations in Drinking Water and The Severity of Fluorosis

Fluoride conc. in drinking water (mg/l)	**Severity of Fluorosis**															
	Dental Fluorosis										**Skeletal Fluorosis**					
	Non affected		**Suspected**		**Mild**		**Moderate**		**Severe**		**Mild**		**Moderate**		**Crippling**	
1	**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<2.0	50	65	3	14	14	10	*	*	*	*	*	*	*	*	*	*
2.1-2.5	15	19	3	14	38	29	7	11	*	*	*	*	*	*	*	*
2.6-3.0	2	3	5	23	15	11	7	11	1	11	*	*	*	*	*	*
3.1-3.5	2	3	1	4	13	10	12	18	1	11	2	6	*	*	2	5
3.6-4.0	3	4	5	23	14	10	16	24	2	22	*	*	*	*	*	*
4.1-4.5	4	5	5	23	18	14	6	9	2	22	1	3	2	11	*	*
4.6-5.0	*	*	*	*	7	5	4	6	*	*	*	*	*	*	*	*
5.1-5.5	1	1	*	*	6	5	4	6	*	*	*	*	*	*	*	*
5.6-6.0	*	*	*	*	2	2	4	6	1	11	*	*	*	*	*	*
6.1-6.5	*	*	*	*	1	1	1	2	*	*	11	33	1	5	*	*
6.6-7.0	*	*	*	*	*	*	*	*	1	11	4	12	8	42	1	3
7.1-7.5	*	*	*	*	3	2	1	2	*	*	3	9	3	16	*	*
7.6-8.0	*	*	*	*	*	*	2	3	*	*	7	21	3	16	1	3
8.1-8.5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8.6-9.0	*	*	*	*	1	1	*	*	*	*	*	*	*	*	1	3
9.1-9.5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9.6-10.0	*	*	*	*	*	*	*	*	*	*	3	9	1	5	6	15
>10.0	*	*	*	*	1	1	2	3	1	11	2	6	1	5	28	78
Total	**77**		**22**		**133**		**66**		**9**		**33**		**19**		**39**	

* Not found

Table 5: Average fluoride concentration for different severity levels of fluorosis

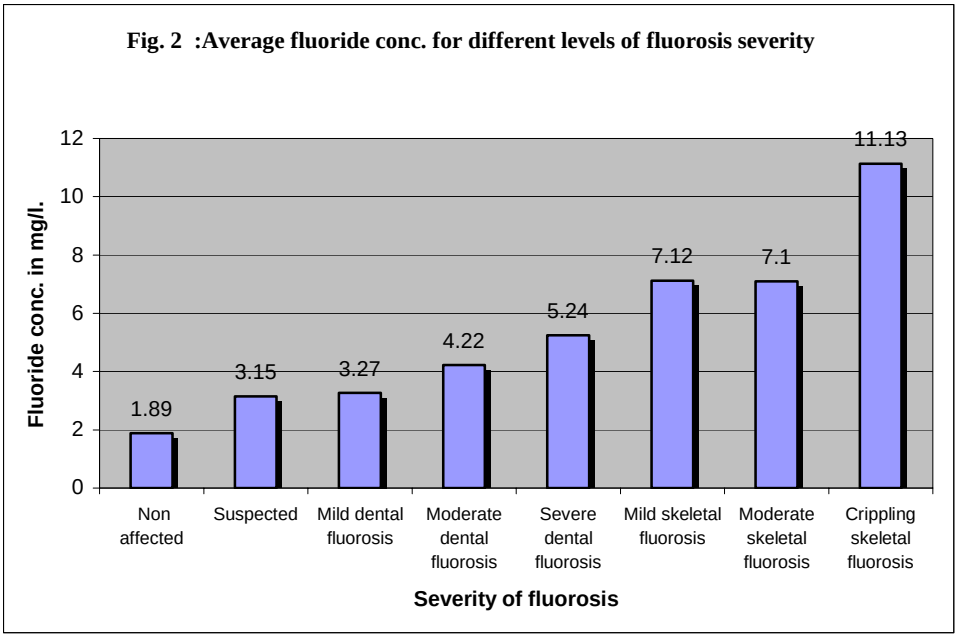
Severity of fluorosis	Number of cases	Average fluoride conc. in drinking water(mg/l)
Non affected	77	1.89
Suspected	22	3.15
Mild dental fluorosis	143	3.27
Moderate dental fluorosis	66	4.22
Severe dental fluorosis	9	5.24
Mild skeletal fluorosis	33	7.12
Moderate skeletal fluorosis	19	7.1
Crippling skeletal fluorosis	39	11.13

Strategies for Fluorosis Mitigation and Control

The data on fluoride concentrations in the water from the different sources and the extent of fluorosis prevalence was shared with the communities at well-attended meetings in each village. These meetings were also used to raise awareness about various aspects of the subject. The communities were informed about:

- The causes and harmful effects of fluorosis
- Nutritional interventions
- Certain precautions in fighting the disease
- Safe drinking water, a fundamental right
- Alternative sources of safe drinking water in respect to fluoride concentration
- Regular monitoring of water quality particularly with respect to fluoride concentration
- Sensitization of different groups within the society and the administration about fluorosis and their mitigation measures

Fig. 2 :Average fluoride conc. for different levels of fluorosis severity



Separate meetings were held with the community in each village to determine ways of accessing water supply with safe levels of fluorides. Among the options considered were:

i) Extending access to existing drinking water sources containing less than 1.5mg/l fluoride concentration

ii) Renovation or construction of sanitary wells at existing wells with less than 1.5mg/l fluoride concentration

iii) Installation of tube wells at locations of safe water

iv) Roof rainwater harvesting

v) Deflouridation of water using Nalgonda technique, activated alumina or reverse osmosis

As a demonstration, activated alumina based domestic deflouridation kits were provided to five families. Later the district administration also distributed similar kits in Parwakodwari. To meet the increasing demand for such kits at a later time, PSI offered to establish a kit-recharging facility at BSA's campus. Flouride removal efficiencies of the kits distributed were tested and the data (Table 6) were shared with the communities.

Table: 6, Defluoridation efficiency of Activated Alumina (AA) Kits

S.N.	Name of the AA kit user	Conc. of Fluoride in the inlet (mg/l)	Conc. of Fluoride in the outlet (mg/l)	% Removal of Fluoride
1	Rohan	11.6	3.2	72.4
2	Vindhyachal Sharma	11.6	1.82	84.3
3	Jai Ram Prasad	1.66	0.45	72.9
4	Manik Chandra	7.69	3.2	58.4
5	Parikha Patel	3.34	0.43	87.1
6	Rajkumar *	3	2.1	30
7	Neeraj	2.21	0.4	82

* Kit was provided by district administration & examined 2 months after distribution.

Based on these discussions and information about the costs and appropriate management systems for each option, each village prepared a detailed fluorosis mitigation plan. The proposals for accessing fluoride-free water are summarized in Table 7. They cover 2146 households out of the total 3875 households in the 21 targetted villages. The estimated cost of Rs 80,70,000.00 for a population of 12988 persons works out to an approximate cost of Rs 621 per beneficiary. Among the possible sources of funds identified with the help of the villagers were:

- Village Panchayats: They can implement mitigation measures upto Rs50,000 per year
- Industries like Hindalco, NTPC or Kanoria Chemicals in Renukoot who are engaged in implementing community welfare and development activities in the region
- The Singrauli Special Area Development Authority which is responsible for implementing development plans at the village level
- Voluntary organizations in the area
- Rajiv Gandhi National Drinking Water Mission
- Families who have opted for domestic activated alumna kits have volunteered to bear 20 per cent of the kit cost

Table 7: Summary of Proposals for Fluorosis Mitigation in the Targetted Villages

S. No.	Activities	No.	Estimated Cost Rs.	Number of Beneficiaries
1	Mitigation Measures			
i	Conversion of existing safe dug well into a sanitary well	62	25,62,000.00	830 households
ii	Conversion of existing safe concrete well into a sanitary well	23	6,00,000.00	
iii	Hand Pump with attached AA kit	48	38,40,000.00	735 households and 970 school children of 9 schools
iv	Borewell with hand pump and attached AA kit	2	1,70,000.00	20 households
v	AA Domestic kit	543	5,43,000.00	543 household
vi	Individual Roof rain water harvesting	1	22,000.00	1 household
vii	Community Roof rain water harvesting	2	3,33,000.00	17 households
viii	**TOTAL**		**80,70,000.00**	**2146 households + 970 school children.**

A one-day meeting was organized in September 2005 by BSA at its campus in Govindpur village to discuss the possibilities of support for implementing the mitigation plans prepared by the villagers. Elected representatives from 14 out of the 21 villages, the senior management of Hindalco, NTPC (Bijpur), NTPC (Shaktipur), Hi-Tech Carbon and Kanoria Chemicals, PSI and BSA attended the meeting. The Chief Development Office of the district who was to preside could not participate at the last minute. PSI presented a project report to the participants. During the discussion of the report, the village representatives publicly endorsed the fluorosis mitigation plans prepared by their communities. The representatives of Hindalco and NTPC (Bijpur) agreed to financially support the implementation of the proposed plans in 7 out of the 21 targeted villages. These villages are Manbasa, Karamdand, and Raspahari (Hindalco) and Chetwa, Nemna, Hadwaria and Rajo (NTPC, Bijpur). The Hi-Tech Carbon representative agreed to have his company sponsor a similar exercise under the guidance of PSI in three villages (Belhathi, Hathwani and Panari) where it has begun rural development activities. The representative of NTPC, Shakti Nagar said that his organization could support the upgradation and renovation of open wells with low fluoride content in the remaining villages provided a formal request came from the district administration. At the meeting a Steering Committee was also formed to guide the entire implementation programme. BSA was asked to pursue the implementation of the mitigation plans in the remaining 14 targeted villages with the district authorities. The latter set a meeting for this purpose on October 19, 2005.

IV. CONCLUSIONS

The project highlights can be summarized as below.

(i) Fluorosis, both dental and skeletal, are serious endemic problems of the area. Twenty- one villages in 3 discreet geographical clusters (Jhirgadandi, Govindpur and Chetwa) had particularly severe fluorosis problem and were chosen for intensive study and mitigation planning.

(ii) Most of the currently used drinking water sources in these 21 villages have fluoride concentrations above the permissible 1.5 mg/l, some of the sources have fluorides as high as 15.5 mg/l.

(iii) The incidence of fluorosis with fluoride concentration in drinking water revealed the following thresh-hold fluoride concentrations:

a. Initiation of mild dental fluorosis : 2 mg/l

b. Initiation of severe dental fluorosis : 4 mg/l

c. Initiation of mild skeletal flurosis : 6 mg/l

d. Initiation of severe skeletal fluorosis : 10 mg/l

(iv) With proper scientific inputs and information dissemination campaigns the affected communities were made aware of the problem and motivated to participate in its mitigation.

(v) No single technique or measure can ensure water of permissible fluorides concentration to all households of a village, except of course a village–level or a cluster level low–fluoride tube–well or defluoridation plant along-with piped water distribution system. This is not only highly capital intensive but also poses maintenance and operation problems. It would also be an externally imposed solution, much beyond the expected village-level competence and unlikely to enhance self-reliance.

(vi) In 21 villages the communities have prepared proposals involving a mix of technologies appropriate for a village. These technologies are:

(a) Renovation and upgradation of existing low fluoride sources to make them fit for wider use.

(b) Defluoridation kits attached to handpumps.

(c) Domestic defluoridation kits.

(d) Roof-top rain-water harvesting and storage.

(vii) The proposed plans involve an over-all financial input of about Rs 100 lakhs. This cannot be called excessive for the case of mitigation of a severe health problem of 21 villages inhabited by about 2150 households with 12,988 residents. Early steps need to be taken to finalize, detail and implement the proposed measures.

(viii) Local corporations, Hindalco, NTPC and Hi-Tech Carbon have agreed to promote a fluorosis mitigation programme in 10 villages. A Steering Committee has been setup to guide the programme. PSI will provide technical support and BSA will assist and monitor the community mobilization.

REFERENCES

1. SUSHEELA, A.K. : A Treatise on Fluorosis, Fluorosis Research and Rural Development Foundation, New Delhi, 2001.
2. _____ : Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 1998.