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Fluorosis Management Programme in India: The Impact of Networking between Health and Rural Drinking Water Supply Implementing Agencies

A.K. Susheela
Fluorosis Research and Rural Development Foundation, New Delhi-110 016

Abstract

India is one among the 23 nations around the globe, where the people have serious health problems due to consuming fluoride contaminated drinking water. An estimated 62 million people in India in 16 states out of the 32 are affected with dental, skeletal and non-skeletal forms of fluorosis and associated health complaints. Even children of the age of 8-10 years, have been crippled due to consumption of high fluoride contaminated water. The extent of contamination of drinking water with fluoride vary between 1.5 - 48.0 mg/l. The malnourished women, after couple of parturition (child birth) are particularly vulnerable to the health risks.

To tackle the problem effectively, an innovative approach has been adopted. Networking between Public Health Engineering, Health sector personnel besides nutrition experts of the various endemic states, and phasing out the activities with well defined objectives for implementation, resulted in a multidisciplinary approach, with the main goal to provide safe/defluoridated water, preventing fluorosis and improving the health status of the community through interventions.

The information arising from research and development activities on fluorosis patients, are translated into well defined modules for clinicians to be able to use it in their out-patient departments while screening the patients. This is essentially required as the health complaints due to fluoride are often overlapping with manifestations of other diseases and mislead to treating the patient wrongly.

This communication focuses the importance of such clinical modules for preventing the disease. Early detection besides providing defluoridated / safe water and nutritional interventions on a sustainable basis for management of the disease is highlighted.

In the Fluorosis Management Programme, the major thrust is on awareness generation among professionals, developing information, education, communication packages, community involvement, and location-specific strategy for opting the technology for fluoride removal / other approaches for providing safe water and consuming calcium, vitamin C and other antioxidant rich diet on a sustainable basis.

Invited lecture

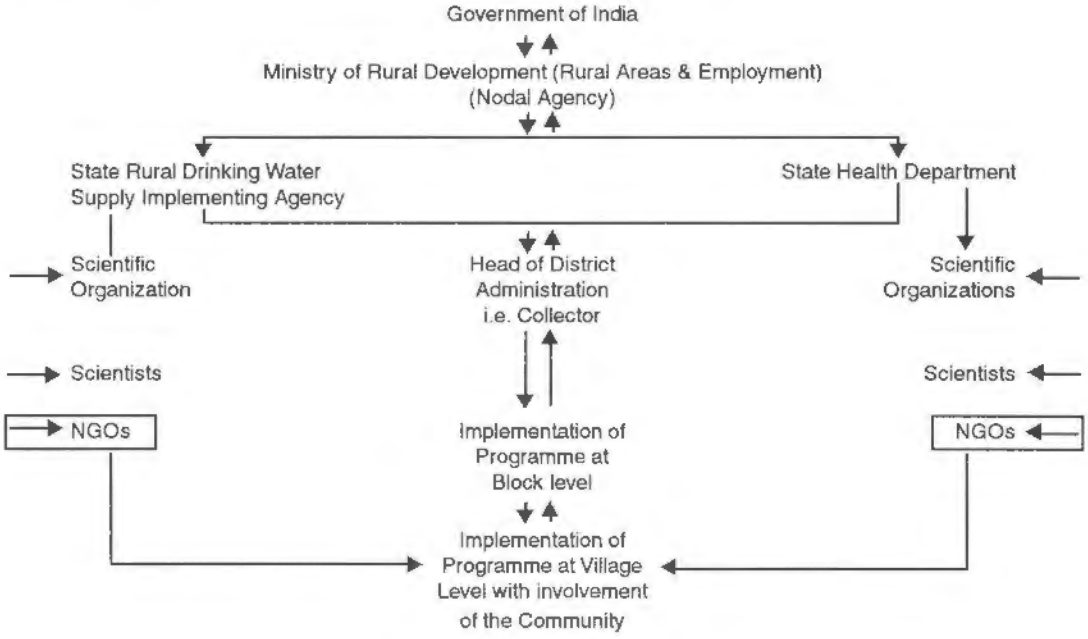
Introdction

In India an estimated 62 million population which includes 6 million children have serious health problems due to consuming fluoride contaminated water. Fluorosis a well defined clinical entity although identified as early as 1937,[1] a programme for controlling the disease, through networking between rural drinking water supply implementing agencies and health departments came into existence in India during 1986-87. Ministry of Rural Development (subsequently renamed as Ministry of Rural Areas and Employment), the nodal Ministry under the Government of India, drew-up the policies and action plan, after several rounds of in-depth discussion with (1) leading scientists / scientific organizations in the country, (2) Rural drinking water supply implementing agencies and (3) Health department officials both in the central and state governments. The policies and plans evolved had the inputs from those who administered the districts, which was then looking after the needs and requirements of the village community.

Basic Plan

India, had the unique advantage, when the National Drinking Water Mission was launched during 1986-87, to formulate a submission on "Control of Fluorosis", as there was substantial scientific data emerged from the country over a period of 5 decades through research and development activities, supported by central and state Governments besides International funding agencies.[2] The data that was then available on fluoride removal technologies, indigenously developed was identified for large scale field operations and testing. Water quality testing laboratories were strengthened in terms of infrastructure and capacity building of the personnel, so that sustainability of safe water is ensured.

Fluorosis Control Programme in India



An Overview of Networking

As Fluorosis can be easily prevented through appropriate interventions, provided the disease is diagnosed at the very early stages, a protocol was designed, developed and field tested for use in rural areas which is presently used very widely in the country.[3,4]

Yet another basic issue that was dealt with is (1) awareness-cum-update for doctors, dentists and public health engineers on all aspects of fluoride action on body tissues, fluorosis and its prevention. Besides, emphasis was laid on provision of safe water. The options available are incorporated into the training module viz. (1) providing safe water through existing safe water sources or (2) bringing water from a distance if economically viable or (3) making use of rain water (rain water harvesting) if rain fall is adequate or (4) chemical treatment. The two major technologies that have been indigenously developed for fluoride removal from water are:

- Nalgonda technology using lime & alum
- Activated alumina technology which has undergone several innovations through R&D during the last one decade has resulted in developing a domestic filter.[5,6]

The above two technologies have been scaled-up for use in (1) Community plants (2) Hand pump attached versions and (3) Domestic fillers.

The last and the most important aspect in the National programme on "Control of Fluorosis" was sensitizing grassroot level functionaries and bringing out appropriate IEC (Information, Education, Communication) material on the disease and all aspects dealing with its prevention for operationalising the action plans.

Field Operations

As the disease is quite widespread in 16 States of the 32 States and Union Territories of the Indian Republic, adequate precautions had to be introduced for carrying out meaningful activities involving the community in shorter span of time, with judicious use of funds.

How to Identify a Village Whether it is Endemic for Fluorosis or Not?

There are two options available:

- The first option is to test drinking water quality with focus on fluoride of 100 percent sources which includes ground and surface water sources. Although it is a time consuming exercise and involves enormous expenditure, in many districts such activities have been carried out. The data reported in Table 1a and 1b reveal the nature of the activities and the data generated.
- The second option is to short-list villages through Dental Fluorosis Survey in School children of the age 8 years and above and locate endemicity for fluorosis. The villages short-listed were then taken-up for water quality testing (Table 2).

The latter approach is preferred as it saves time, energy and funds.

Table 1a. Drinking water fluoride levels in 3 blocks in the state of Andhra Pradesh[12]

S. No.	*Block*	*No. of water samples tested*	*Sources with Fluoride within safe limits*	*Contaminated source*	*Fluoride ranges mg/litre*
1.	Thamballapally	100*	65	35	1.6 - 3.3
2.	Medak	121*	54	67	1.6 - 6.5
3.	Nadigama	168*	53	115	1.6 - 7.1

*Hand pump, bore well, open well

Table 1b. Information on water fluoride level in 14 blocks of Dindigal district in Tamil Nadu

S. No.	*Name of the Black*	*No. of Panchayats*	*Population*	*No. of Villages*	*No. of water samples tested/existing*	*Water sources contaminated with fluoride*				*Population at risk*
						1.0-2.0 mg/l	*2.1-3.0 mg/l*	*3.1-4.0 mg/l*	*4.1+ mg/l*	
1.	Kodaikanal	12	44322	65	85/85	None	None	None	None	None
2.	Oddan Chathram	31	84369	144	165/165	None	None	None	None	None
3.	Athoor	25	135673	82	85/85	3	None	None	None	18587 at risk (13.7%)
4.	Nillakkottai	10	44283	56	43/69	17	1	None	None	30068 at risk (67.9%)
5.	Bhatlakundu	11	51468	39	74/74	30	10	1	1	29130 at risk (56.6%)
6.	Dindigal	15	89452	100	118/118	39	9	2	2	69504 at risk (77.7%)
7.	Vadi Madurai	17	72908	151	206/206	59	21	3	1	44911 at risk (61.6.7%)
8.	Shanarpatty	21	93471	121	153/153	69	29	3	2	59821 at risk (64%)
9.	Natham	21	84759	138	179/179	78	23	2	1	72892 at risk (86%)
10.	Reddiarchathram	22	98626	128	180/180	78	69	18	4	98626 at risk (100%)
11.	Palani	14	38675	52	71/71	16	2	None	None	29276 at risk (75.7%)
12.	ThoppanamPatty	23	71698	108	147/147	40	7	2	1	44811 at risk (62.5%)
13.	Gujiliamparai	8	32386	55	65/65	29	3	None	None	22799 at risk (70.4%)
14.	Vedasandur	13	36423	105	140/140	59	4	1	None	31651 at risk (86.9%)
	TOTAL	243	978513	1344	1711/1737	517	178	32	12	5646022 at risk (57.7%)
						(30.2%)	(10.4%)	(1.9%)	(0.7%)	

Source : Gandhigram Rural University Report to the Government of India Ministry of Environment and Forests: 1991

Table 2. Dental fluorosis survey data in school children from all the 18 sistricts of Gujarat state[9]

S. No.	Name of the district	No. of Schools surveyed	No of Students examined in the schools (8 years and above)			No. of students with D.F.	Percentage affected with D.F.
			Boys	Girls	Total		
1.	Ahmedabad	199	27947	20123	48070	8537	17.75
2.	Gandhinagar	29	4436	4023	8459	967	11.43
3.	Mehsana	415	62322	38912	101234	25307	24.9
4.	Banaskantha	367	36463	20925	57388	10032	17.78
5.	Sabarkantha	278	21000	18405	39405	5728	14.5
6.	Baroda	240	13826	11825	25651	4329	16.87
7.	Kheda	210	24064	19219	43283	5266	12.16
8.	Panchmahal	311	34603	25729	60332	5207	8.4
9.	Bharuch	42	4781	4459	9240	1378	14.9
10.	Surat	19	1697	1581	3278	260	7.9
11.	Valsad	14	1939	1889	3828	101	2.6
12.	Junagadh	50	7075	5314	12389	4097	33
13.	Amreli	75	9159	7975	17134	2855	16.6
14.	Surendranagar	71	7442	6010	13452	2961	22
15.	Jamnagar	28	3070	2316	5386	838	15.5
16.	Bhavnagar	77	10667	8472	19139	2714	14.1
17.	Rajkot	44	6065	7320	13385	1971	14.7
18.	Kutchch	13	1599	1561	3160	640	20.25
Total		**2482**	**276155**	**206058**	**484213**	**83188**	**% Range: 7.9 - 24.9**

D.F = Dental Fluorosis Source of Information: Gujarat Health Department - 1996 - 99.

Responsibilities of the Health Department

To carry out a bench-mark health survey assessing the magnitude of the health problem due to fluorosis. A house-to-house survey is preferred, instead of camp based, to cover 100% population of the village. While carrying out the survey, the three forms of Fluorosis viz., Dental Fluorosis, Skeletal Fluorosis and Non-skeletal Fluorosis were identified separately. Among the Non-skeletal Fluorosis, significance was attached to early warning signs of fluoride toxicity manifestations viz., non-ulcer dyspeptic complaints and other clinical manifestations (details provided in the module developed for clinicians for use in out-patient's clinics). Early warning signs are the most important complaints / manifestations that the community ought to know as it is those complaints which disappear when interventions are introduced.[4,7] The bench mark health survey results of Kurnool District in the State of Andhra Pradesh reveals the prevalence of the 3 forms of Fluorosis (Table 3).

Table 3. Prevalence of the various forms of Fluorosis in Kurnool District of Andhra Pradesh

Total population surveyed	*Population affected with Dental Fluorosis*	*Population affected with Skeletal Fluorosis*	*Population affected with Non-Skeletal Fluorosis*	*Disease manifestations in Total*	*Percentage affected*
1491791	43927	8833	30400	83160	5.6

Survey data emerged since launching of the Technology Mission Activity

Responsibilities of the Rural Drinking Water Supply Implementing Agencies

To carry out water quality testing with focus on fluoride, Total Dissolved Solids (TDS), Hardness, Alkalinity, Sulphate (SO_4) and other parameters and to decide a strategy for provision of safe water is the responsibility of the agency. The data thus generated by water quality testing of 100% sources are further classified into 4 categories based on fluoride level.

Category I : Water sources having fluoride level 1.0 mg/litre or below (considered as safe sources)

Category II : Water sources have fluoride level raging from 1.1-2.0 mg/litre (marginally high fluoride level)

Category III : Water sources having fluoride level ranging from 2.1 - 5.0 mg/litre (high risk sources)

Category IV : Water sources having fluoride level ranging from 5.1 mg/litre and above (extremely high risk sources)

The practice earlier followed of testing of 10 - 15% raw water sources and implementation strategy based on the data emerged for erecting defluoridation plants has become an event of the past. Instead, 100% sources to be tested for water quality has been made mandatory before any decision is taken for provision of safe water. Data generated through Health and Rural Water Supply Implementing Agencies (RWSIA) are correlated to view the issues in its totality viz.,

- The total population in a village dependent on category I or II or III or IV of the water sources are identified.
- The prevalence of Dental, Skeletal and Non-skeletal Fluorosis in the population of the villages categorized (I to IV) are ascertained.
- To prioritize the villages for provision of safe water. Category IV villages would however, be the first priority
- Category III villages would follow as the second priority and RWSIA would commence its activities.
- However, in category II and category I villages, epidemiological survey data, is scrutinized and if fluorosis is prevalent, those households are identified and

they are diverted to the existing safe sources of water in the village (through appropriate labeling of the sources. The contaminated sources are marked unfit for consumption; but can be used for other purposes.[8]

Interventions for Prevention of Fluorosis

Provision of sustained supply of (1) Safe water (2) Nutritional interventions are being practiced in India, for preventing fluorosis.

Safe Water Intervention: Depending upon (1) the raw water quality, (2) the geohydrology, (3) geomorphology, (4) topography / terrain, (5) population / community to be catered to and (6) annual rainfall pattern, the plan of action which is area specific, is drawn-up and implemented for providing a sustainable source of safe water.

Nutritional Intervention: Presently nutritional intervention is being practiced with patients who are fluorosed and seek hospital intervention. Nutritional intervention requires counselling of the patients and educate the female members of the households who are responsible for cooking and serving food for the family. They are educated on the locally grown / available food / or agriculture crops which are high in calcium, vitamin C and other anti-oxidants which need to be consumed on a daily basis through breakfast, lunch and dinner.

The fluoride levels in blood, urine and drinking water are monitored for a period of 3-6 months when the complaints due to Non-skeletal Fluorosis, gradually disappear, providing great relief to the patient. They would then continue the dietary regime which they have practiced and continue to consume safe water which prevents the disease and the individuals begin to enjoy better health..

The Module Specially Developed for Early Detection of Fluorosis for Use in Out Patient Clinics in a Hospital

If a Patient has complaints related to:

- Aches and pain in the joints viz. neck, back, hip, shoulder and knee joint without visihle signs of fluid accumulation, suspect fluoride toxicity manifestations besides other reasons.
- Non-ulcer dyspeptic complains viz., nausea, feeling of vomiting, pain in the stomach, bloated feeling / gas formation in the stomach, constipation followed by diarrhea, suspect fluoride toxicity manifestations besides other reasons as fluoride destroys the lining mucosa of the gastro-intestinal system.
- Polyurea (tendency to urinate more frequently, although volume of urine may be low) and polydipsia (excessive thirst) suspect fluoride toxicity manifestations besides diabetes.
- Muscle weakness, loss of energy, anemia with very low hemoglobin levels (6-8 gm%) suspect fluoride toxicity besides other reasons as fluoride is known to destroy skeletal muscle, and red blood cells.

- Complaints of repeated abortions / still birth, suspect fluoride toxicity besides other reasons as fluoride is known to harden / calcify blood vessels and blood flow to the growing foetus is hampered.
- Complaints of male infertility, with abnormality in sperm morphology and low testosterone levels,[9] suspect fluoride toxicity, besides other reasons.

If situations of the above nature arise, it is necessary to test the fluoride content in blood (serum), urine and drinking water of the patient for correct diagnosis of the disease.[7]

Major Problems in Achieving the Desired Results in Controlling Fluorosis

- Due to widespread occurance of fluoride in the earths' crust fluorosis and related diseases are on the increase.
- The professionals, viz., Health Professionals including Dentists and Public Health Engineers are not fully aware of the disease characteristics and its ramifications and therefore, extensive up-dates are called for in Medical and Dental Schools.
- Networking between two major Departments i.e. Health and Public Health Engineering Departments, is a new approach and the professionals are not used to the new work culture.
- Monitoring of the quality of the water and its sustainability rests on Public Health Engineers and the Health Professionals are now being inducted to surveillance activities (i.e external auditing)
- Although adequate steps are taken to educate the community to ensure their inputs and their participation for sustaining the endeavor, the expectations of the community from the Government far outweighs and maintenance of the hardware structures on the ground are neglected by the community.
- Substantial amount of funds are required to provide drinking water to the desired extend to the rural community in 16 States which are fluoride contaminated. Government funds and bilateral agency contributions need to be enchanced considerably.
- The project mode operations which are continuing, require major changes. A village / block as a unit need to be tackled in a holistic manner. Unless such strategies are adopted by the Government / bitateral agenices, Fred Pearce's recent comments (*Guardian*. July 9, July 16, 1998) on UN Agencies sinking boreholes, but never tested the water for its quality, is likely to be repeated as the "system" do not make provision for testing as hard and software activities need to be integrated at the planning stage itself.
- The damaging effect caused by Multinational Corporations promoting fluoridated products (viz., fluoridated toothpaste, mouth rinse, varnish, tablets etc.) in India, in the name of prevention of dental caries, (although Fluoride has very little to offer in prevention of caries), is considerable and is counterproductive. The regulatory agencies both national and international need to con-

sider such issues and set guidelines for MNCs to follow, so that such publicity is not permitted in countries where fluorosis is an enormous public health problem due to natural contamination of drinking water with fluoride.

Fluoride action: Dental Fluorosis vs Dental Caries

The data reported on dental fluorosis and the biochemical reactions taking place, adequately substantiates the need for up-date, so that the out-dated, unscientific concepts on use of fluoride for prevention of caries could be appropriately viewed so that promoting fluoride for prevention of caries arising from UN Agencies (WHO) and MNCs making use of it, could be curbed.

Some of the relevant scientific data on dental fluorosis and dental caries are highlighted in the following pages. Human fluorosed teeth of varying severity analyzed for the 4 major elements are reported in Table 4. It is quite evident that as fluoride accumulates in the teeth, irrespective whether the teeth is central or lateral incisor or premolar or molar, calcium is depleted. Magnesium and phosphate contents do not have appreciable change.

Table 4 . Fluoride, calcium, magnesium and phosphate in human normal an fluorotic teeth of different grades[10]

Teeth	*Fluoride (ppm) & Calcium Phosphate, Magnesium (mg/gm Tooth)*	*Normal Teeth*	*Fluorotic Teeth*		
			Grade I (mild)	*Grade II (moderate)*	*Grade III (severe)*
Central Incisor	Fluoride	402	318	2420	2960
	Calcium	318	302	260	247
	Phosphate	125	128	130	137
	Magnesium	3.3	4.3	4.7	5.1
Lateral Incisor	Fluoride	390	2200	2770	2940
	Calcium	320	290	261	251
	Phosphate	225	116	127	141
	Magnesium	2.9	3.2	3.9	5.0
Premolar	Fluoride	400	2400	3020	3320
	Calcium	320	260	260	240
	Phosphate	125	128	132	134
	Magnesium	4.2	4.0	3.9	4.8
Molar	Fluoride	410	2980	3240	3920
	Calcium	330	280	370	265
	Phosphate	129	130	137	145
	Magnesium	4.8	4.6	4.7	4.3

The investigations on the glycosaminoglycan content and sulphated isomers of normal and fluorosed human teeth have unequivocally provided the evidence to substantiate the fact that dermatan sulphate content is enhanced in fluorosed human teeth (Table 5).

Table 5. Glycosaminoglycan disaccharides[a] and sulphated isomers[b] in fluorosed human teeth

	Control from non-endemic areas (n=3)	*Control from endemic areas (n=3)*	*Fluorosed tooth (n=6)*
Total GAG disaccharides	0.42 ± 0.11	0.61 ± 0.18	0.27 ± 0.12*
Chondroitin-4-sulphate	48.57 ± 4.39	51.57 ± 2.73	41.93 ± 13.26
Dermatan sulphate	10.60 ± 5.63	18.61 ± 6.08	27.37 ± 7.37**
Chondroitin-6-sulphate	40.83 ± 2.44	29.83 ± 3.15	30.72 ± 7.35

*p<0.02 compared to endemic controls

**p<0.05 compared to non-endemic controls

All values are mean ± standard deviation

[a] mg/g dry defatted toothpowder

[b] Relative percentages of isomers

The dermatan sulphate content unlike chondroitin-4-sulphate and chondroitin-6-sulphate, was significantly enhanced in fluorosed human teeth as compared to the controls.[11]

It is now evident that the tooth matrix, when exposed to fluoride, induces dermatan sulphate formation. The site of dermatan sulphate formation gets demineralized and gets pitted and perforated. Rajan and Gnansundaram[10] have provided data on human fluorosed tooth samples revealing reduction in calcium content but not in magnesium and phosphorus contents. Fluoride induces demineralization in the tooth. It is also evident that dermatan sulphate production and accumulation are initiated in fluoride toxicity. These are two highly significant observations which have now dispelled the six decade old concept that "fluoride makes the tooth stronger". It is now known that, on exposure to fluoride, the tooth loses its calcium, besides dermatan sulphate is formed in the tooth matrix, leading to demineralized loci, which are pitted and perforated, enhancing cavity formation. The cavity formation in dental fluorosis is on the surface of the enamel and is distinctly different from the cavity formation in dental caries which begin from lateral sides of the teeth and / or hidden crevices of the teeth which is due to bacteria breeding in unhygienic oral cavity, acids produced and the enamel get etched away leading to cavity formation.

The data provided in Table No. 6 reveal that, even if fluoride content in drinking water is within 0.5 - 0.9 (safe limits) 99% and 88% of the children have dental fluorosis in Salem and Dharmapuri districts, respectively. Fluoride 1.0 to 1.4 mg/litre falls under safe limit of WHO guidelines and the dental fluorosis incidence is 95% and 90% in Salem and Dharmapuri, respectively. When fluoride content in water is as high as 5.0 mg/litre and above, 100% and 97% of DF incidence, respectively have been recorded in the these districts.

Table 6. The correlation of water fluoride levels with Dental Fluorosis incidence in Salem and Dharampuri Districts of Tamil Nadu[10]

	SALEM			DHARMAPURI		
Mg/lt. water fluoride level	*No. of individuals examined*	*No . of individuals having D.F.*	*%*	*No . of individuals examined*	*No . of individuals having D.F.*	*%*
0.5-0.9	383	381	99	472	417	88
1.0-1.4	422	401	95	564	513	90
1.5-1.9	382	372	97	562	555	98
2.0-2.4	274	272	99	435	430	98
2.5-2.9	386	383	99	168	164	97
3.0-3.9	168	166	98.8	361	356	98
3.5-3.9	230	230	100	142	138	97
4.0-4.5	-	-	-	80	76	95
5.0 and above	102	102	100	112	109	97
Total	**2347**	**2307**	**98%**	**2896**	**2758**	**95%**

D.F = Dental Fluorosis

In the same two districts, the incidence of dental caries have been ascertained by Professional Dentists of Madras Dental College in Tamil Nadu and the results are reported in Table 7.

Table 7. Incidence of dental caries in salem and Dharmapuri districts in Tamil Nadu in relation to fluoride content in drinking water[10]

	SALEM			DHARMAPURI		
Fluoride level mg/lt.	*No. of Fluorosed Teeth*	*No. of Caries Teeth*	*%*	*No. of Fluorosed Teeth*	*No. of Caries Teeth*	*%*
0.5. - 0.9	7240	1030	14.23	8054	1620	20.11
1.0 - 1.4	8150	1320	16.20	11161	1728	15.8
1.5 - 1.9	7229	1144	15.83	13858	1850	13.35
2.0 - 2.9	6278	1009	16.07	9493	2754	29.01
2.5 - 2.9	8631	1200	13.90	3231	974	30.15
3.0 - 3.4	3220	914	28.36	7772	1614	20.76
3.5 - 3.9	53366	1064	19.82	2372	579	24.40
5.0 and above	2227	431	19.35	2618	695	26.55
Total	**48341**	**8112**	**16.78**	**58559**	**11814**	**20.27**

The information provided above on the levels of fluoride in drinking water 0.5 - 1.4 mg/litre in Salem and Dharmapuri districts reveal that the number of caries teeth (%) vary from 14 - 16% and 15 -20%, respectively, when water fluoride levels are in the "safe limits". When 2.5 - 2.9 mg/litre of fluoride is present in water, the incidence of caries is 13.9% in Salem and 30.15% in Dharmapuri. Data from other districts on caries also reveal the fact that the presence of fluoride in water do not reveal any beneficial effects, rather it has damaging effect causing demineralization, chipping off the teeth and at a relatively younger age, the individuals become edentulous. Use of fluoride for preventing caries is therefore considered a "myth" rather than science.

The present report on fluorosis management programme in India, is evolved after several years of field operations, incorporating amendments and midcourse corrections at various stages of operations until such time patients of fluorosis truly derived benefit by way of improvement of health.

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