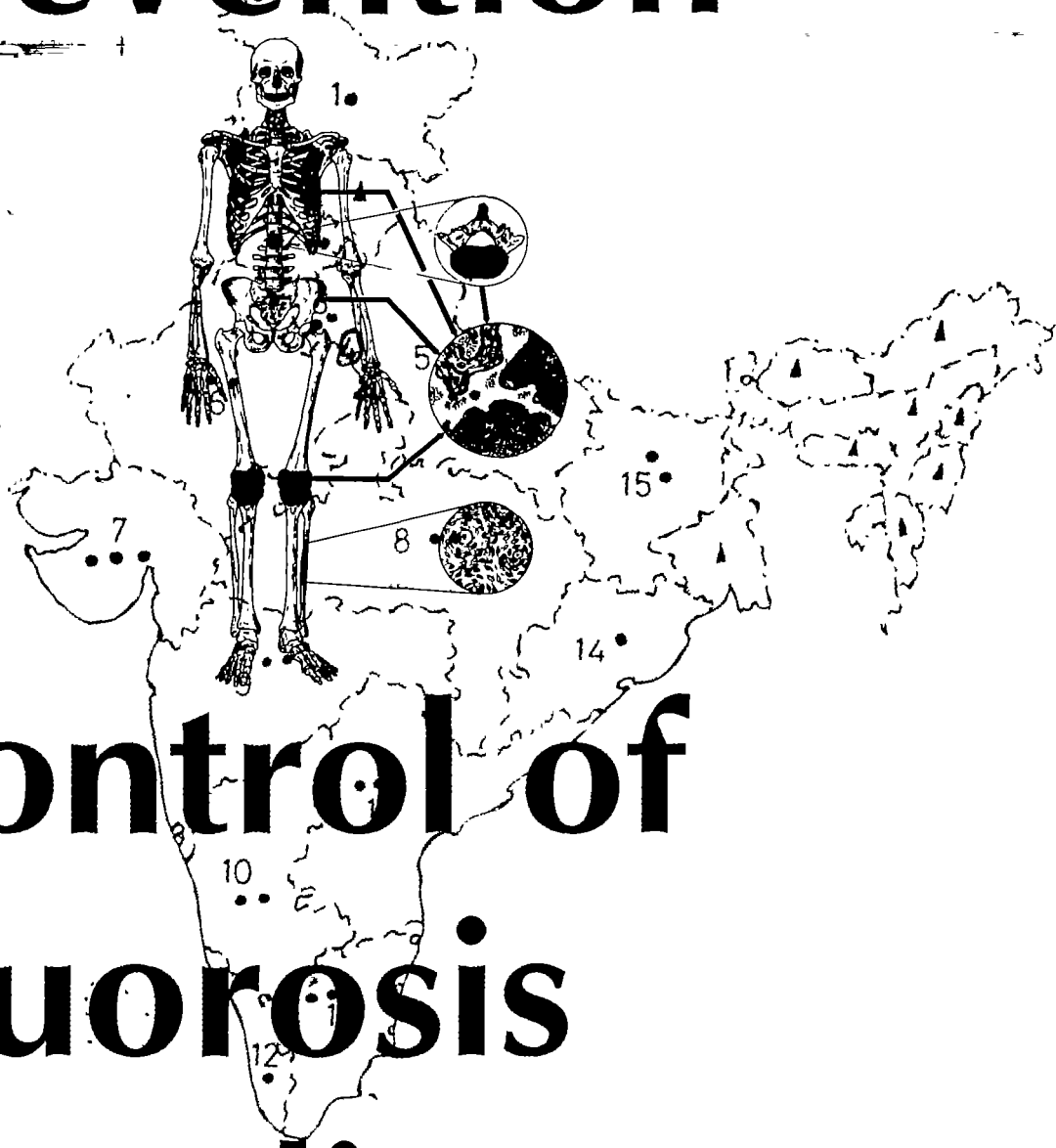


Prevention

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Control of Fluorosis in India



RAJIV GANDHI NATIONAL DRINKING WATER MISSION
NEW DELHI

245.4-11868

PREVENTION AND CONTROL OF FLUOROSIS

HEALTH ASPECTS

Volume I



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**MINISTRY OF RURAL DEVELOPMENT
9TH FLOOR, B-1 BLOCK
PARYAVARAN BHAVAN
C.G.O. COMPLEX
NEW DELHI - 110 003**

1993

Reprinted 1994

B. N. YUGANDHAR

Secretary to The Govt of India



ग्रामीण विकास मंत्रालय

कृषि भवन, नई दिल्ली - 110 001

MINISTRY OF RURAL DEVELOPMENT
KRISHI BHAVAN, NEW DELHI - 110 001

November 9, 1993

FOREWORD

Fluorosis, a crippling disease known to be prevalent in 150 districts in 15 States of India is caused by the intake of water contaminated beyond the tolerable limits of 1.5 ppm and above. The efforts of the Rajiv Gandhi National Drinking Water Mission, through its awareness campaign from 1987 - 1993, coordinated by Fluorosis Control Cell at the All India Institute of Medical Sciences, had a limited coverage.

With the universal access of safe water targeted to be achieved by the end of the Eighth Plan, the Government have thought of a campaign against fluorosis involving all sections of people who can contribute to the success of this campaign. The actual campaign would be in the villages by grass-root level functionaries drawn from various disciplines and department of the Government and voluntary organisations and local Governments. This would involve awareness campaigns followed by a survey of the prevalence of the disease and the quality of water and efforts to provide fluoride free water to prevent its further occurrence or spreading. In order to develop grass - root workers, Trainers are drawn from endemic districts of 15 States and UTs. These trainers will be trained in the five national level Institutes by leading experts in the field of fluorosis.

The present volume which is a companion to the other two volumes viz , **An Introduction to Rural Water Supply and Sanitation Programmes in India and Water Quality and Defluoridation Techniques**, deals in detail with the health aspects of fluorosis. This is to act as a basic reference book from which guidelines can be drawn by the experts and voluntary workers to educate the public about various health aspects of fluorosis. Dr. A. K. Susheela and her team of experts have done a good job of bringing together a lot of information on the subject in one volume. I do hope the States where the fluorosis is prevalent will make use of these volumes and bring out their own adaptations in local languages to bring the knowledge closer to the beneficiary groups.

(B. N. Yugandhar)

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INTRODUCTION

Government of India introduced the "Technology Mission on Safe Drinking Water" during 1986 for providing 'potable water' for people of rural India. The "Water Mission" took cognizance of the problems of drinking water in rural areas. As drinking water is collected from bore-wells, open wells, ponds, rivers and lakes, the contamination with chemicals, living organisms (bacteria, worms, and micro-organisms) and total unawareness of the health problems associated with drinking polluted/contaminated water was wide spread. Facilities for checking drinking water quality in rural areas then either did not exist/ or were not within the easy reach of the common man.

In order to approach the problem(s) in a realistic manner, it was the decision to formulate programmes centered around 'a contaminant/or a specific problem' Keeping in view the above decision, the following Sub-missions were identified :

- Sub-mission on 'Control of Fluorosis'
- Sub-mission on Iron Removal
- Sub-mission on removal of Salinity and Brackishness
- Sub-mission on Guineaworm Eradication
- Sub-mission on Source Finding (Where water scarcity was the main problem)

The details of the Government policies, programmes under Water Mission, Sub-mission are adequately dealt with in the treatise entitled "**Introduction to rural water supply, sanitation and related activities**"

Prevention and control of Fluorosis is being dealt with in the following 2 volumes viz :

Volume I Health Aspects

Volume II A text on Drinking Water Quality and Defluoridation Technologies

These volumes are brought out under the aegis of Rajiv Gandhi National Drinking Water Mission, Government of India.

The Sub-mission "Control of Fluorosis" unlike other Sub-missions is dealing with a serious crippling health problem "Fluorosis", its control and prevention.

The implementation strategies involve the professionals and grass root level workers from both Health and Public Health Engineering Sectors, besides Administrators from State/District/Taluk/and Village level.

The Sub-mission activities commenced in rural areas from April 1987, on a well structured plan of action which is phased out on the following objectives :-

Phase I : To update and create awareness on Fluoride action on body tissues and on the disease 'Fluorosis'. Activities comprises of a 2 day awareness-cum-update camp on all aspects of Fluorosis, diagnostic procedures (Hospital and Field based) and water quality testing and Defluoridation technologies.

Phase II . To conduct a Health and Water Quality survey from house to house in all affected villages, taluks, districts and states.

Phase III : To introduce ameliorative and preventive measures for prevention and control of Fluorosis

The Phase I activity is being conducted for State, District, Taluk & Village level functionaries both from PHED & Health Departments by a group of experts who have several years of experience in field of Fluorosis, Fluoride toxicity, Epidemiological Survey, Water Quality testing and defluoridation procedures.

During the 7th Five Year Plan period, 27 camps (Phase I activity) have been held in 27 districts in the country. The total number of districts which are considered to be endemic for Fluorosis and which are yet to be covered are 150, spread over 15 States.

The Ministry of Rural Development has introduced certain innovative approaches in order to speed-up the activities during the 8th Five Year Plan. One such activity is centered around Human Resource Development in the country. This would ensure that the Government will be able to tackle the problem in a shorter span of time, as and when, the activities are decentralized after ensuring adequate human resource availability.

The 2 companion volumes that are produced, are with a specific objective to train teachers and others for conducting awareness cum update camps at State and District level (Phase I activities) so that the village and community level activities (Phase II & III) are also speeded-up. These efforts are aimed to achieve the overall goals of the Sub-mission, listed below:

GOALS :

1. To provide safe water (with less than 1.5 ppm of Fluoride/or lesser the Fluoride the better, as excess causes health problems.
2. To control and prevent Fluorosis and fluoride toxicity manifestations and promote health in endemic areas for Fluorosis

The treatise entitled (1) Introduction to rural water supply, sanitation and related activities (2) Prevention and control of Fluorosis in India (in 2 volumes) are brought out considering the serious limitations in the text books of Medicine/Dentistry/Public Health/Environmental Engineering and teaching of Life Sciences in Universities. These volumes are providing information of Indian origin. But information from other countries are cited only if found absolutely necessary. It is compiled and edited for use of students, research scholars, teachers, scientists and professionals from diverse Biomedical and Public Health Engineering disciplines, as well as, for NGOs and Governmental organizations.

The various Appendices are providing additional information on methodologies, check list for conducting training programs at the State and District level.

Editor.

PREVENTION AND CONTROL OF FLUOROSIS:8TH FIVE YEAR PLAN APPROACH:

Improvements & amendments proposed

- Information flow to be encouraged from Village, District, State, to Centre and vice versa. Village and District level committees to be formed; committees to meet in each quarter and the status report of the activities both in the health and water sector to be submitted both to the State and the Centre (Fluorosis Control Cell, RGNDWM)
- The exact number of villages and districts affected with excess fluoride problem is yet to be ascertained. The task of water quality analysis of all drinking water sources is already taken up by the State Government under The "Survey of Status of Drinking Water Supply in Rural Habitations. It may have to be reconfirmed with focus on Fluoride
- Regional Water Quality Monitoring and Surveillance Centres (5nos) to convene meetings with the States under their jurisdiction at more frequent intervals and to evaluate activities in the water sector
- R & D activities in defluoridation technology to be promoted in a time-bound manner
- In order to speed-up the activities under the Awareness cum Update in Fluorosis Control Programme, decentralization of the activities have been initiated. To develop adequate manpower through a crash programme on training trainers have been initiated. The curriculum for training trainers has been drawn-up incorporating all the relevant established scientific facts on Fluorosis

The training of trainer will be undertaken at the 5 Regional Centres; At each Regional Centre, trainees from different locations from each of the States under their jurisdiction will participate. The 5 Regional Centres and its linkage with State Governments and Fluorosis endemic States are as follows :-

Regional Centres	Endemic States to cover
• All India Institute of Public Health & Hygiene, Calcutta	Bihar, Orissa, Andhra Pradesh
• Defence Laboratory, Jodhpur	Rajasthan, Haryana
• Industrial Toxicology Research Centre, Lucknow	Uttar Pradesh, Jammu & Kashmir, Punjab, Delhi
• Bhabha Atomic Research Centre, Bombay	Madhya Pradesh, Gujarat, Maharashtra
• S J. Engineering College, Mysore	Tamil Nadu, Karnataka, Kerala

From each State, participants from the following sectors/institutions nominated by the State Government would undergo training as trainers at the respective Regional Centre:

- Teachers from Social and Preventive Medicine (Community Medicine)
- Teachers from Public Health /Environmental Engineering Colleges
- Ground Water Board/Water Testing Laboratories

-
- Teachers of Home Science - Foods and Nutrition Departments
 - Teachers from Bioscience/Life Science Departments
 - Dentists

The total number of participants from each State should not exceed 30 Nos. The team of trainers thus developed at the Regional Centre(s) will be responsible for conducting training camps at the State level for sensitising and creating awareness among the Administrators, Engineers, Health Personnel and NGOs. The State level training camps will also be attended by the District Health Officers and Executive Engineers from those districts which are linked to a particular State Training location considering its proximity

The same trained team will subsequently conduct two days awareness-cum update camps in districts which are endemic. It is envisaged that the training teams developed at the 5 Regional Centres (for the 15 States) would be able to complete the exercise of conducting a 2 day awareness cum update camps in the 150 districts in a relatively short span of time

The preparation for implementing the decentralized activities, and conducting the 2 day awareness cum update camps through the trained trainers, have been debated at various forums and it is hoped that the trainees will commit themselves to the cause and contribute to the success of the programme.

STRUCTURAL FRAME WORK OF THE CURRICULUM DEVELOPED ON FLUOROSIS FOR HUMAN RESOURCE DEVELOPMENT

Epidemiology

- Introduction on water-borne and water related diseases (Refer Introduction to Rural Water Supply and Sanitation Programmes in India)

Introduction of Fluorosis

- What is fluorosis
- Magnitude of the problem
- Distribution of the problem
- Historical events in the field of fluorosis

Fluoride and its Physiological Characteristics

- Highly reactive due to negative charge
- High reactivity with positively charged calcium ions
- Fluoride uptake
- Fluoride excretion

Sources of fluoride

- Water, Hydrofluorosis
- Food [Information incomplete - Research required]
 - Food borne Fluorosis
- Industrial pollution
 - industrial fluorosis
 - Neighbourhood fluorosis
- Cosmetics [Toothpaste & Mouth Rinses] & Drugs
 - Drug-induced fluorosis
- Cumulative effect - Cause for disease onset.

Determinants of Disease

- Duration of exposure

-
- Dosage/Quantity ingested
 - Climatic conditions
 - Nutritional Status <
 - Calcium
 - Vitamin C
 - Trace element interaction
 - Hormonal profile

Vulnerable Groups

- Young adults - Hard-working
- Pregnant, Lactating mothers
- Foetus and children
- Adolescent age group

Tissues Affected and clinical manifestations

- Dental
- Skeletal
- Non-skeletal

Laboratory Investigations

- Fluoride estimation in:
 - Water (Refer Vol II)
 - Blood
 - Urine
 - SA/GAG Test (Sialic acid and Glycosaminoglycan ratio)
- Choice depends on purpose and available resources, facilities

Epidemiological Features of the Fluorosis Problem

Cause - Effect relationship

Age - Sex distribution

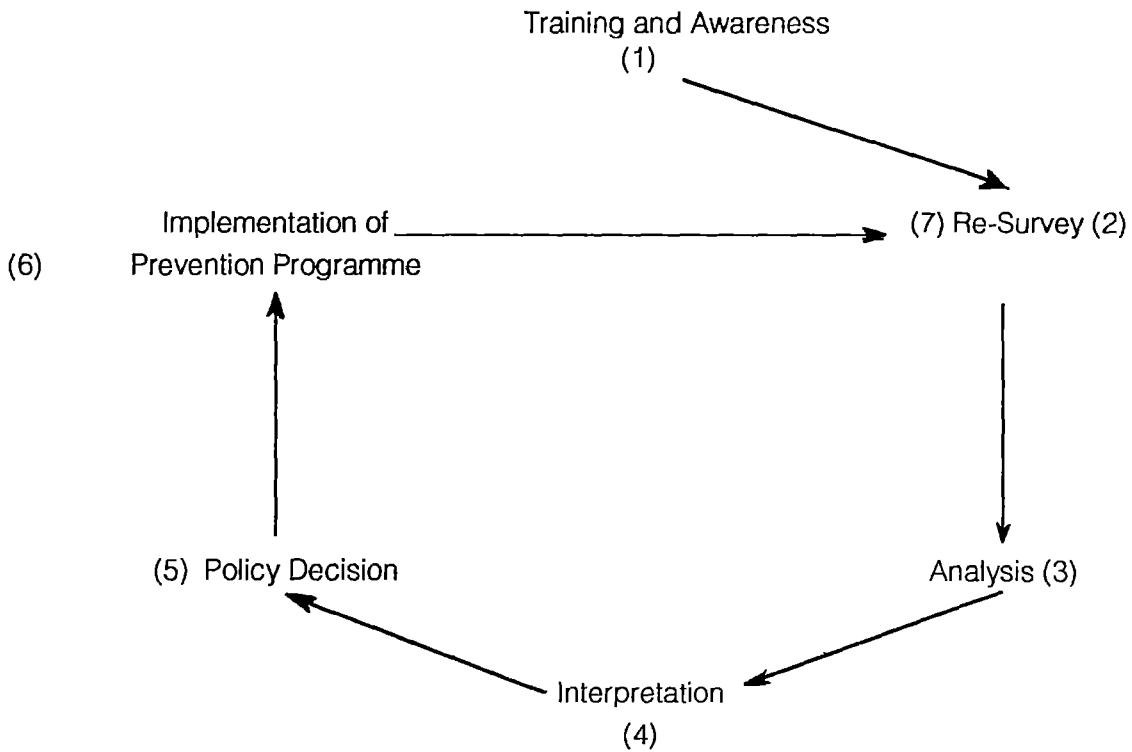
Socio - economic status

Occupation

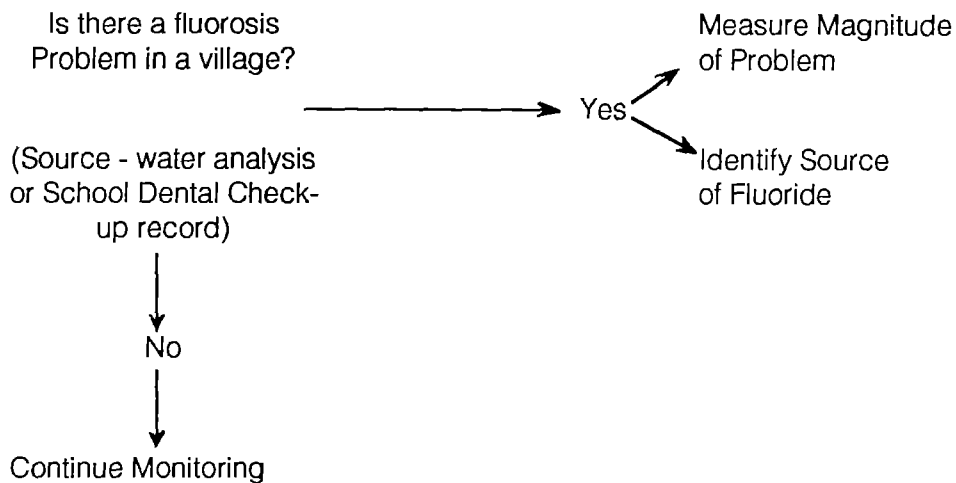
Nutritional Status

At risk group

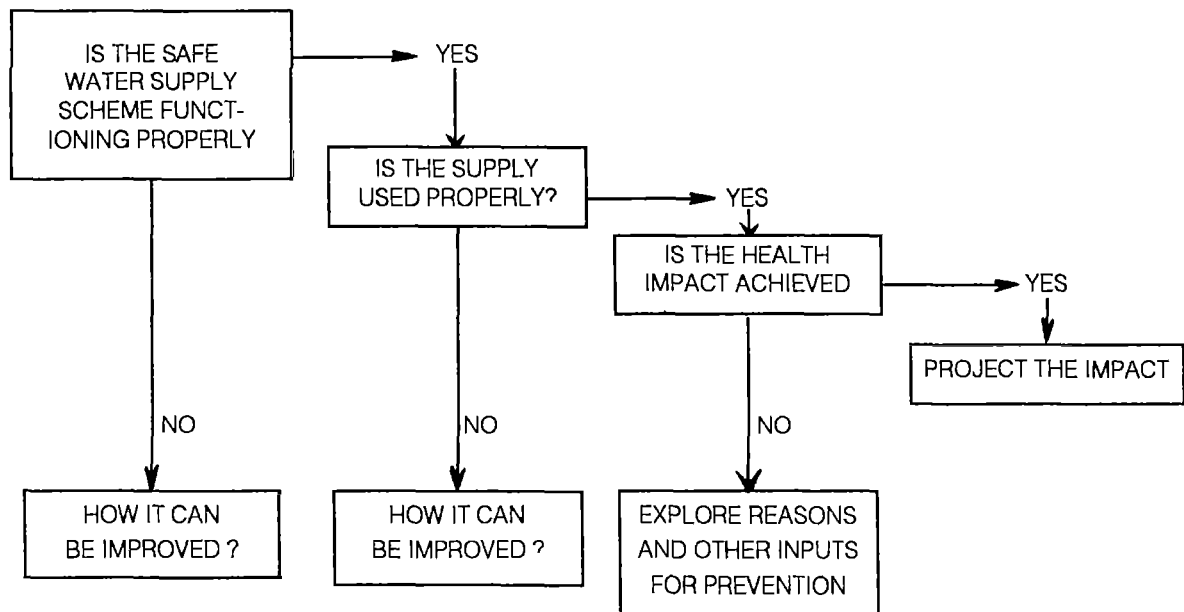
Fluorosis Prevention Programme : Planning Cycle



Fluorosis Surveillance



EVALUATION OF FLUOROSIS PREVENTION PROGRAMME



Cattle fluorosis

- Manifestations (Need for further research)

Prevention programme

- Primary Prevention:
 - Potable low fluoride containing water supply
 - Adequate calcium and Vitamin C
 - Higher emphasis on Women and children
- Secondary Prevention:
 - Timely detection of early cases
 - Removal of fluoride source(s)
 - Calcium and Vitamin C supplementation
- Tertiary Prevention:
 - Dental fluorosis
 - Laminated Veneering
 - Caping
 - Skeletal fluorosis
 - Decompression and or reconstructive Surgery
 - Removal of Fluoride Source
 - Calcium and Vitamin C supplementation

Health education

- Technical Personnel
 - Village level functionaries
 - Mahila Mandal representatives (Womens Organizations)
- Social Organizations , Community

Role of national drinking water mission in "Control of Fluorosis" in India

- Human Resource Development
- Awareness-cum-Update Programmes
- Fluoride & Fluorosis Mapping in India
- Implementation of Prevention Programmes
- Evaluation and monitoring of the Impact of Prevention Programmes on Health
- Research and Development to Supplement and strengthen existing knowledge

DENTAL FLUOROSIS

Normal Dentition

Human being is blessed with two sets of teeth:

- Primary or milk teeth and
- Permanent teeth

Primary teeth are 32 in number, 16 in upper jaw and 16 in lower jaw. These teeth start erupting from 6 years of age replacing temporary teeth. All permanent teeth are seen in mouth between 18 to 25 years of age.

Function of teeth are chewing of food , speech and phonation and aesthetics.

Parts of Tooth:

- Crown - part visible in the mouth
- Root - hidden in the bone of upper and lower jaw

Outer most part of crown is known as Enamel and is the hardest calcified structure in the body.

Outer most part of the root is known as Cementum- which is again a calcified structure.

Dentin forms bulk of tooth found between enamel and cementum.

Central part of the tooth (pulp) contains blood vessels, nerves and are seen in Crown and Root.

Root of the tooth is attached to alveolar bones by group of thread like fibres known as periodontal ligament.

Types of Teeth

Starting from the mid-line of face

- Central incisor
- Lateral incisor
- Canine
- Pre-molars
- Molars

Common Dental Diseases

- Caries or Decay
- Periodontal disease or Pyorrhoea
- Fluorosis

Caries is caused by production of Acids by the action of bacteria present in the mouth on food particles specially by sugar rich diet. Acids thus produced remove calcium from the enamel. Caries appears as black spot or cavity in the tooth when decay reaches dentin. Person complains of sensitiveness and acute pain when decay reaches pulp.

Pyorrhoea is caused by action of bacteria present in the mouth on food, resulting in the form of brownish hard deposit on the surface of teeth near gum. Hard deposit, known as Tartar and it irritates gum resulting in bleeding of gums and bad breath.

Fluorosis is caused by ingestion of fluoride through water, food, cosmetics like toothpaste, fluoride mouth rinses during pregnancy and early childhood when teeth are developing. It affects permanent teeth though decay of temporary teeth are also reported. It occurs when level of fluoride in drinking water exceeds:-

1.5 ppm

It is of three types:

- (i) Mild
- (ii) Moderate
- (iii) Severe

Staining of teeth

Other causes of staining of teeth apart from Fluorosis are nutritional deficiency like calcium, vitamin-D during pregnancy and early childhood, trauma to erupted teeth also causes staining of teeth. Habits like smoking, pan-chewing, tobacco chewing also cause staining.

Sources of ingestion of Fluorides

Drinking water is the main source. Other sources are found in food like tea, fluoridated tooth paste

and certain drugs. Occupation like persons working in Aluminium industry, welding industry and inhaling fluoride fumes, dust, is yet another source of fluoride entry into the body.

Teeth affected by Fluorosis

- Permanent Incisors
- Permanent First Molars
- Premolars
- Canines

At a particular time period different teeth are in various stages of development. So depending upon the time when the child gets exposed to fluoride the particular group of teeth forming at that age would be involved and affected.

Superstition regarding Dental Fluorosis. viz.,

- Brinjal eating
- Banana biting
- Palm leaf biting
- Coconut leaf chewing. These lead to discoloration and are mistaken for dental fluorosis by lay public. People are not aware that fluorosis is a condition of teeth which cannot be reversed to its normal white shiny appearance by application of medicine or by taking tablets

In some villages people offer different pujas to God for the change of colour and often seek blessings from Tantriks.

Treatment of Fluorosis like veneering, capping

Young girls and boys who are affected with Dental Fluorosis have aesthetic problems because of discolouration of teeth and are not ready to open their mouth in public for fear of showing their discoloured teeth and thus they become introverts. So they can be told how veneering of the teeth could be done to improve the appearance. In laminated veneering, a plastic material of the normal colour of the teeth is placed on the front surface of the tooth. In capping, a cap is placed over the tooth and thereby discoloured tooth is masked.

Preventive measures: Avoid intake of fluoride containing water, food items (if known), tooth-paste, mouth rinses etc.

INTRODUCTION OF FLUOROSIS

Fluorosis, caused by intake of fluoride has been prevalent in India for 6 decades, is a slow, progressive, crippling malady, affects young and old, poor and rich; rural and urban population has attained an alarming dimension. The Sub-Mission "Control of Fluorosis" as envisaged in Rajiv Gandhi National Drinking Water Mission, is adopting a multidisciplinary approach involving Health, Water Supply, Awareness and Nutritional aspects. The Sub-Mission has laid down the policies, guidelines and directions for dealing with the problem in an effective manner. Area specific/locations specific approach is being adopted for implementation

MAGNITUDE AND DISTRIBUTION OF THE PROBLEM

Fluorosis, a disease caused by excess intake of Fluoride was first detected in India, among Cattle, by the farmers of Andhra Pradesh (a southern State of India) during early 1930s. In those days, Bullocks were used for ploughing the land for cultivation. It was the farmers who noticed the inability of the Bullocks to walk due to painful and stiff joints. The episode was repeated within 6 months, when a new pair of Bullocks were acquired in exchange to the sick ones. It was during years later, the same disease was detected in human beings and Short-et-al (1937) published the first report on endemic fluorosis from India. The disease was then known to be prevalent in 4 States in India i.e. Andhra Pradesh, Tamil Nadu, Punjab and Uttar Pradesh

During the period 1960-1986, nine more States have been identified as endemic for Fluorosis. The total number of States endemic for Fluorosis, when the "Water Mission" was formulated during 1986, were known to be 13. However, during 1990-92, two additional States, i.e. Kerala and Jammu & Kashmir have also been identified as endemic for the disease. Thus, the total number of States declared endemic for Fluorosis are 15. The endemic States are shown in Fig. 2.1

GRADING OF FLUOROSIS IN STATES

1	Jammu & Kashmir	•
2	Punjab	••
3	Haryana	••
4	Delhi (Union Territory)	•
5.	Uttar Pradesh	•••
6	Rajasthan	•••
7.	Gujarat	•••
8	Madhya Pradesh	••
9	Maharashtra	••
10	Karnataka	••
11	Andhra Pradesh	•••
12.	Kerala	•
13.	Tamil Nadu	•••
14	Orissa	•
15.	Bihar	••

INDIA : ENDEMIC STATES FOR FLUOROSIS

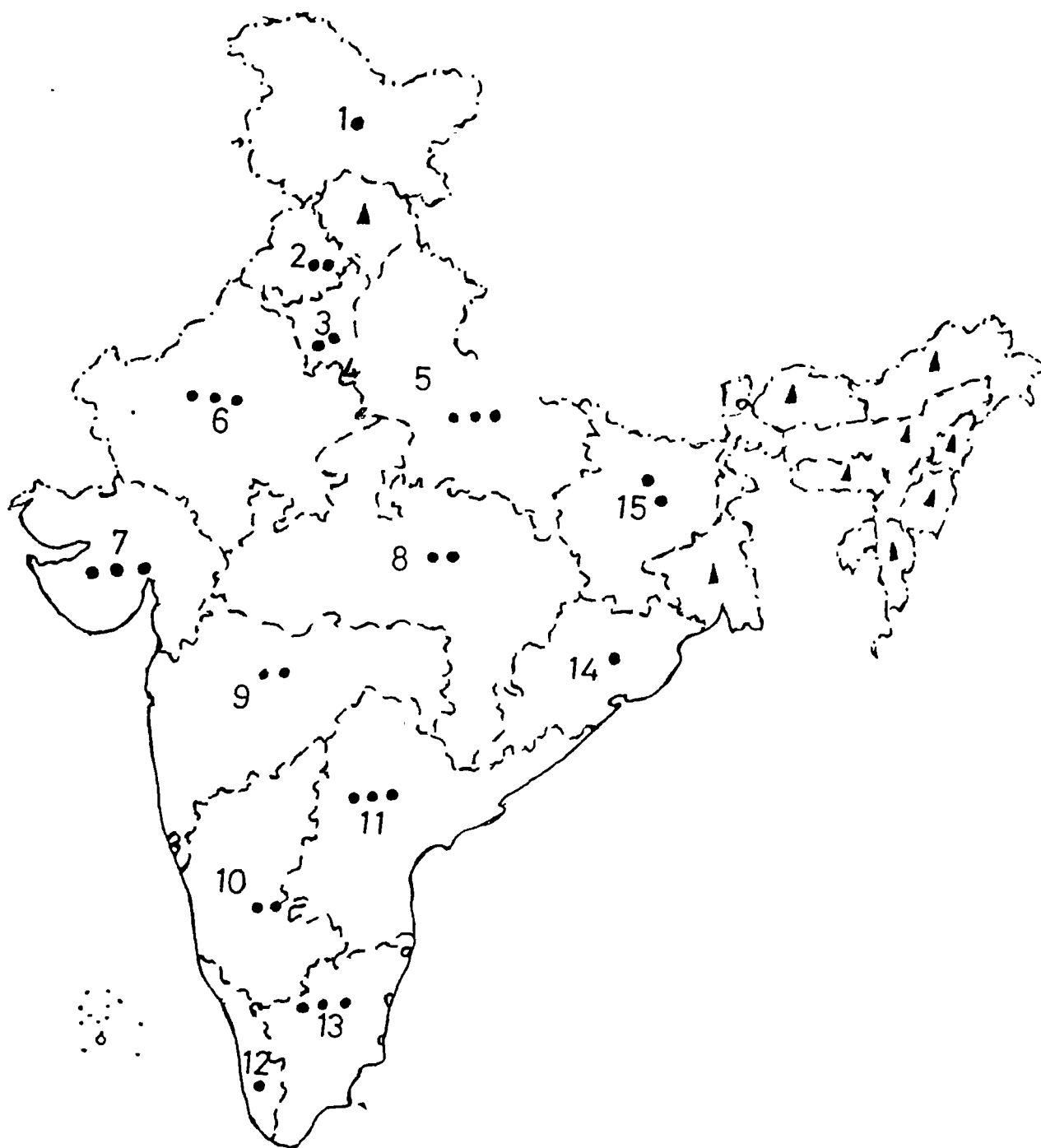


Fig 2 1

With the available information on the prevalence of the disease, the States have been graded as :-

Category I	(•) Less than 30% of districts affected ; 4 states
Category II	(••) 30 - 50 % districts affected, 6 states
Category III	(•••) 50 - 100 % districts affected; 5 states
	(▲) - disease not detected yet

This does not rule out the possibility that the remaining 15 States and Union Territories of the Indian Republic are free from Fluoride poisoning. Possibly there are no published reports on the disease and therefore not considered as endemic states.

The reasons for the spread of the disease are as follows:-

- Population over-growth, necessitating for more and more water.
- Indiscriminate digging of tube-wells
- Total unawareness of the importance of water quality assessment and drinking water from any source and every source.

Although, the number of States endemic for Fluorosis are fairly large, the exact number of districts, taluks and villages in each State endemic for Fluorosis is being ascertained. Since the field survey activities have commenced under RGNDWM, the information that is emerging from the house to house epidemiological surveys is rather shocking as there are villages where nearly 75% of the population are seriously affected, great majority crippled, leading a vegetative life. The affected individuals are not only a liability on the family/and society but they are also a drain on the economy of the villages, as they are truly unproductive human subjects.

The information on the prevalence of the disease, District/Taluk/Block/Village-wise and primary health centre-wise in endemic States, is forthcoming. Focusing on the prevention and control of Fluorosis is a recent event after the "Water Mission" activities have been launched in the country. Such information was non-existent during earlier years in the country due to the following reasons :-

- As the disease was hardly taught in the medical schools/colleges, the Medical Professionals, posted in these areas were unaware of the disease characteristics and were not able to distinguish the disease with ease from other orthopaedic disorders (Bone diseases)
- Radiographs were used for the diagnosis of the disease, which was helpful in detecting the disease during late stages and not during early onset of the condition. Those affected could not get any medical aid or treatment as the disease is untreatable.
- Patients of Fluorosis are seldom admitted to hospitals for fear of the bed being blocked. It is also true that the patients from endemic areas seldom visited hospitals as they accepted the unhealthy condition as a curse of God and remained in their homes.
- Large segment of the population affected and crippled due of Fluorosis remained in rural areas, did not draw the attention of Doctors/Decision-makers nor the press or the media, and very few were aware that the Drinking Water contaminated with Fluoride is the cause for their illness.

However, both Central and State Governments in India supported research and development activities extensively for nearly 6 decades. The research and development activities in India have also

been supported during 1980s by International Development Research Centre, Canada. The results of these efforts have led to greater understanding of the disease, early detection of fluoride toxicity manifestations (Susheela, 1989) and methods for prevention and control of the disease. The wealth of information, the country has generated during the past 6 decades in diagnosing fluoride toxicity and Fluorosis, the effects on various tissues, organs and systems have stood in good stead in formulating an action plan and evolving a strategy for "Control of Fluorosis" in India. This is perhaps the first time, a National Programme involving both Health and Public Health Engineering Sector personnel have been formulated, based on the hard core data the country has generated during the past several decades.

India is not the only country, but several other nations in the world, are severely affected by the problem of Fluorosis (Fig. 2.2)

FLUOROSIS :- GLOBAL PROFILE



- | | | | |
|-----------------------------|-----------|------------------|----------------|
| 1. Argentina | 6. Egypt | 11. Iran | 16. China |
| 2. United States of America | 7. Jordan | 12. Pakistan | 17. Australia |
| 3. Morocco | 8. Syria | 13. Kenya | 18. New-Zeland |
| 4. Algeria | 9. Turkey | 14. Tanzania | 19. Japan |
| 5. Libiya | 10. Iraq | 15. South Africa | 20. Thailand |

Fig 2.2

FLUORIDE AND ITS PHYSIOLOGICAL CHARACTERISTICS

On June 26, 1886, a major break-through occurred when Henri Moissan, Professor of Chemistry isolated a pale yellow, highly toxic and reactive gas by electrolysing a cooled solution of Potassium Hydrogen fluoride in anhydrous hydrofluoric acid in an all-platinum apparatus at the Ecole Supérieure de Pharmacie and at the Sorbonne, Paris. Moissan thereby solved one of the most difficult chemical challenges of his time, an achievement which was recognized in 1905 by the award of a Nobel Prize.

In late 19th and early 20th centuries fluorine was generally regarded as a mere laboratory curiosity. Moissan himself had serious doubts that his discovery might ever be of practical use.

The decade of 1920s, marked a new era in Fluorine Chemistry and many useful applications were discovered which have made the element indispensable to modern industry.

Properties of Fluorine

In the free state it is a pale yellow gas with a pungent, irritating odour. On cooling, it condenses to a liquid boiling at -188°C , and on further cooling it freezes to a solid melting at -220°C .

Fluorine is estimated to be the 13th most abundant element in the earth's crust

Elemental fluorine exists as a diatomic molecule (consisting of two atoms in a molecule) with a remarkably low dissociation energy (38 Kcal/mole) as a result, it is highly reactive and has a strong affinity to combine with other elements to produce compounds called fluorides

As the most electronegative of all the elements, fluorine is the strongest oxidizing agent known.

When liquid fluorine combines with hydrogen, the reaction produces a temperature of 4700°C , which is even hotter than that obtained by burning atomic hydrogen in oxygen (4200°C)

Fluoride and Biological tissues

Fluorine being an electronegative element and having a negative charge (represented by F^{-}) is attracted by positively charged ions like calcium (Ca^{++}). Bone and tooth having highest amount of calcium in the body, attracts the maximum amount of fluoride and is deposited as calcium Fluoro apatite crystals. At the same time in certain locations in the same tissue, the unbound calcium for reasons unknown, are lost

It is important to understand that while it appears that fluoride causes a multiplicity of ill-effects, each of these ill effects, can be traced to the effects of fluoride on enzymes or proteins as well as its possible effect on the DNA molecule itself

Considerable amount of fluoride although get bound in the body tissues, some amount is excreted through sweat, urine and stool. The extent of excretion is determined by the level of different hormones and efficiency of kidney function, age of the individual, nutritional status, climatic conditions etc.

SOURCES OF FLUORIDE

Fluoride entry into the body

Fluoride enters into the body through a variety of sources viz.

- Water • Food • Air • Medicaments. and • Cosmetics

Water and Food

Water and food, mainly agricultural crops are contaminated with fluoride as the earth's crust in India is heavily loaded with fluoride containing minerals/salts. Fluoride bearing minerals are in abundance in India.

The Geological survey of India has brought out considerable data which reveals that (1) Fluorite (2) Topaz (3) Appetite and Rock Phosphate (4) Phosphatic nodules, Phosphorite are wide spread in India. and contains high percentage of fluoride. As a result of the rich mineral content, fluoride leaches out and contaminates the water and the earth/soil.

A profile of fluoride content in drinking water in different States/Districts/Villages is given below. The information given below is from the data collected ever since the Water Mission has been in operation and also from the records of the Fluorosis Control Cell (FCC), AIIMS This does not indicate that other States/Districts/Villages in the country are unaffected. As the Water Mission activities and messages are getting spread, more and more people are becoming aware of the hazards due to fluoride and the common man is coming forward to get their water tested for water quality including the concentration of fluoride,.

Fluoride Contamination in Drinking Water

Fluoride present in drinking water would lead to health problems, when the concentration of fluoride is greater than 1.5 ppm (mg/litre)

The Bureau of Indian Standards, in view of the health problems has laid down the Indian Standard as 1.00 ppm as the maximum permissible, although RGNDWM is still working with 1.5 ppm as the upper limit of fluoride. This would mean that the body may tolerate fluoride upto certain limits 1 or 1.5 ppm depending upon the nutritional standards and body physiology. It is also a fact that there is no method(s) presently available that would remove the fluoride totally from the drinking water. There will be traces of fluoride in any water sample. Therefore, although the BIS (Bureau of Indian Standards) has laid down the upper limit as 1.00 ppm, it is further specified that "lesser the better" as fluoride causes health problems

Although a companion volume is dealing with water quality and defluoridation procedures, this volume would provide a brief account on the extent of fluoride contamination of drinking water as a prelude to the health problems wide spread in the country

In Indian villages drinking water is collected from the open wells, tube wells, hand pumps, river, lake, streams or wherever water is available. Although the country has produced considerable data on Fluoride content in drinking water over the last 6 decades, through (1) Central Ground Water Boards (2) Public Health Engineering Departments (3) Water Authority/Board of various States (4) Research

Institutes/Universities and Colleges, the information recorded in this Volume will refer to information which has emerged since 1987 after the RGNDWM activities have commenced in the country, when information on precautions on water sample collection (i.e. water sample should be collected from the source and not from stored containers; the sample should be collected in plastic containers and not in a glass bottles as silica of the glass will react with the fluoride in the water and low values may be recorded) was imparted to the field workers and values would refer to the data produced under the banner of the "Water Mission" and those of the authors who have contributed to this volume/or otherwise specified

A few tables are given below to reveal fluoride content in drinking water samples obtained from different regions of the country. The data is presented primarily to reveal that safe water sources (fluoride content with an upper limit of 1.5 ppm) do co-exist with excess fluoride contaminated water within the same area, village or location. Therefore, checking fluoride content in a few samples from a locality and to generalize the information based on that shall not be the right step to ensure Water Quality unless every source is tested.

Each of the tables will reveal that (1) different sources are used for collecting drinking water in rural India (2) there are sources having safe water in the same village/district i.e. with fluoride less than 1.5 ppm (3) the range (minimum and maximum in which the fluoride content is present in the water) (4) the data is depicting the profile of water fluoride content in drinking water in a few states in the country but not the total information. This package of information is only to alert the people that water quality testing is of prime importance prior to certifying for human consumption. The procedure for water quality testing has been adequately dealt with in the Volume dealing with "Water Quality Testing and Defluoridation Procedures."

It is cautioned that the states which are not included in the list of Endemic States for Fluorosis, may be identified as endemic for Fluorosis during later years, when the disease may surface through new water sources which are tapped for drinking water as a result of population overgrowth.

Table 4.1

Fluoride Content in Drinking Water in 3 PHCs of Amreli District in Gujarat

(RGNDWM Survey Data)

Number of PHCs surveyed	Number of Villages surveyed	Number of Families surveyed	Population surveyed	Range of Drinking Water F ⁻ Content (ppm)
Lilya	23	6612	32,012	1.8 - 7
Gundaran	19	2511	15,152	2.5 - 11
Damnagon	13	2732	13,330	2.0 - 10

Table 4.2

Fluoride content in drinking water in a few villages in the district of Mehsana in Gujarat

(RGNDWM Survey Data)

Total number of villages surveyed	Total number of water samples analysed	Name of the villages	Fluoride content (ppm)	Range
127	139	Gokharva	2.4	1.58 - 9.9
		Pinpharpur	1.8	
		Kholwada	8.9	
		Thakrasan	3.6	
		Lihoda	9.9	
		Upera	5.9	
		Khayasadu	1.6	
		Madhasana	2.8	
		Badarpur	4.0	
		Sarna	2.0	
Mirzapur	1.58			

Table 4.3

Fluoride content in Drinking Water in Doda District of Jammu & Kashmir

(Fluorosis Control Cell, AIIMS Data)

Name of the Village	Source	Fluoride Content	Range
1. Barr	Not indicated	2.04	0.05 - 4.21
2. Malwal	Spring	1.15	
3. Malwas	Nallah	4.21	
4. Monkhli - Darumuni	Spring	3.60	
5. Doda	Not indicated	0.23	
6. Gandhi Meya Jammu	Tube Well	0.08	
7. Jammu City	Tube Well	0.05	

Table 4.4

**Fluoride content in Drinking Water in a few villages in Jalgoan District
(Maharashtra)**

(RGNDWM Survey Data)

Name of the Village	Source	Total number of Drinking water sources	Fluoride Content ppm	Range
1. Takli	Hank pump (HP)		2.4	
2. Godon Tanda	Hand pump		1.56	
3. Nimkhedi	Tube well	47	1.80	0.11 - 3.0
4. Mandre	Tube well		3.0	
5. Mehgaon	well		0.28	
6. Fattepur	Well		0.96	
7. Fattepur	Well		0.11	
8. Balaokmu	Well		1.72	
9. Rahire	Well		0.82	
10. Godon Tanda	Well		2.32	

Table 4.5

**Fluoride content in drinking water in Bhandara district in Maharashtra
(RGNDWM Data)**

Number of villages surveyed	Number of water sample analysed	Name of the villages	Fluoride content (ppm)	Range
74	1200	Mujabi	3.5	
		Thana	2.0	1.5 - 10.2
		Falmagerh	5.0	
		Waghbodi	4.4	
		monudura	1.8	
		Kamartola	10.2	
		Kamartola	6.7	
		Aalesur	1.5	
		Varlikheda	2.0	
		Gatgaom	4.0	

Table 4.6

**Fluoride content in Drinking Water in a few villages in Unnao district
in Uttar Pradesh**

(Fluorosis Control Cell AIIMS Data)

Source Code Number	Source	Fluoride content (ppm)	Range
36	Not indicated	4.30	0.12 - 19.00
37	"	12.90	
38	"	19.00	
39	"	2.66	
41	"	3.76	
44	"	1.32	
47	"	0.78	
48	"	0.29	
71	"	1.20	
50	"	0.12	

Table 4.7

**Fluoride content in Drinking Water in a few villages of Dharwad
district in Karnataka**

(RGNDWM Survey Data)

Total number of Villages afflicted	Number of Taluks	Total number of water samples analysed	Name of villages	Source	Fluoride content (ppm)	Range
44	3	259	Haripur	Bore well	6.5	0.40 - 18.0
			Hulkoti	Open well	4.6	
			Alur	"	1.4	
			Benhinalli	"	7.0	
			Dambal	Bore well	1.0	
			Malikajunpur	"	5.2	
			Kalkeri	"	10.0	
			"	"	9.5	
			"	Open well	18.0	
			Tipapur	Bore well	8.0	
			Menndi	"	2.0	
			Hirevaddatic	"	0.4	

Table 4.8

Fluoride content in drinking water in a few villages of Gulberga district of Karnataka

(RGNDWM SURVEY Data)

Total number of villages afflicted with fluorosis in Taluks of Shorapur & Shahpur	Total number of water sources	Total number of sources analysed	Number of sources having F ⁻ Within safe limits	Name of Village	Fluoride content (ppm)	Range
33	203	129	14	Santhapur	2.4	0.2 - 5.6
				Jalibenchu	0.94	
				Huskera	3.92	
				Sawook	5.6	
				aldal	2.5	
				Habbaccu	2.8	
				Tekurala	0.2	
				Madaninanhal	4.8	
				Balkul	1.5	
Tonnur	4.0					

Table 4.9

Fluoride content in a few villages of Raichur district in Karnataka

(RGNDWM SURVEY Data)

Total number of villages where survey was carried out	Total number of water samples analysed	Villages surveyed	Fluoride content (ppm)	Range	Number of safe water sources
147	488	Hamberal	7.5	0.4 - 8.5	137
		Jambaldinni	0.8		
		Karkihalli	3.6		
		Begur	2.0		
		Rajalbandu	1.0		
		Jakkudinni	4.6		
		Shakapur	8.5		
		Bheemraj Camp	5.0		
		Timmapur	0.4		
		Gudadur	1.0		

Table 4.10 a

**Fluoride content in drinking water in a few villages in Gurgaon district
in Haryana**

Number of Villages	Total number of sources tested	Fluoride Range	Number of safe water sources
26	1440	0.17 -24.17	10 0.3 to 17

Table 4.10,b

Gurgaon District (RGNDWM data)

	Name of the Village	Source	Fluoride content (ppm)	Number of safe water sources
1	Dhanwapur	Well	0.60	10
2.	Madanpuri	Hand puri	12.92	0.3 - 1.7
3.	Shahpur	N.I	9.03	
4.	Madanpuri	N.I	17.10	
5.	Madanpuri	Hand pump	19.10	
6.	Madanpuri	Hand pump	24.70	
7.	Sihri	N.I	5.74	
8.	Manesar	Tube well	1.05	
9.	Madanpuri	N.I.	15.58	
10.	Gurgaon	N I	1.10	
11.	Tigra	Hand pump	0.90	
12	Gulpahari	N.I.	2.28	
13	Hayatpur	N I	3.23	
14	Saria Alwaraj	N I	6.08	
15	Nurpur	N.I.	4.17	
16.	Sancholi	N.I	6.17	
17.	Ghamroj	N.I.	0.30	
18.	Palra	N.I	10.30	
19.	Hasanpur	N.I.	4.90	
20.	Kiranki	N.I.	1.20	
21.	Khandwela	N.I.	1.50	
22.	Nakanpur	N.I	0.17	
23.	Aiduka	N.I	0.53	
24.	Sewka	N.I	0.53	
25.	Notki	N.I	1.14	
26.	Nagina	N.I	1.71	

N.I. - Not indicated

Table 4.11

Fluoride content in Drinking Water in a few villages in Shivpuri and Jabua districts of Madhya Pradesh

(RGNDWM Survey Data)

Name of the Village	Source	Fluoride Content (ppm)	Range
1. Hatedu	Well	2.9	1.5 - 4.2
2. "	Hand pump	2.6	
3. "	Well	2.2	
4. "	Hand pump	1.7	
5. Jirawni	Hand pump	1.7	
6. Bichi	Well	2.0	
7. Richhvi	Well	1.5	
8. Poowala	Well	4.2	
9. Detad	Well	3.3	
10. Jambukheda	Well	2.0	
11. Devigarh	Well	2.9	

The names of the various villages listed in table 4.1 to 4.11, in the event incorrectly spelt, it may be brought to the notice of the Editor.

Fluoride in Agricultural crops and other edible items

Although, it is very well recognized that fluoride enters the body through various food items, the data available in the country is rather scanty. The information that is available is based on food analysis or agricultural crop analysis of certain regions/locations. The data thus emerged from a location is unlikely to be valid for other regions or locations. The main reason being the Fluoride content of water and soil being variable from location to location. There is a need for Fluoride analysis of agricultural crops district wise, which will add invaluable information to educate and create awareness on the importance of selection of agricultural crops which are health promoting food/ and crops.

The data available on Fluoride content of agricultural crops and other edible items dates back to 1970s and 1980s. However, in the recent past, as RGNDWM activities are gaining greater momentum, the message that fluoride content in food, agricultural crops need to be investigated is being spread, more and more publications on fluoride content of various foods, total intake of fluoride through water and food are now being published from different parts of the country.

An exhaustive study has been conducted and results published which focuses on the fluoride content of crops and other items grown/available in Anantpur district in A P. (Venkateswara Rao and Mahajan 1991) . The highlights of the publication are :-

1. 98 food items commonly used in 41 villages of Anantapur district in Andhra Pradesh, were investigated for fluoride content.
2. 32 locally grown agricultural crops are known to have fluoride ranging from 0.2 to 11.0 mg/kg⁻¹ with the exception of coconut water where even traces of fluoride was not detected.

- 3 The intake of Fluoride from water and food ranges from 2.2 - 7.3 mg (0.05 - 0.32 mg/Kg⁻¹ BW)
4. The 6 brands of tea analysed for Fluoride have shown the Fluoride content ranges from 60mg/kg to 112mg/kg.

Table 4.12

Fluoride content in 6 Brands of Tea

	Brand Name	mg/kg
1	Lamsa	Highest Fluoride content
2	All Dusi	Second Highest
3.	Three Roses	Third Highest
4.	Red Lable	Forth Highest
5.	Taj Mahal	Fifth Highest
6.	Super	Sixth Highest

Fluoride content of 1.=112 mg/kg 6 =60 mg/kg

Fluoride content in different food items has been studied in detail by various investigators (Nanda and Kapoor, 1971; Sengupta and Pal, 1971; lakdawala and Punekar, 1973; and Charı et al, 1975). The available data indicates that in general and decreasing order of fluoride content in various food items is in cereals followed by leafy vegetables, pulses, fish, meat and fruits. Fluoride content in some of the food items as reported by various investigators from different regions of India are as follows :

Table 4.13

Fluoride content in agricultural crops and other edible items

Food Item	(Fluoride in ppm)			
	A Sengupta and Pal (1971)	B Lakdawala and Puneker (1973)	C Chan et al (1975)	D Rajyalaxmi (1982)
Cereal				
Wheat	4.6	2.59-3.3	-	-
Rice	5.9	3.27-14.03	2.9.3	-
Bajra	-	1.72-2.23	2.82	74.0
Maize	5.6	-	-	-
Pulses & Legumes				
Bengal gram	6.2	3.84-4.84	-	14.8
Green gram dal	2.5	2.34-4.84	-	21.2
Red gram dal	3.7	2.34-4.84	-	52.8
Soyabean	4.0	-	-	-
Leafy Vegetables				
Spinach	2.0	0.77-4.14	-	-
Cabbage	3.3	1.28-2.29	-	-

Amaranth leaves	5.8	4.91-7.14	-	-
Lettuce	5.7	-	-	-
Mint	4.8	-	-	-
Bathua leaves	6.3	-	-	-
Chowli leaves	-	1.79-7.33	-	-
Other Vegetables				
Cucumber	4.1	2.57-3.58	-	-
French Beans	-	1.07-1.96	-	-
Tomato	3.4	1.00-2.08	0.33	-
Brinjal	1.2	1.62-2.48	1.24	-
ladies Finger	4.0	2.2-3.62	1.74	-
Snake Gourd	2.3	2.16-3.44	0.75	-
Roots & Tubers				
Beet root	4.2	-	-	-
Carrot	4.1	1.9-4.9	-	-
Potato	2.8	1.27-2.92	-	-
Onion	3.7	1.00-3.00	-	-
Sweet Potato	3.2	-	-	-
Fruits				
Banana	2.9	0.84-1.58	0.84	-
Dates	4.5	-	-	-
Grapes	-	0.84-1.74	-	-
Figs	4.2	-	-	-
Mango	3.7	0.8-1.80	-	-
Apple	5.7	1.05-2.2	-	-
Guava	5.1	0.24-0.52	-	-
Nuts & Oil seeds				
Almond	4.0	-	-	-
Cashewnut	4.1	-	-	-
Coconut	4.4	-	-	-
Mustard seeds	5.7	-	-	-
Groundnut	5.1	-	-	-
Beverages				
Tea (Dry leaves)	-	39.8-68.59	-	-
Tea infusion	-	18.13-56.19	-	-
(1 gm boiled for 5 min. in 125 ml water)				
Tea infusion	-	11.13-37-34	-	-
(1gm in 125 ml) of hot water				
Aerated drinks	-	0.77-1.44	-	-
Coconut water	-	0.43-0.60	-	-
Spices & Condiments				
Corriander 2.3	-	-	-	-
Cumin seeds	1.8	-	-	-

Garlic	5.0	-	-	-
Ginger	2.0	-	-	-
Tamarind pulp	3.8	-	-	-
Turmeric	3.3	-	-	-
Foods from animal sources				
Mutton	-	3.0-3.5	-	-
Beef	-	4.0-5.00	-	-
Pork	-	3.0-4.5	-	-
Fishes	-	1.0-6.5	-	-

Region Fluoride in drinking water (ppm)

A Calcutta	0.4
B Bombay	0.15-0.48
C Podli(Andhra Pradesh)	2.5-5.0
D Andhra Pradesh	1 - 12

Nanda (1972) has analysed a variety of spices which are collected from lucknow (UP) and the Fluoride content is as follows.

Table 4.14

Showing fluoride content of spices (ppm)

Cardamom (Big ilachi)	14.4
Red Pepper (Kashipuri)	10.7
Small cardomam (Small ilachi)	8.3
Red Pepper (Patna)	8.07
Coriander Powder	8.3
Coriander Leaves	0.3-0.9
Ajwain (omum)	2.9
Dalchini	2.4
Turmeric Powder	4.6
Cumin Seed	4.6
Cumin Seed (Black)	3.8
Pepper (Black)	3.6
Cloves	3.2
Fenugreek Seed	3.6

Table 4.15

Showing fluoride content of certain other items

Areca Nut (Supari)	3.8 - 12.0
Betal Leaf (Pan)	7.8 - 12.0
Tobacco	3.1 - 38.0

Hydrofluorosis and Food-borne Fluorosis

Ingesting food and consuming water containing fluoride, over a period of time, is likely to result in toxic manifestations.

It is well recognized in India that consuming fluoride contaminated water and/or food for a period of 6 months to 1 year is adequate to have the ill effects on health.

It is also known that the adverse effects of fluoride would vary from individual to individual depending upon several factors: which are dealt with in the next chapter.

Water borne fluoride is known to cause Hydrofluorosis; whereas food borne fluoride is known to cause Food-borne Fluorosis. The fact remains that it is not an easy task to differentiate these two forms, however, it is known that fluoride entry through food and water causes Fluorosis.

DRUG INDUCED FLUOROSIS, INDUSTRIAL FLUOROSIS AND NEIGHBOURHOOD FLUOROSIS

The Drug Induced, Industrial and Neighbourhood fluorosis are dealt with in this Chapter, so that the problem of prevention and control of Fluorosis can be viewed in a holistic manner. This chapter would reveal the importance of taking a proper history of a subject which includes occupation, undergoing any treatment, the drug prescribed, duration of treatment, residing area, whether there are any industries if so what kind and where it is located etc., should be kept in view. Individuals living in an endemic area for Fluorosis may be involved in cottage Industry and there is a possibility of the disease, being aggravated within a short span of time as the fluoride ingested through water and inhaled from environmental pollution are the casual factors. Providing defluoridated water alone would not be sufficient; the individual should be made alert that he need to move out of the environment to improve his health unless the Management of the Industry get to installing emission controlling devices in the Industry

Drug induced Fluorosis

The prolonged use of drugs containing sodium fluoride is known to cause skeletal fluorosis. Some of the chapters in this volume have dealt with sodium fluoride treatment for Osteoporosis, Otosclerosis and Dental caries and associated health problems. During 1982, 2 cases of Drug Induced Skeletal Fluorosis were reported from Switzerland. Patients of rheumatoid arthritis received uninterrupted and prolonged treatment with niflumic acid. Treatment continued for 10 years. The daily dose of drug administered was 3 capsules of 250mg niflumic acid (Nifluril, UPSA Laboratories, France).

The first patient was 28 years old and had also received a low dose of Cortico therapy. The second patient, 62 years old, who had not received Corticotherapy, showed moderate renal failure. Biopsy material obtained from iliac crest region of the pelvic girdle, in one patient and a fragment of the distal metaphysis was taken close to fracture callus from the second patient, revealed histologically pronounced signs of skeletal fluorosis. The bone fluoride content was higher in the second case. Hypervascularization was only observed in the second case. To understand the effects of niflumic acid on bone tissue, UPSA Laboratories in France conducted animal studies. The preliminary results confirmed the stability of C-F bond but emphasized the fact that a certain percentage of these bonds is broken, provoking an increase in the blood ionized fluoride level as well as in the bone fluoride content which lead to skeletal fluorosis (Baud et al 1982).

There has been cases in India when a patient of Dental Fluorosis, aged 22 years was prescribed fluoride mouth rinse (Proflo) "to render the tooth stronger" although her problem could have been solved by masking the brown teeth. Fluoride mouth rinse does not make a fluorosed teeth stronger. After rinsing the oral cavity 3 times a day with proflo, within 4-6 months, the patient developed severe complaints of non-ulcer dyspepsia, besides became severally anaemic which are early warning signs of Fluoride toxicity. Identifying the cause and withdrawal of Proflo mouth rinse and providing adequate Calcium and Vitamin C prevented the warning signs of fluoride toxicity. The timely intervention helped the individual from further deterioration of her health and culminating in skeletal Fluorosis. The Dental Fluorosis, which the individual had developed by living in an endemic area during early childhood, was masked by

laminated veneering technology, which was causing cosmetic problems for which she had initially sought hospital intervention.

Industrial Fluorosis

A number of industries use hydrofluoric acid and/or fluoride containing salts, in the different sections of an industry for one reason or other. The Industries use fluoride either as raw material in the manufacturing process or fluoride arises as a biproduct or it may even be the end product. The Industries that use fluoride are 1) Aluminium 2) Steel 3) Enamel 4) Pottery 5) Glass 6) Bricks 7) Phosphate Fertilizer 8) Welding 9) Refrigeration 10) Rust removal 11) Oil refinery 12) Plastic 13) Pharmaceutical 14) Tooth-paste 15) Chemical Industries 16) Automobile industry and the list of Industries are ever increasing.

Fluoride dust and fumes, pollute the environment (table 5.1) ; inhaling the dust and fumes is as dangerous as consuming fluoride containing food, water and or drugs.

In an Industry, there are several possibilities forgetting the people afflicted with Fluorosis. After residing in an endemic area for fluorosis, may move out in search of job opportunities and may settle in an industrial establishment. They may have been consuming high fluoride containing water until then but remained asymptomatic. Within a short span of exposure to fluoride dust and fumes, manifestations develop, and they become incapable of carrying out the work. The management terminates the appointment of such individuals and sent them away by giving compensation.

There is yet another category, where people move from a non-endemic area in search of job opportunities and take up work in certain industries and after working for a few years, develop manifestations of fluoride toxicity and fluorosis and leave/discontinue the job due to ailment. Smelter (pot room) workers in an Aluminium Industry are the vulnerable group.

Industrial fluorosis is a serious problem in the developed western and other industrialized countries. However, due to rapid industrialization in India, the problem of Industrial fluorosis is reaching an alarming state and is compounding the problem of endemic, water and food borne fluorosis.

Neighbourhood Fluorosis

It is now well established that not only the Industrial workers get-afflicted with skeletal and non-skeletal manifestations; but the people living in the neighbourhood of the industry, young and old also get afflicted with fluorosis.

Neighbourhood fluorosis has been investigated in India extensively by Desai and her group of investigators from Gujarat. Investigations were carried out in 15 villages and 3 urban residential areas within 3500 meter radius from a fluoride processing industry manufacturing refrigeration gas i e. Freon, situated in the west coast of India, north of Bombay. 47 samples of Drinking Water 44 samples of fodder and 127 soil samples were collected during different seasons from areas surrounding the industry for fluoride estimation and to assess the effect of industry on the environment, Drinking water of the area was not contaminated with fluoride. Fluoride deposits on fodder, which decreased in relation to increase in distance from the industry, were minimum during mansoon season. Observations were correlated with wind pattern of the area and the distance from the Industry (Bhavsar et.al 1985a)

In a population study of 7059 persons of the neighbourhood of the same Industry, health complaints, fluorotic dental changes, fluoride excretion in spot urine samples and x-ray of the forearm

were used to assess the effect of Industrial emission of fluoride on health. 17.02% of individuals complained of adverse effects on health. The prevalence of dental changes i.e. 23.58% was highest in the 7-14 year old children. Mean fluoride level of 395 spot urine samples was 1.94 ppm (the normal level may vary upto 0.1 ppm) Radiological evidence of fluorosis seen in older individuals was observed in 9.5% of the population (Bhavasari et al, 1985b).

Desai and her group further carried out an epidemiological study in tribals residing near a Fluorospar mine to assess the prevalence of dental fluorosis (Desai et al 1988). A total of 4544 tribals from 24 villages living in the vicinity of the mine were examined in a house to house survey. 2637 Tribals from downstream villages (along the river into which the fluorospar plant effluent is discharged) and 1907 tribals from neighbouring villages (with 8 km radius from mines) were studied. Water fluoride level in the villages varied from 0.4 - 5.6 ppm.

The prevalence of Dental Fluorosis was 35.3% and Dental caries was 3.0%. Dental fluorosis showed significant positive association with water fluoride level. River water fluoride level was 17.0 ppm at the point of effluent discharge which gradually declined with increasing distance from the point of discharge, perhaps due to dilution. Dental fluorosis among children also showed gradual decline with increasing distance from the point of effluent discharge in downstream villages. The pattern of dental fluorosis, high fluoride excretion and radiological changes is suggestive of Skeletal Fluorosis.

The base-line study conducted in the neighbourhood of the fluorospar mine, was re-surveyed after an interval of 12 years by the same team when the Industry had introduced pollution check measures in the industrial emission. The pollution was reduced by 90-96% during the interim period. Dental fluorosis was selected as an indicator of health monitoring. The re-survey results revealed a decline in the incidence and prevalence of dental fluorosis "then and now" confirming the effectiveness of Control of fluoride emission by the industry (Desai et al 1993).

This chapter would reveal the importance of viewing the problem of endemic fluorosis, keeping in view the various other possibilities of getting afflicted with fluorosis i.e. inhaling fluoride dust and fumes emitted from the Industry itself or by living in the neighbourhood of a fluoride processing Industry.

Table: 5.1

Estimated total inorganic fluoride Emission from major Industries in the United States (1968 data) (Waldbolt et al, 1978)

Sources	Emission Tons /Year
1. Steel	40,100
2. Ceramics	21,200
3. Phosphate Fertilizer and Processing industries	18,700
4. Aluminium industries	16,000
5. Combustion of Coal	16,000
6. Non-ferrous metal Foundries	4,000
7. Welding Operations	2,700

Such data are not easily available from India, although we have such industrial establishments in the country and therefore the U.S. data is cited.

EFFECTS OF FLUORIDE ON THE BONES, THE SKELETAL SYSTEM & SKELETAL FLUOROSIS

To reveal the effect of fluoride on Bones/Skeletal System, certain basic information on gross and microscopic characteristics of the bone need to be explained.

The effects of fluoride on the bone depend on the type of bone and its inorganic and organic constituents. There are 200 distinct bones in the body. They are found in different regions as indicated below:-

The spine or vertebral column	
(Sacrum & Coccyx included)	26
Canium (Bones in the Head)	8
Face	14
Hyoid bone, Sternum & ribs	26
Upper extremities	64
Lower extremities	62
Total	200

The bones are grouped into 4 classes on the basis of shape and size viz. Long, Short, Flat and Irregular.

Long Bones

These are found in the limbs. A long bone consists of a shaft (**diaphysis**) and two extremities (**epiphysis**). The bones belonging to this class are:

Humerus, Radius, Ulna, Femur, Clavicle, Metacarpel & Metatarsal bones, and Phalanges

The shaft (diaphysis) is a hollow cylinder. The wall of the hollow tube is made up of a special type of bone i.e. **Compact bone/Dense bone** or **Cortical bone**. Whereas the epiphysis or the two ends of the long bone, are made up of a **Spongy bone/or Cancellous bone** with a thin covering of compact bone substance (The structure and other characteristics will be described later in this Chapter)

Short Bones

These bones are Cancellous/Spongy throughout except at their surfaces where there is a thin crust of compact bone substance. Patella in the knee joint is a Cancellous/Spongy bone (The structure and other characteristics will be described later). Iliac crest region of the pelvic girdle, body and spine of the vertebrae are cancellous bones. Fig 6.1 reveals the cancellous and cortical bony regions in the body.

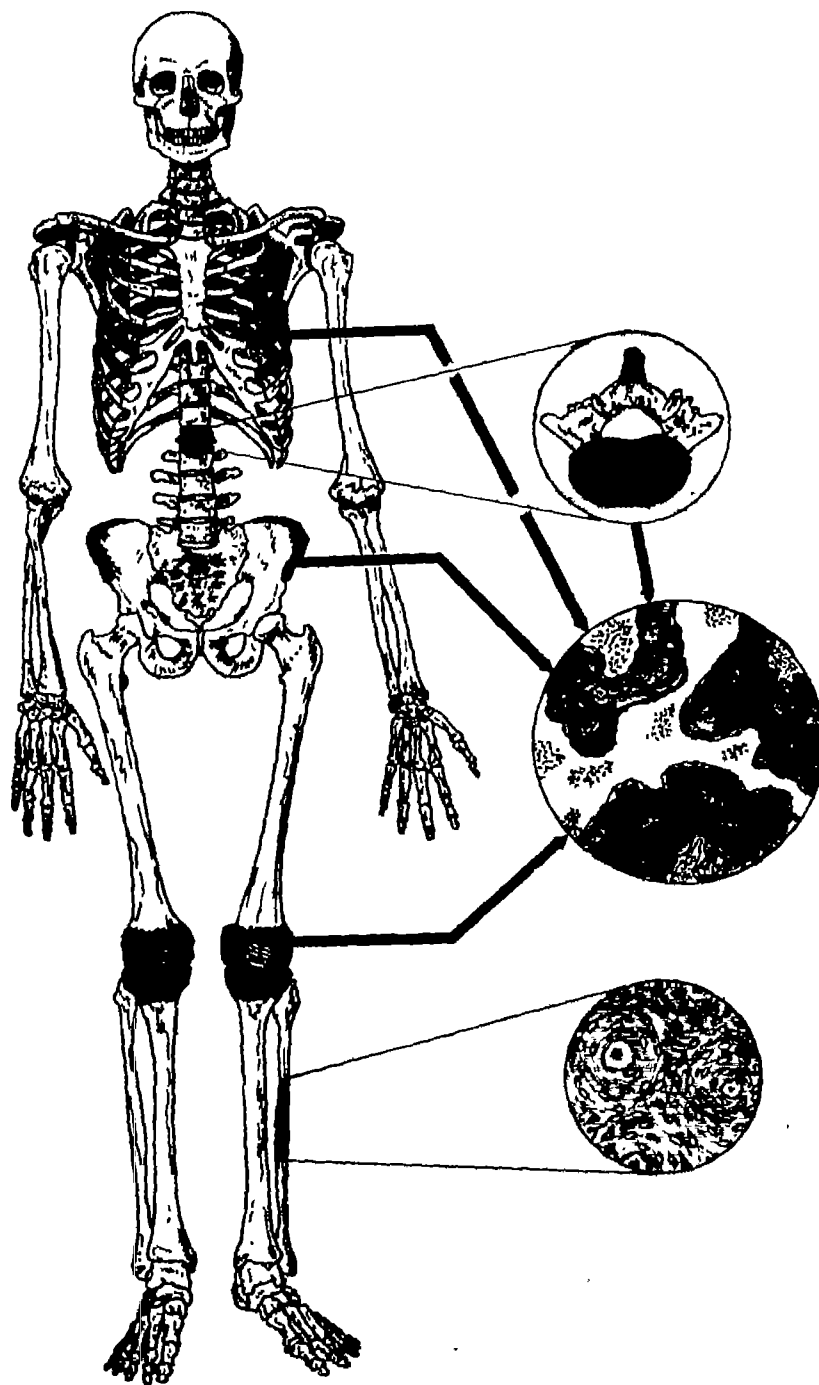


Fig 6.1 Showing the skeletal frame work of the body. The regions coloured red are constituted with cancellous bone. The inset at the top reveals that the body and spine of the vertebrae are cancellous ; the inset in the middle reveals the microscopic structure of cancellous bone revealing bony trabeculations with bone marrow. The inset at the bottom reveals the microscopic structure of cortical bone, which is found in long bones, with well defined circularly organized osteons. (Courtesy Dr T.M. Sunil) Cancellous bony regions accumulate more fluoride compared to cortical and get affected more severely in fluoride poisoning

Flat Bones

These bones are composed of two thin layers of compact tissue, enclosing a variable quality of cancellous bone. The occipital, parietal, frontal, sternum and ribs are flat bones.

Irregular bones

The irregular bones are the vertebrae, sacrum, coccyx etc. Their structure is same like other bones with an outer layer of compact with cancellous/spongy bone within.

Cancellous and Cortical bones

Based on the microscopic structure, bones are classified into cancellous and cortical types.

Major differences of cancellous and cortical bones: (Fig : 6.1 insets)

Cancellous bone

Porous
Osteons are not well defined
Copious blood supply
Haversian system does not exit
Larger surface area is exposed to blood supply due to the presence of trabecular bone surfaces and bone engulfing bone marrow.

Cortical bone

- Compact
- Osteons are well defined.
- Scanty blood supply
- Haversian System well developed
- Limited surface area exposed to blood supply due to compactness of the bone.

A fluorosed bone shows characteristic structural changes viz.

1. Increased bone mass and density.
2. Exostosis (bony outgrowth) at bone surfaces.
3. Increased osteoid seam and resorption surfaces
4. Increased trabecular bone volume, cortical porosity and periosteocytic lacunar surface.
5. Increased Osteon diameter and mottling of the Osteons
6. Formation of unmineralized cartilagenous loci within the trabeculae of the cancellous bone but not in the cortical bone.
7. Accumulation of Glycosaminoglycans specially the isomer Dermatan sulphate in the Cartilagenous lesion of the cancellous bone (Fig 6.2)



Fig 6.2 Cross sectional view of cancellous bone. Note the cartilagenous locus within the trabecular bone (arrow) stained with Ruthenium red showing accumulation of glycosaminoglycans.
(Courtesy Mohan Jha & A.K. Susheela)

Excess ingestion of fluoride and skeletal Fluorosis

Skeletal Fluorosis is not easily recognizable until the disease has developed to an advanced stage. Excessive quantities of fluoride when deposited in the skeleton, it is more in cancellous bone compared to cortical bone. Changes in the bone will then be revealed through radiographs. Maximum ill effects of fluoride are detected in the neck, spine, knee, pelvic and shoulder joints. It also affects small joints of the hands and feet.

Skeletal Fluorosis manifestations are seen in young as well as adults. The usual complaints of the patients viz. pain in the neck, back, joints and rigidity begin in regions where cancellous bones predominate as it is well recorded that cancellous bone accumulates more fluoride compared to cortical bone.

With increase in severity of skeletal Fluorosis, pain is associated with rigidity and restricted movement of cervical and lumbar spine, knee and pelvic joints as well as shoulder joints.

In severe cases of Fluorosis, there is complete rigidity of the joints resulting in stiff spine described as Bamboo spine and immobile knee, pelvic and shoulder joints.

Crippling deformity is associated with rigidity of joints and include Kyphosis (abnormally increased convexity in the curvature of the thoracic spine as viewed from the side), Scoliosis (lateral curvature of vertebrae column), Flexion deformity (the act of bending or the condition of being bent) of knee joints, paraplegia (Paralysis of the lower part of the body including the legs) and quadriplegia (Paralysis of all the four limbs). As depicted in Fig 6.3a, 6.3 b & 6.3 c.

In patients with paralysis, it begins with vague pain in the back and extremities



Fig 6.3 a



Fig 6 3 b

Symptoms develop due to pressure caused by Osteophytes (bony outgrowth)/narrowing of intervertebral foramen and increase in size of the body of the vertebrae or narrowing of the spinal canal, can lead to paralysis.

Excess fluoride mainly through drinking water, food items, drugs and cosmetics (toothpaste, mouth rinses and tablets) can cause Fluorosis and other health problems. The permissible limit of fluoride in drinking water prescribed by national drinking Water Mission is 1.00 - 1.5 parts per million (ppm); but lesser the better.

Although fluoride levels in drinking water is the main reason for causing the disease; the health complaints are aggravated when fluoride enters through other sources and when the water has high alkalinity and low calcium contents and diet deficient in Vitamin and minerals.

An individual may suffer from Skeletal Fluorosis or Dental Fluorosis or non-skeletal manifestations or All or a combination of the above.

Skeletal Fluorosis Affects young children as well as older individuals. Fluoride can also damage a foetus, if the mother consumes water/food with high concentrations of fluoride during pregnancy/breast feeding. Infant mortality due to calcification of blood vessels can also occur. Abortions, still births and children born deformed, are common in endemic areas.



Fig 6.3 c

Fig . 6.3 a, b, & c. Individuals afflicted with skeletal fluorosis; can only move about with external support.

Skeletal Fluorosis :Symptoms & Complaints

- Severe pain and stiffness in the neck and back bone
- Severe pain and stiffness in the joints
- Severe pain and rigidity in the hip region (pelvic girdle)

- X-ray would reveal increased girth, thickening and density of bone. Fig 6.4, 6.5, 6.6. In certain patients - due to calcium deficiency Osteomalacia type changes where bone would appear weak revealing the inner structures may be seen
- Constriction of vertebral canal and intervertebral foramen exerts pressure on nerves, blood vessels leading to paralysis and pain

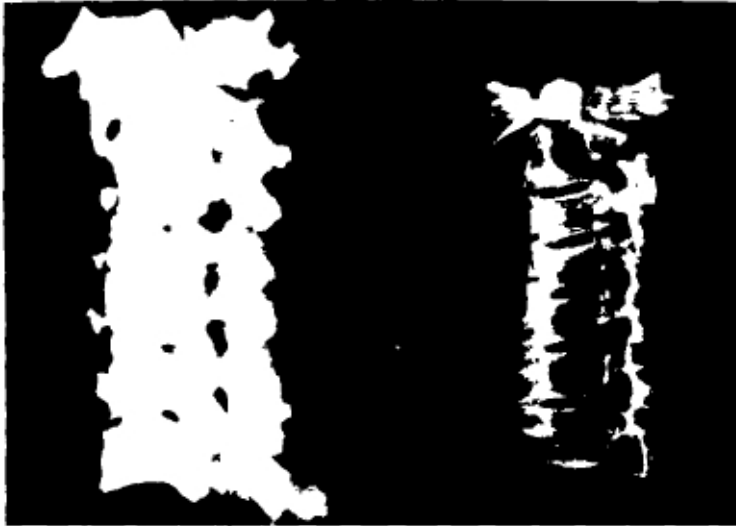


Fig. 6.4
 Two pieces of backbones are shown, one from a normal and the other from a subject died of Skeletal fluorosis. Normal piece of vertebrae is on the right and the one from an individual afflicted with fluorosis is on the left. The fluorosed bone is dense, bone mass is increased, individual vertebra cannot be distinguished. The normal bone clearly shows that there are 6 vertebrae. It is less dense; bone mass is less.
 (Courtesy S. S. Jolly)

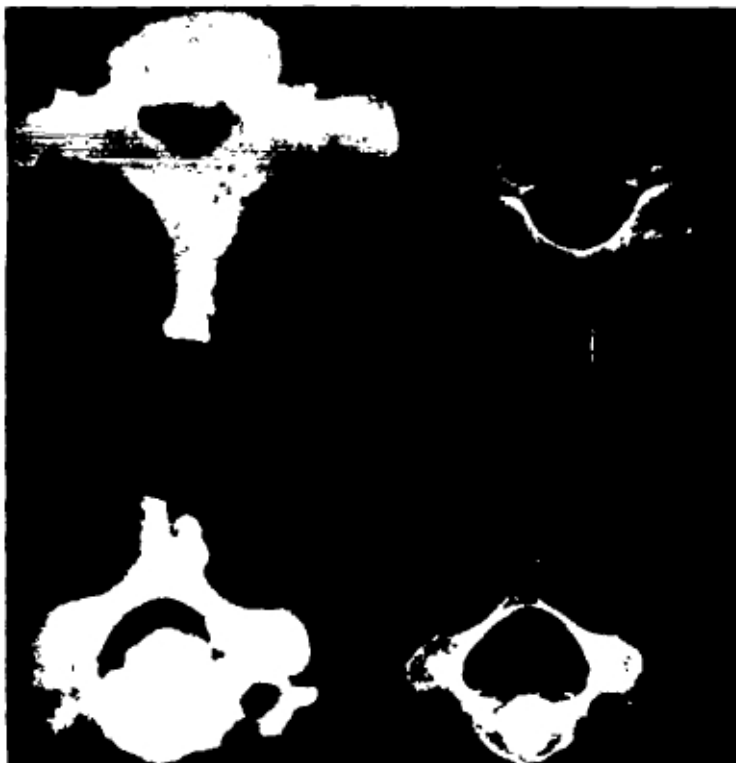


Fig 6.5
 Note the 2 sets of vertebrae; normal vertebrae; (right) Fluorosed vertebrae, (Left) Note the difference in the density and bone mass between the 2 sets of bones.
 (Courtesy S. S. Jolly)



Fig 6 6 Radiograph of the Pelvic girdle from a Patient of Fluorosis showing increase in the density of the bone.

Physical tests The 3 physical tests illustrated in Fig 6.7 will reveal the onset of changes in the joints as it will be associated with pain.

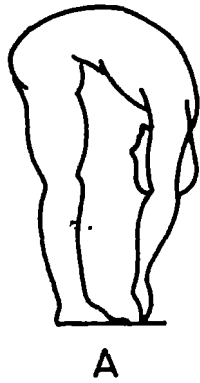
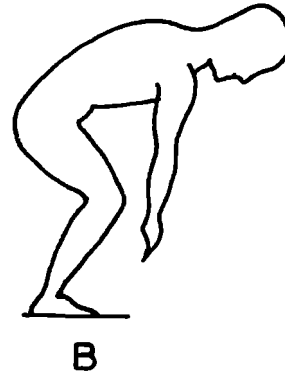


Fig. 1 Normal healthy individual can bend his body and touch the floor/toes



Unable to bend, without folding his Knees

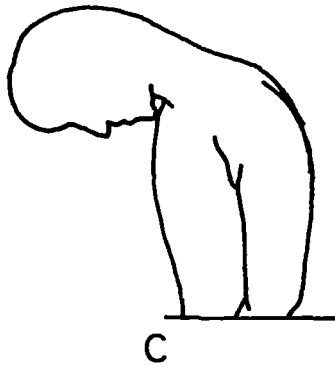
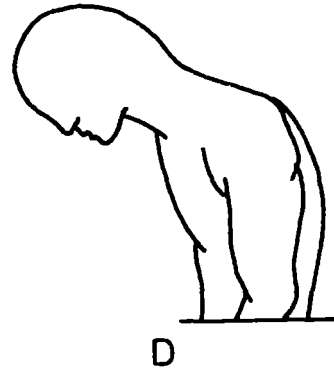


Fig. 2 Normal, healthy individual can touch the chest with chin



Unable to bend the neck- touching the chest with chin not possible

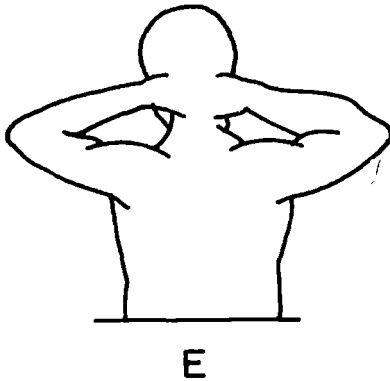
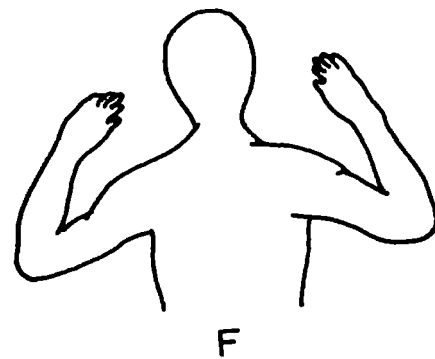


Fig 3 Normal, healthy individual can stretch the hands, fold the arms and touch the back of the head



Unable to stretch the hands, fold the arms and touch the back of the head

Credit V. K. Desai

(Drawing by Dr Taposh K Das)

- One of the major problems in rural areas is that if one asks questions regarding pain and stiffness in the joints, the answer invariability is 'No'. Such answers are not dependable. Instead, the simple physical tests are carried out to assess whether the joints are affected or not.
- The individual is made to bend and touch the toes without bending the knees. If there is pain or stiffness in the backbone, hip and joints, this exercise will not be possible.
- The individual is made to touch the chest with the chin. If there is pain or stiffness in the neck, this exercise will not be possible.
- The individual is made to stretch the arms sideways, fold the arm and try to touch the back of the head. If there is pain or stiffness in the shoulder joint and backbone, this exercise will not be possible

The incidence of Skeletal Fluorosis is wide spread in endemic states. However, there are individuals who may remain asymptomatic, inspite of drinking high fluoride containing water. The following table reveals the magnitude of the problem.

Table : 6.1 Showing the prevalence of Skeletal Fluorosis in a sample of 14 villages from Liliya & Lathi Taluks of Amreli District in Gujarat where Dental Fluorosis co-exist with Skeletal Fluorosis . (RGNDWM Survey 1987);

Name of the Village	Population Surveyed	Prevalence of Dental Fluorosis %	Prevalence of Skeletal Fluorosis %
1. Antalia	349	14.32	35.53
2. Lonki	765	19.60	0.91
3. Mona Liliya	1050	20.66	16.95
4. Punja Padar	1674	21.80	6.27
5. Mota Liliya	5138	15.16	11.45
6. Haripur	1037	23.52	64.51
7. Kalyanpur	511	13.69	37.37
8. Katano	552	57.42	44.74
9. Hathigadh	1600	10.0	34.62
10. Sejanimba	1000	12.3	53.2
11. Havlad	572	9.61	55.94
12. Ansodar	770	25.71	59.45
13. Ingorala	690	10.57	75.94
14. <u>Shedhovodar</u>	600	0.69	<u>28.33</u>

The Table is showing the incidence of Skeletal Fluorosis and Dental Fluorosis in a sample of 14 villages of Amreli District. The percentage of affliction is shown. Incidence of Dental Fluorosis is given in 14 villages, ranges from 9.6 to 57.4% and Skeletal Fluorosis 1% to 75.9%. The remaining people in each village may or may not be totally unaffected; those having early symptoms have not been taken into account in the survey conducted under the RGNDWM guidance during 1987. Those figures which are highlighted, are the highest incidence of the disease in the 14 villages reported here. The data will also reveal that it is not necessary that wherever Dental Fluorosis is high, Skeletal Fluorosis also will be high. Dental Fluorosis may be low and Skeletal Fluorosis may be high such possibilities also exist.

FLUORIDE IN DRUGS & COSMETICS

Besides water and food, Fluoride can enter the body through drugs and cosmetics.

Fluoride containing drugs have been in use for years. The use of Fluoride containing drugs for Osteoporosis and Otosclerosis is very common among the developed and developing countries.

A dose of 50-80mg of sodium fluoride each day is administered to Osteoporotic patients and treatment may continue for several years. Sodium fluoride treatment for Osteoporotic patients may lead to :

1. The patient who was suffering from excruciating pain may get relieved of the pain and the patient is happy with the treatment. As a result, the individual may continue with the drug over a period of time, the atrophied bone of the patient may reveal through radiographs an increase in bone mass and bone density. Although, it may appear that the bone is improving in terms of the atrophied structure, in reality, secondary Skeletal Fluorosis is setting in. The use of sodium fluoride for treating Osteoporotic and Otosclerotic (impairment in hearing) patients continue to be a subject of debate among the Professionals. There is now a strong view that Fluoride degenerates the bone rather than improves the bone.
2. During sodium fluoride therapy, unlike the group referred to above, some patients develop excruciating pain and they abandon the treatment at the very outset.

It has also been observed that those patients who are on NAF therapy, do suffer from **Non-Ulcer dyspeptic** complaints which they may or may not realise, is the side effect of Naf therapy. Gastro-intestinal discomfort and Non-ulcer dyspepsia in fluoride toxicity has been dealt with in greater detail in one of the ensuing chapters.

Fluoride Containing Cosmetics viz. Toothpastes & Mouth Rinses

Thirty Brands of Toothpastes (Which are labelled as "Fluoridated" and those which are not labelled as Fluoridated but both manufactured by the same firm,) have been analysed for fluoride content by laboratories practising quality control procedures.

It has been evident that there is no brand of tooth paste so far analysed, that is free of fluoride.

The Fluoride content arising from the raw material used for the manufacturing of paste viz. calcium carbonate, talc and chalk have high fluoride arising as a contaminant from raw material, can be as high as 800-1000 ppm. In the fluoridated brands, there is a deliberate addition of fluoride which may range from 1000 - 4000 ppm.

The mouth rinses that are sold with special brand names, are nothing but fluoridated water of a very high content of fluoride.

The contention has been that if fluoridated toothpaste or mouth rinse when used (the reason(s) for its use will be dealt in diseases of the teeth), it is only a topical application and when the oral cavity is rinsed with water, the chemical is washed away. These views no longer hold good as the blood vessels in the oral mucosa and the sublingual blood vessel (the one below the tongue) absorb fluoride within minutes. The sub-lingual blood vessel is used as a route of drug delivery, specially for cardiac patients. Indian studies have also shown that absorption of fluoride within minutes after brushing the teeth with

fluoridated toothpaste (Rajan, et al 1987; 1988, 1989). The Saliva obtained from the oral cavity when analysed for Fluoride, an hour after brushing the teeth, has also revealed high fluoride content.

In view of these evidences, the Drugs and Cosmetic Act of 1945, which had no specific stipulation(s) in the addition of toxic chemicals to toothpaste, was amended during 1991. The Draft Gazette notification had brought out 3 stipulations for the manufacturing of toothpaste:

1. The toothpaste, when manufactured, should not contain more than 1000 ppm of Fluoride (The 1000 ppm is not for deliberate addition) but was providing room for the natural contaminant fluoride, as it was considered unfair to the manufacturer that the raw material should be defluoridated and then manufacture the paste.
2. Children below 7 years should not use Fluoride containing toothpaste, and this should be inscribed on every tube and carton.
3. Expiry and manufacturing date should be inscribed on the carton as some brands of paste are known to decompose due to addition of sodium monofluorophosphate.

The final Gazette Notification was published in 1992, almost a year after the publication of the Draft Gazette Notification (60 days are normally granted for eliciting the views of the public) and strange enough the 2nd stipulation that "children below the age of 7 year should not use Fluoride containing toothpaste" and the warning to be inscribed on the carton and tube "vanished" from the notification.

At present we therefore have two stipulations 1 & 3. Therefore the manufacturers are adding fluoride and they inscribe on the carton that the paste contains 1000 ppm of fluoride at the time of manufacture.

Secondly manufacturers producing those brands of paste where no fluoride is added, are not checking the quality of products and are not indicating the content of fluoride arising as a contaminant from the raw material which may be as high as 1000 ppm.

This clearly indicate that the Drugs and Cosmetic Act 149A of 1992 requires further amendment. The consumer needs to be alerted about the dangers of fluoride.

It may be relevant to quote at this juncture a passage of John Lee's article "Fluoridation and osteoporosis" a letter to Editor, published in fluoride 25 (3) 1992:

"Fluoride Therapy for osteoporosis"

It has been proposed in the past that, since fluoride is "calcium seeking", it might be a good treatment for those with osteoporosis. This has resulted in a number of "therapeutic" fluoride trials. The results of these trials are now available and the conclusion is that fluoride has no place in the treatment of osteoporosis. These trials include those of Riggs (1990), of Kleerekoper (1989), and of Hedlund and Gallagher (1989), all of which reported significantly increased hip fracture incidence as well as an unacceptable rate of gastrointestinal and osteoarticular side effects in the treated group compared to the controls. Professor Avioli of the Washington University School of Medicine concluded in 1987 that "sodium fluoride therapy is accompanied by so many medical complications and side effects that it is

hardly worth exploring in depth as a therapeutic mode for postmenopausal osteoporosis" (1987). Riggs, after several years of touting fluoride for osteoporosis, finally conceded in 1989 that fluoride had no place in osteoporosis treatment (1989) The chairman of the FDA advisory committee reviewing fluoride's effect on fracture incidence was quoted as saying the FDA "should quietly forget" about fluoride reported in Medical World News 13th November, 1989, p 25.

ORAL CAVITY, TEETH AND DENTAL FLUOROSIS

Teeth are important components of the facial skeleton. Apart from the function of mastication of food, teeth add to the aesthetics, phonation and speech.

Development of teeth start during the 6th week of intrauterine life. The complicated process of this development ultimately blossom into a set of teeth

- a) primary or milk teeth - 20 in number - 10 in the upper jaw and 10 in the lower Jaw
- b) Permanent teeth - 32 in number - 16 in the upper jaw and 16 in the lower jaw.

Primary teeth are called as Milk Teeth as they are "milky white in colour". The child starts getting tooth from 6 months of age and all milk teeth are ween in the oral cavity by 2 1/2 years of age

Permanent teeth start erupting from 6th year of age and complete between 18-25 years of age.

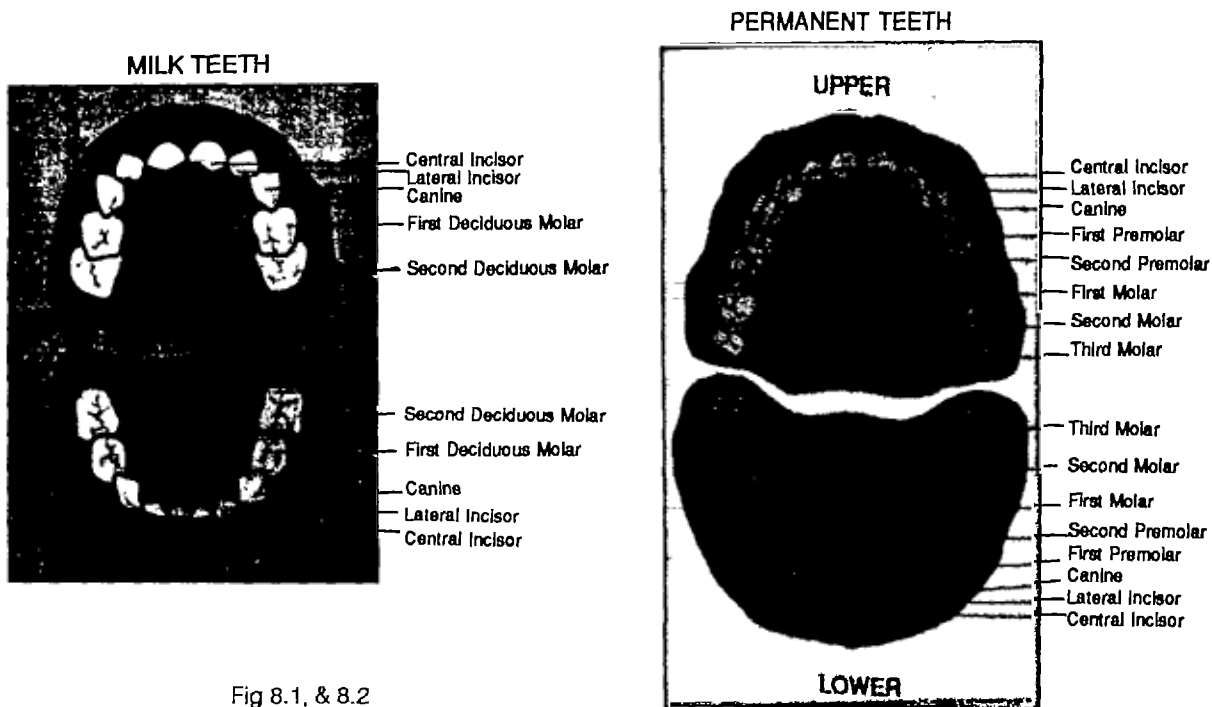


Fig 8.1, & 8.2
(Contributed by K.S. Nagesh)

Parts of a tooth : Basically the tooth has

1. Crown - visible into the oral cavity
2. Root - embeded in the jaw bone.

Teeth are named as incisors, canines, premolars and molars, commencing from the midline.

Structurally, each tooth consists of several parts

- a) Enamel
- b) Dentin
- c) Cementum
- d) Pulp
- e) Periodontal ligament/membrane
- f) Alveolar bone

Enamel, the outermost covering of tooth, is the hardest structure in the body with inorganic components, mainly with calcium salts. Enamel protects the tooth beside giving colour and lustre.

Dentin is also a calcified structure forming bulk of the tooth and is constituted of collagen fibres.

Cementum, another calcified structure covering the root portion.

Pulp, the central part of the tooth, viewed in a sagittal section, contains nerves, blood vessels, serving nutrition to the tooth and carries sensation

Periodontal ligament, a band of connective tissue attaches tooth to the alveolar bone. It carries, pain, pressure sensations and allows movement of tooth within physiological limits.

Root of the tooth is well protected by gingiva or gum.

CROSS SECTION OF ANTERIOR TOOTH

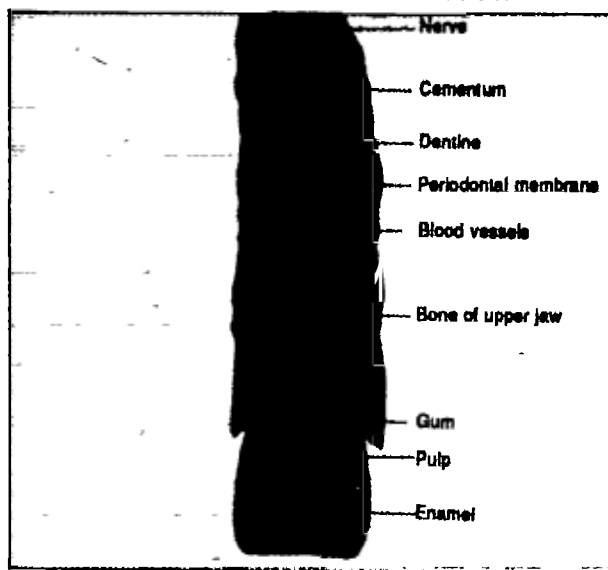


Fig 8.3 (Contributed by K S. Nagesh)

Common Dental Diseases

Like any other organs in the body, teeth are also affected by various factors leading to diseases. Common dental diseases are -

1. Dental caries or decay/cavity formation
2. Periodontal disease or pyorrhoea
3. Dental Fluorosis

Dental caries and periodontal disease account for a high percentage of mortality and morbidity of tooth.

Caries is defined as chronic, irreversible disease of the hard structures of teeth characterised by demineralisation of inorganic components of teeth and dissolution of organic substance of microbial aetiology. Caries is a result of bacterial growth in unhygienic oral cavity; leading to acid production and acids etch away the enamel.

Micro organisms breed in the oral cavity in the food debris and produce acids by fermentation. The acid(s) thus produced are lactic, propionic and acetic acid. The acids bring about demineralisation of the enamel.

Caries appears as black spot or cavity on tooth.

Initially it remains asymptomatic. Lodging of food particles between teeth is often a common complaint and if oral hygiene is not maintained, may lead to cavity formation. When caries/cavity reaches dentin, the individual would complain of sensitiveness to hot and cold food substances resulting in pain. As the disease advances and when affects the pulp, pain becomes severe; with inflammatory changes in pulp. If untreated, it results in periapical abscess commonly known as Dental abscess.

Periodontal disease is the inflammation of gingiva gum and periodontal ligament. Unhygienic oral cavity leads to deposition of inorganic salts on the teeth surface towards the gum and is commonly known as tartar.

Tartar cannot be removed by brushing. It irritates the gingiva, producing gingivitis. At this stage, an individual would complain of bleeding from the gum, sore gum, and bad breath.

Gingivitis progresses to periodontitis, leading to abscess and loosening and exfoliation of teeth.

Periodontal disease is more common amongst persons suffering from diabetes mellitus, nutritional deficiency, especially protein and Vitamin C deficiency

Dental Fluorosis

Drinking water from sources having high fluoride is the cause of Dental Fluorosis.

Fluoride is also found in tooth paste, mouth rinses and varnish and can contribute to the fluoride burden of the body.

Dental Fluorosis is an aesthetic and social problem, besides being a health problem.

The discoloration of the teeth may start from white, yellow, brown to black. The discoloration may be in spots, streaks invariably horizontal in orientation, as during development, new layers of the matrix are added horizontally.

In Dental Fluorosis, the discoloration will be away from the gums and on the enamel surfaces and it can never be removed as it is an integral part of the tooth matrix.

In Dental Fluorosis, the enamel will lose its lustre and shine.

The discoloration i.e. yellow, brown, black, when seen along the gums and on the periphery of the teeth, is due to other reasons viz. dirty teeth, smoking, tobacco chewing and it is possible to get the teeth cleaned when one is able to have white, shiny teeth

Persons with discoloured teeth develop an inferiority complex, presenting psychosociological problems to self and the family. In case of females, discoloured teeth would be an impediment in the matrimonial propositions.

Calcium rich constituents of teeth viz. enamel and dentin have strong affinity for fluoride during the formation of teeth. Fluoride combines with calcium forming calcium fluoroapatite crystals during the mineralisation of teeth.

Enamel matrix is laid down in incremental lines before and after birth i.e. pre-natal period. Hence, Dental Fluorosis is invariably seen as horizontal lines or bands on the surface of teeth and never as vertical bands. It may also appear as spots. Fluorosis is seen as (a) mild (b) moderate and (c) severe, involving the entire or part of the crown. This depends on the amount of fluoride ingested during the stages of formation of the teeth.

Teeth commonly affected are (a) central incisors (b) lateral incisors (c) molars of the permanent dentition - Fluorosis affects both the inner and outer surfaces of the teeth.

Teeth affected by Fluorosis being poorly calcified (hypomineralized) loses enamel under the normal masticatory stress. Enamel has no regenerative capacity. Once it is lost, it is lost for ever. The dentin is then exposed. Cavities initiated in dentin then spreads much faster and involves the pulp easily, leading to loss of teeth. Pitting on enamel surface encourages food lodgement, aggravating caries formation.

The teeth once affected by Dental Fluorosis cannot be reversed to normal . But the discoloured teeth can be masked by bleaching and or by other methods.

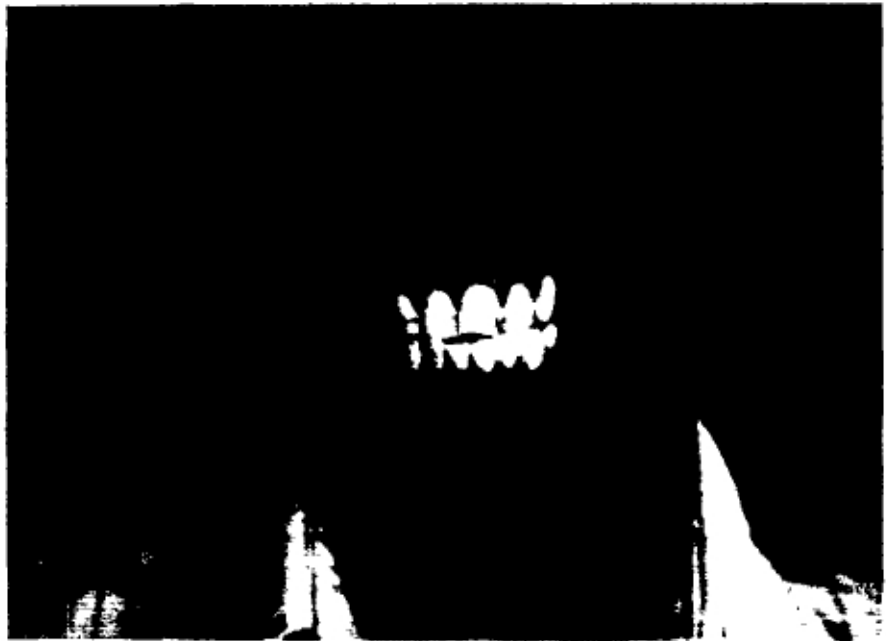
The various treatments available for Fluorosed teeth are:

a) Bleaching of teeth

b) filling with light cure material and laminated veneering

c) Capping or crowing of teeth with metals like chrome, cobalt, gold, porcelein and acrylic.

Dental Fluorosis is prevalent in children who are born and brought up in an endemic area for Fluorosis. Dental Fluorosis can occur in milk teeth and permanent teeth. Discoloration due to excess fluoride intake will be visible to the naked eyes. (Fig : 8.4)



8.4 Dental Fluorosis: note the discoloration in horizontal streak on the lateral incisor

The Symptoms

- Glistening white teeth become dull, lose the shine - develops white and yellow spots (Fig 8.5)
- White yellow discoloration turns brown and presents itself in horizontal streaks or spots on the enamel surface. The discoloration near the gums is due to dirty teeth and should not be mistaken for dental Fluorosis.
- The brown streaks if present at the tip of the teeth it would indicate that the child has been exposed to high fluoride up to the age of 2 years. From the level of the discoloration on the teeth, the dating of exposure to fluoride can be made.

- The brown streaks, if in the middle of the teeth indicate that the child has been exposed to high fluoride from the age of 2 to 4 years.
- The brown streaks in the upper part of teeth denote that the child has been exposed to high fluoride from the age of 4 years upto 6 years and after. Fig 8.6)
- It is also possible that the whole teeth may become black. They will be pitted or perforated and may even get chipped off.
- Dental fluorosis is not only a cosmetic problem but is also known to cause social problems.
- Loss of teeth at an early age (edentulate) is common in endemic areas.



8.5 Dental Fluorosis The teeth have lost the shine and lusture. White and yellow spots predominate the tooth surface.



8.6 Dental Fluorosis : Note the brown black horizon discoloration on the two central incisors. The discoloration is towards the upper part of the teeth away from the gums, which denotes that the child had been exposed to fluoride during the age of 4-6 years. Had the child been exposed to fluoride during the age of 2.3 years, the tip of the teeth would reveal discoloration.

EFFECTS OF FLUORIDE/FLUOROSIS ON SOFT TISSUES/ORGANS/SYSTEMS

The conventional belief that fluoride affects only bone and tooth has been negated in recent years as the evidences on the involvement of the soft tissues/organs/systems of the body are convincing, the soft tissue involvement is dealt with in this chapter. Although, the radiographs taken on fluorosed individuals do reveal that ligaments (a thin flimsy soft tissue) do calcify, very little attention was paid in past to understand the extent of soft tissue involvement in Fluorosis.

Investigation on soft tissue involvement in Fluorosis has drawn the attention in the recent past and convincing evidences from Fluorosis patients are now available from India to demonstrate the damage/involvement of (1) Skeletal muscle (2) Erythrocytes (3) Gastro-intestinal System as well as (4) Ligaments in human fluorosed patients. There are evidences of involvement of other organs and systems of the animal models viz kidney, liver, adrenal gland and reproductive organs. In this chapter, however, information on the derangement of muscle structure and function; destruction of erythrocytes through formation of echinocytes and the damage and derangement in the intestinal mucosa causing non-ulcer dyspeptic symptoms are described. This chapter will focus on soft tissue involvement and early warning signs of fluoride poisoning and Fluorosis, which have gained considerable importance in detecting the disease at the early stages, Therefore prevention of the disease has become possible.

Fluoride Toxicity/Fluorosis and skeletal muscle involvement

Calf muscle (Gastrocnemius muscle) biopsies and blood samples of patients of skeletal Fluorosis admitted to Government Medical College hospital, Patiala (Punjab) under the care of Late Prof. S.S. Jolly have been obtained and investigated using techniques in the field of Light and Electron Microscopy; histochemistry and biochemistry

- In the normal muscle tissue sectioned longitudinally reveals the characteristic arrangements of actin and myosin filaments with dark and light bands
- In the fluorosed muscle there are wide spread changes within a fibre revealing destruction of the actin and myosin filaments
- The mitochondria loses its structural integrity, thereby providing evidence that muscle energy is likely to be depleted.
- Biochemical studies on serum creatine phosphokinase enzyme have shown that the levels are high in the serum samples of fluorosed individuals. It is a fact that phosphocreatine content in skeletal muscle is greater than all other tissues in the body and is known to be concentrated in the mitochondria as the enzyme creatine phosphokinase (CPK) has been localized in muscle mitochondria. The enzyme creatine phosphokinase is responsible for accelerating reversible transfer of phosphate radicle between adenosine di-phosphate and phosphocreatine. Creatine phosphokinase are high levels in serum is an indication that the muscle mitochondria is destroyed and muscle membrane has become highly permeable.

In Fluorosis patients, the muscle fiber degeneration to the level of actin and myosin filaments, muscle membrane (plasma membrane) and mitochondrial membrane defects leads to rise in CPK level in serum

These studies for the first time have shown that skeletal muscle is directly involved in Fluorosis. Muscle involvement was earlier considered as 'secondary' effect due to neuronal involvement. As the increase in bone mass and narrowing of the vertebral canal as well as intervertebral foramen through which the spinal nerves emerge degenerative changes in muscle occur.

The Electron-microscopic observations and biochemical data on CPK further suggests that there is primary muscle destruction in Fluorosis. It is evident from patients of Fluorosis that they suffer from muscle weakness, loss of muscle energy and inability to carryout normal routine activities.

The above information should be kept in view while interviewing a patient of Fluorosis for 'history taking'. The question posed to the patient(s) should be so structured to assess the magnitude of tiredness/weakness.

For Example: A few classical examples are as follows:-

If the patient is a female, she should be asked whether she is able to carryout her routine domestic activities viz. sweeping the floor, washing clothes, washing utensils etc. in the same manner as she used to do in earlier years.

If the patient is a male then he should be asked the nature of his occupation and whether he is able to carryout his duties in the same manner and with the same efficiency as he was doing prior to the onset of the symptoms.

Likewise if the patients are interviewed, keeping in view specific issues, considerable information would emerge which would provide meaningful clue. That patient has muscle weakness, although the naked eye observation on the muscle bulk may not be helpful

Fluoride toxicity and Fluorosis and its effects on Red Blood Cells (RBCs)

As red blood cell membrane is an important structural entity which lodges the chemical factor(s) responsible for blood group substances, considerable enquiry into the membrane structure, function has been carried out. These studies have led to certain vital information on fluoride action on red blood cell membrane and the cell as a whole.

It is now known that when fluoride is ingested, it will also accumulate on the erythrocyte membrane, besides other cells, tissues and organs. The erythrocyte membrane in turn loses calcium content.

The membrane which is deficient in calcium content, is pliable and is thrown into folds. The RBCs attain the shape of an amoeba with pseudopodia like folds projecting in different directions. Such RBCs are termed as Echinocytes (Fig : 9.1; 9.2)

The Echinocytes will be found in circulation in large numbers, depending upon the extent of fluoride poisoning and duration of exposure to fluoride. The RBCs, in human, although have a life span of 120-130 days, the echinocytes undergo phagocytosis (eaten-up by macrophages) and are eliminated from circulation. This would mean that RBCs in individuals exposed to Fluoride poisoning, shall not live the entire life span, but are likely to be eliminated as echinocytes. This would lead to low haemoglobin levels in patients chronically ill due to fluoride toxicity.

It has also been observed among industrial workers exposed to fluoride pollution in Aluminium Smelters, that the number of echinocytes are increased depending upon the duration of exposure to

the fluoride polluted environment (Susheela et al 1985) It has also been observed in new born infants having physiological jaundice as bile salts induce echinocyte formation.

As a word of caution, echinocytes are also produced by certain other chemicals, The list of chemicals is as follows:

Chemicals inducing Echinocytes formation are :

- Rose Bengal
- Fatty Acids
- Bile Salts
- Sodium barbiturate
- Lecithin
- Phospholipids
- Fluoride

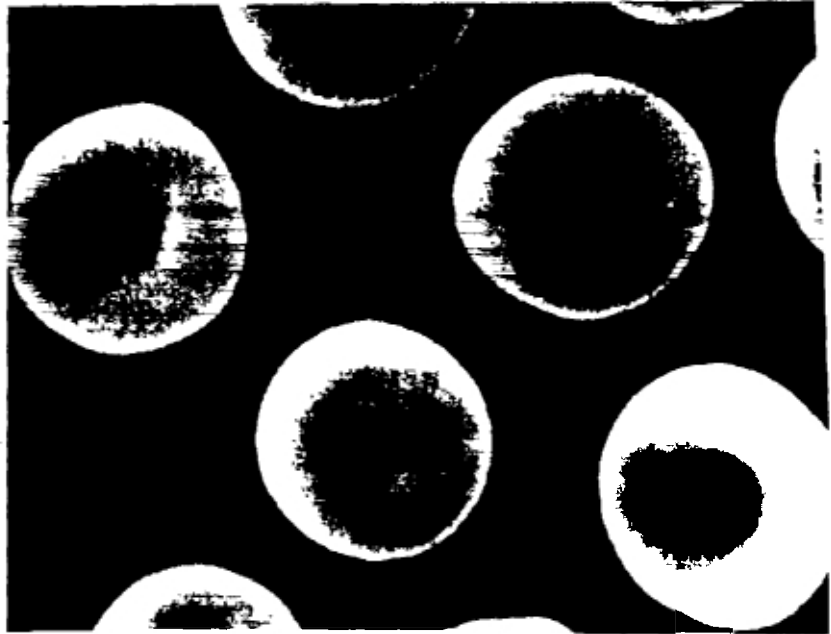


Fig. 9.1 Normal RBC

Effects of Fluoride poisoning on the Gastro-intestinal mucosa

Gastro-intestinal problems

Acute abdominal pain, diarrhoea, constipation, blood in stools, bloated feeling (gas), tenderness in stomach, feeling of nausea (Flu-like symptoms) and mouth sores, loss of appetite are common complaints due to fluoride poisoning/toxicity. The complaints with the G-I system in endemic areas are now established as early warning signs of fluoride toxicity. Fluoride is known to combine with hydrochloric acid of the

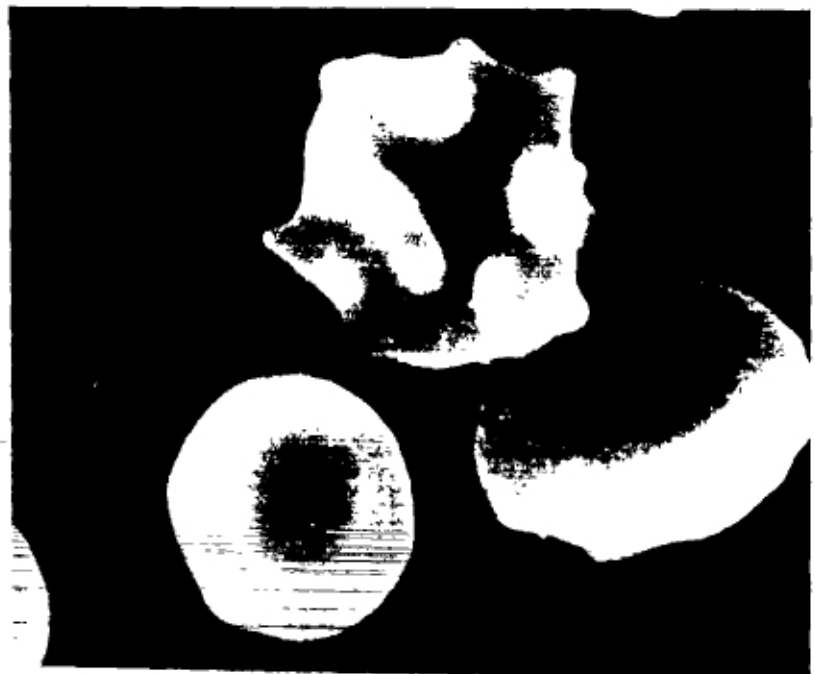


Fig 9.2 Fluorosed RBC (Echinocyte Seen)
(Courtesy · S. K. Jain & A. K. Susheela)

stomach and is converted to hydrofluoric acid ($F+HCl \rightarrow HF + Cl^-$) Hydrofluoric Acid is highly corrosive. The stomach and intestinal lining (mucosa) is destroyed with loss of microvilli (the structures which are responsible for absorbing nutrients from food), drying up and cracking of the cell surface and mucus (the slimy substance required for comfortable bowel movement) production is hampered (Susheela et al 1992) (Fig. 9.3; 9.4)

Neurological Manifestations

Nervousness, depression, tingling sensation in fingers and toes, excessive thirst (polydipsia) and tendency to urinate frequently (Polyurea) are controlled by certain regions of the brain and it appears to be adversely affected.

Allergic Manifestations

Very painful skin rashes, which are perivascular inflammation, prevalent in women and children, pinkish red or bluish-red, round or oval shaped spots on the skin that fade and clear up in 7-10 days can also occur.

Urinary Tract Manifestations

Urine may be much less in volume; yellow-red in colour and itching in the region may occur.

Ligaments and Blood Vessel Calcification

A unique feature of the disease is soft tissues like ligaments, blood vessels tend to harden and calcify and the blood vessels will be blocked (Susheela and, Kharb, 1990) Calcified ligaments and blood vessels can be seen in X-rays. (Fig. 9.5)



Fig 9.3 Normal intestinal lining. White drops (arrow) are mucus. Cell surface with microvilli(circle)
(Courtesy Susheela et. al, 1992)



Fig 9 4 Human intestinal lining revealing :-
1 Exposed cell surfaces (arrow) due to loss of microvilli and
2. Scanty mucus droplets(circle)as a result of consuming excess fluoride.
(Courtesy Susheela et al, 1992)



Fig 9.5 Left - Normal forearm X-ray Note the smooth outer and inner surfaces of the bone
Right -Radiograph of the forearm of a skeletal fluorosis patient calcified ligaments are seen between the 2 bones of the forearm (arrow)

Mechanism of Fluoride Poisoning

Once fluoride enters the body either through the blood vessels in the mouth or through the gastrointestinal route, it reaches the various organs and tissues in the body. Fluoride being an electronegative element and having a negative charge (represented by F^-), is attracted by positively charged ions like calcium (Ca^{++}). Bone and tooth having highest amount of calcium in the body, attracts the maximum amount of fluoride and is deposited as calcium fluoroapatite crystals. At the same time, from certain areas (location) in the bone and tooth, the unbound calcium is lost.

When calcium fluoroapatite deposition takes place in the bone, the bone density and bone mass get increased. In the backbone, the perforations through which nerves and blood vessels pass through, are constricted, leading to excess pressure on nerves and blood vessels culminating in paralysis and excruciating pain.

Detection of the Disease

The conventional method of detection of the disease until recent times is through X-rays (i.e. Radiographs). Radiographs can be helpful for detection of the disease only when the disease has reached the late stages, when the bone density and bone mass are increased and ligaments are calcified

Cure of Fluorosis

Fluorosis has no treatment, but it can be easily prevented provided the disease is recognized/detected at an early stage.

Early warning signs

Three methods are currently used for detecting the disease at an early stage specially in rural areas, endemic for Fluorosis where hospital based tests are not possible.

- 3 different physical movements are checked to detect whether the neck, back, hip and joints are immobile, rigid and painful.
- Whether the teeth of individuals specially children have developed :
 - Loss of lusture and shine of the enamel of teeth
 - Discolouration of the teeth to yellow, brown and black streaks and or spots
 - pitting and chipping off the teeth
 - Loss of teeth
- Gastro-intestinal discomfort viz , nausea, vomiting, pain in the stomach, constipation followed by intermittent diarrhoea and gas formation. These are the earliest signs of fluoride poisoning.

Word of Caution

Fluoride is one of the factors responsible for causing such gastro-intestinal health complaints. It should not be misunderstood that the above mentioned symptoms are always due to fluoride poisoning.

FACTORS INFLUENCING THE ONSET OF THE DISEASE (DETERMINANTS OF DISEASE)

Fluoride poisoning and the biological response leading to ill-effects depends on the following factors:

- Concentration of fluoride in drinking water: higher the fluoride greater the chances of being afflicted
- Low calcium and high alkalinity of drinking water can also cause severe forms of the disease even if the fluoride concentration are relatively low.
- Total daily intake of fluoride is the cause for concern as the additive or cumulative effect of fluoride results in the disease
- Duration of exposure to fluoride. It is now established that 6 months to 1 year exposure to fluoride can cause Fluorosis
- Age of the individual! Low intake of fluoride for a longer duration, will set in the disease as age advances; whereas exposure to high levels of fluoride ingested by a pregnant mother, can lead to the child develop Fluorosis at a relatively young age.
- Fluoride is known to cross the placenta as there is no barrier and it also enters maternal milk. Expectant mothers and lactating mothers are the most vulnerable groups.
- Derangement in hormonal profile either as a result of fluoride poisoning or cause, aggravate the disease. The hormones are: calcitonin, parathormone, vitamin D and cortisol are the important hormones for healthy bone formation and bone function.

Factors to Counteract Fluoride Poisoning

- Adequate calcium in the diet is one of the most important entities to combat the ill-effects of fluoride poisoning. Calcium interacts with fluoride to form calcium fluoride (CaF) which is an insoluble salt and being a larger molecule is not absorbed to a large extent. Such large molecules of fluoride are than excreted through faces. An expectant and lactating mother and a growing child should normally have 3 gms of calcium in diet. An adult should have 1.5 gms of calcium in the daily diet. Calcium is most essential for laying down of a normal, healthy and strong bone and tooth. Calcium rich dietary products viz., milk, curd, green leafy vegetables, cheese (paneer) etc should be consumed.
- Adequate vitamin C (ascorbic acid) in the diet is yet another important entity to ameliorate the ill -effects of fluoride. Vitamin C, acts as a cofactor or co-enzyme in the process of hydroxylation of prolein, one of the most important aminoacids of the collagen protein, the base material of bone and tooth matrix. If the bone and tooth have to be well calcified strong and normal, healthy collagen protein need to be laid down. 500-1000 mg of vitamin C a day is normally recommended. Unlike other vitamins, vitamin C is not produced in the body and one is totally dependent on vitamin C intake through dietary sources. Special efforts ought to be made to consume Vitamin C rich fruits and vegetables daily. Amla is an exceptionally rich source of Vitamin C, besides citrous fruits

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- A good balanced diet, can combat the ill-effects of fluoride. It is for this reason, the disease is seen highly prevalent in the economically backward strata of the society and those who are uneducated and unaware of the importance of good nutrition and balanced diet.

Control and Prevention of Fluorosis

Fluorosis although untreatable, can be easily prevented and controlled provided, the following procedures are adopted

Preventive Measures

- Water contaminated with fluoride more than 1.00 or 1.5 ppm should not be consumed. Should look for safe water for consumption.
- High fluoride containing products viz., (1) Supari (2) Tobacco (3) Black rock salt (4) Red rock salt (Sindhi), (5) Drugs and (6) cosmetics like toothpaste, mouth rinses and any other products proven to have high fluoride should not be used / avoided.

Control Measures

Individuals already affected and having health problems, specially early manifestations, the disease can be controlled as follows: however, those who are crippled and immobile little can be done:

- Avoid all possible sources of fluoride containing items viz., drinking water, food, drugs, toothpaste, mouth rinses
- Pain in the back bone, neck, hip and joints should not be dismissed as casual, hospital intervention to be sought.
- Expectant and lactating mothers who are the most vulnerable groups should only consume defluoridated water (domestic defluoridation procedures recommended as an interim measure)
- Consume adequate calcium and vitamin C in the daily diet
- Dental Fluorosis causing social and cosmetic problems can be over come by adopting any one of the three procedures to mask the discolouration of the teeth.
 - Laminated veneering (painting the teeth with a plastic emulsion)
 - Capping the teeth with a plastic mould
 - Bleaching

FLUOROSIS : PROCEDURES RECOMMENDED FOR DIAGNOSIS (A) HOSPITAL AND (B) FILED BASED APPROACHES

Fluorosis was recognized and diagnosed in India as early as 1930s. The disease remained unattended to largely because there is no treatment. Patients of Fluorosis were not admitted to hospitals as it would only block the beds without any beneficial effects to the patient. However, in recent years, patients of Fluorosis are being admitted either for subjecting them to detailed investigative procedures or for surgical intervention specially when paralysed.

The text books of medicine, community medicine, and other specialities in Health Sciences hardly describe the disease in adequate dimensions and therefore those graduating from medical schools are not well informed to deal with the disease effectively.

However, students of dentistry on the other hand are being taught the benefits of Fluoride as envisaged and practiced by the western world.

In Public health Engineering too, training is imparted for fluoridating the drinking water which again suggests that we continue to impart education based on western concepts.

This chapter is therefore, dealing with human Resource Development in India to deal with the issues pertaining to control and prevention of Fluorosis

Human Resource Development

One of the major tasks undertaken is to develop adequate human resource both in Health and Public Health Engineering Sectors so that the problem is dealt with effectively

During human resource development, special focus is laid on updating the information for Doctors to recognize the disease correctly as invariably the disease is misdiagnosed. In a similar manner, the focus for Public Health Engineers is to practice water quality testing, internal quality control and external quality assessment procedures for obtaining reliable results for fluoride while testing water

Besides, it is important for Public Health Engineers to acquaint themselves with procedures that are economically viable for removal of fluoride from drinking water

Human resource development programme has been initiated at the Regional level for information to percolate to the State, District and Village level. Programme implementation begins at the village level.

Emphasis is laid on establishing District level water testing laboratories, provision is made for fluoride ion testing meters, manpower trained for its operation, use and maintenance.

A village level house to house epidemiological survey through a pre-coded questionnaire provides the statistics and magnitude of the health problems related to fluoride toxicity/poisoning which was never before attempted in the country

The survey results reveal that in endemic areas for Fluorosis, a large percentage of people suffer from Gastro-intestinal complaints viz. loss of appetite, nausea, vomiting, pain in the stomach, constipation and intermittent diarrhoea and flatulence as a result of fluoride toxicity besides Dental and Skeletal Fluorosis. The expectant mothers and lactating mothers are the most vulnerable groups of the community. Two major approaches are adopted for recognizing the disease viz

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- Hospital based approach
 - Field based approach

Hospital based approach

The hospital based approach involves, carrying out the following tests for arriving at a meaningful and scientific diagnosis of the disease:

- Estimation of Fluoride content in:
 - Drinking water
 - Serum (blood)
 - Urine (24 hours collection, if possible)
- Radiographs of the :
 - Fore arm (to check ligamental calcification)
 - Pelvic region
- SA/GAG (Sialic acid upon Glycosaminoclycan) test of blood serum

Among these 3 groups of tests, mentioned above, fluoride estimation in drinking water is useful to obtain circumstantial evidence. The drinking water fluoride may range form 0.1 ppm to any level; 1.0 ppm is being considered as the permissible upper limit, 38.5 ppm is the maximum so far detected in India. However, fluoride lower than 1.0 ppm is better. If fluoride in drinking water is high (above 1.0 ppm), one ought to suspect the possibility of fluoride toxicity and its manifestations among the people consuming the fluoride contaminated water

The serum fluoride levels may or may not be informative as it depends upon when the blood sample was drawn from the subject (patient). If the blood sample was drawn within 2 hour after the last ingestion of food or water (contaminated with fluoride), the serum fluoride is bound to be high. However, if the blood sample has been drawn after 2 hour, after the last ingestion of food or water, then the circulating levels of fluoride may be normal even if a patient is suffering from Fluorosis, as fluoride in circulation never maintain a steady state, as it is diverted to other tissues; absorbed by tissues / excreted.

The urinary fluoride level is more useful compared to the blood fluoride level. If the urine collection is of 24 hr, it is better than spot samples. The volume of urine should be measured and pH should be checked. Some patients may excrete very little urine; urine colour will be deep yellow to red; the pH will be highly alkaline. It is also possible that some patients may suffer form diuresis (excretion of excessive volume of urine). If the subject has been ingesting food, water, drugs or any other substance contaminated with fluoride urinary fluoride is bound to be high. There is also yet another possibility and that is when an individual moves out of an endemic area and start living in a non-endemic area, there is a tendency for excreting high levels of fluoride for short duration of time (viz 1-2 months) and the subject will also have less pain in the joints and other regions. This would also mean that high excretion of fluoride may happen while living in a non endemic zone. History taking is an important task.

The **radiographs** are useful in diagnosing Fluorosis when it has reached an advanced stage of the disease. The radiographs will reveal

- Increase in bone mass
- Increase in bone density
- Translucency of the bone is lost
- Translucency and Trabeculations of the bone shall be visible in patients of Fluorosis those having calcium deficiency
- ligaments calcified

However, the radiographs may not be useful in diagnosing the disease in early stages/early onset of Fluorosis.

The SA/GAG test is a recent development in the country as the test was developed at the All India Institute of Medical Sciences during early 1980s, for the early detection/diagnosis of fluoride toxicity. The rationale of the test is based on the fact that when fluoride is ingested in large quantities, it brings about dearrangement in the bone matrix both in structural and biochemical parameters. The changes which are detected at very early stages, indicate enhanced production of Glycosaminoglycan (GAG) (mucopolysachrides) in the cancellus bone but not in the cortical bone. The zone in which GAG is found accumulated reveal cartilagenous structure. The enhanced production of GAG in the bone matrix is reflected in raised levels of GAG in circulation.

The sialic acid(SA) yet another Glycoporein in the bone matrix is not altered greatly. The ratio of SA/GAG in those subjects afflicted and having fluoride toxicity manifestations, will be almost 1/3rd or 1/2 of the normal value.

It has also been tested in various Orthopaedic conditions having similar complaints as that of Fluorosis and it has been recorded that SA/GAG ratio does not alter in Osteoporosis, non-specific backache and spondylosis. Whereas in Ankylosing Spondylytes, the SA/GAG ratio is enhanced considerably. It therefore has emerged that SA/GAG test is now recommended for diagnosing Fluorosis (in the early stages) and for differentiating it from Ankylosing spondylytes, where clinical manifestations are invariably overlapping.

The procedure for estimating SA and GAG are provided in appendix II and III along with the methods for estimation of fluoride in , blood and urine using Ion-selective electrode technology in appendix I.

Field based approach

In the field based approach, where there is no provision for carrying out laboratory based tests, the following procedure is adopted for arriving at a presumptive diagnosis of the disease

- History taking which involves
 - 3 simple physical tests to check rigidity and pain of the neck region, back, knee and shoulder joints.

-
- Gastro-intestinal complaints, if any to assess early warning signs of fluoride toxicity. The complaints are : (a) loss of appetite (b) nausea (c) pain in the stomach (d) constipation (e) diarrhoea and (f) gas formation in the stomach with bloated feeling (flatulence).
 - Muscular manifestations, anemia and inability to carry out routine domestic/other activities.
 - Correlation of the Health complaints mentioned above with fluoride content of the drinking water

If the complaints mentioned above are existing and drinking water fluoride is above the permissible levels, provision of safe water (defluoridated water) and consumption of the same relieves the Gastro-intestinal complaints within 15-20 days, if fluoride was the causative factor for the ill health.

Provision of safe water (even if it has to be brought from a distance) for proving the point that fluoride in the drinking water was the main cause of ill health, is far the best approach so far detected, to convince the rural community, to accept the fact that the drinking water source is bad, unhealthy and a change of the source or adopt a procedure for removal of fluoride

Subsequent to history taking and introducing the concept of 'Safe water consumption for better health', adequate emphasis is also laid on imparting information on preventive approaches for Fluorosis viz.

- Awareness generation on the disease
- Early warning signs
- Health education
- Importance of drinking safe water
- Water conservation
- Importance of adequate calcium and Vitamin C in the diet
- Calcium and Vitamin C containing sources viz. vegetables and fruits and other food items
- Beneficial aspects

During the last 6 years (1987 - 93), when the "Water Mission" operations have gradually spread into the villages, where dispensaries, sub-centres and primary health centre facilities are not adequately manned with trained, well informed man power to deal with control and prevention of Fluorosis, the Water Mission field based approach and the results have provided great relief and hopes to the people of the endemic areas in the country.

During water quality survey, an activity which is shouldered by the Public Health Engineering Departments/Laboratories, emphasis is laid on the fact that every source of drinking water, whether private or government owned would be checked for quality, The data would reveal :

- Total number of sources in a village and their locations
- Number of Good sources (safe sources)

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- Number of sources contaminated with fluoride, extent of contamination
 - Source(s) ideal for defluoridation; site for creating a community defluoridation tank/plant.
 - Sources from where the water samples can be mixed and dilute the fluoride content, and supply through standpoints.

Based on the above information, provision for safe drinking water for the community is made in the following order of priority:

- Safe water sources, if available, to be used for cooking and drinking purposes only - sources to be labelled as "Safe" in local language.
- Tube wells may be dug deeper; there is 50% chance that the water then obtained may be safe.
- To mix different water sources which are marginally high in fluoride content with that of low fluoride containing sources and provide safe water through standposts. To label the source as 'safe' and only for cooking and drinking purposes.
- No good source available, distant source and pipe water supply scheme to be explored.
- If the above alternatives are not feasible and economically viable, community defluoridation procedure to be adopted. (Refer Vol II for further Information)

Sensitizing the community with information on Fluorosis, its mode of affliction, early warning signs and importance of drinking safe water are of utmost importance for prevention and control of Fluorosis.

EPIDEMIOLOGICAL SURVEY : BASIC PRINCIPLES, GUIDELINES & PRECAUTIONS

This Chapter is introduced because Fluorosis being a preventable disease and the main objective of this Chapter is to encourage the applications of epidemiology to prevent Fluorosis and promote health. As the disease has certain unique characteristics viz. Prevalent in rural areas compared to urban areas; people are aware of the fact that here is no treatment and cure for the disease; accept it as a curse of God, remain within the household waiting for death; the epidemiological survey requires to be planned considering the circumstances in which the people of the endemic areas are living and leading an unproductive life

As this volume is prepared for training trainers - not only from Community Medicine, but also from Life Science, Home Science, Public Health Engineering; Water Chemists, Dentists and others, the basic principles, guidelines and precautions for Epidemiological studies are highlighted.

Objectives : Epidemiological surveys are conducted with certain well defined objectives : The objectives are :

- To reveal the nature of the disease considering the casual factors.
- To encourage the application of epidemiological, approach for prevention of the disease, as well as, promotion of health.
- To sensitize those in Health and Public Health Sectors to deal with the disease effectively.
- To impart information to conduct a meaningful epidemiological survey.

In epidemiology the unit of study is a "human population".

The unit of study therefore could be variable as follows.

- A hospital based population
- School based population
- Camp based population
- Community based population in a village, block or district
- Environmental exposure based population

To obtain the correct profile of the disease, the unit should be well defined prior to the epidemiological survey, considering the disease characteristics and the endemicity of the disease; the population that are likely to be affected viz either children, young adults, women, men, older age groups, expectant mothers, lactating mothers or all

Epidemiology deals with the course and outcome of the disease Epidemiology can be effectively used for -

- To find the cause of the disease (Environmental/or Genetic)
- To find the natural history of the disease
- To describe the health status of the population

-
- To evaluate the health/disease status of the population.

Epidemiology can play a central role to provide knowledge about the distribution of cases, extent of contamination of water with fluoride or other aggravating factors, if any

Measuring Health & Disease

"Health" as per the WHO definition, is a complete physical, mental and social well being and not merely the absence of disease or infirmity.

Diagnostic criteria usually takes help of information on symptoms, signs and test results.

Early detection of the disease is most important in the case of Fluorosis, as the disease cannot be reversed to normal after reaching an advanced stage when the individual is crippled, paralysed and bed-ridden.

Measures of Disease Frequency

To measure the disease frequency (occurrence) is the basis of epidemiology Population at risk is an important factor Prevalence and incidence also need to be taken into account. The prevalence rate is the ratio of the population affected by the disease to the population at risk at a specified point of time. Prevalence rate is a proportion and is often expressed as 'cases per 1000 population' or 'cases per 100 population' Prevalence rate do not usually provide information on casual factors. Prevalence rate is helpful in determining the need for health & public health activities. The prevalence rate may greatly vary and these would suggest the importance of environmental factors causing the disease.

Observations and Experiments

Epidemiological studies can be classified into 2 major categories

Observational Studies

This is also designated as Descriptive and Analytical studies which include prevalence, case reference, follow-up study etc

Experimental Studies

This is also known as Intervention Studies which include clinical trials, field surveys and community trials etc.

In the former i.e. Observational Studies, the investigator measures but does not intervene. All epidemiological studies to begin with are descriptive and analytical in nature.

In the latter i.e. Experimental or Intervention Studies, investigator changes the progress of the disease by interfering with the casual factor(s)

In Epidemiological study designs for prevention and control of Fluorosis both observational studies and intervention studies are a part of the programme, especially when the disease process and amelioration need to be followed up after the provision of defluoridated water, improving dietary, Vitamin C, Calcium and other dietary requirements.

Levels of Prevention

Four levels of prevention can be identified corresponding to different phases in the development of a disease:-

- Primordial prevention
- Primary prevention
- Secondary prevention
- Tertiary prevention

All are important and complimentary though primordial and primary prevention have the most to contribute to the health and well-being of the whole population.

The disease prevention at early stages is secondary prevention Tertiary prevention is when the disease has reached late stages when treatment is not possible In Fluorosis tertiary prevention and rehabilitation has very little scope.

In preventing Fluorosis, the most important stages are Primary cum Primordial and Secondary prevention

Screening

Screening is the process by which unrecognized disease or defects are identified by tests which can be applied rapidly on a large scale. The 3 physical tests recommended in Chapter 6 for identifying aches and pain in joints is a screening test which can be applied to field based environment. Screening is an initial exercise, it is usually not diagnostic, requires appropriate investigative follow-up. Screening can be:

- Mass screening (whole population)
- Targeted screening (of groups)
- Opportunistic screening (screening restricted to a patient)

Epidemiology aims to identify the cause(s) of a disease so that effective prevention programmes can be implemented. The 4 levels of prevention can then be applied i.e. Primordial, Primary, Secondary and Tertiary prevention.

The levels of prevention overlap with therapeutic medicine in various disease conditions, but in Fluorosis as there is no treatment or cure, prevention is the only solution.

The opportunities for primordial prevention are limited; but primary and secondary prevention for chronic diseases like Fluorosis has great scope

There are 2 strategies for primary prevention (1) the population approach, which attempts to reduce the risk of the population as a whole (2) the high risk strategy, which focuses on the small number of individuals at greater risk. In Fluorosis prevention programme, both the population approach and high risk strategies are adopted. The population approach works out ideal while dealing with water supply to a community, and the high risk approach is adopted for lactating and expectant mothers and growing children living in an endemic area for Fluorosis by awareness programmes and providing safe drinking water.

Each strategy has advantages and disadvantages. But the benefit is mostly derived from population approach.

Effective secondary prevention requires screening of population with strict screening criteria i.e. (a) 3 Physical tests for aches and pain in the joints and rigidity (b) Gastrointestinal complaints of non-ulcer dyspeptic type (c) Muscle weakness (d) Poly-dyspsia and other non-skeletal (soft) tissue manifestations. Once the early warning signs of Fluorosis are identified, secondary prevention programme will be effective and meaningful. Tertiary prevention has very little scope in Fluorosis.

The central concern of epidemiology is the identification of cause(s) of the disease so that they may be prevented and controlled. For this to occur, epidemiological research results must influence public policy; including health policy, The researches conducted in India in the field of Fluorosis is a classical example, to indicate that the results have influenced the Policy Planners both in the Public Health Engineering and Health Sectors, to focus on prevention and control of Fluorosis through provision of sustained supply of safe water and improving nutritional standards and awareness generation among the community/population

Precautions

1. Those who attend the Training cum awareness camp at the District level (i.e. Phase I activity) should only enter the field for epidemiological survey.
2. The correct information on the disease and its prevention and control strategies should be imparted.
3. Those who are dealing with field level activities should have adequate confidence on the subject matter.
4. Although entry into the field is for dealing with the Sub-mission "Control of Fluorosis" should have concern in general, for the welfare of the community
5. Village Pradhan or Sarpanch is the most important person and he should be met first: explain the nature of the programme to him; gain his confidence and clearance; the community will then participate in the programme
6. Women folks of the community usually have their personal problems; ailments; give time for hearing their complaints; help if you can.
7. Try to speak in the language and dialect of the people.
8. Should be aware of the timings when the members of the family are available at home. Survey should be timed accordingly.
9. Working hours 9 A.M - 5 P.M. may or may not be ideal, instead timings should be adjusted with the availability of people in their homes.
10. Water sample should be collected from each household by the health worker instead of Public Health Engineering worker, to develop better rapport with the community.
11. Trained staff are likely to be transferred; may go on long leave and the people/community will loose the impact of the survey and therefore completing the survey in a shorter span of time would be in the best interest of people and the programme.
12. This survey is a one time activity unlike many other programmes; so do it well; the community will be most grateful to you for the good work done

THE MISSION APPROACH TO DEAL WITH THE HEALTH ASPECTS TO CONTROL FLUOROSIS: ACTIVITIES AND ACHIEVEMENTS DURING 1986-1993

Since the inception of the National Drinking Water Mission during 1986, 'Control of Fluorosis' is identified as one of the major Sub-missions to be tackled. The activities under this Sub-mission are being introduced in a phased manner i.e Phase I, II, & III.

Considering that the curriculum in Medical Schools, in this country, do not impart adequate basic information on Fluorosis (as it was never identified as a National Health Problem until the RGNDWM was announced), the medical officers working in District Hospitals, Primary Health Centres, Sub-Centres and Dispensaries are not well informed on Fluorosis. Considering that some of the doctors in State Health Service have been employed for 15-20 years they would be totally unaware of the recent developments on early warning signs of fluoride toxicity and associated manifestations and detection procedures.

In a similar manner, the Public Health Engineers have not been exposed to fluoride ion testing in water and defluoridation procedures. In view of these lacunae, the Sub-mission activities were introduced at the district level to take care of the people living in the different villages which are endemic for the disease.

Phase I Activities

This Phase comprises of activities for imparting training, updating information and creating awareness for (1) Public Health Engineers (2) Medical Officers (3) District level Administrators (4) Multipurpose workers which include Anganwadi workers (5) Village Pradhans/Sarpanchs and (6) NGOs on various aspects of fluoride toxicity and Fluorosis through lectures, demonstrations, a session is devoted on epidemiological survey procedure and information retrieval from the village population on their health complaints which are relevant to fluoride toxicity and associated complaints.

The training is imparted by a Group of 4 experts, who have been identified as the most knowledgeable in the country in the field of Fluorosis and defluoridation procedures.

Awareness-cum-update Camps (Phase I Activity) and the Achievements during 1986-93

Since the inception of the RGNDWM activities in the Sub-Mission 'Control of Fluorosis' 27 district level camps have been held in 15 States, sensitizing approximately 15000 personnel until May 1992.

As a part of the awareness programme, 28 public lectures on Fluorosis, Importance of water quality checking, defluoridation procedures have been delivered by the experts to High School students, Science College students, Medical Students, students at IITs, Home Science Colleges, Indian Medical Association meetings, Rotary and Lions Club meetings & Dental association meetings.

Besides, popular articles to educate the public on the dangers of fluoride have also been brought out by the print media on several occasions.

A documentary on "Fluorosis - A Threat to Millions" has also been prepared which is of 20 minutes duration and has been hooked on to the National TV network for creating awareness among the public.

Phase II Activities

This Phase comprises of activities involving a house to house health survey in the affected districts and water quality testing of every drinking source in a district/taluk/village. The responsibility of conducting the health survey and water quality analysis is entrusted with those who attend and participate in the Phase I activity. On successful completion of the health and water quality analysis, the data collected could reveal the following:-

Health Survey Report

1. The exact number of people in the district having early warning signs of fluoride poisoning (ie Non-ulcer dyspeptic complaints)
2. The exact number of pregnant and lactating mothers
3. The exact number of children having early manifestations
4. The number of teenage girls and boys having dental Fluorosis and having social and cosmetic problems (for masking the discoloration)
5. The number of subjects who are crippled.

Those living in the district and belonging to category (1) to (4) mentioned above can be helped in preventing and controlling the disease, the activities for which would commence in Phase III.

Water Quality Analysis Report

1. The total number of drinking water sources in the district
2. The number of sources contaminated with fluoride; and the extent of contamination
3. The number of safe water sources, if any
4. Alternate strategy for providing safe water to be sought viz., (i) bringing water from a distance through pipelines, if available (ii) digging tube wells deeper.
5. if item (4) above is not feasible, defluoridation to be introduced; identifying raw water source(s) for defluoridation (Refer Vol II)
6. The location for erecting the community defluoridation plant to be identified in the village involving the community.

HEALTH AND WATER QUALITY SURVEY (PHASE II ACTIVITY) AND ACHIEVEMENTS DURING 1986-1993

Water Quality Testing Laboratories

District level water testing laboratories are being established under the programme. The World Health Organization has provided 25 Ion Analysers with Fluoride Ion Selectrodes for fluoride estimation. These equipments have been handed over to district level laboratories in endemic states and one each

to 5 Regional laboratories under the RGNDWM, by the Secretary, Ministry of Rural Development, during July 1990; 1992. During 1993-94, 20 more meters would be distributed.

For the Operation, use and maintenance of the equipment, 2 persons from each laboratory including the Regional Laboratory have been adequately trained for a duration of 15 days at the Fluorosis Control Cell of the RGNDWM, located at the All India Institute of Medical Sciences, New Delhi.

Health Survey Data

The data emerged from the following 5 districts from a house to house health survey: & water quality survey is cited as an example: (Susheela & Ghosh, 1990)

- Amreli (Gujarat)
- Gurgaon (Haryana)
- Dhrwad (Karnataka)
- Raichur (Karnataka)
- Kurnool (AP)

The number of people afflicted with fluoride poisoning in the 5 districts and the extent of contamination of drinking water with fluoride would reveal the magnitude of the problem

	Total population examined	Range of Fluoride in water (ppm)
Amreli	56,189	1.8 - 11.00
Dental Fluorosis	9,199	
Skeletal Fluorosis	6,762	
Gastro-intestinal Problems	245	
Gurgaon	85,792	0.2 - 16.6
Dental Fluorosis	6,970	
Skeletal Fluorosis	600	
Gastro-intestinal Problems	200	
Dharwad	72,744	0.3 - 15.0
Dental Fluorosis	12,266	
Skeletal Fluorosis	3,747	
Gastro-intestinal Problems	6,304	
Raichur	1,50,215	0.2 - 7.5
Dental Fluorosis	12,933	

Skeletal Fluorosis	2,999	
Gastro-intestinal Problems	1,882	
Kurnool	14,91,791	0.1 - 9.6
Dental Fluorosis	43,927	
Skeletal Fluorosis	8,833	
Gastro-intestinal Problems	30,400	

The water quality analysis of the drinking water sources as well as the door to door health survey in a district is totally under the purview of the Public Health Engineers and Health Department; co-ordinated by the Collector/Chief Executive Officers/Chief Secretary, Zilla Parishad. A State level co-ordination committee also exist

However, under the Habitation Survey of the RGNDWM, the detailed water quality analysis of all the drinking water sources, in order to identify the exact magnitude of the problem is also being under taken by the state

Phase III Activities

Based on the information emerged from the health and water quality survey (during Phase II), appropriate and location specific activities both in the health and water sectors are launched.

Health Sector Activities (Phase III) and Achievements during 1986-93

The activities during Phase III are under the District Administration, monitored by the State.

The Activities involve organising public awareness programmes, sensitizing the public on dangers of fluoride, the importance of drinking safe water, the need to check drinking water quality. If safe water not available, domestic defluoridation programme to be resorted to as an interim measure, until alternate community installations are created. Operation and maintenance of safe water source, importance of consuming a nutritive diet, importance of calcium and vitamin C rich diet, the locally available agricultural crops and its food value to be imparted. Special advice to pregnant mothers and lactating mothers to consume only defluoridated water and avoid high fluoride containing agricultural crops, if still-births and abortions are to be avoided.

The major achievements at Dharwad district during Phase III activities are

- Extensive public awareness programmes on the dangers of fluoride, importance of consuming safe water were promoted
- Milk supply to school children was increased so that calcium intake is improved
- Milk booths for sale of milk was also increased for the benefit of the public.
- Importance of consuming a balanced diet was stressed upon
- Kitchen gardens started focusing on growing calcium rich green leafy vegetables and vitamin C rich citrus and tomatoes

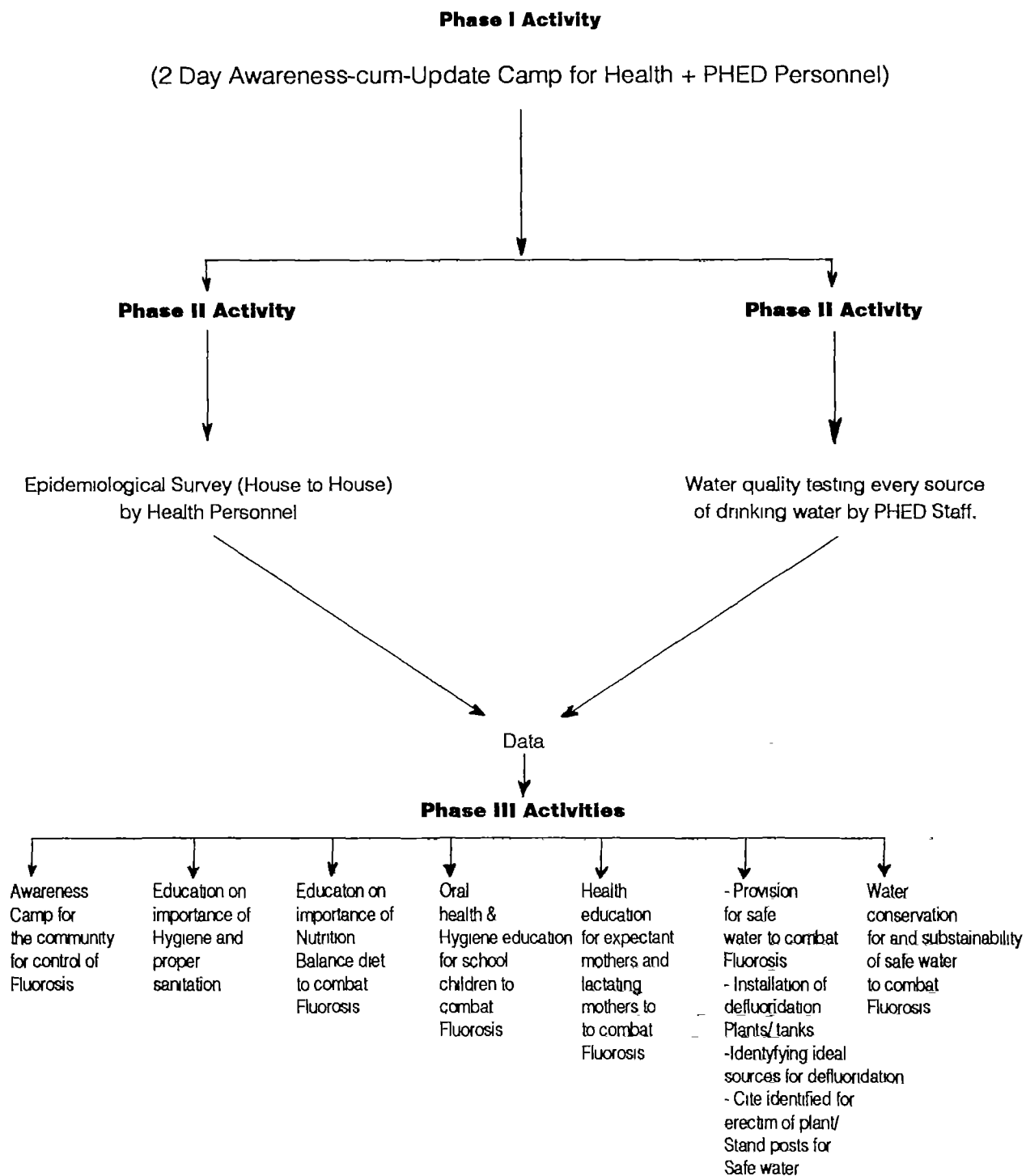
**Details of the Training cum Awareness Camps (Phase I) held in different Districts/
and Phase - II survey conducted**

Table 13.1 showing the districts, date of the camp and the status of the Phase II survey

S.No.	District	Date	Phase II survey status
1.	Amreli	April 27-29, 1987	complete
2.	Gurgaon	Dec 8,9 & 10, 1987	complete
3.	Mehsana	Dec.21 & 22, 1987	complete
4.	Karnool	Dec.28,29, & 30, 1988	complete
5.	Dharwad	Feb. 12 & 13, 1988	complete
6.	Chanderpur	April 21 & 22, 1988	complete
7.	Periyar	June 18 & 1988,	complete
8.	Gulberga	July 8 & 9, 1988	
9.	Jaipur	Aug. 24 & 25, 1988	
10.	Nagaur	Sept. 20 & 21	
11.	Raichur	Feb 3. & 4, 1989	complete
12.	Turnkur	April 22 & 23, 1989	
13.	Jalgaon	April 29 & 30, 1989	complete
14.	Sabarkantha (Himmatnagar)	Oct. 7 & 8, 1989	
15.	Panch Mahal (Godra)	Oct. 14 & 15, 1989	
16.	Shivpuri	Jan. 18 & 19, 1990	complete
17.	Kachch	April 20-21, 1990	
18.	Banaskantha (Palampur)	April, 23-24, 1990	
19.	Bandara	Feb 15-16, 1991	
20.	Nangloi	March 21-22, 1991	
21.	Unnao	August, 8-9, 1991	
22.	Kolar	August 30-31, 1991	complete
23.	Yavatamol	Nov. 30 - Dec. 1, 1991	
24.	Bellary	Dec. 9-10, 1991	
25.	Phalghat	March 9-10, 1992	
26.	Rewari	March 14-15, 1992	
27.	Dharmapuri	May 21-22, 1992	

Among the 27 districts where Phase I activities are over, 11 districts have completed Phase II Survey; 16 districts yet to complete Phase II activity, except Dharwad, the remaining 26 districts yet to introduce Phase III activities.

Flow chart of District level Activities



Phase III activities are carried out by personnel from PHED, Health Sector, NGOs, and Community themselves.

METHOD AND DETAILED PROCEDURE FOR ESTIMATION OF FLUORIDE IN SERUM AND URINE (HALL et al, 1972)

REAGENTS

Preparation of Acetate Buffer

It is prepared by mixing 5.7 ml of acetic acid and 70 ml of deionized water. Neutralise the solution with sodium hydroxide (2N). Solution of P^H 5.2. Dilute this solution to 100 ml with de-ionized water. This solution is further diluted 10 times; means that the 100 ml of solution is made upto 1000 ml. This 10 times diluted solution is used for fluoride estimation.

30 % perchloric acid - is used to adjust the P^H of (5.2) of urine samples. Add only 2-3 drops of solution.

Working Standard Solution

Prepare by diluting the stock standard solution using de-ionized water for the estimation of fluoride in serum and urine, 0.01, 0.1, 1.0, 5.0, 10.0 ppm concentration of the standard are generally preferred.

Procedure

Take 4.5 ml of acetate buffer and 0.5 ml of standard solution in a plastic beaker for each of the concentrations. Mix, stir and dip the electrode in the beaker and calibrate the instrument.

Sample (Urine/Serum) Analysis

Take 4.5 ml of buffer and 0.5 ml of sample (Urine or Serum) in a plastic beaker. Mix, stir and dip the electrode in the beaker. When the reading is stable, read it in ppm and get the print out.

TO DETERMINE SA : GAG RATIO IN SERUM : (SA = SIALIC ACID ; GAG = GLYCOSAMINOGLYCANS) (Wingler 1961)

Sialic Acid estimation in Serum

Reagents required

- 5% trichloroacetic acid (TCA)
- Diphenylamine (DPA)
- -19 mg DPA recrystallized (if recrystallized salt is not available from BDH) then DPA is recrystallized by dissolving 19mg DPA in 10ml of ethanol and keep in a deep freeze at 20° C for overnight. Decant the ethanol. Dry the crystals & use. 1 gm DPA is dissolved in a mixture of 90ml of glacial acetic acid and 10ml of Conc. H₂SO₄
- Acid mixture - 90 ml of glacial acetic acid and 10 ml Conc. H₂SO₄.
- Glycoprotein standard - Sialic acid standard 0.2 mg/ml dissolve in distilled water.

Procedure

- Add 4.8 ml of 5% TCA slowly with shaking to 0.2 ml of serum sample and to 0.2 ml of sialic acid standard in 15 X 150 mm test tube.
- Place the tube in boiling water bath for exactly 15 minutes with a glass-marble to prevent evaporation
- Cool the tube by immersion in ice cold water and centrifuge at 1500 rpm for 15 minutes
- Pipette 2.0 ml of clear supernatant into each of the two 15 x 150 mm tubes.
- Place 4.0 ml of DPA reagent into one of each pair of test tubes and 4.0 ml of acid mixture containing no DPA into the other.
- Prepare reagent blank 2.0 ml of 5% TCA, 4.0. ml of DPA reagent
- Mix, cover the test tubes by a glass-marble and immerse the tubes in a boiling water bath for exactly 30 minutes.
- Cool the tubes in ice cold water and read Optical Density at 530 nm with reagent blank set at zero in a Spectrophotometer.

Calculation

$$\frac{(\text{ODU} + \text{DPA} - \text{ODU} - \text{DPA})}{(\text{ODS} + \text{DPA} - \text{ODS} - \text{DPA})} \times 0.2 \times 100 = \text{ug Sialic acid /100 ml}$$

ODU = Optical density of unknown

ODS = Optical density of standard.

ESTIMATION OF GLYCOSAMINOGLYCANS IN SERUM (CARNEY 1987)

This assay is based upon the precipitation of alcian blue-GAG Complexes and the dissociation of this dye from the complex by the use of suitable surfactants. The inclusion of $MgCl_2$ is important, In this assay since at low concentrations of this salt all GAG species will bind to Alcian blue. Increasingly the concentration of $MgCl_2$ will prevent the binding of certain GAG to Alcian blue. The assay outlined has a $MgCl_2$ concentration such that all GAGs will bind to Alcian blue.

Reagents

- Dissolve 5 mg of Alcian blue in 100 ml of 50 mM sodium acetate and 50 mM $MgCl_2$ pH (5.8).
- Dissolve 10 gm of sodium dodecyle sulphate in 50 mM sodium acetate pH 5.8. (final volume 100ml)
- Dissolve Chondroitin -4- sulphate in distilled water to a concentration of 1 mg/ml as a stock solution. Dilute the standard stock solution in five working standards 5 mg/ml-40 mg/ml.

Method

- Dilute the serum samples five times. Add standard solution and test samples (0.5ml) each to stand for 2hr. at room temperature. Centrifuge the tubes at 2000 rpm for 15 minutes.
- Discard the supernatant and resuspend the precipitate in 4 ml of absolute ethanol, vortex and mix
- Centrifuge the tube at 2000 r.p m for 15 minutes.
- Discard the supernatent and dissolve the precipitate in 4 ml of reagent B.
- Vortex the tubes and read the absorbance at 620 nm. Plot a graph and determine the concentration of glycosaminolycans.

Calculation

Readings from graph = G ug/ ml

Sample GAG = 5G ug/ml = mg/100ml (5 is the dilution factor)

SA/SAG Ratio

Value of Salic acid

Value of GAG

If is reduced by 50% - 30 % = Fluorosis

If is enhanced by 30% - 50% = Ankylosing spondilytes

CHECK LIST FOR HOLDING TRAINING-CUM-AWARENESS CAMP (PHASE I ACTIVITY) UNDER SUB-MISSION : "CONTROL OF FLUOROSIS"

- First day camp will be for Public Health Engineers, Doctors, District level administrators and any other group interested to attend. Maximum attendance should not exceed 250. Proceedings will be in English on the first day.
- Second day camp will be for Para-medical Workers, Representatives of Mahila Mandal, Social Workers and Village Pradhan/Surpanch and any other category of persons from the PHEDs those who would like to join. Maximum attendance should not exceed 250. Proceedings will be in Hindi/Local Language/English as per the requirement of the participants.
- Activities should commence at 8.30 AM and shall continue until 6.00 PM with a short lunch break of 45 minutes.
- Hall with adequate seating arrangements to accommodate participants to a maximum of 250 should be made available.
- The hall should have curtains etc. to make the hall dark for slide projection.
- Working lunch arrangements to be made to 2 days for the number of participants attending the camp.
- Mid-morning and mid-afternoon tea arrangements to be made for 2 days for the participants.
- Handout in English for participants of the first day will be provided at the request of district/ State level organisers by FCC (AIIMS)
- Handout in local/regional language for distribution among the participants of the 2nd day to be prepared by the district level organizers on the basis of the sample provided by the Fluorosis control, Cell, AIIMS
- Writing pad and pen for every participant.
- Slide Projector- 2 ¹/₂ (with spare bulb)
- Screen
- Pointer
- Overhead projector (with spare bulb)
- Extension Board with 10-15 meters of wire.
- Arrangements to bring a few patients of Skeletal and Dental Fluorosis to the camp if possible.
- If private practitioners wish to attend they may be permitted to do so on first day.
- A TV and VCP or VCR to hire for an hour each day, to show the film on Fluorosis : A Threat to Millions. Video film to be collected from State Chief Engineer's office.

Selection of Participants:- Method

1. Select the Health and PHED Staff from those Villages/Blocks, where the existing data on water fluoride content is high
2. Select participants from those areas where the School Children show discoloured teeth/ Dental Fluorosis.

REGIONAL TRAINING

Training aids provided to trainees (who are the future trainers).

- Transparency sheets (overhead projection sheet) - 1 packet / participant
- Colour Pen set - 1 set / participant.
- A set of 3 books
 - Introduction to Rural Water Supply and Sanitation Programme in India.
 - Prevention and Control of Fluorosis:
 - Volume I : Health Aspects
 - Volume II: Water quality testing and Defluoridation (Fluoride removal) technologies.
- A set of 15 slides (2*/2*) to Community Medicine Experts.

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