FLUOROSIS MITIGATION IN JHABUA

Based on Lessons Learned from Dirishavancha and other Endemic Fluorotic Villages

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Preface

Endemic skeletal fluorosis is a disease caused by excessive ingestion of fluoride through water, food or both. Fluorine is a halogen with an atomic number of 9 and atomic weight of 18.9984032 and this element was first identified by Scheele in 1771AD which being electronegative and reactive of all elements does not occur in free form in nature. Fluorine was first isolated and produced in a pure elemental form in 1886 AD by Henri Moissan for which he received Nobel Prize in chemistry in 1906 AD. Fluorine combines directly with most elements and indirectly with few to form fluorides. Fluorides are ubiquitous in nature and are present in rocks, soil, water, plants, foods and even air. This accounts for its presence in nearly all foods and natural waters.

The relationship between fluoride and dental caries was first noted in the early part of the 20th century when it was observed that residents of certain areas of U.S.A. developed brown stains on their teeth. These stained teeth, though unsightly were highly resistant to dental decay and caries. In the 1930's it was discovered that the prevalence and severity of this type of mottled enamel was directly related to the amount of fluoride in the water. Subsequently it was recognized that fluoride consumption in optimal amounts in the water supply imparted protection against the development of dental caries without staining the teeth. Another benefit of fluorides is that the incidence of osteoporosis seems to occur less frequently in regions with high fluoride content in water than in those in which the inhabitants consumed little fluoride. Excessive ingestion of fluoride through water, food or dust causes acute toxicity or a debilitating disease called 'fluorosis' a term coined and first used by Cristiani and Gautier in 1925. The acute lethal dose of fluoride for a 70 kg man is about 2.5-5.0 grams. Chronic fluoride poisoning is much more common and can affect animals as well as humans. Excessive intake during pre-eruptive stage of teeth leads to dental fluorosis and further continued ingestion over years and decades causes bony or skeletal fluorosis. Lastly crippling disease produces neurological manifestations. Feil first mentioned fluorosis in humans as an occupational disease in 1930. This was substantiated when the occurrence of skeletal fluorosis in cryolite miners in Denmark was reported by Moller and Gudjonsson in 1932. Cryolite is a naturally occurring mineral containing elements of sodium, aluminum and fluoride. Roholm in 1937 published a classical monograph

on chronic fluoride intoxication based on his study of 12 postmortem cases and 68 persons exposed to cryolite dust. Skeletal fluorosis was next reported as a disease endemic to an area in India by Shortt and his colleagues in 1937. Their study led to the publication of first reports of neurological manifestations of fluorosis in late stages. Subsequently cases of endemic and industrial fluorosis have been reported from various parts of India. There have also been occasional reports of its occurrence from sixty odd countries around the world mostly from Asia and Africa by World Health Organization in 1970.

High incidence of endemic fluorosis in India is due to the fact that large areas of the country contain drinking water supplies having high levels of fluoride especially in rural areas. Rural drinking water supply in India is to a large extent dependent on ground water to an extent of 85%. In contrast most cities get their water supplies from perennial rivers which have an optimum amount of fluoride. In addition foods grown in endemic areas of fluorosis also contribute to the high levels of fluoride through food. All states of India except northeast and Himachal Pradesh reported cases of fluorosis and cases of fluorosis have been reported from 275 out 640 odd districts spread over 20 states. Same is true of China where 29 of the 30 provinces are endemic for fluorosis. In that country 300 million people are living in endemic areas of fluorosis of which 40 million have dental fluorosis and 3 million suffer from skeletal changes. About 60 countries of the world reported the presence of dental fluorosis and about half of them are found to have cases of skeletal fluorosis. Most of the severe forms of fluorosis have been found in countries of Asia and Africa and enormity of this public health problem led to the publication of monograph No.59 on fluorosis titled 'fluorides and human health' by World Health Organization in 1970. This monograph indicated that skeletal fluorosis was predominantly water borne disease and any daily fluoride intake of more than 20 milligrams was harmful in endemic areas. This organization also published extensively on dental fluorosis over the subsequent decades. Extensive research around the world on skeletal fluorosis and ways to contain this intoxication was reflected in the second monograph on skeletal fluorosis by the World health organization in 2002 AD titled 'environmental health series 227-fluorides'. WHO stressed the role of excessive amounts of fluorides from food and water, malnutrition and kidney dysfunction in the causation of skeletal fluorosis. This monograph also indicated that any daily intake of fluoride more than 6 milligrams is harmful. In addition WHO stressed the difficulties

with defluoridation plants which are costly and difficult to maintain and advised that good surface water sources should be looked for drinking water needs in endemic areas.

Two national conferences on fluorosis were organized in India to discuss all aspects of the widely prevalent skeletal fluorosis. First one was conducted in 1974 at Hyderabad and second one was organized at Nagpur in 2004. Proceedings of these two conferences outlined the problem of fluorosis in India (Symposium on fluorosis, Indian academy of geosciences, 1977; Workshop on medical geology, I.G.C.P.-454, Nagpur, 2004). Exact figures of the incidence of fluorosis were not available in India but a rough estimate was made of the incidence in the country in 1974. It was thought that there are two main endemic belts one in the north comprising the states of Punjab, Haryana and Rajasthan and in the south predominantly the states of Andhra Pradesh, and parts of Karnataka and Tamil Nadu. Rough estimates in 1970's suggested that there were 25-30 million people living in the endemic areas of the country and half a million are crippled because of skeletal fluorosis. The first conference highlighted the problem of fluorosis and more cases of fluorosis have been reported from other parts of the country such as Uttar Pradesh, Bihar, Gujarat and Madhya Pradesh. It is now estimated that the number of fluorosis affected districts in India are 201 out of the 604 districts in the country and these are spread out over twenty states. Sixty million people are residing in these endemic and are risk of contracting the disease and six million people are crippled because of fluorosis according to UNICEF in 1999. The high incidence of fluorosis in India is not only because of increased awareness of chronic fluoride intoxication in the country but it also appears to be spreading in rural areas. The incidence of the disease of fluorosis has been updated by the ministry of health & family welfare in 2009 and it states that 275 districts in 20 states reported cases of fluorosis and the population at risk is about 66 millions. It is obvious that fluorosis is a major public health problem affecting millions of people in India especially in rural areas and deserves detailed epidemiological surveys and methods to contain the disease if not ways to prevent it. Jhabua is a tribal region of Madhya Pradesh and fluorosis is prevalent in this area. The increasing incidence of fluorosis in our country is a reflection of the dependence of rural population on ground water for their needs and also on prevalence of malnutrition. Hence two villages of Jhabua namely Miyati and Jasodha Kumji have been selected for study to understand the disease and methods to control the fluorosis menace by INREM foundation of Anand in Gujarat.

Chapter 1
Introduction

First ever cases of endemic skeletal fluorosis and also its neurological manifestations in the world were recorded from Podili, Darsi and Kanigiri areas of Prakasam district in 1937 by Shortt and his colleagues in 1937. Pandit and his team in 1940 made a detailed analysis of the fluoride content of drinking water supplies in these areas. They were surprised to find that the content of fluoride in majority of water samples was in the range of 1-3 ppm or 1-3 mg/L and the fluoride levels rarely exceeded 6 ppm (parts per million). World Health Organization monograph on fluorides and human health recorded that none should develop skeletal fluorosis drinking water containing 5 ppm of fluoride and the chance of disease developing with 8 ppm of water is only 10%. Pandit et al also noted that such levels of fluoride in drinking water supplies in other parts of the world such as U.K. and U.S.A. did not cause skeletal fluorosis. Hence they made a detailed survey of some of the villages such as Dirishavancha and towns like Kanigiri, Podili and Darsi to ascertain causes of skeletal fluorosis. Reasons adduced by Pandit et al for the incidence of severe forms of skeletal fluorosis in these areas were the following: (1) Tropical weather in these regions especially in summer with temperatures reaching up to 115-116^{o} F forcing people to consume more water thereby increasing the fluoride intake. (2) It is the farm laborers who were more prone to develop fluorosis rather than sedentary workers in these regions and the inference is obvious that more these people sweat more fluoride they consume. (3) Nutrition does seem to play a role in the causation of fluoride intoxication. A diet poor in calories as well as deficient in their content of vitamin C does seem to aggravate fluoride toxicity. Chinese study by Liang and Cao in 1997 from endemic areas has conclusively proved that nutrition does play a role in the incidence of fluorosis in that country. The incidence of skeletal fluorosis in this study from an endemic area of fluorosis in China was that individuals with normal nutrition was 43.8%, whereas in individuals with deficient nutrition it was 69.2%. The latter consumed less than 20 grams a day of protein and their calcium intake was less than 400 mgs a day. A diet poor in calcium, increases the body's retention of fluoride. All factors being similar the incidence of skeletal fluorosis is higher in individuals whose diet is deficient in calories as well as in their content of calcium intake. World Health Organization in its monograph in 2002 on fluorides also

confirmed that nutrition does play a role in the incidence of fluorosis. National nutritional monitoring bureau studies in seven states of India confirmed that rural nutrition of children was in poor shape. National family health survey (NFHS-III) of 2005-2006 conducted in 29 states reported that 45.9% of children below the age of 3 are underweight and malnourished and 38.4% had stunted growth and 57.9% of pregnant women are anemic (Table 1). The intake of calcium of children in all the states was poor and it never gone more than 400 mg per day in growing children (Table 2). These may be the reasons for severe forms of fluorosis in rural population. Experimental studies have confirmed that a diet poor in calcium increases body's retention of fluoride. Experiments in animals by Ranganathan in 1941 have proved that calcium protects the animals from toxic doses of fluoride by binding it with calcium which gets eliminated through stools. Nalgonda district has high levels of fluoride in ground water going up to 20 ppm and the reason for this high fluoride content is attributed to low calcium content of soils and rocks in this district by the Dutch team in 1993. The average calcium intake of individuals in Nalgonda was around 300 mgs in contrast to those in Punjab which is 900 mg. These are reasons for high incidence of fluorosis which affects more than 600 villages out of 1165 villages in this district. Dietetic element magnesium has a peculiar relationship with fluoride. Experiments by Marier in 1969 have proved that fluoride toxicity and magnesium deficiency symptoms are similar and she suggested that magnesium supplementation may be beneficial to reduce the fluoride toxicity. Our studies in 1974 on fluorotic dogs have confirmed that magnesium increases fluoride excretion from the body through urine. Chinese studies have confirmed the beneficial role of calcium and magnesium in the prevention and lessening the toxic effects of fluorosis. Pandit team's studies in 1940 in endemic fluorotic villages have confirmed that that the incidence of fluorosis was high in individuals whose diet was poor in vitamin C content. How this vitamin affects the fluoride metabolism is not understood and short experiments on vitamin C in fluorosis have not confirmed the beneficial role of vitamin C in fluorosis.

Table 1: National Family Health Survey (NFHS – III) 2005-06

- Conducted in 29 states
- 45.9% of children below the age of 3 are under weight and malnourished
- 38.4% had stunted growth
- 79% of the children are anemic
- Among married women (15-49 years), 56% are anemic
- 57.9% of pregnant women are anemic

Another factor that seemed to have gone unnoticed in the report by Shortt's team in 1937 was that the majority of their patients suffered from latent kidney disease in Podili, Darsi and Kanigiri areas of fluorosis. Our observation in some of the villages confirms the high incidence of kidney disease in fluorosis regions of Prakasam district. High content of some of the trace elements such as uranium, silica and chromium may be responsible for the renal disease in these areas. It is now evident that those with latent kidney disease are more prone to skeletal fluorosis even while drinking low levels of fluoride in drinking water supplies. It is now well documented that diseased kidneys cannot handle even low levels of fluoride intake making them retain more fluoride and hence the disease.

Table 2: Nutritional status of selected villagers in 29 states of India

State		Protein (g)	Total Fat (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)	Vit.-A (µg)	Thiamin (mg)	Ribo. (mg)	Niacin (mg)	Vit.-C (mg)	Free Folic Acid (µg)
Kerala (n=122)	Mean	41.5	30.4	1405	367	9.9	78	.7	.5	10.4	22	35.3
	Median	40.1	29.9	1361	333	9.5	60	.7	.4	9.8	16	32.6
	SD	17.0	15.2	365	220	4.4	70	.3	.2	3.1	19	14.9
Tamil Nadu (n=82)	Mean	30.7	16.0	1308	279	7.7	127	.8	.4	10.9	30	40.4
	Median	30.7	15.7	1260	220	6.1	74	.8	.4	10.5	23	40.2
	SD	8.3	8.1	326	184	5.5	138	.3	.2	3.5	25	12.2
Karnataka (n=141)	Mean	41.6	22.4	1616	476	11.8	164	1.0	.6	9.9	23	38.9
	Median	40.4	18.6	1599	301	11.2	105	1.0	.6	9.5	18	36.7
	SD	12.2	14.3	405	370	5.1	222	.4	.3	3.5	19	14.3
Andhra Pradesh (n=121)	Mean	38.9	17.2	1691	263	7.7	123	.6	.5	9.5	22	32.1
	Median	37.1	14.5	1666	210	7.1	80	.5	.4	9.0	18	28.4
	SD	12.1	10.1	440	158	3.7	160	.3	.2	2.9	19	14.8
Maharashtra (n=181)	Mean	40.5	26.8	1456	308	13.8	152	1.2	.6	11.0	20	42.2
	Median	39.0	24.3	1437	212	12.3	72	1.1	.5	10.3	10	39.8
	SD	13.8	15.2	415	273	7.1	239	.5	.3	4.6	26	17.6
Gujarat (n=117)	Mean	58.1	27.8	1892	393	23.5	167	1.7	.9	13.3	35	68.4
	Median	56.7	26.6	1796	347	20.2	132	1.7	.8	12.4	25	63.3
	SD	18.2	12.3	529	213	13.0	140	.6	.4	5.0	34	28.5
Madhya Pradesh (n=173)	Mean	43.1	13.0	1525	203	12.9	146	1.2	.5	12.9	28	42.7
	Median	42.0	11.2	1497	173	10.4	76	1.2	.5	12.6	17	39.8
	SD	18.5	9.6	515	142	8.4	254	.8	.3	6.2	35	23.1
Orissa (n=121)	Mean	32.4	11.1	1387	308	10.6	217	.9	.3	13.9	52	39.7
	Median	30.0	10.3	1332	205	7.4	40	.9	.3	13.9	36	37.8
	SD	9.7	6.0	292	302	8.7	355	.3	.2	3.7	51	16.0
West Bengal (n=169)	Mean	35.1	14.6	1434	353	10.7	297	1.0	.4	14.5	62	42.1
	Median	32.8	12.1	1419	223	8.6	44	.9	.3	14.2	40	37.0
	SD	13.1	10.7	397	399	8.5	615	.3	.2	4.5	68	22.4
Pooled (n=1227)	**Mean**	**40.4**	**19.9**	**1524**	**326**	**12.2**	**168**	**1.0**	**.5**	**11.9**	**33**	**42.3**
	Median	**37.6**	**16.4**	**1475**	**238**	**9.8**	**76**	**.9**	**.5**	**11.1**	**21**	**38.2**
	SD	**15.9**	**13.6**	**449**	**283**	**8.7**	**312**	**.6**	**.3**	**4.7**	**40**	**21.2**
	RDA	***54***	***22***	***2190***	***600***	***34***	***600***	***1.1***	***1.3***	***15***	***40***	***70***

Table 31 : Intake of Nutrients (per day) 10-12 year Girls

Nutritional status of selected villagers in 29 states of India is given in many tables in this study. One such table providing the intake of nutrients in 10-12 year old girls is given table above. Pooled calcium intake of growing girls in 29 states was only 326 mg per day which is pitiably low. Same was true of children of all ages in rural population in this study.

Role of trace elements

It is also realized in recent years that presence of abnormal amounts of certain trace elements can influence fluoride toxicity some beneficial and others detrimental. Every country has set the optimum or safe upper limit of major and trace elements in drinking water supplies, W.H.O., Commission for European communities, Indian council for medical research etc also published what should be the quality of drinking water supplies and what are permissible levels of these elements in their areas. Only 7 of the 18 water sources in Podili, Darsi and Kanigiri areas were found to be good for human consumption according to WHO guidelines. Fourteen out of the 60 trace elements that were tested in the drinking waters were in abnormal concentrations. The concentrations of some elements like chromium and uranium were very high and these are known to be nephrotoxic. High incidence of renal disease noted in people who developed the severe forms of fluoride intoxication in these areas may be due to these elements aggravating fluoride toxicity.

Chapter 2

Demographic studies in endemic fluorotic villages

Demographic studies of fluorotic population reveal the incidence and the factors governing the development of skeletal fluorosis in that area. Five villages from endemic fluorosis areas were selected and each of them represents certain aspects of fluorosis problem. Three villages of Prakasam in Andhra Pradesh namely Dirisavancha, Hanumanthapuram and Neredupalli and one village each in Nalgonda district of Andhra Pradesh (Yellareddyguda) and Nagaon district of Assam (Tapatjurigaon) were studied. Dirisavancha has been studied because Pandit et al in 1940 investigated this village in detail. This village has been provided with good drinking water supplies for the past 13 years to check what effect it caused on the incidence of fluorosis in that village in 2006. Hanumanthapuram village has been selected because it has very high levels of strontium in its water supplies. Strontium is a bone-seeking element like calcium and fluoride and it causes bone changes similar to those of fluoride. Neredupalli has been selected because this village is representative of other similar villages of the area, which has a very high incidence of kidney disease and crude death rate. Yellareddyguda has high fluoride levels of fluoride in drinking water supplies as well as in ground waters which are used for cultivation resulting in high levels of fluorides in food supplies. Tapatjurigaon was selected because it has severe malnutrition problem in children along with skeletal fluorosis due to high tea drinking habit.

a. Dirisavancha village

Dirisavancha village is located in the Kanigiri mandal of Prakasam district and its population was studied as for the incidence of dental, skeletal fluorosis, neurological manifestations and the results compared with the findings of the study in 1940. Water supplies were analyzed for their content of fluorides, nitrates, total dissolved solids and their content of trace elements. The results are listed in Tables 3 and 4. The population, incidence of dental and skeletal fluorosis and the fluoride levels are compared between 1940 and 2006 in Table 3. The Table 4 lists the contents of major and trace elements of the two water sources available now for drinking namely Krishna and the village tank water.

Table 3: Comparison of village Dirisavancha: 1940 and 2006

Village Dirisavancha	Population	Fluoride levels in drinking water supplies	Dental fluorosis	Skeletal incidence
1940	700	2.4 – 2.8 ppm	100%	4.4%
2006	566	0.3 – 3.1 ppm	100%	23 (4.0%)

Table 4: Water quality of tank water and Krishna water

	PH	Nitrate	TDS	F	Sr ppb	Se ppb	U ppb	Cr ppb	As ppb
Tank Water	8.3	10	400	3.1	818.65	<100	11.45	30.58	4.23
Krishna water	8.4	<5	215	0.3	635.50	<100	2.26	13.94	<1

(Nitrates, TDS and fluoride levels are in PPM and trace elements are in ppb. Only relevant trace elements, which are related to fluoride toxicity, are listed here.)

The population of the village declined which may reflect the changing demographic pattern of the villages after independence. More educational and job opportunities led to migration of people from the villages. The incidence of dental and skeletal fluorosis almost remains the same. The number of women with skeletal fluorosis is 16 and the males are 7. This incidence in women is exceptionally high and the reasons are unknown. Majority of reports reveal a male preponderance with regard to the incidence of skeletal fluorosis and the reasons put forward for the discrepancy are that women come to the endemic regions in adult years and they do not sweat as much as males in the fields. There are four villagers in the village who underwent surgery, which is performed in late stages of the disease causing spinal compression with neurological deficits. Out of those operated, two were women. Whether such cases were present in 1940 is not known and even if they were detected, there were no neurosurgical facilities available in the country then. Villagers are scared of skeletal fluorosis because once it develops none survives beyond ten years. The ages of those with skeletal fluorosis ranged between 32 and 65 years. . Even in 1940, this village was considered as relatively prosperous one. As for nutrition, only change that occurred is that the consumption of dairy products and vegetables declined during the interim period. This seemed to have happened because of commercial

interests of the farmers who sell milk and vegetables to the dairy companies and markets in towns in recent decades. Krishna water from Nagarjuna Sagar dam is only supplied once in four days and the tank is small. Hence, people do not get enough water, which has optimum levels of fluoride. Hence, villagers depend upon tank water supplied by the village 'panchayat' for their drinking and cooking needs. This tank water gets it supply from the bore wells and naturally, its fluoride content is higher than before. Domestic defluoridating units are not successful since they are expensive to maintain, as the filters need to be changed every three months. Another reason for the failure to rid off the fluoride intoxication in the village is that they get significant amounts of fluoride through their food. Foods grown in the endemic villages have a higher content of fluoride and Dirisavancha being a farming community the villagers eat what they grow locally. Another reason for the high fluoride content of the foods grown in villages during the past few decades is the use of phosphate fertilizers, which contain 3 % of fluoride. In 1940's only organic manure was used to grow crops. Only way they can reduce the intake of fluoride from their food is to cultivate the crops with water drawn from Krishna River. This can only happen if the government provides Krishna water for irrigation also. Another alternative is to import and consume the foodstuffs, which are grown, in non-endemic areas of the country.

This village was studied by us in the month of November of 2011 and there is no change in the incidence of fluorosis as compared to either 1940 or 2006 (Fig.1 & 2). Every child in the village suffers from dental fluorosis and all adults of the village who are poor and their nutrition is not good and continue to live in the village will develop skeletal fluorosis of varying severity depending upon their occupation. The problem with Nagarjuna Sagar water supply is that the supply is not regular and hence it supplemented from ground waters having high levels of fluoride. Another bad aspect is that the nutrition of village poor has deteriorated especially with regard to their intake of calcium which mostly comes from dairy products. Villagers stopped consuming dairy products and started selling them to dairy co-operative societies denying the growing children their requirement of calcium.

The government and the medical profession were under the illusion that fluorosis is only caused by excess amounts of fluorides which comes from water. The role of nutrition and the excess fluoride coming from food were not taken into account. Most popular textbook of preventive and social medicine by Park in its 19th edition of 2007 deals with endemic fluorosis in less than half

a page and the intervention suggested was changing the water source and if this was not possible to chemically treat the water containing excess fluorides by Nalgonda technique. All the 29 defluoridation plants provided by the government spending hundreds of crores are lying rotten in Nalgonda district alone. None of these plants ever worked and the medical students are still taught about fluorosis based on outdated knowledge.

Lessons learned: Correcting the fluoride content of drinking water alone will not eradicate fluorosis. Attention to fluoride content of foods consumed and nutrition are equally important.

What needs to be done in Dirishavancha village?

1. The supply of Sagar water should be regular round the year. If that is not possible make arrangements to supply drinking and cooking water from tanks from Kanigiri Reservoir.

2. Tea drinking should be stopped in the village since it increases their fluoride intake.

3. A glass of milk a day to school children will increase their intake of calcium which lessens the amount of fluoride absorbed and deposited in their bones.

4. Since rice is the main diet the rice from non-endemic areas to be provided as part of 1 rupee kg program.

5. Villagers should be encouraged to eat green leafy vegetables which have a high content of calcium such as thotakura and chamakura.

6. Diets can be supplemented with laddus made of sesame and jaggery to increase calories as well as calcium intake.

Similar advice is applicable to the residents of all fluorotic affected villages in the country.

Government need to establish a fluorosis research centre in high endemic area such as Nalgonda to learn about the fluorosis problem in our country.

Figure.1: Every resident of Dirishavancha village suffers from dental fluorosis. If water alone was responsible for fluorosis this boy born after the village was provided with Krishna water should not have suffered from dental fluorosis.

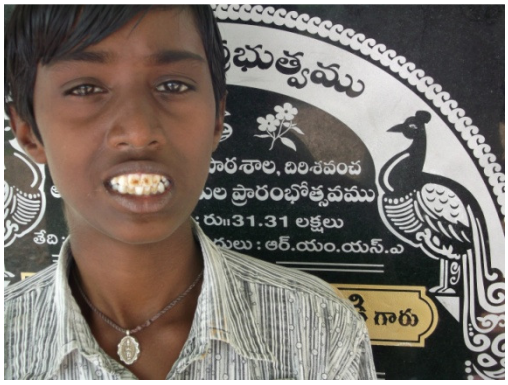


Figure 2: Every adult member of the village who continues to reside in the village suffers from skeletal fluorosis like the person shown above. This fact alone demands that optimum control of fluorosis needs effective planning.

b. Hanumanthapuram village

Hanumanthapuram is in Hanumanthuni Padu Mandal of Prakasam district and has a population of 185. Dental fluorosis is universal in the people of the village and there are cases of skeletal fluorosis though their exact incidence is not known. Hanumanthapuram village presents a different kind of problem and how to solve it needs understanding the quality of drinking water in that village. There are four water sources and their content of major elements (PH, fluorides,

nitrates, and total dissolved solids) and trace element strontium are listed in the table 5. The ideal way would be to supply Krishna water to this village both for drinking, cooking and for cultivation of the crops. If that was not forthcoming, a water purifying plant based on reverse osmosis would be ideal. Reverse osmosis is a mechanism, which removes all kinds of elements in water supplies and used in renal dialysis units. The filtration by activated alumina though reduces the content of elements as depicted in table 6 but it is not as effective as the method based on reverse osmosis. In one sample tested by reverse osmosis, the findings of the contents of elements before and after are as follows: F: 0.3 to 0.1 ppm; nitrates: < five to <five; TDS: 215 to 17 ppm; strontium; 635.50 to 4.91 ppb. However, this method is very expensive.

Table 5: Analysis of drinking water supplies in Hanumantharuram of Prakasam district

Sl No.	PH	Fluorides ppm	Nitrates ppm	TDS ppm	Strontium ppb
1	8.1	1.3	260	1330	8709.62
2	8.3	1.5	245	1500	9931.74
3	8.4	1.7	50	685	4581.15
4	8.0	1.3	50	640	4396.27

Desirable upper limits of the elements are: PH-8.5; Fluoride - 0.5 ppm; nitrates-45 ppm; Total dissolved solids-500 ppm. Strontium – There is no WHO guideline for normal upper limit of strontium levels in drinking water supplies due to inadequate experimental data. The average strontium levels in mineral waters in Japan are 94 ppb. The strontium levels in this village have to be grossly abnormal.

Table 6: Content of elements in water before and after filtration with Activated Alumina

	Sl. No.	PH	Fluoride	Nitrate	TDS	Strontium
Before	1	8.3	1.5	245	1500	9931.74
	2	8.4	1.7	685	1550	4581.15
After	1	7.6	0.3	890	1350	4621.51
	2	7.4	0.1	960	1220	2487.73

Note: The contents of nitrates after dialysis are worse and this may be because of activated alumina granules. Hence, defluoridation by filtration with activated alumina is not ideal and it may increase the content of alumina in the treated water. In one sample tested, the aluminum content of fresh water was less than 25 ppb, which increased to 95.62 ppb.

It may be noted that each endemic fluorotic village is different and need tackling by learning the underlying causes of fluorosis in that village.

Lessons learnt: In some endemic areas with skeletal fluorosis having relatively lower levels of fluoride, one must look for other aggravating factors such as higher levels of strontium in water supplies aggravating bone changes. Suppling Krishna water alone is the answer to control fluorosis in such villages.

c. Neredupalli village

This fluorotic village is in Pedda Cherlopalli Mandal of Prakasam district and has a population of about 2000. This village was selected because this village has a high crude death rate and has a high incidence of kidney disease. This may be true of many other villages of Prakasam such as Chimakurthi, which also has been studied. The results of the water quality examination and the contents of fluoride, nitrates, total dissolved solids and some important trace elements, which are known to cause nephrotoxicity, are listed in the table 7. In one calendar year, 30 persons of the village died and their ages ranged between30-70 and twenty of these died of kidney disease and the rest due to cancer. Quite a few villagers are suffering from similar diseases. The crude death rate of our country is eight per 1000 population and obviously, the number of dead in a year is very high. Uranium, chromium and cadmium in abnormal concentrations are known to be nephrotoxic. Uranium levels are higher but the contents of chromium and cadmium are normal. The role of other trace elements is not known. Strontium levels are high and they may explain the incidence of fluorosis with relatively low levels of fluorides in drinking water supplies.150 people of the village with disease symptoms were found after a questionnaire was given to them. Out of 80 people, tested 30 have a proven kidney disease. This incidence confirms the high incidence of kidney disease in this village. Further studies are under way.

Table 7: Water quality in Pedda Cherlopalli Mandal of Prakasam district

Sl. No.	PH	F	Nitrate	TDS	Strontium	Uranium	Chromium	Cadmium
1	8.0	0.5	20	380	2078.41	5.20	31.98	0.01
2	8.3	1.5	10	530	1783.30	14.39	5.18	0.03
3	8.0	0.3	110	650	3481.43	6.15	6.35	0.01
4	7.6	0.4	140	790	4790.96	7.18	22.48	<0.01

Lessons learnt: The high incidence of kidney disease in some villages of endemic fluorosis areas needs a detailed study. Another aggravating cause for high incidence of kidney disease might be the abuse of analgesics even for minor aches and pains which are common in fluorosis.

d. Tapatjurigaon

This village is in Nagaon district of Assam. Every resident of the village is affected by fluorosis including infants. The villagers have severe forms of fluorosis starting from dental to skeletal. The young children have severe limb deformities and malnourished to an extent that some of them manifest with kwashiorkor. All residents have dental fluorosis and the incidence of skeletal fluorosis varies depending upon their nutritional status. The life expectancy of the villagers must be lower than national average since very few elderly persons are noted in the village. All households have bore wells installed and the fluoride content of the water of these sources ranges between 5-6 PPM. The food habits of villagers are terrible. Hardly any child is given milk which is the only source of calcium. It was shocking to know that children are addicted to tea to such an extent that sometimes they are given only tea to drink and they go to bed without any food is given to them to eat at dinner. This was the reason for severe forms of malnutrition and fluorosis. Silver lining for the village is that panchayat water source which is some distance away from the village has ideal amount of fluoride in it. But the sad part is that none use that water in spite of repeated explanations from the geologists. People prefer to use the bores in their backyard even for drinking and cooking knowing that they contain high levels of fluoride. Even in the schools there is no provision for mid day meals. Other governmental help too is not within their reach. There must be high level of corruption in the system in that part of the country.

Lessons learnt: High intake of tea made from water containing high levels of fluoride and neglect of nutrition of children are main causes for severe forms of fluorosis in this kind of village.

e. Yellareddyguda

This village is in the Nalgonda district of Andhra Pradesh and has been studied extensively from 1945 onwards, first by Daver (1945) Siddiqui (1955), Krishnamachari & Krishnaswami (1973) and in recent years by Reddy (1986).The quality of drinking water supplies in the village are listed in two tables 8 & 9.

Table 8: Water quality in Yellareddyguda

Yellareddyguda					
S.No	Nitrate	TDS	F	Ca	Mg
1	106	1350	8.85	60	50
2	29	954	7.25	50	45
3	16	363	1.45	50	15
4	120	1092	4.25	50	30
5	235	1914	3.05	120	50
6	358	2544	3.45	95	85
7	156	1806	3.6	75	70
8	8	960	5.1	35	50
9	128	1944	8.75	60	80
10	15	1206	5.75	45	30
Total	**1171.00**	**14133.00**	**51.50**	**640.00**	**505.00**
Min	**8.00**	**363.00**	**1.45**	**35.00**	**15.00**
Max	**358.00**	**2544.00**	**8.85**	**120.00**	**85.00**
Mean	**117.10**	**1413.30**	**5.15**	**64.00**	**50.50**
SD	**112.55**	**635.51**	**2.49**	**25.91**	**22.54**

Table 9: Abnormal content of trace elements in Yellareddyguda and other fluorotic villages

Element (ppb)	VAGELLA				YELLAREDDYGUDA				YEDAVALLI			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Li	24.80	90.00	42.74	20.62	3.47	23.60	16.78	6.00	10.80	29.70	17.97	5.58
Al	10.00	52.00	16.36	13.63	10.00	80.00	37.12	29.90	10.00	60.00	15.84	15.70
Fe	80.00	1120.0	343.3	321.37	100.0	550.00	268.60	179.67	137.00	500.00	277.00	100.97
Zn	7.87	577.00	151.42	190.89	11.40	1106.0	247.65	348.49	5.00	3366.0	733.45	1069.08
Se	2.02	14.80	6.45	5.33	0.65	20.00	8.82	5.89	2.02	18.00	9.92	5.63
Sr	470.00	3160	1360.6	876.32	897.0	4800.0	2561.7	1129.59	1015.0	4120.0	2369.6	940.75
Ba	5.00	66.20	31.52	20.86	146.0	1040.0	459.60	285.17	74.00	494.00	276.30	146.62
Pb	2.00	77.30	15.47	27.90	2.00	13.00	5.13	4.17	2.00	3.45	2.42	0.59
U	15.70	5390.0	801.87	1707.46	2.82	61.00	33.81	14.98	12.60	46.50	35.05	10.56

The foods cultivated and consumed in Yellareddyguda and other neighbouring villages contribute significantly to the daily intake of fluorides in these areas (Table 10, 11).

Table 10: Fluoride content of foods cultivated in Yellareddyguda and neighboring villages

Sl.No.	Sample	Fluoride (ppm)
01	Rice	60
02	Brinjal	120
03	Bean (Bobbarulu)	120
04	Cucumber	80
05	Little gourd	160
06	Chillies (Powder)	60
07	Wheat	100
09	Turmeric	240
10	Millet (Jowar)	30
12	Bean (Chikkudu)	180
14	Gingerly	40
15	Tamarind	60
16	Green Gram	80
17	Millet (Sajjalu)	60

Table 11: Daily fluoride intake of an adult farm laborer in high endemic area villages: Naibai, Yellareddyguda and Yedavalli

Village	Fluoride in Milligrams
Naibai (2.0 - 6.2 PPM)	75.76
Yellareddyguda (2.6 - 10.0)	54.66
Yedavalli (4.4 - 7.5)	62.20

Note: In brackets are given fluoride levels in water samples of the villages. Fluoride through water was less than 20% to the total daily intake of fluoride.

Lessons learnt: In high endemic areas of fluorosis such as villages in Nalgonda district of Andhra Pradesh, fluorosis can only be controlled by providing these villages with supply of Krishna Water for drinking as well as cultivation, besides efforts to improve the nutrition of rural population. The only provision of drinking water has not helped in eradicating fluorosis in these villages.

Chapter: 3

Factors governing development of fluorosis and methods to control fluorosis

The epidemiological and demographic studies contributed to an understanding the disease of fluorosis and ways to control fluorosis. The tropical weather and the occupation do play a role in the incidence of skeletal fluorosis but these cannot be controlled. The other factors which govern the development of skeletal fluorosis are (a) the prevalence of high levels of fluoride intake through water and food; (b) continued exposure to fluoride; (c) strenuous manual labor; (d) poor nutrition; (e) impaired renal function and lastly (f) abnormal concentrations of certain trace elements. In regions having very high fluoride content the disease may affect younger age groups including children. Obviously the longer the exposure to fluoride the higher will be its incidence. It is farm laborers in engaged in manual works that are prone to fluorosis rather than those belonging to sedentary occupations. Some constituents of water accounting for its hardness or alkalinity also seem to promote the incidence of fluoride by affecting the amount of fluoride absorbed from the gut. Epidemiological observations show that nutritional status has a bearing on chronic fluoride toxicity and that the diets having low calcium and vitamin C accentuate it. The most important factor, which throws light on the development of fluoride toxicity, is the status of the kidney. Abnormal concentrations of certain trace elements such as strontium will also affect fluoride toxicity.

It would be rewarding to know the sources of fluorides from water, beverages and food.Air is a source of fluoride especially in certain parts of China but not in India. Hence air as a source of fluoride will not be discussed further. Biological effects of fluoride intoxication are related to the total amount of fluoride ingested whatever the source be it food, water or both. It is important to know sources of fluoride in each habitation so that effective measures can be instituted to control the fluorosis in that region.

a. Sources of fluoride:

Food, water and beverages are the principal sources of supply of fluoride to humans; the relative and respective contribution of each of which varies from place to place. But what matters is the

total intake of fluorides from all these sources, which makes for the development of skeletal fluorosis.

i) Foods

Nearly all foods contain small quantities of fluorides. WHO report of 1970 based on earlier studies indicated that the total daily intake through any average human diet is small, amounting to about 0.2-0.4 mg. But the recent studies of dietary fluoride content in areas with fluoridated water supplies indicated that the daily fluoride intake of food ranged from 0.6 to 5.4 mg which was three to five times that of non-fluoridated areas. Such an increase might be due to the use of fluoridated water for cooking and changes in the diet during the past two to three decades. In certain endemic regions of India the fluoride content of raw vegetables and foods may be very high. The contribution of food to the total daily intake of fluoride varies from region to region. Staple diets rich in Sorghum, Ragi or Bajra containing high fluorides contributing up 11.3 mg to the daily fluoride intake. Besides foods even the added spices, condiments and table salts contribute fluoride. Yellareddyguda, Yadavalli and Naibai are three high endemic villages for fluorosis in Nalgonda district of Andhra Pradesh in India. Rice and cereals are the predominant diet of these villagers which are cultivated in these villages with water containing high amounts of fluoride in ground waters. Fluoride content of the common food stuffs eaten in these villages has been estimated and average of those for each food are listed in the table 12.

People in these villages eat what they grow locally from crops which are cultivated with ground water containing high levels of fluoride. High content of fluoride in seeds and foods irrigated with high fluoride contaminated water has been confirmed in experimental studies by Gupta and Banerjee (2009). The mean fluoride decreased in the order: roots, leaves, stem and seeds. Rice seed content of fluoride in that study was 12.31 ppm when irrigated water fluoride content ranged between 0.62-4.06 ppm whereas fluoride levels of well water in these villages are much higher.

Table 12: Results of analysis of foods in three villages and their content of fluoride, calcium, magnesium, arsenic and cadmium are listed

Results of analysis of food stuffs

Village	Sl. No.	Sample	Ca ppm	Mg ppm	F ppm	As ppm	Cd ppm
Naibai	1.	Rice	720	216	60	<1	<1
"	2.	Brinjal	4600	1100	120	SNS	SNS
"	3.	Bean (Bobbarulu)	2000	420	120	<1	<1
"	4.	Cucumber	1700	2220	80	<1	<1
"	5.	Little gourd	SNS	SNS	160	<1	SNS
"	6.	Chillies (powder)	2400	4320	60	<1	SNS
"	7.	Wheat	1600	600	100	<1	<1
"	8.	Millet (Sajjah)	1600	600	20	<1	<1
"	9.	Turmeric	4000	3840	240	SNS	SNS
"	10.	Millet (Jowar)	1200	1920	30	<1	<1
"	11.	Green Gram	1200	1680	20	<1	<1
"	12.	Tamarind	3600	1920	30	<1	<1
"	13.	Chillies (Green)	SNS	SNS	SNS	SNS	SNS
"	14.	Bean (Chikkudu)	SNS	SNS	180	SNS	SNS
"	15.	Chillies (Powder)	3600	3840	SNS	SNS	SNS
"	16.	Bean (Bobbarulu)	2000	480	20	<1	<1
"	17.	Turmeric	SNS	SNS	SNS	SNS	SNS
"	18.	Gingelly	SNS	SNS	40	SNS	SNS
"	19.	Tamarind	5600	1440	60	<1	<1
"	20.	Green Gram	1600	480	80	<1	SNS
"	21.	Millet (Sajjalu)	2000	960	60	<1	<1
Yedavalli	22.	Rice	1600	240	50	<1	<1
"	23.	Millet (Jowar)	1600	1200	70	<1	<1
"	24.	Bottle Gourd	SNS	SNS	SNS	SNS	SNS
"	25.	Cucumber	2000	960	40	<1	SNS
"	26.	Coriander	4800	2880	50	<1	SNS
"	27.	Millet (Sajjalu)	1200	1920	70	<1	<1
"	28.	Bengal Gram	1200	960	70	<1	<1
"	29.	Castor	-	-	-	-	-
Yellareddy guda	30.	Rice	400	480	60	<1	<1
"	31.	Millet (Jowar)	1200	480	60	<1	<1
"	32.	Bean (Bobbarulu)	2880	1200	50	<1	<1
"	33.	Green Gram	1200	720	70	<1	<1
"	34.	Bitter Gourd	1200	2400	SNS	SNS	SNS

Note: (1) S.N.S – Sample not sufficient for analysis, after processing.

(2) Sample No. 40 became semi-solid on processing. Hence could not be taken up for analysis.

ii) Water and Beverages

In case of natural waters, the variation in the fluoride content from region to region is dependent upon such factors as the source of water, type of geological formation and the amount of rainfall. Surface waters generally have low fluoride of about 1ppm, while ground waters may have high concentrations of fluoride as has been found in many parts of Asia, Africa, Europe, Australia, North and South America according to WHO report in 1970. In many places around the world the fluoride content of water is as high as 10 ppm, but rarely 20 ppm or more. The highest fluoride concentrations of 53 and 95 ppm were reported from certain regions of South and North Africa. Table 13 lists the fluoride levels in drinking water supplies in different states of India. The highest fluoride concentration of 28.9 PPM was reported from India. Among beverages tea has an exceptionally high fluoride content which varies in different brands from 122-260 PPM or more with an average of 186 ppm. Infusions of tea may contain 1 ppm of fluoride and each cup of tea may supply 1-2 mg or more of fluoride. Tea may make a significant contribution to the daily fluoride intake causing at times fluoride intoxication.

The fluoride intake dependent upon consumption of drinking water and beverages is determined by such factors as body size, physical activity, food habits and variations in atmospheric temperature and humidity. That is why in tropical countries like India where average daily temperature is around 80^{o} F with the temperature rising to 110-118^{o} F in summer, the daily intake of fluoride intake is very high. Farm laborers in these regions may drink as much as 6-8 liters of water during summer months and 2-3 liters in other months.

Table 13: Incidence of fluoride in water resources of India

States	No. of Villages having	Maximum: F>2.0 mg/L
Andhra Pradesh	1245	28.9
Bihar	100	2.4
Gujarat	250	5.0
Haryana	360	11.0
Karnataka	300	8.0
Madhya Pradesh	150	7.0
Maharashtra	250	3.8
Orissa	200	4.0
Punjab	80	12.0
Rajasthan	450	28.0
Tamil Nadu	315	8.0
Uttar Pradesh	300	4.5

Optimum fluoride level in drinking water for a tropical country like India is<0.5PPM or 0.5mg/L. Three villages of Nalgonda namely Naibai, Yedavalli and Yellareddyguda have been surveyed for the incidence of dental and skeletal fluorosis and drinking water samples of these villages have been investigated and these are listed in table 14. Fluorosis Studies at Nalgonda villages.

Table 14: Results of some parameters of Water Quality tested from Yallareddyguda area

Parameters of WQ	Naibai	Yedavalli	Yellareddyguda
pH range	7.2-8.1	7.1-7.9	6.8-7.8
Alkalinity mg/l	100-460	350-504	400-820
Hardness mg/l	200-760	270-450	180-400
Fluoride mg/l	2.0-6.2	4.4-7.5	2.6-10.0
Magnesium mg/l	19-98	38-100	36-820
Dental fluorosis (%)	89.3	93.0	91.2
Skeletal fluorosis (%)	6.8	13.5	14.6

Fluoride content can vary greatly in the wells in the same area, depending upon the geological structure of the aquifer and the depth at which water is drawn. The fact that fluoride is unevenly distributed in ground water, both vertically and horizontally means that every water source has to be tested individually for fluoride in areas endemic for fluorosis.

Drinking water qualities in three fluororotic villages of Nalgonda are listed in table 14. PH of water is important for drinking purposes as water which is too acidic or alkaline will not be preferred for drinking by the villagers. The incidences of dental and skeletal fluorosis in these villages are listed. The individuals in these villages who are not suffering from dental fluorosis are women who came to these places from non-endemic regions after their marriages to local men.

Fresh water supplies only account for 1% water in the world whereas of 95% of it is the ground water which is being extracted more and more for drinking water needs as well as for agriculture in the recent decades. It is true that fluoride content of ground water is more than the rain or surface waters and this appears to be the reason for spread of fluorosis in rural areas of India. India has 17% of world population but it has only 4% of world's fresh water sources. China is somewhat better placed as it 20% world population and has 7% of accessible fresh water sources. That is the reason for increasing use of ground waters mostly in rural areas of the country whereas most big cities in India get their water from perennial rivers which have optimum

amounts of fluorides. Fluorosis is also becoming more severe because of higher intake of fluorides from ground water sources in India.

iii) Nutrition

Nutrition does play a significant role in the incidence of fluorosis and it is true that rural nutrition has deteriorated during the past few decades. More so the nutrition in certain parts of Andhra such as Nalgonda is very grim. When Daver first recorded cases of skeletal fluorosis from this region in 1945 AD and by Siddique in 1955 AD, there were no children with deformed limbs. These cases with deformed limbs were recorded in 1970's. Rural nutrition in the past few decades has gotten worse in many parts of state and in other parts of the country. National institute of nutrition conducted surveys of status of rural nutrition in 715 villages of seven states in 2002 and 2003. Eighty villages in AP were studied and AP has the distinction of having highest incidence of dental fluorosis among seven states. The results of nutrition study are contained in National nutrition monitoring bureau reports 21 and 22, which reveal the appalling state of nutrition of rural population in the country. Sixty percent of the children below 6 years of age are malnourished and a third of them suffer from severe under weight problem. Only a third of the children studied were getting an optimum diet. Calcium intake is exceptionally low in all states and calcium does play a big role in Nalgonda having very high incidence of skeletal fluorosis in our country. Drinking water supplies of Nalgonda have a high content of fluoride because the calcium content of Nalgonda soils and rocks is low. This allows more fluoride to seep in to the water supplies (Netherland study-1986). Siddiqui study revealed that average daily intake of calcium in Nalgonda individuals was only 300 mg whereas it was 900 mg in Punjab. NNMB report of 2002 reveals that calcium intake of rural population is appallingly low in Andhra and hardly averages around 300 milligrams whereas it should be around 800-1000 milligrams in growing children. Hence, there are no children with deformed limbs in Punjab villages with similar levels of fluoride in drinking water supplies. Nutrition status study of 50 children in Sharbanapuram village of Alir mandal of Nalgonda revealed that only one boy was normal as per BMI and percentile studies. Mid day meal scheme has not helped these children in Nalgonda in this regard. Children hardly get 300 calories of diet and most of the times the food supplied is not even hygienically good. National family health survey-III by the government of India in 2006 in 29 states revealed that 45 % of the children below are undernourished and 57 %

of women are anemic. All government policies to improve nutrition of rural folk have been a dismal failure so far.

What needs to be done? One has to pragmatic. Ideal way would be to supplement the diet of children in the endemic areas with calcium, magnesium and vitamin C. This was also the basis of Chinese research work in early 1990's.The best way would be to give a glass of milk and a banana to every school-going child in these endemic areas. Milk is perishable and can be adulterated. A pouch containing 300 ml of milk becomes very expensive. A tablet containing 500 milligrams of calcium, 300 milligrams of magnesium and 40 milligrams of vitamin C with vitamin D to improve absorption of calcium would be cheap and practical in addition to midday meal scheme, which needs to be improved. Since anemia is widely prevalent in rural population it may be advisable to add iron also to this tablet. The skeletal fluorosis was discovered in our country in Prakasam district seventy years ago and this continues to be major health problem even today. All efforts to contain this disease have been a dismal failure so far. Unless pragmatic steps are taken this problem is going to affect the lives of millions of people in our country for a long time to come.

Chapter 4

The clinical studies of children in Miyati and Yasodha Kumji of Jhabua district of Madhya Pradesh

Jhabua district of Madhya Pradesh is highly endemic to fluorosis. The onset of fluorosis here is relatively more recent compared with many affected places of Andhra Pradesh. The reason is that the dependence on groundwater for drinking water was quite low till the late 1980s when handpumps were first introduced here. The first fluorosis cases were noticed in late 1990s and then later a UNICEF programme launched in 2005 detected skeletal fluorosis in many villages of Jhabua. When INREM first visited this district in 2009, the widespread incidence of juvenile skeletal fluorosis was observed in many villages.

Jhabua was a princely state in British India rule. Prior to 1818, Jhabua was paying annual tribute to Indore. The Rajas were Rathor Rajputs who had been established in the area since 17th century. They descended from the Rajas of Jodhpur. In 1818 Jhabua came under British protection and control. Jhabua district in Madhya Pradesh is located in a tribal belt which extends to the adjacent contiguous areas located in Gujarat, Maharashtra and Rajasthan states of India. The majority of populations are Bhil tribals who were hunter gatherers till about one hundred and fifty years ago. This area was covered by dense forests and most of them cleared in two separate periods. One was in middle of 19th century when railway line was established between Mumbai and Delhi which passes through this belt. There were large numbers of princely states in Madhya Pradesh, Gujarat and Rajasthan including Jhabua which got railway lines. The laying of railway tracts in various parts of the country necessitated use of wood which was procured from this belt. Second time when the remaining forests were denuded and destroyed were between 1944 and 1946, when the local rulers knowing that they would not have power after Indian independence, sold away the trees. The tribal's mostly belonging to Bhil had to adjust to a new set up. They have poor farming methods and their diet has become poor and malnourishment is witnessed among the younger population.

Some image of coins of those times of Jhauba is shown below:

JHABUA - Paisa (1840 - 1895)

Based on the lessons learned from Dirishavancha and other villages documented by Dr Raja Reddy and also from the guidelines and information contained in the latest monograph of World Health Organization, INREM has undertaken the Jhabua fluorosis mitigation program. INREM's work also brings together learnings from many other previous efforts such as the work of Dr Tapas Chakma in understanding the importance of calcium deficiency in tribals, the work of Dr Leela Iyengar with defluoridation filters for household in the UNICEF programmes and the work of Dr A K Susheela in diagnosis and in developing nutrition based resilience to fluorosis.

INREM's objective was to develop ideas and solutions that can sustain in a remote tribal area such as Jhabua and result in significant improvement to patients. Initially INREM selected 25 children from two villages of Miyati (located in northern part of Jhabua) and Jasoda Khunji (located in southern part of Jhabua) for this purpose. As of January 2013, the children who are being offered mitigation support have shown significant improvement and presently the the number of fluorosis patients have increased to around 120 under the INREM program in these and nearby villages together.

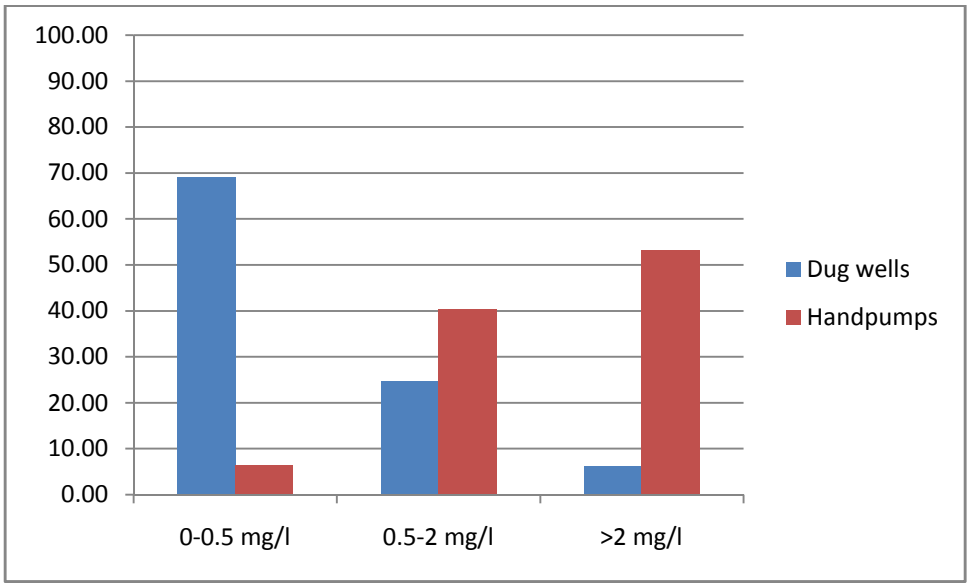
The studies in children in two villages of Jhabua of Madhya Pradesh namely Jasoda Khumji and Miyati since 2010, confirmed the diagnosis of fluorosis and that their nutritional status is poor. Body mass index (BMI) of children confirms that they are all malnourished. The radiograms of limb bones reveal the severe changes of fluorosis compounded by malnutrition. How to provide them with good water and how to improve their nutrition should be useful for implementing similar programs in the endemic fluorotic villages around the country.

a. Water quality analysis: fluoride in all sources of water

The safe permissible limit for fluoride is 1 mg/l. This can be checked using field kits and in laboratory with an Ion selective electrode using a potentiometer. Water quality testing of all sources was performed with active participation of the community using field kits. Laboratory analysis with Ion electrode was done using fluoride ion electrode method. Results from 5 villages of Jhabua show that hand pumps have greater fluoride levels than dug wells (Figure 4). Most of the water samples collected from dug wells have fluoride levels less than 1 mg/l. Samples collected from hand pumps have fluoride levels even up to 12 mg/l in some cases. Consumption of such high fluoride water leads to fluorosis – mainly Dental and Skeletal. Overall, on average, hand pumps have higher fluoride than dug wells.

Figure 3: Fluorosis affected boy testing water sample with field kit

Figure 4: Analysis of fluoride in dug wells and hand pumps



b. Dental and Skeletal fluorosis

Our survey of 49 Jhabua schools in August-September 2010 for Dental Fluorosis (DF) shows that 22% of children have some symptom of DF. Many children are also affected with Skeletal Fluorosis with range of symptoms such as bowed legs, Genu valgum, knocking knees etc. This sample need not be representative for the entire district, but it is the only such survey conducted. So many cases of DF among children, points out that in the future with continued water supply and malnutrition conditions, the cases of skeletal fluorosis would only increase.

Table 15: Dental fluorosis survey of 4226 children in 49 schools of Jhabua district

No DF		**Mild DF**		**Medium DF**		**Severe DF**		**Total students**		
Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Total
1775	1493	405	264	157	79	32	21	2369	1857	4226
958 out of 4226 (22%) surveyed children have DF symptoms										

c. Food nutrition and fluoride analysis

In order to understand the overall nutrition content of food and as well as to figure out any entry of fluoride through food, we carried out a study of food consumed by the people. Totally around 102 samples of Maize, Tuwar Dal, Udad Dal, Paddy, Wheat and other cereals and pulses were collected. Out of these, around 40 samples were tested for nutrition content and fluoride content.

Nutrition content analysis of Maize samples show that they do have significant amount of Calcium, Magnesium and Iron as seen in Table 16. However, consuming Maize Roti provides for only 10% of daily requirement for Calcium. There is low to nil consumption of milk and dairy products. Also, nutrition for infants being very poor, child malnutrition is very high in Jhabua. As a result, we have many cases of Juvenile Fluorosis which is caused by a combination of high Fluoride in water and poor consumption of Calcium. There is low to nil consumption of milk and dairy products. Also, nutrition for infants being very poor, child malnutrition is very high in Jhabua. As a result, we have many cases of Juvenile Fluorosis which is caused by a combination of high Fluoride in water and poor consumption of Calcium.

The entry of fluoride through food does not seem to be a cause for great concern as of now. As shown in Table 17, the fluoride content in Maize and others is still quite low. Since irrigation for these crops is either very low (being rain-fed) or through shallow dug wells only, the fluoride content in food is still less. However, with more electrification and irrigation through deep bore wells, the entry of fluoride through food could increase in the future.

Table 16: Nutrition content of Maize samples

	Maize (Sample no. 1110)	**Maize** (Sample no. 1111)	**Maize** (Sample no. 1112)
Calcium (mg/kg)	148.93	381.47	238.65
Magnesium (mg/kg)	1074.22	1348.88	1140.18
Iron (mg/kg)	43.95	67.14	129.45
Crude protein (%)	22.16	12.49	6.54

Table 17: Fluoride in main food samples from 2 villages of Jhabua

	Average			Maximum		
	Miyati	Jasodha Khunji	All	Miyati	Jasoda Khunji	All
Chana	3.55	1.18	1.97	3.55	1.45	3.55
Jowar	3.22	0.78	2	3.22	0.78	3.22
Maize	1.08	0.66	0.92	2.78	0.86	2.78
Paddy	2.59	0.63	1.61	4.7	0.78	4.7
Tuwar Dal	2.9	1.24	2.62	5.77	1.24	5.77
Udad	0.81	NA	0.81	1.97	NA	1.97
Wheat	1.17	0.72	0.95	2.68	0.82	2.68

d. Clinical Diagnosis of Fluorosis Symptoms

With confirmation of presence of fluoride in water and analysis of food along with an initial detection of fluorosis symptoms, the next step is to clinically confirm fluorosis through analysis of blood serum, urine and by x-ray of fore-arm and legs.

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i) Blood and Urine Analysis

To be noted is the absence of diagnostic facilities for fluorosis throughout the country makes it difficult to confirm observed cases. As a result, most cases are mis-detected and passed off for example as Muscolo-skeletal disorder (MSD). Most of reputed laboratories across the country were contacted for fluoride blood serum analysis and they reported as having no facilities.

In our case, we collected blood and urine samples through a private local laboratory in Jhabua town. Then, the blood serum was separated in the same laboratory. The serum and urine samples were then placed in ice-boxes and taken to New Delhi overnight by train to Dr A K Susheela's laboratory.

Urine and serum levels of fluoride were estimated using ion selective electrode method and the results are listed in Table 18. Monitoring of blood serum and urinary fluoride is very important. Whereas urinary fluoride levels shows us how much fluoride is being ejected from the body, the blood serum fluoride levels can inform us about fluoride present in the body.

The initial analysis of urine and blood serum samples shows high presence of fluoride. As shown here, the samples have fluoride levels much higher above safety limits.

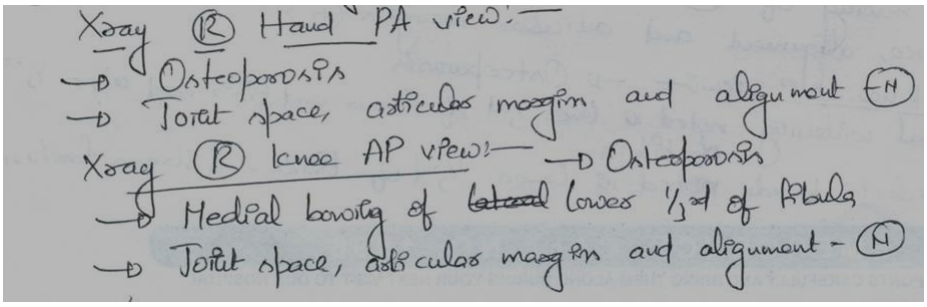
Table 18: Urinary and Blood serum fluoride for samples patients (March 2011)

Patient code	Fluoride in Urine (mg/l) – Unsafe beyond 1 mg/l	Fluoride in blood serum (mg/l) – Safe range 0.01-0.04 mg/l
M1	10.9	0.099
M2	7.26	0.125
M3	8.94	0.088
M4	4.99	0.148
M5	7.12	0.166
M6	5.21	0.106
M7	23.4	0.251
M8	10.6	0.169
M9	3.3	0.117
M10	4.45	0.151
M11	1.41	0.106
M12	3.54	0.092
M13	NA	0.153
M14	7.49	0.092
M15	8.6	0.071
M16	11.6	0.199
J1	32.3	0.244
J2	21.8	0.351
J3	27.1	0.311
J4	12.6	0.203
J5	18.5	0.263
J6	15.5	0.273
J7	23.4	0.331
J8	NA	0.249

ii) X-ray analysis

X-ray of fore-arms and legs of patients were conducted at Jhabua district hospital and these were analyzed by radiologists at Apollo hospitals, Hyderabad. The analysis showed that these children suffer from juvenile osteoporosis along with fluorosis. This along with observation of Osteoporosis confirms Skeletal Fluorosis for this patient. This analysis also showed that Juvenile fluorosis is a combination of both fluoride excess and calcium deficiency. Liad and Wu (42) describing the radiological features of endemic skeletal fluorosis from China concluded that osteoporosis towards the ends of long bones is an early radiographic sign in individuals under the age of 40 years even among those with a good nutritional status. In high endemic regions with a very high intake of fluoride and diets being deficient in calcium there is a secondary hyperparathyroidism, which also adds to the radiological changes. Hence the radiological changes in endemic regions with poor nutrition a variety of radiological appearances are seen.

Figure 5: X-ray Diagnosis of one of the patients



Mitigation Approach and Solutions

Dealing with fluorosis needs to take two dimensions – of safe water free from fluoride and good nutrition rich in Calcium and related minerals. Through the Fluorosis Mitigation Centre (FMC) established in Jhabua since August 2010, INREM has intervened in two villages – Miyati and Jasoda Khunji – in the quest to bring meaningful changes in the lives of fluorosis affected people.

i) Safe drinking Water

Within the geographical situation that people live in Jhabua and given problems of electricity and roads, one needs to think of technologies which can be easily maintained and used. Also, these need to easily connect with people's culture. One of the best solutions is to search for local water sources that are free from fluoride. Some of the hand pumps are always free from fluoride and most of the dug wells have very low fluoride too. Therefore, that safe fluoride free water needs to be the first option. However, to convince people opting for such water sources which are further away and sometimes also more scarce, is difficult.

With these in mind, INREM has developed an earthen pot filter which has Activated Alumina (AA) for fluoride removal and Zero-B as a disinfectant. We use 3 kgs of AA per filter. INREM has specially designed and produced a micro-filter for this purpose. This micro-filter allows a flow of water at 8 litres per hour and is suited for a specific AA based filter.

The filter consists of an exterior casing currently made as earthen pot, filtration material known as Activated Alumina (AA), a micro-filter, Zero-B and other smaller parts. The final product on location is shown in Figure 6 and the schematic design diagram is in Figure 7.

1. Exterior Casing

The earthen pot exterior has a capacity of 15 litres. A requirement for efficient fluoride removal is that the contact time of raw water with the filtration material is at least 20 minutes. In order that this is maintained, it is necessary that the water column is as long as possible. In our case, we have designed a water column of length 24 cm. Traditional pots are more round in shape

broader base and would be less suited for this purpose. Hence one would need a more elongated or taller shape as we have made.

The earthen pot exteriors are now prepared by potters located in Meghnagar town of Jhabua district who have been trained by INREM for this purpose.

2. Micro-filter

Roughly, the raw high-Fluoride water has to be in contact for about 20 minutes with AA. Given our design, this comes to about 10 litres/hour of flow. Keep a factor of safety, we have designed a micro-filter which can release water at a rate of 8 litres/hour. This micro-filter has been designed by INREM and mould has been prepared by Brahma Industries, Ahmedabad.

The schematic diagram of micro-filter is shown in Figure 7. There are two main design aspects of this micro-filter:

a) To disallow AA particles of size 0.4 mm to 1.2 mm into the micro-filter. Taking into account small probability of tinier particles, we have kept this slit size at 0.2 mm.
b) Secondly, the orifice diameter of the micro-filter is kept such that the filter-flow at around 8 litres /hour. After experiments, this was arrived to between 1-1.5 mm. We have kept this orifice diameter at 1 mm size.
c) Thirdly, in between the slits the hood is made downward angular to avoid deposition of AA at the slits during the flow of water. This will not block the flow of water from the micro filter.

3. Fluoride Removal

We are utilizing high grade Activated Alumina (AA) for Fluoride removal. Currently this material is manufactured by Siddhartha Industries, Surat. The quantity of AA in a filter will depend on (i) fluoride content in water, (ii) adsorbing capacity of AA, and (iii) how much quantity of water to be filtered in a specified time period.

That is, if A = Adsorption Capacity in mg/kg of AA

M = Quantity of AA in kg

C = Concentration of fluoride in mg/litre

D = Daily water use in litre/day

Then, N = A*M/C*D, where N is the number of days that AA will work properly.

For the average Fluoride levels that we encounter in Jhabua (4 mg/l – 8 mg/l) and replacement time for AA as 5-6 months, we have set the amount of AA within the filter as 3 kgs. After N number of days, i.e. 5-6 months, either same AA can be regenerated using Caustic soda and Sulphuric acid, or a new pack of 3-kg AA can replaced. The procedure for regeneration is documented in text and video/photo form by INREM in a separate documentation.

4. Bacteria removal

Since we find that bacterial contamination is prevalent even for water from handpumps, there is need for bacteria removal filter. Also, there is a possibility of a bacterial bio-film getting formed (layered) on AA crystals or granules. So we need to pre-filter the raw water for bacterial content. For this purpose, we are using Zero-B Surakhsha resin filter manufactured by Ion Exchange, Mumbai. We are fitting it at the bottom of a funnel mouth which is placed on top of the upper compartment of the filter. Using Zero-B does not remove bacterial loading completely. Other options for such bacterial removal will slow down the filtration process even more and make it infeasible for users, so we are currently using this technology. But our search for an alternative continues.

5. Other parts

Apart from the above, we have an iron tripod stand (if required) for the filter, a perforated plastic lid cover for the upper layer of AA granules inside the earthen container to allow uniform spread of input raw water over AA bed and a funnel for Zero-B at the top.

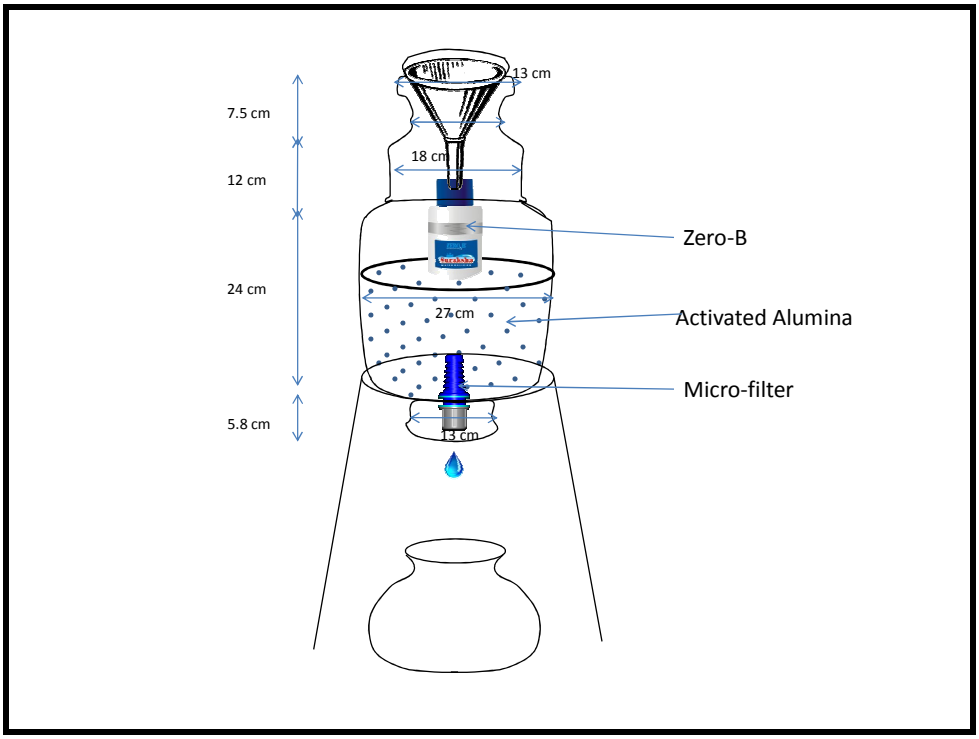
The following table summarizes the above:

Table 19: Components of fluoride removal filter

Sr no.	Part name	No. of units	Made by
1	Earthen pot	1	Potters in Meghnagar, Jhabua
2	Activated Alumina	3 kgs (we recommend 2 such sets at the beginning)	Supplied by Siddhartha Industries, Surat
3	Micro-filter	1	INREM Foundation
4	Bacteria removal resin filter	1	Ion Exchange, Mumbai

Figure 6: Final product of INREM's filter on location in Jhabua

Figure 7 : Schematic design diagram of INREM's filter



ii) Nutrition supplementation

The Fluorosis of the kind observed in Jhabua is closely linked to the condition of malnutrition there. Especially as our studies show, juvenile fluorosis and Osteoporosis is due to a combined effect of low Calcium and high Fluoride intake. As recommended by medical specialists, enhancing certain nutrition can develop resistance to fluorosis and also remove fluoride from the body to some extent. We follow a combination of pharma supplements, food supplements and herbal products to provide Calcium, Magnesium and Vitamin C to fluorosis patients.

The situational background requires us to tackle the problem from many angles. In the longer term, food habits need to converge towards a more nutritious diet, but this is not possible unless the market supplies it and people can afford it. Since, to some extent, entry of fluoride in food cannot be avoided, we must look at ways of countering it within the body. Also prevention of disease should be of prime importance, eg., focusing on proper food for infants and their mothers

so that juvenile fluorosis and pregnancy related fluorosis is avoided. We look at three approaches:

a) Pharma supplements
b) Food and herbal/Ayurvedic supplements
c) Fortification of food

1. Our experiences

Within INREM's fluorosis mitigation programme in Jhabua, all of the following approaches have been tried. We list them here:

a) Til Chikki

Sesame (*Til*) and Jaggery (*Gur*) are very good sources of Calcium and Magnesium. Sesame has 1000 mg Calcium and 360 mg Magnesium per 100 g, whereas Jaggery has 1638 mg Calcium per 100 g. From our calculations, one *Til-Chikki* (Sesame and Jaggery) or a *Laddu* of weight 20 gms, provides 237 mg of Calcium and 32 mg of Magnesium and overall 282 Calories of energy. Especially in the winter season, this is easier to store and consume. We have provided one such *Chikki* per day to our patients for 3 winter months. This has been a very successful effort in our work, but the problem of delivery remains. It is hard to restrict the consumption to patients only and that too ask them to keep the savouries intact till the next time of delivery.

b) Calcium-Magnesium tablets

In order that a basic minimum amount of Calcium and Magnesium is consumed by patients, we recommend pharma-supplements for these. The combination that we provide has content per tablet: Calcium (210 mg elemental), Magnesium (100 mg elemental), Zinc (4 mg elemental), Vitamin D3 (200 I. U.). The advantage of providing these tablets has been that they are easy to deliver and we can be sure that it is being consumed by the patient only. Currently we advise usage of this supplement for 2 years.

c) Dried Amla (Gooseberry)

One of the highest sources of Vitamin C is Amla (Indian Gooseberry). It has 700 mg per 100 g of fruit pulp. However availability is only for 2-3 months a year from December to March. There are many traditional methods of storing Amla for year-around use. Drying in shade, pickles, *Morabba* are some common methods. We have tried dried form of Amla in Salted and Sweet form. The sweet candy form generally is useful for immediate consumption and attracting people towards this. The salted form can be consumed directly or within *Dal*.

The salted Amla we provide are of 1-2 gms size. Generally a few of them are used within *Dal.* Or calculations show that one such piece of 1 gm weight contains around 20 mg of Vitamin C.

d) Soya items

Though there is high Soya production in Jhabua, there is no consumption of Soya as food. However Soyabean oil is used for cooking purposes. Also, textured Soy chunks, also known as textured vegetable protein, locally known as *Vadi* is liked by people due to its texture similar to meat. However, people are mostly not aware that it is made from Soya. Often households have several quintals of Soya production, but they sell it entirely to the market.

We requested farmers to keep aside 5-10 kgs, and collected around 100 kgs in 2011-12 season. Using these, we have prepared a Soya Laddu/Chikki/Sukhdi using collected Soya, groundnut and Ghee. Families have been trained to prepare this and response has been very good.

e) Amla tablets

When we look at practicality of delivery, storage and acceptance by people, then in the short term, what interests people are "tablets" *(goli)* or the faith people seem to have in them. With Amla, the sweet is immediately consumed by people and perceived as a savoury. The salted form gets distributed at a family level and some families complain that the taste that it adds to Dal makes it salty. We then thought of Amla powder and along with an Ayurvedic doctor of Anand, Gujarat realized that Amla powder can be made into tablets. Each tablet of 750 mg contains roughly 7 mg of Vitamin C.

f) Cassia Tora

Cassia Tora is a monsoonal plant widely prevalent in the rain-fed areas. It is known as Puvadia, Kuvadia, Chakora locally and as Chakra Mardha in Ayurveda. Chakram Mardha seeds are used in Ayurveda for skin ailments.

The Cassia Tora leaves were first identified by Dr Tapas Chakma as being very high in Calcium content and also containing essential minerals for bone development. INREM took this up since Cassia Tora is available in Jhabua during the monsoon and people consume the tender leaves as a *Bhaaji*. But there is no drying and storage done since the leaves turn dark green and toxic soon after the monsoon.

One option which INREM followed was to cold-dry the leaves. This was done using a process called lyophilization at a factory in Vadodara. Though expensive, it allowed testing this concept for a year. Around 250 kgs were collected overall and roughly 35 kgs of dried powder were obtained.

This dried powder contains around 4000 mg of Calcium, 350 mg of Magnesium, 100 mg of Vitamin C and 25% Proteins. The powder is now being given to patients in two ways – first by mixing it with Jaggery and dried Ginger into small Laddus for the

winter and second, as a ready-mix Masala by adding other contents such as Dhania seeds, Jeera and Ajwain.

g) Ayurvedic sources

We are also currently looking at Ayurvedic sources of nutrients and combinations that help in better assimilation. One such combination is that of a neutralizing mixture of *Yashtimadhu, Ushir, Rakta Punarnava, Gokhru, Prabal and Moti*. The effectiveness of this combination to detoxify fluoride from the body is currently under observation.

Table 20: Different types of nutritional interventions

Nutritional Intervention	**Type of Supplement**	**Dosage and frequency**
Calcium, Magnesium, Vitamin D3 and Zinc Tablets	Pharma Supplement	1 tablet per day providing 210 mg Calcium, 100 mg Magnesium, 200 I. U. Vitamin D3 and 4 mg Zinc
Amla tablets	Dried fruit extract in tablet form	1 tablet per day providing 20 mg of Vitamin C
Til Chikki	Food Savoury	1 per day in Winter; 237 mg of Calcium and 32 mg of Magnesium for 20 g piece
Soya Chikki	Food Savory	Significant source of Proteins, Calcium and Magnesium; not estimated yet
Amla (dried)	Dried fruit	20 mg of Vitamin C in 1 g piece
Cassia Tora powder	Dried leaves	Roughly 5 g/day of dried powder providing 200 mg of Calcium, 20 mg of Magnesium, 5 mg of Vitamin C and 2 g of Proteins
Neutralizing mixture	Ayurvedic	Mixture enabling detoxification of fluoride and absorption of Calcium

Figure 8: Nutrition supplements (pharma and food based) being used currently

f. Improvement in Health and the Impact of intervention

The effort from INREM's side has been to connect in the people's minds that the problems they see in children are as a result of drinking unsafe water and nutrient-deficient food. This can be hard to communicate since fluoride cannot be tasted in water. Also, the fact is that fluorosis symptoms have a long gestation time and many symptoms are not reversible. These factors make the communication aspect of such interventions very difficult and therefore the sustainability of such efforts is poor.

It is important to remember that the positive benefits of safe water and good nutrition on health have to be therefore emphasized. Simple tools such as field kits are useful for demonstrating that different source of water have different properties. However, linking this to their problem is another task which takes a longer time. To some extent, INREM's efforts have borne fruit with

people coining terms such as "*Langda paani"* (water causing crippleness) and refraining from using such water for drinking. But as far as taking ideas to larger number of people, there is still much to be done. Since health problems such as fluorosis are to a great extent "socially determined", there solutions also lie in society.

Nevertheless, the good news is that many indicators of improvement in health of the patients are coming out of INREM's fluorosis mitigation programme. Currently the programme has patients from 4 villages with 47 families having filters and 120 patients getting benefits of nutrition supplementation.

The most remarkable change amongst all affected children has been the case of three children of Jasoda Khunji village. These children are part of the mitigation programme. Their families use the fluoride removal filter and the children are part of the nutritional mitigation programme since March 2011. As Figure 9 shows, visually these children show significant changes in bone deformities. The manner of sitting, walking and running has also improved. The x-rays of these children analyzed after a gap of 1 year show improvements in bone density and bowing of legs.

Similar such observations are being seen for many other children too. Our experience shows that especially for small children, starting them on a programme of safe water and nutritional supplementation can save them becoming crippled. Also since they are growing, there is opportunity to revert back some of the bone deformities. This might not be possible for all patients, but we need to try this approach for all such affected children before it is too late. The message should be "Start early and get rid of Fluorosis".

Figure 9: Changes in bone deformities for three children

Nilesh of Jashoda Khumji - Dec 2010

Nilesh of Jashoda Khumji - Dec 2010

Nilesh of Jashoda Khumji - Dec 2010

Nilesh of Jashoda Khumji – Dec-2012

Prabhu of Jashoda Khumji - Dec 2010

Prabhu of Jashoda Khumji - Dec 2012

Deepak of Jashoda Khumji - Dec 2010

Deepak of Jashoda Khumji - Dec 2012

December 2010

Prabhu Deepak Nilesh

December 2012

Epilogue

In India much of ill-health of humans can be traced to lack of safe drinking water and sanitation and hence water should be easily accessible, free from contamination and readily available to the population throughout the year. In 1980, the United Nations General Assembly launched the International drinking water supply and sanitation decade, 1981-1990. Its aim was to provide all people with adequate supplies of safe water and sanitation by the year 1990. In 1981, the 34th World Health assembly in a resolution emphasized that safe drinking water is a basic element of 'primary health care' which is the key to the attainment of 'Health for all by the year 2000 AD'. Hence providing safe drinking water was the duty of the governments around the world including India but they failed to achieve the goal of providing safe water to all by that date. All the governments have been trying to meet the challenges of the Millennium Development Goals by 2015 to halve the population without access to safe drinking water and they hope to achieve the goal of providing safe water to all much later. Water is essential for human survival and also for the flora and fauna on this earth. The difficulties of providing safe water to all are obvious.

There has been phenomenal increase in world population which increased from 1.5 billion at the beginning of 20th century to over 7 billion now and this adds to the burden of providing safe water to all. The earth's water reserves are abundant but paradoxically the sources of surface water are scanty for the needs of growing population. The earth has more than 1400 million Km^3 of water of which 97.25% are in the form of oceans and seas which is not fit for human consumption. Fresh water reserves are only 2.75% of total reserves of water on this planet but 75% of fresh water is trapped in glaciers as well as in ice and 24.5% of it is underground. Surface water which can be used for drinking represents only 13500 km^3 or one-hundred-thousandth of earth's water reserves.

All the urban areas in India are much better off in providing safe water in these areas since major cities get their water from perennial rivers whereas 90% of rural population is dependent on ground water. The water from perennial rivers has got optimum amount of fluoride whereas 50% of ground waters have excess amounts of fluorides. This is the reason for spread of fluorosis to 275 districts in the country affecting 66 million Indians and crippling 6 million of them. It has been estimated that 40 liters of water is the minimal requirement for each individual per day

though this amount is not ideal and average of two liters is required for drinking water purposes and another one liter is necessary for cooking needs.

One of the main causes of fluorosis to humans in endemic areas is due to excessive amount of fluoride which comes from water and from food which is cooked with water containing high amounts of fluoride. Hence it is very essential that there must be a method to provide the people in endemic areas with the provision for three liters of safe water to every individual to lessen the amount of fluoride intake. It is shocking to know that 360 million gallons of good Krishna and Manjira water is supplied to 4.5 million citizens of Greater Hyderabad city whereas 50 kilometers away from the city in neighboring Nalgonda district where people suffer from fluorosis because they do not get good water for drinking and cooking. The citizens of Hyderabad do not need good water for their toilets, gardens and washing clothes etc. All the methods of providing good water to rural population in endemic areas of fluorosis have failed. Most families spend hundreds of rupees per month buying water from private bodies without any control over the quality of water and their content of fluoride. Not all the people can afford to buy so called bottled water even and hence it is the duty of the government to provide safe water for cooking and drinking. Till such time the government provides safe water, at least part of the problem can be overcome by collecting surface water from tanks and shallow wells which have optimum amounts of fluoride but may be bacteriologically impure and this can safely be used for drinking purposes after boiling.

Within all the malaise that surrounds fluorosis, we also see some hope. If it is high fluoride water as well as Calcium deficiency which together aggravate fluorosis, then we also have a twin handle to approach the problem. Since fluorosis takes time to gestate, it also offers us opportunity to detect it at an early stage and thereby, prevent further aggravation.

There are many ways to arrange for safe water free from fluoride and also to adjust one's food habits (within reasonable affordability) to enhance nutritional intake. Within some limits, achieving these partly is a matter of choice and alignment of priorities in life. Health, and especially preventive health, however, is a matter of low priority, irrespective of education and awareness levels or economic status.

How can we assign a high priority for such a problem before it gets too late? How can we connect the early signals and alert people to the possible future consequences? After all, why would people act strongly unless they make this connection, and unfortunately by the time they realize, it often gets too late?

For all those who know about the disease, it is therefore a prime challenge on how to communicate about it widely. The best messengers of the disease, namely the doctors, are the first who need to be developed to tackle it. Only through doctors can the larger public be continuously reminded of early signals and ways to prevent further progress of disease.

Most importantly, the government through its various arms can play very important roles. Using existing health and nutrition delivery arms, and improving water supply, much progress can be made. Till now much of the efforts have been about water supply in fluoride affected areas, however the sustainability of water supply efforts have been poor overall with "slippage" of situation back to previous situation being very high. The poor sustainability has been linked to problems related to finance of such projects and also low people's participation. This again brings back the question of choice and priority given by people in matter of safe water.

Definitely, there is much to be done in terms of better communication of fluorosis aiming at positively reinforcing good behavior patterns for accessing safe water and improved nutrition. Going ahead, the message from experiences at Dirisivancha and Jhabua would be useful to all media – public and private health practices; civil society and NGOs; various government programmes to bring out the message that fluorosis can be prevented and acting in the early stages can help in arresting further progress of the disease.

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INREM Foundation is a group of professionals involved in action, research, and education for promoting sustainable management of water to achieve an improved quality of life and environment. In this process, we wish to enable a vibrant atmosphere of open creation and sharing of knowledge that permeates all sections of society. India Natural Resources Economics and Management (INREM) Foundation is based in Anand, Gujarat, India. The Foundation is registered under the Societies Act, 1860 and Bombay Public Trust Act, 1950.

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