

FLUOROSIS IN TWO AREAS WITH DIFFERENT
WATER FLUORIDE LEVELS AT BANGARPET TALUK,
KOLAR

DISSERTATION SUBMITTED TO
SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION
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OF THE REQUIREMENT FOR THE DEGREE OF

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By

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APRIL – 2014

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DISSERTATION AS A JOURNEY

D - Discovering original knowledge, based on your own

I - Intuition.

S - Set-backs, followed by

S - Self-discovery. Internal meltdowns so

E - Egregious

R - Reading, lots of it

T - Traveling. Getting from point A to B in both the physical and existential sense.

A - Always in process. Small steps, gradual changes leading you

T - Towards a better place.

I - Individuals in search of

O - Original research,

N - Never, ever giving up—despite how bad you feel like doing so.

LIST OF ABBREVIATIONS

AMPA	→	Amino-methyl-phosphonic-acid
BAIF	→	Bharatiya Agro Industries Foundation
BIRD-K	→	BAIF Institute for Rural Development-Karnataka
BIS	→	Bureau of Indian Standards
$\text{Ca}_5(\text{PO}_4)_3\text{F}$	→	Fluorapatite
CFI	→	Community Fluorosis Index
CI	→	Confidence interval
DANIDA	→	Danish International Development Agency
DF	→	Dental Fluorosis
F^-	→	Fluoride
FRI	→	Fluorosis risk index
GI	→	Gastro-intestinal
GOK	→	Government of Karnataka
HF	→	Hydrogen Fluoride
IMF	→	Infant milk formula
IPCS	→	International programme on chemical safety
IRS&WS	→	Integrated Rural Sanitation and Water Supply Project
Lpcd	→	Litres per capita per day
Na_3AlF_6	→	Cryolite
NaF	→	Sodium Fluoride
NSF	→	Non-Skeletal Fluorosis
OR	→	Odds Ratio
PPM	→	Parts per million
RBC's	→	Red blood cells
RDWSS	→	Rural Drinking Water Supply and Sanitation
SPADNS	→	sodium 2-(p-sulfo-phenylazo)-1,8-dihydroxy naphthalene – 3,6 – disulfonate
USNRC	→	United States Nuclear Regulatory Commission
WHO	→	World Health Organization

ABSTRACT

INTRODUCTION AND OBJECTIVES:

Fluorosis is an endemic disease resulting due to excess ingestion of fluoride. It promotes tooth decay when consumed in lower doses (<0.6 mg/L) and leads to dental, skeletal and non-skeletal fluorosis when consumed in higher ranges (>1.5 mg/L). In India, 17 states have been home for fluorosis. Kolar, being a drought prone area with semi-arid climate, mainly dependent on ground water for drinking is one among 16 fluorosis endemic districts of Karnataka. Studies highlighting the epidemiological factors responsible for fluorosis in Kolar are scarce and hence the present study was taken up with the following objectives:

- 1) To assess the prevalence of Dental and Skeletal Fluorosis in the study population.
- 2) To compare the various epidemiological factors influencing the occurrence of fluorosis among the two groups.
- 3) To estimate fluoride levels in all the sources of drinking water in two study areas.

METHODOLOGY:

A community based cross sectional study was conducted in two areas, Batwarahalli and Thimmasandra (Group 1) with water fluoride >1.5 mg/L and Madinayakanahalli (Group 2) with fluoride <1.0 mg/L of Bangarpet taluk, Kolar district for a period of one year from 1st December 2011 to 30th November 2012. Ethical clearance was obtained from institutional ethical committee.

House to house survey was conducted to estimate the prevalence of dental and skeletal fluorosis among all the household residents aged >8 years. After obtaining

informed consent in local verbatim, the data was recorded in a pre-tested, semi-structured, validated questionnaire about the socio-demographic profile and certain risk factors of dental, skeletal and non-skeletal fluorosis viz., source of water for drinking, cooking and other domestic purposes, type of foods consumed and use of fluoride containing products. Persons with artificial teeth, pregnant women, bed ridden and the persons who were not available even after 2 visits were excluded from the study.

Dental fluorosis was assessed after obtaining hands on training from the dental department by using Dean's index. Skeletal fluorosis was assessed by using three field tests and confirming by radiological examination.

Fluoride levels of drinking water sources in these communities were estimated by ion-electrode method.

The data was analysed using standard statistical package. Proportion of fluorosis and the association of fluorosis with selected individual risk factor were analyzed using appropriate tests viz., chi-square, fisher's exact test, odds ratios and their 95% confidence intervals for the association of the predictor variables with the dependent variable. A p value of < 0.05 was taken as statistically significant.

RESULTS:

The prevalence of dental fluorosis in the study group with fluoride level $>1.5\text{mg/L}$ was 13.17% and in the study group with fluoride level $<1.0\text{mg/L}$ was 3.84%. The prevalence of dental fluorosis among the children and adolescents was 31.83% whereas, in adults it was 1.32%. The risk of dental fluorosis among children and adolescents in the group with fluoride $>1.5\text{mg/L}$ was significantly 6.7 times more compared $<1.0\text{mg/L}$.

Among children and adolescents with fluoride level $>1.5\text{mg/L}$, maximum number i.e., 21 (16.4%) had moderate grade and 20 (15.6%) had very mild grade of dental fluorosis whereas, in the study group with fluoride $<1.0\text{mg/L}$, 5 (5.3%) and 4 (4.3%) had questionable and moderate grades of fluorosis respectively. Among the adults with fluoride level $>1.5\text{mg/L}$, 3 (0.8%) and 1 (0.3%) had moderate and questionable grades of dental fluorosis and in the other group 4 (1.3%) and 1 (0.3%) had moderate and mild grades of dental fluorosis respectively.

Community fluorosis index was 0.8, suggesting slight public health significance among children and adolescents in the group with fluoride $>1.5\text{mg/L}$, and among the other group with fluoride $<1.0\text{mg/L}$ it was negative and suggested no public health importance.

The prevalence of skeletal fluorosis among adults at field level in both the groups with fluoride level $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ was 5.0%.

Among children and adolescents, the prevalence of non-skeletal fluorosis was 0.45%. In the study group with fluoride level $> 1.5\text{mg/L}$, the prevalence of non-skeletal fluorosis was 0.78% and in the study group with fluoride level $<1.0\text{mg/L}$ there were no cases.

Among adults, the prevalence of non-skeletal fluorosis was 5.0%. In the study group with fluoride level $> 1.5\text{mg/L}$, the prevalence of non-skeletal fluorosis was 7.26% and in the study group with fluoride level $<1.0\text{mg/L}$ it was 2.48%.

The groups with water fluoride $>1.5\text{mg/L}$ comprised of Thimmasandra and Batwarahalli villages and $<1.0\text{ mg/L}$ comprised of Madinayakanahalli with a public borewell as the only source in all the villages. The water fluoride levels analysed by

ion-electrode method obtained from Indian Institute of Science (IISc) were 4.13mg/L, 2.59mg/L and 0.61 respectively.

The prevalence of dental fluorosis was significantly higher among the children and adolescents compared to adults ($p < 0.05$). However, there were no cases of skeletal fluorosis among children and adolescents.

In children and adolescents with dental fluorosis, we observed a statistically significant difference between socio-economic status and prevalence of dental fluorosis among high ($> 1.5\text{mg/L}$) and normal fluoride ($< 1.0\text{mg/L}$) groups ($p < 0.05$). Similarly, in adults with skeletal fluorosis, significant difference was observed between socio-economic status and prevalence of skeletal fluorosis among both high and normal fluoride groups ($p < 0.05$). There was no influence of gender, occupation, castes, educational status and other risk factors like quantity of water consumed, use of fluoridated dental products, use of fluoridated medicine, tobacco or arecanut and nutritional status in the prevalence of dental and skeletal fluorosis ($p > 0.05$).

CONCLUSION:

Dental fluorosis is a public health problem among the children and adolescents of Bangarpet taluk, Kolar. Skeletal fluorosis being prevalent in 5% of the adults, affects their livelihood. Hence, there is an urgent need to repel against the problem. Measures like setting up community de-fluoridation units, improving the awareness about this current scenario about fluorosis among the residents of Bangarpet should be considered. Government should consider it as a serious problem and look for effective alternatives to resolve this problem of fluorosis.

KEY WORDS:

fluorosis, fluoride, dean's index, ion-electrode method

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SECTION 1

INTRODUCTION

“The beginning is the most important part of the work”

- Plato

1. INTRODUCTION

Fluorosis is a slow, progressive, crippling disease resulting from excess ingestion of fluoride. It is caused by an element known as fluorine, the 13th most abundant element existing in the earth crust. Fluoride (F⁻) ion in drinking water has both beneficial and detrimental effects on health.^{1,2,3,4}

Main sources of fluoride for human are water, food, air, medicament etc. Although there are several sources of fluoride intake, it is roughly estimated that 60% of the total intake is through drinking water. This is the most assimilable form of fluoride and hence the most toxic.³

Ground water is a significant water source in India for domestic, irrigating and industrial needs. More than 85% of rural, 50% of urban domestic water requirements are met from ground water resources.⁵

World Health Organization (WHO) has set the standards for fluoride levels in drinking water as 1.5 mg/L. Bureau of Indian Standards (BIS) has set the standards for fluoride levels in drinking water with maximum desirable limit as 1.0mg/L and permissible limit in the absence of alternate source as 1.5mg/L.^{6,7}

The fluoride of food items depends upon the fluoride contents of the soil and water used for irrigation, therefore the fluoride content of the food items may vary from place to place. Use of rock salt (kalanamak), smeared snacks, pickles or any such items, canned fish, drinking black tea (without milk), lemon tea, chewing areca nut (supari) and tobacco influence the occurrence of fluorosis.^{3,4}

Infant formulas reconstituted with higher fluoride water can provide 100 to 200 times more fluoride than breast milk or cow's milk. Consumption of certain

locally available foods such as rice, millets, pulses, sorghum, vegetables, milk, fish, chicken, eggs, meat, betel vine, tea and sea salt contribute additional fluoride.^{8,9}

The occupational exposure of fluoride is observed on using inorganic fluoride compounds in production of aluminum and also during manufacturing and use of phosphate fertilizers. WHO standards for fluoride in air is 1 µg/m to prevent effects on livestock and plants, as well as to protect human health.^{3,4}

Prolonged use of certain drugs has been associated with the chronic adverse effects of fluoride e.g. sodium fluoride for treatment of otosclerosis/osteoporosis, Niflumic acid for the treatment of rheumatoid arthritis, fluoride mouth rinse (Proflo) to render the tooth stronger, antidepressants (fluoxetine), anticholesterol drugs, etc.^{3,8}

Regardless of the fluoride ingested by all sources, severity of fluorosis increases with an increase in the malnutrition of people.⁸

Abnormal level of fluoride in water is common in fractured hard rock zone with pegmatite veins. Fluoride ions from these leach into the groundwater and contribute to high fluoride concentrations. The bioavailability of soluble fluoride ingested with water is almost 75–90% and is rapidly absorbed through gastrointestinal tract and lungs. Once absorbed into the blood, fluoride readily distributes throughout the body, with approximately 99% of the body burden of fluoride is retained in calcium rich areas such as bone and teeth (dentine and enamel) where it is incorporated into the crystal lattice. Fluoride is excreted primarily via urine and the rapid excretion takes place through renal system over a period of 4 to 6 h.^{3,10}

Very low doses of fluoride (<0.6 mg/L) in water promote tooth decay. As described earlier it has both beneficial and detrimental effects. It prevents caries by

several different actions. When present in saliva constantly and at low concentrations, fluoride hastens the re-mineralization of tooth enamel lesions. Fluoride also interferes with glycolysis, the process by which cariogenic bacteria metabolize sugars to produce acid. In addition, it has a bactericidal action on cariogenic and other bacteria. Finally, when fluoride is ingested during the period of tooth development, it makes the enamel more resistant to later acid attacks.⁴

However, when consumed in higher doses (>1.5 mg/L), it leads to dental fluorosis or mottled enamel and excessively high concentration (>3.0 mg/L) of fluorides may lead to skeletal fluorosis. The disease may be present in an individual at sub-clinical, chronic or acute levels of manifestation. Crippling skeletal fluorosis can occur when the water supply contains more than 10 mg/L of fluoride. It also causes non-skeletal fluorosis in the form of muscle weakness, tiredness, fatigue, anemia, dyspepsia, male infertility, polyuria, polydipsia, repeated still births, abortions, etc.^{11, 12}

In the global scenario, 23 nations have the problem of excess fluoride in drinking water and resulting endemicity for fluorosis. An estimated 62million people in India, are affected with dental, skeletal and/or non-skeletal fluorosis. The extent of fluoride contamination of water varies from 1.0 to 48.0 mg/L.^{13, 14}

In Karnataka, totally 16 districts are endemic viz, Dharwad, Gadag, Bellary, Belgaum, Raichur, Bijapur, Gulbarga, Chitradurga, Tumkur, Chikmagalur, Mandya, Bangalore Rural, Mysore, Mangalore, Shimoga and Kolar. Kolar, being a drought prone area with semi-arid climate, mainly dependent on ground water for drinking has been home to fluorosis. The majority of groundwater samples from Kolar district fall

in hard to very hard category and majority of the ground water samples do not meet the drinking water quality standards because of excess fluoride ($>1.5\text{mg/L}$).^{5,15}

The studies highlighting the epidemiological factors responsible for fluorosis in Kolar is scarce the present study attempts to discern the magnitude of fluorosis along with some of the epidemiological factors affecting fluorosis.

SECTION 2

AIMS AND OBJECTIVES

*“A goal is not always meant to be reached; it often serves
simply as something to aim at”*

- Bruce Lee

2. AIMS & OBJECTIVES

- 1) To assess the prevalence of dental and skeletal fluorosis in the study population.
- 2) To compare the various epidemiological factors influencing the occurrence of fluorosis among the two groups.
- 3) To estimate fluoride levels in all the sources of drinking water in two study areas.

SECTION 3

REVIEW OF LITERATURE

*“We should regret our mistakes and learn from them, but
never carry them forward into the future with us”*

- Lucy Maud Montgomery

3. REVIEW OF LITERATURE

Discussed under following headings:

- 1. History**
- 2. Magnitude of fluorosis**
- 3. Epidemiological factors affecting fluorosis**
- 4. Different studies on fluorosis**

3.1 HISTORY:

The history of dental fluorosis began in 1900 when a young dentist, Frederick Sumner McKay, during his practice in Colorado Springs, observed an unusual phenomenon i.e., a gritty discolouration of teeth, particularly among the residents living near Pikes Peak. This came to be known as “Colorado Brown Stain” and was later identified as “mottled enamel” or more specifically, chronic endemic enamel fluorosis. He found that the town’s water source had high amounts of naturally occurring fluoride. Later after 21 years of research, he concluded fluoride as the cause.¹⁶

The first comprehensive account of skeletal fluorosis was made by Roholm. Since that time sporadic reports have appeared from almost all parts of the world.¹⁷

Fluorosis history in India:

Fluorosis has been prevalent in India for seven decades. It was first noticed in early 1930s, among cattle’s by the farmers of Andhra Pradesh. They noticed inability of the bullocks to walk due to painful and stiff joints. The episode was repeated within six months when new pairs of bullocks were acquired. A year later, the same disease was detected in human beings and Short et al published the first report on endemic

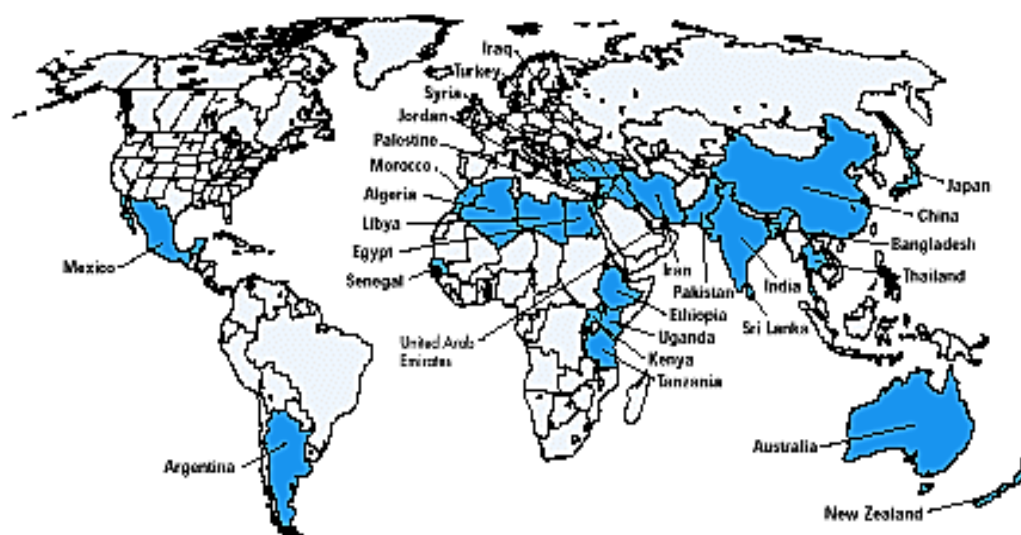
fluorosis in India. During the period from 1960 to 1986, nine states in India had been identified as endemic fluorosis areas.^{18, 19}

3.2 MAGNITUDE OF FLUOROSIS

Fluorosis worldwide:

Fluorosis is endemic in at least 25 countries across the globe. In 1993, 15 of India's 32 states were identified as endemic for fluorosis. In Mexico, 5 million people (about 6% of the population) are affected by fluoride in groundwater. Fluorosis is prevalent in some parts of central and western China and caused not only by drinking fluoride in groundwater but also by breathing airborne fluoride released from the burning of fluoride-laden coal. Worldwide, such instances of industrial fluorosis are on the rise. India lies in the geographical fluoride belt that extends from Turkey to China and Japan through Iraq, Iran and Afghanistan.^{14, 20}

Figure-1: Countries with endemic fluorosis²⁰

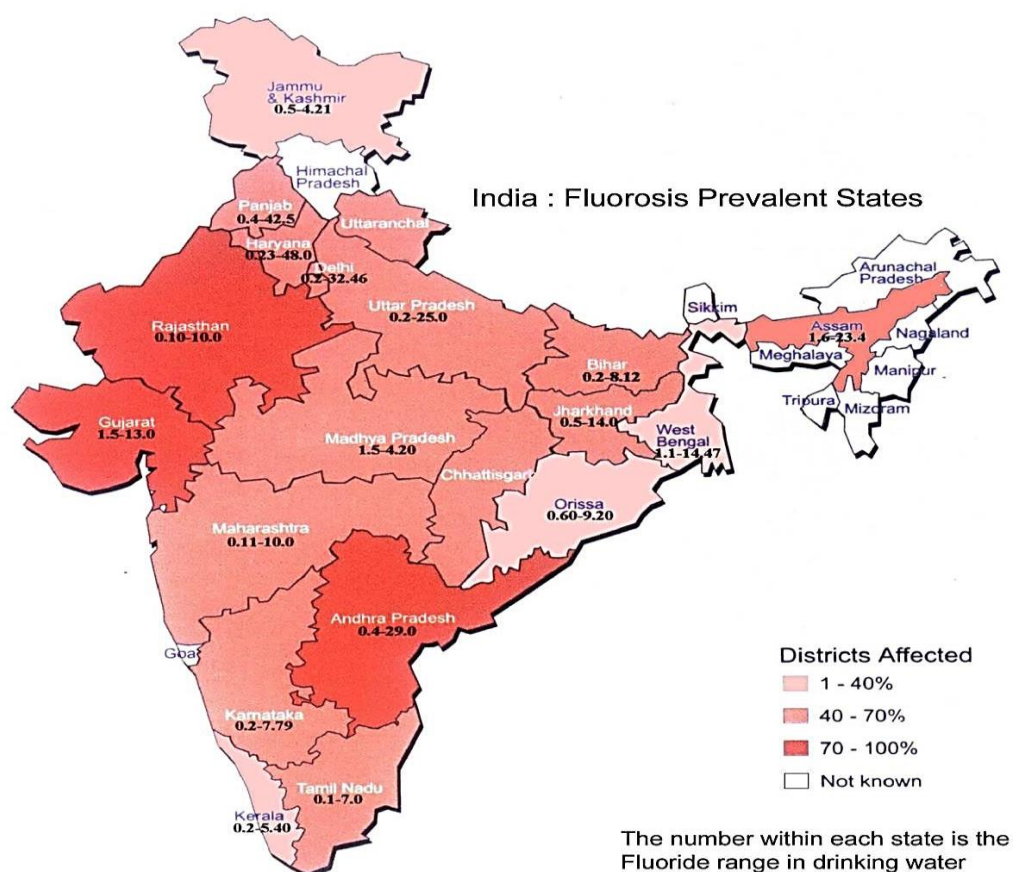


Countries with endemic fluorosis due to excess fluoride in drinking water

National Prevalence:

Fluorosis is an endemic disease prevalent in 20 states out of the 35 states and Union Territories of the Indian Republic. 70-100% districts are affected in Andhra Pradesh, Gujarat and Rajasthan. 40-70% districts are affected in Bihar, National Capital Territory of Delhi, Haryana, Jharkhand, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Tamil Nadu and Uttar Pradesh. 10-40% districts are affected in Assam, Jammu & Kashmir, Kerala, Chattisgarh and West Bengal. While the endemicity for the rest of the states are not known.²¹

Figure-2: Fluorosis prevalent states of India²¹



Source of information: 1) UNICEF State of Art Report, 1999
2) FR & RDF data bank

In Karnataka, totally 16 districts are endemic viz, Dharwad, Gadag, Bellary, Belgaum, Raichur, Bijapur, Gulbarga, Chitradurga, Tumkur, Chikmagalur, Mandya, Bangalore Rural, Mysore, Mangalore, Shimoga and Kolar.¹⁵

Kolar, being a drought prone area with semi-arid climate, mainly dependent on ground water for drinking has been home to fluorosis. The majority of groundwater samples from Kolar district fall in hard to very hard category and majority of the ground water samples do not meet the drinking water quality standards because of excess fluoride ($>1.5\text{mg/L}$).⁵

3.3 Epidemiological factors affecting fluorosis:

Fluorine element:

History:

Fluorine was discovered in 1530 by Georgius Agricola. He originally found it in the compound Fluorspar, which was used to promote the fusion of metals. Fluoride was finally isolated in 1866 by Moissan after nearly 74 years of continuous effort and was awarded Noble Prize in 1931.^{16, 22}

Properties:

Fluorine is the 13th most abundant element available in the earth crust³ and is the first element in the Halogen group (group 17) in the periodic table with atomic number 9 and atomic weight 19. It is a non-metal, a gas at room temperature. It has 5 valence electrons in the 2p level with electron configuration $1s^2 2s^2 2p^5$. Fluorine has many isotopes, but the only stable one found in nature is F-19. It is the most electronegative element and is highly reactive; hence it is available only in its combined form as fluorides.^{22, 23}

Recommended Dietary Allowance of fluoride varies from 0.01 – 4mg/dl.²⁴

Uses:

Fluorine and its compounds are used in producing uranium (from the hexafluoride) and more than 100 commercial fluorochemicals, fluorochlorohydrocarbons are extensively used in air conditioning and refrigeration. Elemental fluorine has been studied as a rocket propellant as it has an exceptionally high specific impulse value i.e. less propellant is required to gain high momentum by the rocket.²²

Sources of fluoride:

The ultimate source of fluoride in water, soil or biosphere is associated with its distribution in rocks and its dispersion in groundwater. Groundwater is a major and sometimes lone source of drinking water worldwide.²⁵

By far the most serious naturally occurring groundwater-quality problem in India derives from high fluoride, arsenic and iron concentrations which are dissolved from the bedrocks by geochemical processes.²⁵

Ground water:

Presence of excess fluoride in groundwater is identified as a naturally occurring health hazard by the WHO. The chemical composition of groundwater is a combined product of the water that enters the aquifer and its reaction with various minerals present in the soil and rock mass, which alter the water composition with time and space.²⁶

The most important controlling factors influencing fluoride presence in groundwater include: distribution of easily weathered fluoride-bearing minerals, the accessibility of circulating water to these minerals, pH of the percolating water, calcium content of the leaching water, temperature of the percolating water and the soil, exchangeable ions in the percolating water, extent of fresh water exchange in an aquifer, evaporation and evapotranspiration, formation of complex of fluoride with other ions, presence of carbondioxide and other chemicals in draining water and residence time of the percolating water in soil. High fluoride concentrations in the ground waters correlate positively with alkalinity (bicarbonate concentration), pH and sodium, and are present in ground waters with low calcium concentrations.²⁵

The three most important minerals of fluoride are fluorite, cryolite (Na_3AlF_6) and fluorapatite ($\text{Ca}_5(\text{PO}_4)_3\text{F}$); cryolite is a rare mineral whereas by far the largest amount of fluorine in the earth's crust is in the form of fluorapatite (about 3.5% by weight of fluorine) which is processed almost exclusively for its phosphate content. Fluorite, fluorapatite, rock phosphate, phosphorites, phosphatic nodules and topaz are major fluoride bearing minerals in India with varying levels of fluoride content. The total mineral reserves of fluorite, rock phosphate and apatite in the country are estimated at 11.6, 71 and 2.82 million tonnes respectively. Fluoride substitutes readily in hydroxyl positions in late - formed minerals in igneous rocks, and in primary minerals especially micas (such as biotites) and amphiboles (such as hornblende).²⁵

There are three major fluoride bearing areas in India: 1) Gujarat-Rajasthan in the north-west and 2) Chandi Dongri-Raipur in central India 3) Tamil Nadu-Andhra Pradesh in the south; besides other areas in Karnataka, Bihar, Punjab and in the North-west Himalayas. The distribution of areas with excess fluoride in groundwater concurs with that of fluorine-bearing minerals. Further high fluoride concentrations

are observed from arid and semi-arid regions of the country and the areas with advanced stage of groundwater development.²⁵

Air:

Fluoride can exist in the atmosphere in gaseous form, attached to particles or in aerosols that can be transported by wind over large distances before being deposited. Most airborne fluoride in urbanized areas comes from industrial sources. Of this, 10% derives from the aluminium industry, and high concentrations can be found around aluminium smelters. Another major source of environmental fluoride is phosphate fertilizer production, where much of the associated fluoride is lost to the atmosphere. Other sources include glassworks, exhaust fumes and the production of metals (e.g. steel, copper and nickel), bricks, ceramics and adhesives. Hydrogen fluoride (HF) is used in the semiconductor industry and in commercial laundries. It is highly soluble in water, forming hydrofluoric acid, which is very corrosive. Sulfuryl fluoride is used as a fumigant - for example, in flour mills.^{4, 22}

Drinking-water:

In certain parts of the world where groundwater naturally contains high fluoride levels, intake of fluoride via drinking-water exceeds that via food. The intake is determined by the fluoride level in the water and the daily water consumption. Water fluoridation has been adopted by several countries as a cost-effective public health measure for the prevention of dental caries. The dental health benefits are obtained when the concentration of fluoride in drinking water is 0.8-1.0 mg/l.⁴

Dental products:

A number of products administered to, or used by, children to reduce dental decay contain fluoride. This includes toothpaste (1.0–1.5 g/kg fluoride), fluoride solutions and gels for topical treatment (0.25–24.0 g/kg fluoride) and fluoride tablets (0.25, 0.50 or 1.00 mg fluoride per tablet), among others. These products contribute to total fluoride exposure, albeit to different degrees. It is estimated that the swallowing of toothpaste by some children may contribute about 0.50 or 0.75 mg fluoride per child per day.¹⁰

Food and beverages other than water:

Vegetables and fruits normally have low levels of fluoride (e.g. 0.1–0.4 mg/kg) and thus typically contribute little to exposure. However, higher levels of fluoride have been found in barley and rice (e.g. about 2 mg/kg) and taro, yams and cassava been found to contain relatively high fluoride levels. In general, the levels of fluoride in meat (0.2–1.0 mg/kg) and fish (2–5 mg/kg) are relatively low. However, fluoride accumulates in bone and the bones of canned fish, such as salmon and sardines, which are also eaten. Fish protein concentrates may contain up to 370 mg/kg fluoride. However, even with relatively high fish consumption in a mixed diet, the fluoride intake from fish alone would seldom exceed 0.2 mg fluoride per day.¹⁰

Milk typically contains low levels of fluoride, e.g. 0.02 mg/l in human breast milk and 0.02–0.05 mg/l in cow's milk. Thus milk is usually responsible for only a small fraction of total fluoride exposure.¹⁰

Tea leaves contain high levels of fluoride (up to 400 mg/kg dry weight). Fluoride exposure due to the ingestion of tea has been reported to range from 0.04 mg

to 2.7 mg per person per day. However, some Tibetans have been observed to ingest large amounts of fluoride (e.g. 14 mg per day) due to the consumption of brick tea as a beverage. This type of tea is made from older leaves and contains much higher levels of fluoride than standard teas such as black or green tea.¹⁰

Drugs:

Prolonged use of certain drugs has been associated with the chronic adverse effects of fluoride.³ e.g. sodium fluoride (NaF) for treatment of otosclerosis/osteoporosis, Niflumic acid for the treatment of rheumatoid arthritis, use of fluoride mouth rinse (Proflo) to render the tooth stronger, antidepressants (fluoxetine), anti-cholesterol drugs etc.⁸

Cigarettes:

This may be another significant source of fluoride intake by humans. Exposure to cigarette smoke causes fluorosis.⁹

Infant milk formulas (IMF's):

IMF's reconstituted with higher fluoride water can provide 100 to 200 times more fluoride than breast milk, or cow's milk.⁹

Chemobiokinetics and metabolism:

Absorption:

Approximately 75–90% of ingested fluoride is absorbed. Ingested fluoride is rapidly absorbed through gastrointestinal tract and lungs. In an acidic stomach, fluoride is converted into HF and up to about 40 per cent of the ingested fluoride is

absorbed from the stomach as HF. High stomach pH decreases gastric absorption by decreasing the concentration uptake. Relative to the amount of fluoride ingested, high concentrations of cations that form insoluble complexes with fluoride (e.g. calcium, magnesium and aluminium) can markedly decrease gastrointestinal fluoride absorption.^{3, 10}

Distribution:

The peaks are reached after 30 min in blood. Once absorbed into the blood, fluoride readily distributes throughout the body, with approximately 99 per cent of the body burden of fluoride retained in calcium rich areas such as bone and teeth (dentine and enamel) where it is incorporated into the crystal lattice.^{3,10}

In infants about 80 to 90% of the absorbed fluoride is retained but in adults this level falls to about 60%. Fluoride crosses the placenta and is found in mother's milk at low levels essentially equal to those in blood. It also appears in low concentrations in saliva and sweat.³

Under certain conditions, plasma fluoride levels provide an indication of the level of fluoride in the drinking-water consumed. USNRC (1993) notes that "provided that water is the major source of fluoride intake, fasting plasma fluoride concentrations of healthy young or middle-aged adults expressed in micromoles per litre are roughly equal to the fluoride concentrations in drinking water expressed as milligrams per litre."¹⁰

Approximately 90% of the fluoride retained in the body is deposited in the skeleton and teeth. The biological half-life of bound fluoride is several years.³

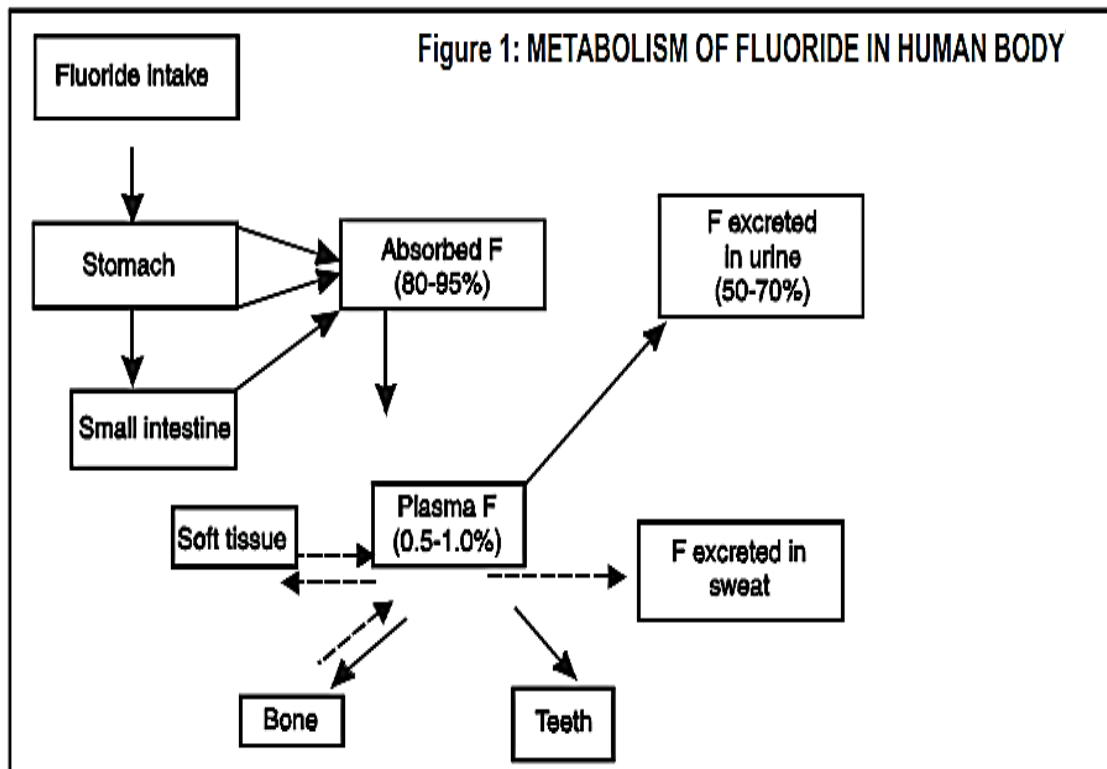
Levels of fluoride that are found in the bone vary with the part of the bone examined and with the age and sex of the individual. Bone fluoride is considered to be a reflection of long-term exposure to fluoride.¹⁰

Excretion:

Fluoride is excreted primarily via urine. The rapid excretion takes place through renal system over a period of 4 to 6 h. In children less than three years of age only about 50% of total absorbed amount is excreted, but in adults and children over 3 years - about 90% is excreted. Urinary fluoride clearance increases with urine pH due to a decrease in the concentration of HF. Numerous factors (e.g. diet and drugs) can affect urine pH and thus affect fluoride clearance and retention.^{3, 10}

It is generally accepted that most of the fluoride in the faeces is not absorbed. Faecal fluoride usually accounts for less than 10% of the amount ingested each day. The literature contains a wide range (0.1–5 $\mu\text{mol/litre}$) for fluoride levels in breast milk. It is probable that problems with the analysis of fluoride have been contributory. The concentration of fluoride in colostrum and mature breast milk is reported to be the same — about 0.4 $\mu\text{mol/litre}$. The same investigators found no significant difference in fluoride concentrations of milk from mothers living in areas with fluoride concentrations in drinking-water of 1 or 0.2 mg/litre, even though their plasma concentrations reflected this difference. Further, they found no diurnal variation in the fluoride concentration.²⁷

Figure-3: Metabolism of fluoride in human body³



Effects of Fluoride on Humans:

It has been recognized for over five decades that fluoride may have both beneficial and potentially harmful effects on dental health.²⁷

While the prevalence of dental caries is inversely related to a range of concentrations of fluoride in drinking-water consumed, the prevalence of dental fluorosis has been shown to be positively related to fluoride intake from many sources.²⁷

Since the first reports by Dean and colleagues published in the 1930s, oral fluoride is still considered an effective means of reducing dental caries. Historically, it was believed that fluoride needed to become incorporated into the crystal lattice of enamel in order to effectively prevent the development of dental

caries. Fluoride was considered to improve lattice stability and render the enamel less soluble to acid demineralization. Since the incorporation of fluoride into enamel, as partially fluoridated hydroxyapatite, was believed to be essential for its action, fluoride was thought best ingested. Populations consuming fluoridated drinking-water had a much lower prevalence of dental caries than did those consuming non-fluoridated drinking-water.²⁷

Over time, the difference in caries prevalence among those consuming fluoridated and non-fluoridated drinking-water has narrowed significantly. This apparent diminution in the cariostatic effectiveness of fluoridated drinking-water is likely attributable to a “diffusion” in which individuals consuming non-fluoridated drinking-water may consume significant amounts of beverages prepared in other locales with fluoridated drinking-water, as well as exposure to fluoride through the use of dental care products — mainly, fluoridated toothpaste.²⁷

There is now, however, an increasing body of evidence to suggest that a substantial part of the cariostatic activity of fluoride is due to its effects on erupted teeth, and that the continual presence of fluoride in the saliva and in the fluid phase of dental plaque is critical to its mechanism of action. There is a growing consensus that through its interaction with the surface of enamel, fluoride in saliva and dental plaque inhibits the demineralization and promotes the remineralization taking place at the surface of the tooth.²⁷

Since the introduction of controlled fluoridated drinking-water, efforts to reduce dental caries have been extended to include the use of fluoridated toothpaste, mouth rinses and topically applied dental treatments (e.g., gels,

varnishes, solutions), as well as through the use of fluoride supplements, fluoridated milk and fluoridated salt.²⁷

Depending upon the annual average maximum daily air temperature, recommended levels of fluoride in drinking-water considered useful for the prevention of dental caries have ranged from 0.5 to 1.2 mg/litre. However, excessive ingestion of fluoride leads to dental, skeletal and non-skeletal fluorosis.²⁷

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

Concentration of fluoride in drinking water, food, cosmetics etc. low calcium and high alkalinity of drinking water, age of the individual, duration of intake, pregnancy, lactating mother, derangement in hormonal profile either as a result of fluoride poisoning or cause, aggravates the disease. The hormones are: calcitonin, parathormone, vitamin D and cortisol are the important hormones for healthy bone formation and bone function.³

Clinical presentations:

The clinical presentation of fluoride intoxication may be of two types:

1. Acute Fluoride intoxication
2. Chronic Fluoride intoxication

1. Acute fluoride intoxication

The acute effects of the ingestion of massive doses of fluoride are first those of an irritant poison, and later become apparent in enzyme systems such as those engaged in metabolism, energetic, and cellular respiration and in endocrine functions. Early involvement of the alimentary, cardiovascular, respiratory and central nervous systems, with corresponding symptoms, is a characteristic feature and such cases commonly have a fatal outcome in two to three days. After ingestion of fluorine compounds in high doses, there is diffuse abdominal pain, diarrhoea and vomiting. There is excessive salivation, with thirst, perspiration and painful spasms in the limbs.³

Lethal dose:

The acute lethal dose of fluoride for man is probably about 5g as NaF.

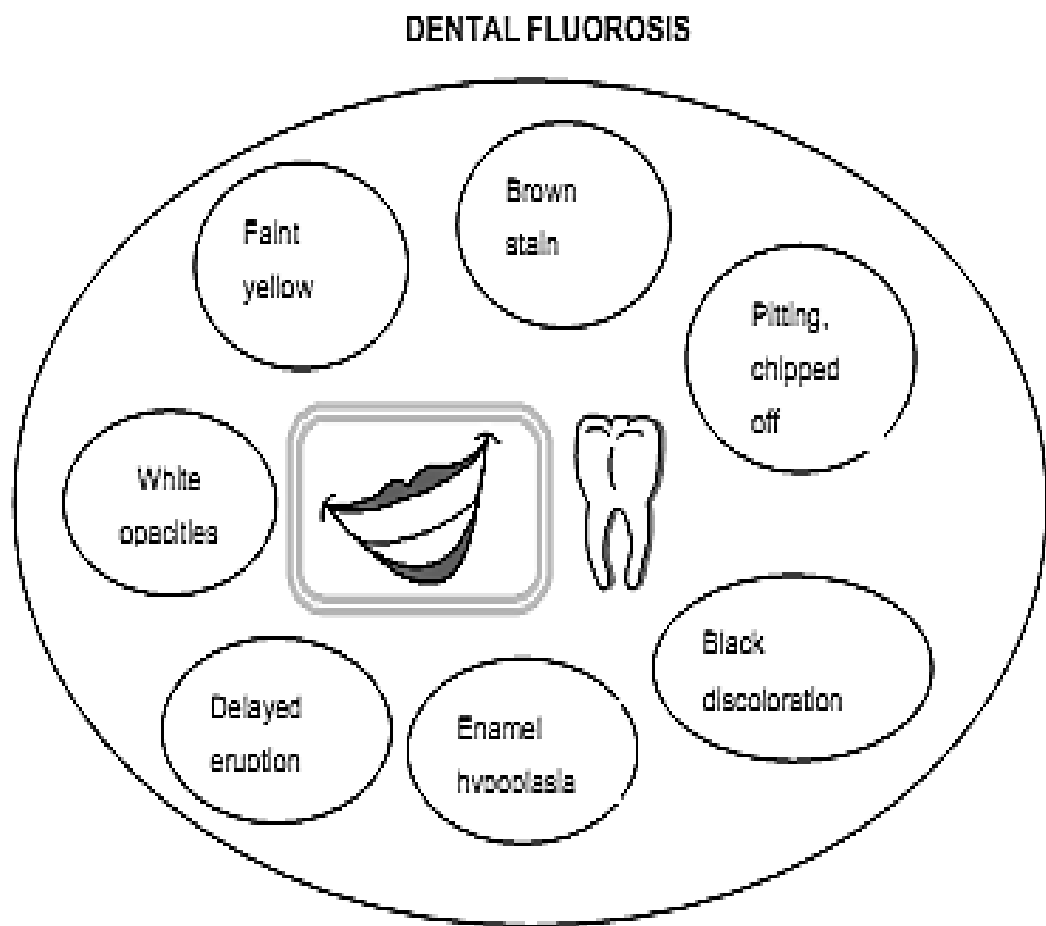
Treatment of acute toxicity:³

- Monitor and support vital signs, including cardiac monitoring.
- Gastric lavage, if emesis has not occurred. Charcoal is probably not of benefit.
- Monitor serum electrolyte, calcium, and magnesium levels.
- Treat hypocalcemia, hypomagnesemia and hyperkalemia or hypokalemia.
- Administer milk, oral calcium salts, or aluminum or magnesium based antacids to bind fluoride.
- Consider hemodialysis in-patients with significant toxicity.
- Treat arrhythmia, especially in the presence of refractory hyperkalemia.
- Consult a regional poison center for the latest treatment recommendations.

2. Chronic Fluoride Ingestion

Toxic effects on human beings: Fluorosis may cause skeletal, clinical, dental fluorosis, non-skeletal manifestations, or any combination of the above and in final stages it causes premature aging.³

Figure-4: Manifestations of dental fluorosis³



Dental Fluorosis:

It is the hypomineralization of enamel characterized by greater surface and subsurface porosity than the normal enamel as a result of excess fluoride intake during the period of enamel formation.²⁸

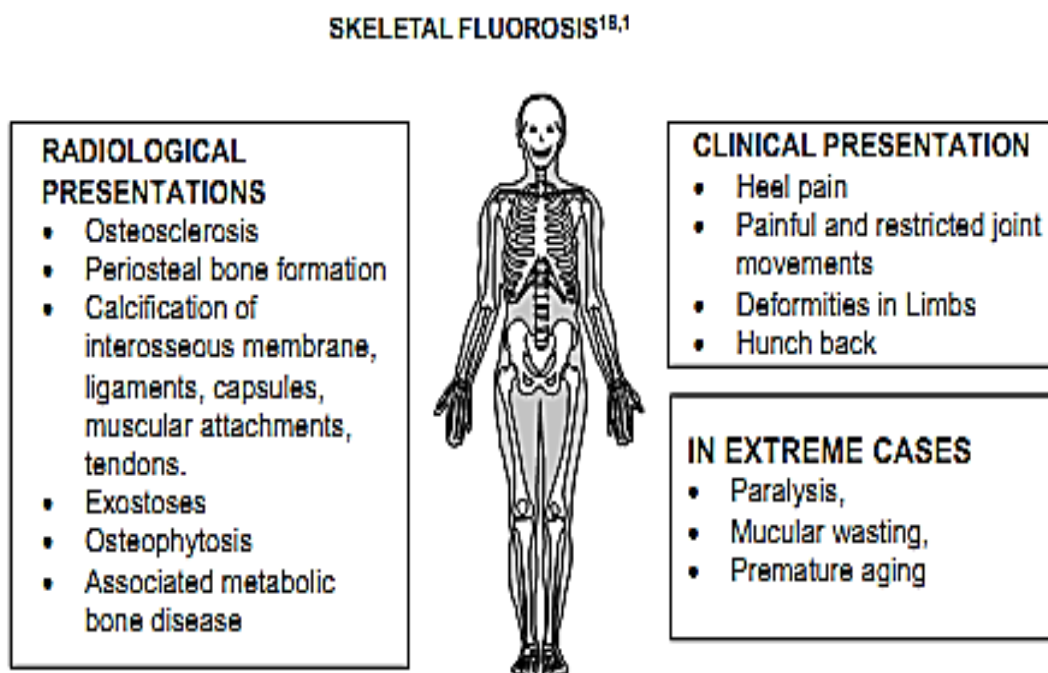
It affects the teeth of a child and not an adult. An adult may show DF and it would mean that he/she was exposed to high fluoride in his/her early childhood.⁸

The tooth germ layer develops in the embryo during early developmental stages. If the mother is exposed to high fluoride through any of high fluoride sources, the child will develop dental fluorosis and the discolouration on the enamel surface shall be visible to the naked eye. The discolouration on the teeth is very evident in the permanent teeth by the age of 8 years and above.⁸

SYMPTOMS OF DENTAL FLUOROSIS:⁴

- Mild dental fluorosis is developed when fluoride is in between 1 and 2.5 mg/l.
- Severe dental fluorosis is developed when fluoride is more than 2.5 mg/l.
- In mild dental fluorosis, affected teeth lose lustre and show chalkiness. In course of time, spots and transverse bands of light yellow to dark brown colour appear.
- In severe dental fluorosis, teeth become brittle and turn black owing to chipping of enamel. In course of time, there can be even loss of tooth.

Figure-5: Manifestations of skeletal fluorosis³



Skeletal Fluorosis:

It occurs when the bone and major joints are involved. Fluoride has a preferential affinity to accumulate in cancellous (spongy) bones, compared to compact (cortical) bones. The major reason being cancellous bone has excellent blood supply whereas, in cortical bone, the blood vessels are less in comparison.⁸

SYMPTOMS OF SKELETAL FLUOROSIS:⁴

- Severity of symptoms increases with increase in age beyond 20 years, malnutrition, and the fluoride content of water. The symptoms include:
 - ✓ Body pains, lethargy and tingling sensation in the extremities
 - ✓ Progressive stiffness of neck, spine and joints
 - ✓ Inability to squat on the floor

- ✓ To see someone on side, the patient has to turn the whole body towards that side
- ✓ To see an airplane, the patient has to lie on the ground
- ✓ Breathing becomes abdominal, gait and posture become ugly, and bones show osteophytic overgrowths.
- Once physiologic saturation of fluoride in hard tissues takes place, there will be flooding of fluoride in the soft tissues resulting in several diseases followed by death.

SYMPTOMS OF GENU VALGUM:^{4,8}

- Genu valgum (otherwise called knock-knee) is similar to rickets (otherwise called bowlegs). Both these disorders cripple lower limbs at a young age. Feet are far apart when knees are together in genu valgum, while knees are far apart when feet are together in rickets.
- Genu valgum develops right from young age, while skeletal fluorosis develops only in adults. As genu valgum is found even in non-fluorosis habitations, high-fluoride drinking water is not necessary for its development. Many children afflicted with genu valgum do not show dental fluorosis. Despite this, many investigators treat genu valgum as fluorosis.
- Development of genu valgum is attributed to drinking groundwater carrying certain chemical elements in excess/deficiency owing to environmental changes caused by natural and manmade activities. It is believed that genu valgum is caused partly due to malnutrition and partly due to low calcium and high molybdenum in drinking water.

- In case of children presenting with severe abnormalities viz., genu valgum, growth retardation, deaf, dumb and mental retardation, they should also be investigated for rickets along with other possibilities viz., fluoride toxicity and iodine deficiency in the same individual.
- Following tests need to be done to understand the problem better:
 - Fluoride in serum, drinking water and urine
 - Hormone levels : Free tri iodothyronine (FT₃), free tetra iodothyronine (FT₄) and thyroid stimulating hormone (TSH)

Normal range for serum FT₃ → 2.30 – 4.2 pg/ml; FT₄ → 0.89 – 1.8 ng/dl
and TSH → 0.50 – 2.5 µIU/ml

- Iodine in urine

Figure-6: Subjects with skeletal fluorosis ²⁹

A VICTIM OF SKELETAL FLUOROSIS WITH STIFFNESS OF NECK AND SPINE



CHILDREN AFFLICTED WITH GENU VALGUM



Figure-7: Manifestations of non-skeletal fluorosis³

NON SKELETAL MANIFESTATIONS

Neurological manifestation



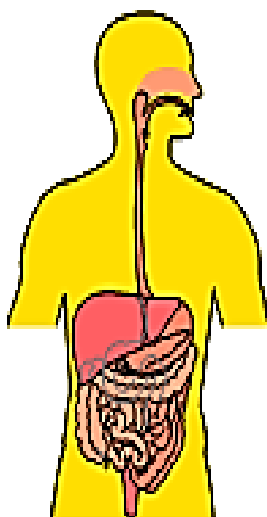
- 1 Nervousness & Depression
- 1 Tingling sensation in fingers and toes
- 1 Excessive thirst and tendency to urinate Frequently (Polydypsia and plyurea): The Control by brain appears to be adversely affected.

Muscular manifestations



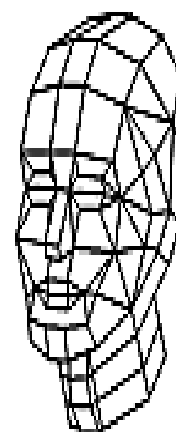
- 1 Muscle Weakness & stiffness
- 1 Pain in the muscle and loss of muscle power

Gastro - intestinal problems



- 1 Acute abdominal pain
- 1 Diarrohea
- 1 Constipation
- 1 Blood in Stool
- 1 Bloating feeling (Gas)
- 1 Tenderness in Stomach
- 1 Feeling of nausea
- 1 Mouth sores

Headache



Urinary tract manifestations

Kidney'



- 1 Urine may be much less in volume
- 1 Yellow red in colour
- 1 Itching in the region of axilla.

Allergic manifestation



- 1 Very painful skin rashes, which are peri vascular inflammation. Prevalent in women and children.
- 1 Pinkish red or bluish red spot, round or oval shape on the skin that fade and clear up within 7-10 days.

Non-Skeletal Fluorosis:

The different expressions of non-skeletal fluorosis will be as following: dyspepsia with nausea/vomiting/pain abdomen/constipation/diarrhoea, muscle weakness, tiredness, fatigue, polyuria, polydipsia, repeated abortions/still births.⁸

Red blood cells (RBC's):

As RBC membrane is an entity which lodges the chemical factor(s), responsible for blood group substances, considerable enquiry into the membrane structure and function has been carried out. It has been said that it results in low haemoglobin and anaemia.⁸

Gastro-Intestinal (GI) Mucosa:

It is now well established that fluoride in drinking water can cause non-ulcer dyspeptic complaints in human subjects. The main complaints are nausea, loss of appetite, pain in the stomach, gas formation and bloated feeling, constipation followed by intermittent diarrhoea and headache.⁸

Sperm Abnormality in fluorosis:

It is also a fact that male infertility with abnormality in sperm morphology, oligospermia (deficiency of spermatozoa in the semen) azoospermia (absence of spermatozoa in the semen) and low testosterone levels are common in those residing in endemic areas for Fluorosis and consuming fluoride contaminated water. However, it is not necessary that all male members would be infertile.⁸

Polyuria and Polydipsia:

Fluoride ingestion in excess can also lead to polyuria (tendency to urinate more frequently though urine volume may be less) and polydipsia (excessive thirst) which are associated with fluoride toxicity. Very often such patients are investigated for Diabetes and not for fluorosis. It has also been observed that when the patient's blood sugar is within normal limits, and he/she is not suffering from diabetes, drugs such as steroids are also prescribed. That fluoride toxicity can also cause polyuria and polydipsia is a revelation to the medical fraternity.⁸

Still birth and repeated abortion in fluorosis:

Fluoride is known to cause ectopic calcification. Among the soft tissues, the aorta (the main blood vessel leaving the heart as right and left branches) is known to accumulate fluoride in very high concentrations. Calcification of blood vessels (arteries) in association with skeletal fluorosis is well established. Repeated abortion /still birth have been reported from endemic areas of fluorosis as fetal blood vessels calcify and arrest the growth of the fetus.⁸

Identification:

Identification of Dental Fluorosis (DF):

DF should be differentiated from other non fluorotic causes of discolouration of teeth like dental caries, dirty teeth.⁸

The discolouration in DF is seen on enamel surface. The discolouration is:

- Horizontally aligned (never vertical)
- The teeth has chalky white appearance
- Discolouration seen in lines or spots.
- Away from gums on the enamel surface.
- Seen in teeth in pairs (never in a single tooth)

The discolouration can be seen as:

- White spots on white teeth
- Yellow colour (spots or streaks) on the white teeth
- Brown colour (spots or streaks) on the white/yellow teeth
- Black colour (spots or streaks) on white/yellow teeth

Damage to the tooth matrix: ⁸

Besides the discolouration, the tooth matrix is pitted, perforated besides having cracks and fissures. These changes are not visible to the naked eye in early stages. The damage to matrix can be seen under higher magnification of a microscope. It has been established that, these structural defects are due to accumulation of fluoride, followed by depletion of calcium. The collagen matrix laid down is structurally and biochemically defective resulting in hypomineralization. Thus, rendering the tooth very weak and get chipped off.

Differential diagnosis of dental fluorosis from dental caries:

Dental caries is a bacterial disorder. Dental caries also reveal discolouration of teeth but unlike DF, the discolouration in dental caries may be brown with no pattern.⁸

Unlike DF, dental caries shall reveal prominent cavities visible to the naked eye. The acids produced by the bacteria shall chew up the teeth; only the stub of the teeth shall remain towards later stages.⁸

The cavities in dental caries shall begin between two teeth or near the base of the crown, closer to the gums where the tooth brush does not reach and food debris collects enabling the bacteria to breed and produce acids.⁸

Differential diagnosis of dental fluorosis from dirty teeth:

In dirty teeth there will be discolouration of all shades but the discolouration will be along the gums and not on the enamel surface. The dirty teeth can be cleaned and polished by a dentist.⁸

Dean's Index:

This epidemiological index was first developed by Dean (1934). According to this index each erupted permanent tooth is ranked according to the six point ordinal scale. The examination is to be conducted using day light. Best results are obtained when using the upper central incisors as the examination teeth.^{28, 30}

Classification	Weight	Diagnostic Criteria
Normal	0	The enamel represents the usual translucent semivitriform type of structure. The surface is smooth, glossy, and usually of a pale creamy white color.
Questionable	0.5	The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots.
Very Mild	1	Small opaque, paper white areas scattered irregularly over the tooth but not involving as much as 25% of the tooth surface.
Mild	2	The white opaque areas in the enamel of the teeth are more extensive but do not involve as much as 50% of the tooth.
Moderate	3	All enamel surfaces of the teeth are affected, and the surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature.
Severe	4	All enamel surfaces are affected and hypoplasia is so marked that the general form of the tooth may be affected. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are widespread and teeth often present a corroded-like appearance.

Community Fluorosis Index (CFI):³⁰

This is computed by summing up the scores of individual grades of dental fluorosis as described by Dean and dividing the sum by the total sample size.

CFI value range	Public health significance
0.0-0.4	Negative
0.4-0.6	Borderline
0.6-1.0	Slight
1.0-2.0	Medium
2.0-3.0	Marked
3.0-4.0	Very marked

Figure-8: Various grades of dental fluorosis²⁹



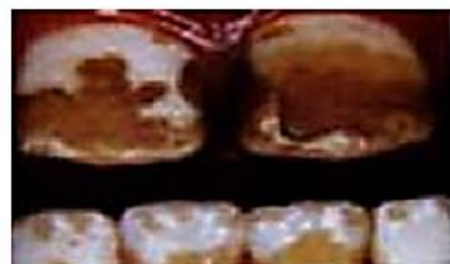
Chalkiness of teeth



Brown stain on teeth



Brown wavy striations on teeth



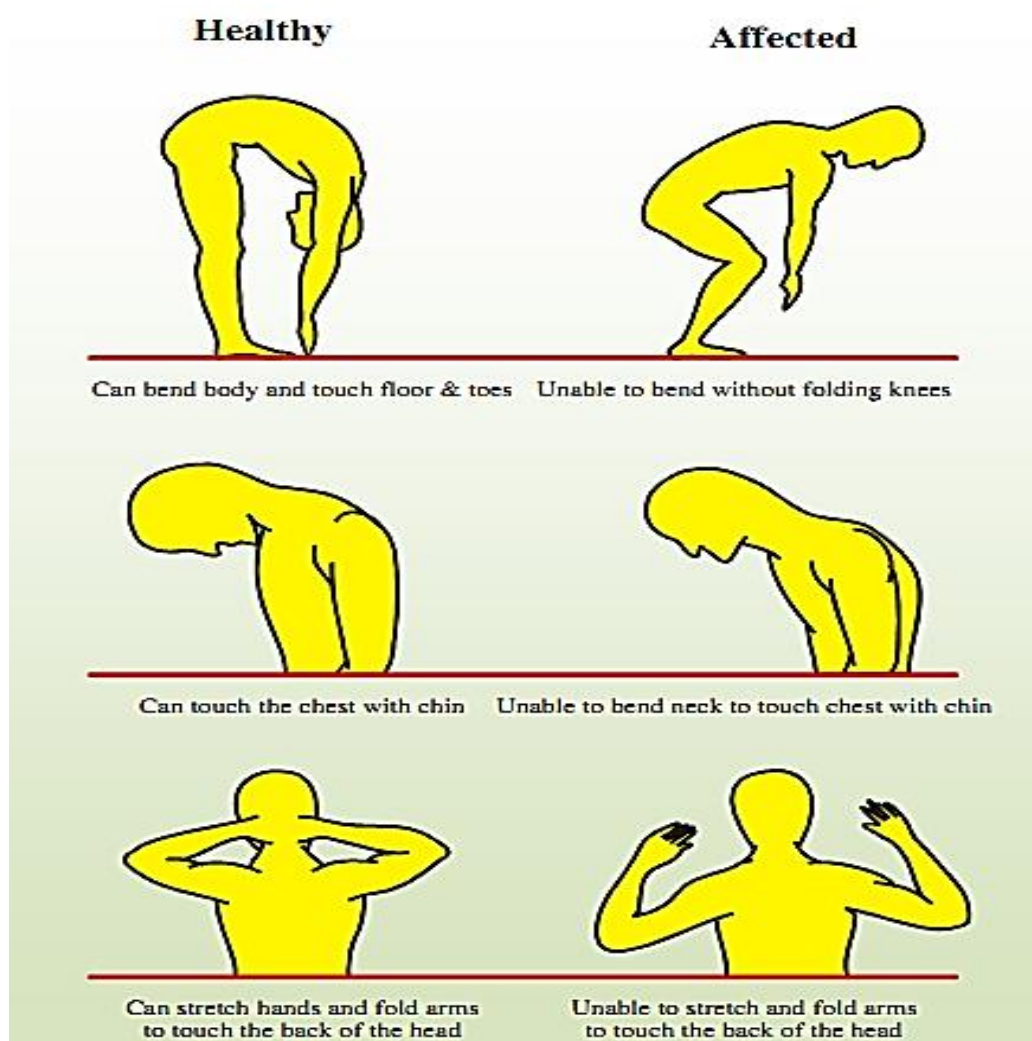
Severe mottling

Detection of Skeletal Fluorosis:

Home based diagnostic procedure:

When laboratory facilities are not available for carrying out the tests mentioned above, the following approach is adopted for arriving at presumptive diagnosis of the disease. It is extremely important to take a good history by interviewing the patient and conducting three simple physical tests to check rigidity and pain of the neck region, back, knee joints and shoulder joints.³¹

Figure-9: Three simple physical tests for diagnosis of skeletal fluorosis at field level ³¹



It is clinically graded into mild, moderate and severe forms.³²

Grade I	Mild	Generalized bone and joint pain.
Grade II	Moderate	Generalized bone and joint pain, stiffness and rigidity, restricted movements at spine and joints.
Grade III	Severe	Symptoms of moderate grading with deformities of spine and limbs, knock knees, crippled or bedridden state.

In view of the information provided, the tests that need to be carried out to confirm the diagnosis of skeletal fluorosis are:

1. Fluoride levels in blood (serum), urine, drinking water:

Drinking water for testing should be collected from the source i.e., hand pump, tube well, open well etc., in plastic bottles and not glass bottles. Glass bottles are unsuitable as fluoride would bind with the silica of the glass and lead to erroneous results. Fluoride in drinking water, as per the national norms should not exceed 1.0mg/L; but lesser the better.⁸

Fluoride in urine can be tested either in 24 hr urine collection or spot sample. The normal upper limit of fluoride is 0.1mg/L.⁸

Fluoride in serum can be tested from blood samples drawn any time of the day. Fasting is not a pre-requisite. The normal upper limit of fluoride in serum is 0.02mg/L.⁸

2. Radiographs of the region/joint:

Radiograph of the joint where there are complaints viz., pain, rigidity/stiffness, the forearm to reveal interosseous membrane calcification. The latter x-ray is a 'must', to diagnose skeletal fluorosis at early stages and to confirm the diagnosis of skeletal fluorosis.⁸

After radiological examination, skeletal fluorosis can be graded into mild, moderate and severe.³²

Grade I	Mild	Osteosclerosis only
Grade II	Moderate	Osteosclerosis, periosteal bone formation, calcification of interosseous membrane, ligaments, capsules, muscular attachments, tendons.
Grade III	Severe	Findings as in moderate with exostoses, osteophytosis and associated metabolic bone disease.

Note: The classification given for skeletal fluorosis is based on radiological findings, whereas the classification of clinical fluorosis is based on clinical examination, which is in fact a mixed presentation of skeletal and non-skeletal fluorosis.

Identification of Non-Skeletal Fluorosis (NSF):

Retrieve history from the members of the family as to whether they have non-ulcer dyspeptic complaints, polyuria, polydipsia and/or fatigue. To confirm whether the health complaints in the family are due to fluoride, divert the family to a safer source of water existing in the village for cooking and drinking purposes, and follow-

up non-ulcer dyspeptic complaints. If the complaints are due to fluoride, they would disappear within 10-15 days following the commencement of safe water consumption. This is the approach to follow in a rural /village setting. If the disease is confirmed as fluorosis, the patient should be monitored for the improvement of his/ her health through interventions. After the nutritional intervention, the blood and urine fluoride levels should be monitored from a fortnight to 3 months, when it would drop to normal limits, while such changes are taking place he/she would be relieved of health complaints as well.¹³

MANAGEMENT:

Estimation of fluoride:

Titrimetry:

A titrant usually containing a rare earth metal, such as thorium, is added to the solution containing fluoride. The fluoride ions are allowed to react with the titrant and then the solution is treated with an indicator dye, such as Alizarin Red S or SPADNS [sodium 2-(p-sulfo-phenylazo)-1,8-dihydroxynaphthalene – 3,6 – disulfonate]. A colour change which occurs when excess thorium reacts with indicator dye, is detected either visually or by using instrumentation techniques. The pH and the composition of the solution must be carefully controlled and interference of other substances is avoided by prior separation. It is an accurate method, but is tedious. Further, the results are highly dependent on the skills and experience of the analyst.³³

Potentiometric Methods:

Fluoride in drinking water can be easily estimated by direct potentiometric analysis using fluoride ion selective electrodes. The single crystal lanthanum electrode was introduced by Frant and Ross (1968), and it has provided a reliable method for measuring the fluoride activity. The sensor used is a single crystal of lanthanum fluoride which has been doped with 0.5 – 1.0 % europium (II) and is fixed at the bottom of a cylindrical glass tube which houses the thirteen reference electrode and the reference solution. The reference solution is usually 0.001M sodium fluoride in 0.1M potassium chloride, and it fills the fluoride electrode. Silver – silver chloride electrode is used as the reference electrode and is dipped into this solution to provide contact.³³

The electrode can be used to measure the activity or the concentration of the fluoride present in water by the use of an appropriate calibration curve. The electrode does not respond to bound or complex fluoride. To overcome this, a buffer solution of high ionic strength must be added to it, so that the fluoride ions bound to complex molecules are liberated. When the concentration of fluoride present in the solution is low (less than 15 mg/L), direct potentiometric methods can be used. This method is less susceptible to interferences from other metals than titrimetry and spectrophotometry. Hence tedious preliminary techniques like crushing and interfering ion separation can be avoided in this case.³³

Spectrophotometric methods:

In this method, a compound of a metal such as aluminium, iron, thorium, zirconium, lanthanum or cerium reacts with an indicator dye to form a complex of low dissociation constant. This complex reacts with fluoride to give a new complex. Due to the change in the structure of the complex, the absorption spectrum also shifts relative to the spectrum for the fluoride-free reagent solutions. This change can be detected by using a spectrophotometer. One of the important dyes used is trisodium 2-(parasulfophenylazo)-1,8-dihydroxy-3,6-naphthalenedisulfonate, commonly known as SPADNS. Erichrome Cyanine R is another commonly used dye. The dye reacts with metal ions to give a coloured complex. In the SPADNS method, zirconium reacts with SPADNS to form a red coloured complex. Fluoride bleaches the red colour of the complex and hence the change in absorbance can be measured using a spectrophotometer.³³

Interventions to Practise:

There is no treatment for fluorosis and therefore prevention and control through interventions, is the only approach to mitigate fluorosis. Having diagnosed the disease, the next step that needs to be followed is management of the patient, so that he/she recovers from the health complaints in the shortest possible time. There are two interventions to practise for the management of the disease:

- Safe drinking water intervention
- Nutritional intervention

Safe drinking water intervention:

The drinking water source requires to be tested for fluoride, Using 'Ion Selective Electrode Technology, if the drinking water source is contaminated with fluoride more than 1.0mg/litre of water, the patient needs to be advised to collect water with the least amount of fluoride i.e less than 1.0 mg/litre for cooking and drinking purposes.³⁴

There is a possibility of getting safe water from hand pumps/tube wells/open wells, which exist in the same village locality. The patient needs to get more water samples collected which exist in the same locality and get them tested for fluoride. If he/she has access to collect 2 buckets of safe water daily for cooking and drinking purposes from the safe source, it ought to be encouraged. It is estimated that one requires 10 litres of water for cooking and drinking purposes per day.³⁴

This approach is preferred in villages where the patient incurs no hardships or expenditure for getting water treated for obtaining safe water for consumption.³⁴

Community installations (erecting tanks) for water treatment, using either the Nalgonda technology or Activated Alumina technology is the other alternative.³⁴

Nutritional Intervention:

The management of fluorosis patients and the complete recovery from the adverse health effects of fluoride can be achieved in a shorter span of time, if nutritional intervention focusing on adequate intake of calcium, vitamins C & E and antioxidants, is also practised simultaneously along with consuming safe drinking water. Nutrient supplementation through dietary regime has been found to be the best approach and is sustainable. Diet and food are substances which one consumes/ingests

at least 2-3 times a day and they have a lot to do with habits and customs of the individual based on religion and other social norms. While counselling for nutritional supplementation, it may be necessary to emphasize on items which are totally banned for a patient of fluorosis.³⁴

Food and other substances rich in fluoride to be avoided:³⁴

- Black rock salt (kalanamak) and any preparation which has used black rock salt for flavour eg: daalmoth, other salty snacks, chaat masala, etc.
- Red rock salt (RRS) and the preparations made by using RRS.
- Black tea (Tea with milk can be consumed but not black tea i.e., without milk)
- Chewing of tobacco by itself
- Chewing of supari (arecanut) by itself
- Use of Fluoride containing tooth paste, mouth rinse, varnish and other items commercially available.
- Fluoride containing drinking water.
- Use of Hajmola - which has high black rock salt
- Use of Calcaria fluoride (Homeopathy drug)
- Use of Prozac or other fluoride containing antidepressant or other drugs on long term treatment

Essential Nutrients:

Diet counselling is extremely important and the messages conveyed shall be practised by the patient whether he/she is educated/less educated/ uneducated. Even minor details need to be explained, so that the patient understands the items to consider consuming for adequate intake of calcium, vitamins C & E and antioxidants.³⁴

Nutritional counselling:

The focus on nutritional counselling should be to ensure that the patient has an idea as to which food substances or products available in the market are preferred, to ensure that the daily diet has all the four essential nutrients. It is also necessary to inform the patient about the different recipes that one can use for consuming the same item during the course of the week, so that adequate intake of the nutrients is guaranteed. The affordability and sustainability are the two major concerns on which the counselling should be based.³⁴

The nutrients and the sources often recommended are listed below:

Calcium : Milk, yoghurt (dahi), jaggery (gur), green leafy vegetables, sesame (til) seeds, cheese/ paneer, kamalkakdi (vegetable), arbi (vegetable), chaulaika sag (vegetable), cumin seed (jeera), drumstick and the leaves (vegetable).

Vitamin C: Amla (gooseberry), guava fruit (amrut), lemon, oranges, tomato, dhania leaf chutney, spouted cereals and pulses and any other.

Vitamin E: Vegetable oil, nuts, whole gram cereals, green vegetables, dried beans and any other.

Antioxidants: Garlic, ginger, white onion, carrot, papaya, pumpkin, sweet potato and any other source known for its richness of antioxidants.³⁴

The different methods of preparing the food (recipes): Suggesting items containing high calcium, vitamins and antioxidants and emphasizing that they should consume more of such food items, has paid less in returns compared to suggesting the different ways, in which one can prepare the food for consumption, so that it is

ensured that they have recipes for 7 days a week without having to consume the same preparation every day.³⁴

Removal of fluoride from drinking water:

Various de-fluoridating methods available include chemical reactions (Nalgonda technology & activated alumina technology), ion exchange process and reverse osmosis.¹²

Nalgonda technique:

Nalgonda technique involves addition of two chemicals, lime and alum to water, followed by flocculation, sedimentation and filtration. Bleaching powder can be added simultaneously for disinfection. The quantities of alum and lime required depend on dissolved solids, alkalinity and fluoride content of raw water.¹²

Activated alumina technology:

The activated alumina procedure essentially involves removal of fluoride by adsorption of the ion on the surface of the activated alumina. Ion exchange resin based approach Resin based ion exchange process for removal of fluoride from ground water is also available in India. It is commercially available but is expensive.¹²

Reverse osmosis:

Reverse osmosis is a process wherein water is forced through a semi-permeable membrane by applying strong pressure, thereby allowing only fine water molecules to pass through it. All contaminants including heavy metal and chemical poisons are removed.¹²

Ion exchange process:

Ion exchange is an effective, versatile means of conditioning boiler feed water. The term “ion exchange” describes the process: as water flows through a bed of ion exchange material, undesirable ions are removed and replaced with less objectionable ones.^{12, 35}

The fluoride selective ion exchange resin is a chelating resin loaded with aluminum ions. The functional group of the resin is an amino-methyl-phosphonic-acid-group or AMPA-group. The phosphonic acid group has a high tendency to bind aluminum. It is significant that the aluminum ion is connected with two binding arms towards the AMPA-group, while the third binding arm of the aluminum core is attached to one chloride ion. In contact with fluoride containing solutions the chloride is exchanged by fluoride. Other ions such as sulfate or nitrate do not interact with the aluminum ion since their affinity to aluminum is very low.^{12, 35}

Prevention & Control:

Rural Drinking Water Supply and Sanitation (RDWSSP) PROJECT:

The RDWSSP is a Danish International Development Agency (DANIDA)-assisted project aims at improved and sustainable drinking water supply and sanitation in three districts of Karnataka, India. Based on the experiences of an earlier DANIDA-supported Integrated Rural Sanitation and Water Supply Project (1990-1996), and following the findings of preliminary ‘quick’ water quality surveys and studies in the project areas, the project partners identified the “development and testing of appropriate solutions to excessive fluoride contents in the groundwater” as one of the four critical, immediate objectives of the project.³⁶

Based on the findings of water quality studies carried out during the Integrated Rural Sanitation and Water Supply (IRS&WS) project (1990-1996) as well as the current RDWSS Project (1996-1997), excessive fluoride levels (i.e., Fluoride >1.5 mg /L) in the groundwater was anticipated to prevail in several parts of the project areas, in particular in the two districts of Kolar and Chitradurga. At the same time, it has been noted that the fluoride levels in these affected sources are moderately high and do not generally exceed 3.0-3.5 mg /L. Quick surveys were carried out in only six of the total 31 taluks in the project area. The total number of sources affected with fluoride ranges from about 11% (Jamakhandi) to 57% (Hiriyur). On the other hand, only 2-5% of the total number of sources had fluoride levels exceeding 3 mg /L.³⁶

Defined classification of the project areas:

Non-problematic: Yield and water quality data indicate that the project will be able to ensure a minimum of 40 lpcd (litres per capita per day) of safe drinking water through rehabilitation and/or augmentation of the existing system/technology. Any other sources, though not necessarily potable, can be used for other purposes.³⁶

Moderately fluoride affected: The data indicate that the project will be able to ensure 10 lpcd of safe drinking water through rehabilitation and/or augmentation of the existing system. Any other sources, though not necessarily potable, will make up for the balance of 30 lpcd, and can be used for other purposes.³⁶

Fluoride affected: The data indicate that fluoride levels in the area are generally in the range of 1-5- 3.0 mg/L, that it will not be possible to ensure a minimum of 10 lpcd of safe drinking water through the mere rehabilitation and/or augmentation of the existing system.³⁶

Severely fluoride affected: The data indicate that most of the sources in the area have fluoride levels exceeding 3.0 mg/L, and thus, that it will not be possible to ensure 10 lpcd of safe drinking water through the mere rehabilitation and/or augmentation of the existing system.³⁶

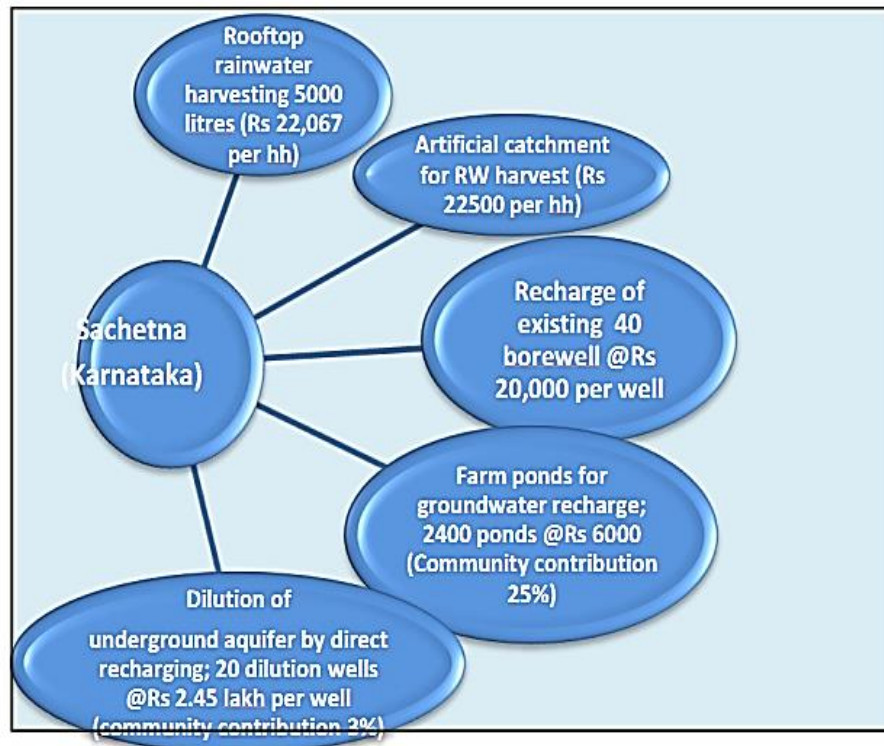
Sachetana Project:^{37, 38}

Government of Karnataka (GOK) entrusted this project to Bharatiya Agro Industries Foundation (BAIF) institute for rural development for five years from April 2006 to March 2011. It covered 60 villages that belong to four taluks namely : Mundargi (Gadag district), Sira and Pavagadataluk (Tumkur district), and Bagepalli taluk (Kolar district) with a goal to ensure availability of safe drinking water to the local community through rain water harvesting and improved ground water.

Objectives of Sachetana project were:

- To provide safe drinking water through innovative rain water harvesting and improved ground water.
- Recharge of ground water through excavation of percolation ponds.
- Recharge of existing bore wells and direct recharge of aquifers.
- Activities for training awareness to promote sustainable management and maintenance of water resources and water harvesting structures.

Figure-10: Sachetana model for fluoride mitigation³⁸



METHODS USED TO ERADICATE FLUOROSIS:²⁹

- Locating local sources of low-fluoride surface- and ground- waters and educating people to use only such waters for drinking and cooking
- Converting local high-fluoride waters into low-fluoride waters through defluoridation at house-hold and community levels
- Collecting rainwater from rooftops and hill slopes in cisterns and reservoirs
- Injecting treated rainwater direct into wells and thereby dilute the fluoride content of well waters
- Abandon local sources of groundwater and formulate public water supply schemes to obtain piped water from far-off rivers As effects of fluorosis are more in people with malnutrition, efforts have to be taken to improve the nutritional status of people by providing special diets.

National Program for Prevention and Control of Fluorosis: ³⁹

As there is no effective treatment for fluoride related disorders, prevention is the most effective measures for the same.

The chairman of National Human Rights Commission reviewed the fluorosis situation in the country and recommended a national program for the same.

National Programme for Prevention and Control of Fluorosis was approved in the year 2007-08 for 100 districts with an amount of Rs.680 crores with the following objectives:-

- To collect, assess and use the baseline survey data of fluorosis of department of drinking water supply for starting the project.
- Comprehensive management of fluorosis in the selected areas.
- Capacity building for prevention, diagnosis and management of fluorosis cases.

The following strategies are adopted for implementing the programme:

- Training - Impart training to health personnel for prevention, health promotion, early diagnosis and prompt intervention, deformity correction and rehabilitation.
- Capacity Building - Capacity building of district and medical college hospital for reconstructive surgery and rehabilitation.
- Laboratory Support Development - Establishment of diagnostic facilities in the district hospitals
- I.E.C - Health Education for prevention and control of fluorosis cases.

3.4 Different Studies on Fluorosis

Studies on prevalence of fluorosis:

A study was conducted by Fewtrell et al, in 2006, in India and China to examine the feasibility of estimating the global burden of disease due to fluoride in drinking water. A literature review was conducted to identify studies on dental and skeletal fluorosis that could be used to establish tentative exposure-response relationships.

Twelve studies were identified for dental fluorosis and, only four studies presented data on skeletal fluorosis attributed to drinking water fluoride concentrations. The dental fluorosis estimate was 24 million and skeletal fluorosis was 10 million.⁴⁰

WHO CRA Region	Country	Dental Fluorosis	Skeletal fluorosis
Afr D	Niger	159	41
Afr D	Senegal	119	18
Afr E	Eritrea	57	15
Afr E	Ethiopia	868	184
Amr A	USA	0	0
Amr B	Brazil	0	0
Amr D	Peru	0	0
Emr B	Saudi Arabia	263	35
Emr D	Pakistan	2234	517
Emr D	Egypt	928	182
Eur A	UK	0	0
Eur B	Kyrgyzstan	68	16
Eur C	Kazakhstan	219	43
Scar B	Thailand	0	0
Scar D	India	18197	7889
Wpr A	New Zealand	0	0
Wpr B	China	23523	10887

A clinical and biochemical study conducted by Shivashankara AR et al in 1998, in children of Kheru Thanda of Gulbarga district, Karnataka showed the fluoride concentration in drinking water estimated by zirconium – SPADNS spectrophotometric method and cross-checked with a fluoride ion selective electrode (ORION 710-A) ranged from 0.6 to 13.4 ppm and 89% of the children had dental fluorosis and 39% of them exhibited skeletal fluorosis.⁴¹

A study conducted by Saravanan et al, in 2003-2004 in Chidambaram Taluk, Cuddalore district, Tamil Nadu, among 5-12 yrs age group, found a prevalence of dental fluorosis of 31.4%.⁴²

A study conducted by Jolly S S et al, in Punjab among 5- 17 yrs age group for dental and among adults for skeletal fluorosis found 210 villages with maximum fluoride concentration 1.4ppm to have 0-10% incidence of dental fluorosis, 96 villages with maximum fluoride concentration of 2.3ppm to have 10-30% incidence of dental fluorosis and 52 villages with >2.3ppm to have >30% incidence of dental fluorosis and concentrations of fluoride from 0.9 to 2.5 p.p.m were associated with an incidence of only 2.4% skeletal fluorosis, but that crippling fluorosis was seen in some villages in which the fluoride range was 1.3 to 5.2 p.p.m.⁴³

A study conducted by Gopalakrishnan et al in 1998 in Alappuzha district, Kerala, on prevalence of dental fluorosis and associated risk factors, has shown that, the prevalence of dental fluorosis among 10-17 years children, assessed by Dean's index was 35.6% and community fluorosis index was 0.69.⁴⁴

An epidemiological study conducted by Abhay S Nirgude et al, in 2008 – 2009, in an urban slum area of Nalgonda, Andhra Pradesh, on fluorosis had shown that, an overall prevalence of skeletal fluorosis was 24.9% and that of dental fluorosis

was 30.6%, which were assessed using three simple diagnostic tests for skeletal fluorosis and on the basis of discolouration of teeth for dental fluorosis.⁴⁵

Padma K Bhat and Amit Kumar in their study for prevalence and severity of dental fluorosis among residents of Hanumantharayanaplaya, Ramnagaram district, Karnataka showed that 89.6% were affected by various grades of dental fluorosis by Dean's index and CFI was reported to be 1.76.⁴⁶

Studies on fluorosis with age, gender, socio economic status and occupation:

A study conducted by Veeresh DJ et al, in 2007-2008 on prevalence of dental fluorosis in two rural areas of Bagalkot District has shown that, the prevalence of dental fluorosis, assessed by Dean's index for 5-6yrs and 12-14yrs in Kategari was 49.8% and 37.3% and in Sikkeri 9.1% and 15.42% respectively. Fluoride concentrations in drinking water samples were 2.0ppm & 1.8ppm in Kategari and 0.9ppm & 1.2ppm in Sikkeri. Dental fluorosis was more prevalent among females than males, but was not found significant. Prevalence of fluorosis increased with age($p>0.001$) and difference was statistically significant ($p<0.002$).¹⁸

A study conducted by Jolly S S et al, in Punjab among 5- 17 yrs age group for dental and among adults for skeletal fluorosis found that development of endemic fluorosis, with a similar fluoride concentration the incidence was found to increase with age. Sex and occupation also have some influence on the development of endemic fluorosis, particularly in relation to severe varieties, such as neurological and crippling fluorosis. The disease was far more common in labourers and farmers who do hard manual work and carry heavy loads on the head.⁴³

A study conducted by Gopalakrishnan et al in 1998, on prevalence of dental fluorosis and associated risk factors in Alappuzha district, Kerala has shown that,

dental fluorosis among girls was more than (not related to the amount of water consumed because boys in the study sample drank more water than girls ($p < 0.001$). An inverse association between age and the prevalence of DF; a higher prevalence was noted in the younger children compared to the older ones.⁴⁴

A study conducted by Saravanan et al, in 2003 – 2004 in Chidambaram taluk. Cuddalore district, Tamil Nadu, among 5-12 yrs age group, did not find statistical significance for dental fluorosis with gender but found a statistical significance of $p < 0.001$ with age.⁴²

A study conducted by QY Xiang et al in 2002 – 2003 in China, among 36–78yrs age group for skeletal fluorosis shows that, in the high-fluoride village of Wamiao, (water fluoride 2.18 ± 0.86 mg/L; range 0.85–4.50 mg/L) and in the low-fluoride village of Xinhuai, (water fluoride 0.37 ± 0.09 mg/L; range 0.21–0.55 mg/L), when the subjects were divided into five subgroups according to their serum fluoride concentration, higher serum fluoride concentration, Gender related differences in serum fluoride concentration, household well water fluoride, and the prevalence of skeletal fluorosis were not found in the subjects in Wamiao village.⁴⁷

An epidemiological study conducted by Abhay S Nirgude et al, in 2008 – 2009, on fluorosis in an urban slum area of Nalgonda, Andhra Pradesh had shown that, an overall prevalence of skeletal fluorosis was 24.9% and that of dental fluorosis was 30.6%, which were assessed using three simple diagnostic tests for skeletal fluorosis and on the basis of discolouration of teeth for dental fluorosis, dental and skeletal fluorosis was more among males, lower Socio-economic status, illiterates, labourers & farmers, tobacco users & alcohol abuse (no p-value) and also prevalence increased with age ($p < 0.05$).⁴⁵

A study conducted by Seem Garg et al in 2010 – 2011, in Agra, found a prevalence of dental fluorosis in both sexes was not much variable but, male subjects showed relatively higher prevalence of dental fluorosis. The occurrence of skeletal fluorosis was 17.6% in children and 18.46% in adults. The prevalence of skeletal fluorosis in both sexes was not so much variable but, male subjects showed relatively higher prevalence of skeletal fluorosis.⁴⁸

A study conducted by Arjunan Isaac et al, in December 2009, among primary school children studying in 1st to 7th standard in the rural areas of Kaiwarahobli, Chikkaballapur district, Karnataka, on prevalence and severity of dental fluorosis and genu valgum, showed that of the 1,544 children examined 42.1% and 8.4% had dental fluorosis and genu valgum respectively. Prevalence of very mild dental fluorosis and moderate grade genu valgum were high compared to other categories. Prevalence rates increased with the age ($p < 0.05$) and was more among girls (45.2%) as compared to boys (39.1%) ($p < 0.05$). Of the 26 water samples analysed, 18 samples (69.2%) revealed the fluoride content above the permissible limit (Colorimetric method).⁴⁹

Studies on fluorosis with source of drinking water and various epidemiological factors:

A study conducted by Gopalakrishnan et al in 1998 on prevalence of dental fluorosis and associated risk factors in Alappuzha district, Kerala has shown that, pipe water was the major source of drinking water in the taluk. Most of the children consumed fish in their diet and 4/5th drank brick-tea. Nearly 3/4th → toothpaste for cleaning their teeth Compared to rural areas, the prevalence of dental fluorosis in the urban areas. Severity of dental fluorosis was greater in children in the urban area.⁴⁴

A study conducted by Jagan Kumar et al in 2006, in Kanyakumari district, Tamil Nadu, among 11-15yrs for dental fluorosis, found differences between the

fluorosed and non-fluorosed population in terms of gender, socioeconomic status, age, oral hygiene habits, and diet were insignificant. Children who consumed more than four glasses of water were found to be more prone to dental fluorosis. The prevalence of dental fluorosis is high among children who use pipe water for drinking purposes ($p < 0.001$). Significant positive association between water fluoride content and prevalence of dental fluorosis.⁵⁰

A study conducted by QY Xiang et al in 2002 – 2003 in China among 36–78yrs age group for skeletal fluorosis has shown that, in the high-fluoride village of Wamiao, (water fluoride 2.18 ± 0.86 mg/L; range 0.85–4.50mg/L) and in the low-fluoride village of Xinhuai, (water fluoride 0.37 ± 0.09 mg/L; range 0.21–0.55mg/L), when the subjects were divided into five subgroups according to their serum fluoride concentration, higher serum fluoride concentration was strongly associated with a higher prevalence of skeletal fluorosis in the form of a significant positive dose-response relationship. In Wamiao village a significant difference was also found between serum fluoride concentrations in 41 subjects with X-ray detectable skeletal fluorosis and in 91 subjects without X-ray detectable skeletal fluorosis.⁴⁷

Studies on fluorosis with fluoride levels in water:

A study conducted by Gopalakrishnan et al in 1998, on prevalence of dental fluorosis and associated risk factors in Alappuzha district, Kerala has shown that, water fluoride content of more than 1 ppm was associated with 1.85-fold elevated risk of prevalence of dental fluorosis, compared to the reference group with a water fluoride content of less than 1 ppm.⁴⁴

A study conducted by Saravanan et al, in 2003 – 2004 in Chidambaram taluk, Cuddalore district, Tamil Nadu, among 5-12 yrs age group, found positive co-relation between fluoride levels of water and community fluorosis index.⁴²

A study conducted by Jagan Kumar et al, in 2006 in Kanyakumari district, Tamil Nadu, among 11-15yrs for dental fluorosis, Prevalence of dental fluorosis attributed to the level of fluoride in the drinking water exhibited a step-wise increase when the water fluoride levels increased from 1.5-1.7 ppm.⁵⁰

A study conducted by QY Xiang et al in 2002 – 2003 in China, among 36–78yrs age group for skeletal fluorosis shows that, in the high-fluoride village of Wamiao, (water fluoride 2.18 ± 0.86 mg/L; range 0.85–4.50mg/L) and in the low-fluoride village of Xinhuai, (water fluoride 0.37 ± 0.09 mg/L; range 0.21–0.55mg/L), when the subjects were divided into five subgroups according to their serum fluoride concentration, serum fluoride concentrations had a significant positive dose-response relationship with the prevalence of skeletal fluorosis in an endemic fluorosis area associated with high-fluoride drinking water.⁴⁷

A study conducted by David G et al, in 1993 – 1994, among the residents of six non-fluoridated communities in Massachusetts and Connecticut aged between 10 to 13 year old children, born after 1979 were observed for enamel fluorosis was measured using the Fluorosis Risk Index (FRI) (29), which categorizes fluorosis cases and controls based on the presence of mild-to-moderate fluorosis on enamel surfaces forming during defined developmental periods. On applying logistic regression analyses it was revealed that a moderate association between mild-to-moderate enamel fluorosis on early forming (FRI classification I) enamel surfaces and both fluoride supplement use (odds ratio (OR) = 2.25, 95% confidence interval (CI) 1.08-4.69) and early tooth-brushing habits (OR = 2.56, 95% CI 1.34-4.88). There was a strong association between mild-to-moderate fluorosis on later forming (FRI classification II) enamel surfaces and both supplement use (OR = 7.97, 95% CI 2.98-21.33) and early tooth-brushing habits (OR = 4.23, 95% CI 1.72-10.41). Infant

formula was not found to be associated with fluorosis on either FRI classification I or II surfaces.⁵¹

A study conducted by Murugan et al, in Tamil Nadu District, found an incidence of dental fluorosis to be well documented in low fluoride areas & non-linear relationship is observed between the percentage prevalence of dental fluorosis and the drinking water fluoride concentrations. A high prevalence of dental fluorosis (32.56%) in low fluoride area (0.68 mg/L) and a low prevalence (12.51%) of dental fluorosis in high fluoride area (1.76 mg/L) is well discussed. The study also explains the age and sex specific incidence of dental fluorosis. In males it is 21.42% and in females 19.98%. The inhibitory roles of fluoride on various blood components are very clear in dental fluorosis cases. 'B' and 'O' blood group individuals are found more vulnerable to water fluoride intoxication than 'A' and 'AB' blood group people.⁵²

Studies on fluorosis with nutritional status:

ChoubisaSL et al, conducted a cross-sectional survey of 18,621 adults living in rural tribal areas of the Dungarpur and Udaipur districts of Rajasthan, India was conducted to correlate the prevalence of osteo-dental fluorosis with nutritional status, living habits, and occupation. The mean fluoride (F) concentration in drinking water sources ranged from 1.0 to 6.1 ppm. Among subjects with poor nutrition, the prevalence of dental fluorosis rose to 61.6% and skeletal fluorosis to 23.9%. A high incidence of fluorosis was also observed in subjects using substances such as alcohol, betel nuts, citrus fruits, edible ghee or fat, tea, and tobacco. The highest incidence of dental (90.1%) and skeletal (60.8%) fluorosis was observed in alcohol or beverage users and the lowest (30.8% and 8.9%) in the citrus fruits users, respectively. Subjects with different occupations exhibited a variable incidence of dental and skeletal

fluorosis. Labourers showed the highest incidence of dental and skeletal fluorosis (63.1% and 26.2%), followed by farmers (61.2% and 21.8%), housewives (57.1% and 13.2%), businessmen (54.2% and 14.4%), students (54.2% and 9.5%), and servicemen (51.5% and 15.9%), respectively. These data pertaining to the relationship of osteo-dental fluorosis with nutritional status, living habits, and occupation were statistically analysed and found to exhibit highly positive correlations.⁵³

Raj AJ conducted a cross-sectional survey of 12,485 people of both sexes living in 25 villages of Agastheeswaram Union, India, to correlate the prevalence of fluorosis with nutritional status, socioeconomic and academic background and occupation. The highest incidence of dental fluorosis was observed among the daily wagers (21.9%) followed by farmers (20.5%), house wives (19.9%), students (17.3%), private sector employees (8.5%) and government employees (5.4%). Fluoride (F) levels were determined in 51 randomly sampled water sources in 25 villages of 10 fluorotic areas of Agastheeswaram Union using a fluoride ion selective electrode. Nearly all the samples had elevated fluoride concentrations ranging from 1.3 to 2.7 mg/l which were capable of causing health risk to the community. These data pertaining to the relationship of dental and skeletal fluorosis with nutritional status, socioeconomic background, fluoride content of drinking water source and occupation were statistically analysed and found to exhibit high positive correlations. A level of 2.5 mg/l of fluoride was found to be a critical threshold manifestation of crippling skeletal fluorosis.⁵⁴

Sampaio F C et al investigated the relationship between nutritional status and dental fluorosis in areas with fluoride in the drinking water in Paraíba, Brazil. Rural villages of comparable low socio-economic status and stable water fluoride levels were selected. Lifelong residents (6-11 years old, n = 650) were examined for

nutritional status (height-for-age index; WHO methods) and dental fluorosis of central incisors and first molars (TF index). The sample was divided into three groups according to fluoride levels in the drinking water: low (below 0.7 ppm F, n = 164), medium (between 0.7 and 1.0 ppm F, n = 360) and high (above 1.0 ppm F, n = 126). Dental fluorosis was observed in 30.5, 61.1 and 71.4% of the children in these F groups, respectively. The prevalence was significantly related to the water F concentrations ($\chi^2 = 59.93$, d. f. = 2, $p < 0.001$). The severity of dental fluorosis ranged from TF 1 to 3 in the low F group and up to 7 in the others. Malnutrition prevalence was approximately 20% in all F groups, but was unrelated to dental fluorosis.⁵⁵

SECTION 4

MATERIALS & METHODS

*“If you don’t know what you’re doing you don’t know when
to stop”*

- **Anonymous**

4. MATERIALS AND METHODS

Bureau of Indian Standards (BIS) has set the standards for fluoride levels in drinking water with maximum desirable limit as 1.0mg/L and permissible limit in the absence of alternate source as 1.5mg/L. Most of the water samples in Kolar are not potable for drinking because of fluoride above the permissible limit. There are very few studies highlighting the epidemiological factors responsible for fluorosis and hence this study was conducted.

I. Source of Data:

1. **Study Setting:** Community based study in fluoride contaminated and non-contaminated drinking sources among villages of Bangarpet taluk, Kolar District
2. **Study Duration:** One year, from 1st December 2011 to 30th November 2012
3. **Study Design:** Cross-sectional study design.
4. **Topography of Kolar district**

Kolar is a district of Karnataka state with an area of about 3979 sq.km situated between 12° 46' and 13° 58' north latitude and 77° 21' and 78° 35' east longitude and comprise a population of 1,536,401. It consists of five taluks viz., Mulbagal, Kolar, Bangarpet, Malur, Srinivaspura.^{56, 57}

The Bangarpet taluk is bound by Malur, Kolar & Mulbagal taluks of Kolar district; Chittoor district of Andhra Pradesh and Salem & Dharmapuri districts of Tamilnadu. It geographically lies between 78° 28' 11'' & 78° 5' 50'' longitude and 12° 45' 40'' & 13° 4' 54'' latitude. The geographical area of the taluk is 864 sq.km. This taluk is further divided into six hoblies, viz. Bangarpet, Robertsonpet, Kyasamballi, Bethamangala, Kammasandsra and Budikote. The population of

Bangarpettaluk is about 4, 67,528. There are 355 inhabited villages with three towns.

Bangarpet town is the taluk headquarters. All the taluk level departments are located in Bangarpet, Bethamangala and K.G.F. towns.^{56, 58}

The average rainfall is 702 mm and receives actual rainfall for 72 days in a year. Ground water is the most significant source of water. The depth of bore wells dug ranges between 100 - 300 metres below ground level.^{59, 60}

The taluk has more of gravelly soil and some parts have red loam soil. The main agriculture crops grown in the taluk are ragi, paddy, maize, red gram, horse gram, oil seeds like ground nut, sugarcane, etc., horticulture crops grown are tomato, potato, cabbage, carrot, brinjal, beans, green chillies, radish, beetroot, leafy vegetables, etc. The major fruits grown in the taluk are mango, banana, sapota, water melon, etc. The main spices grown in the taluk are tamarind, dry chilly, ginger, coriander, etc.⁵⁹

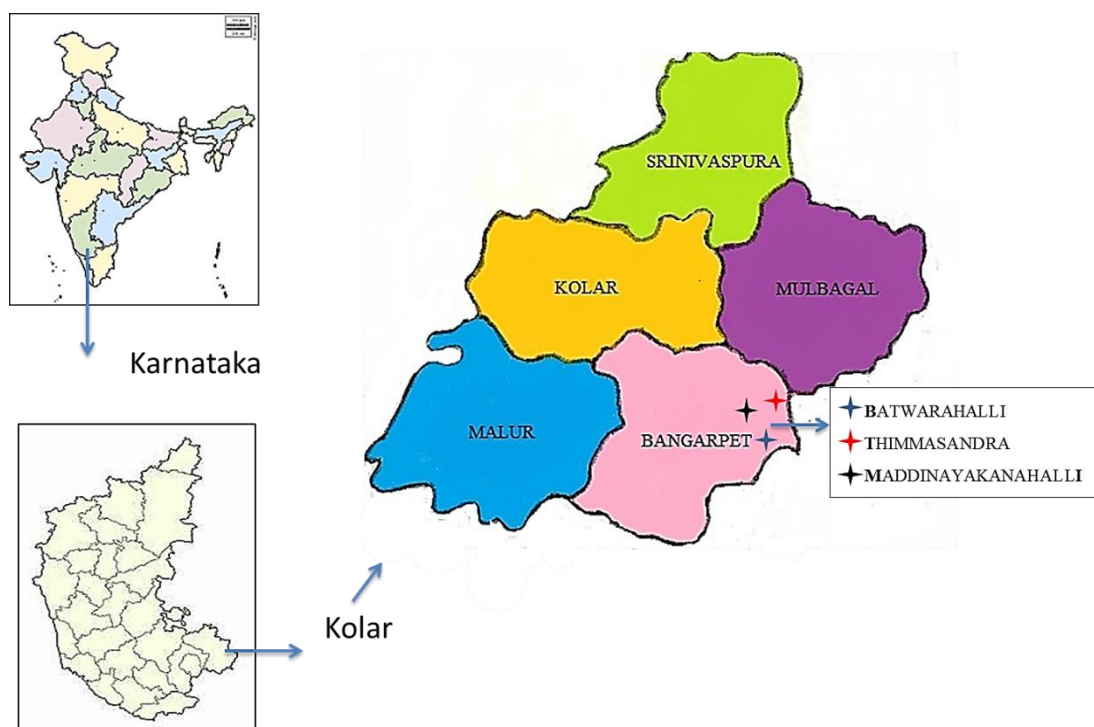
The taluk has rich mineral resources. The black granite, building stone deposits are available in large quantity in the taluk. Quality and quantity of rock stones are abundantly available.⁵⁹

Demographic characteristics of Kolar district:⁵⁷

Demographic characteristics	2011
Actual Population	1,536,401
Male	776,396
Female	760,005
Population Growth	10.77%
Area Sq. Km	3,979
Density/km ²	386
Sex Ratio (Per 1000)	979
Average Literacy	74.39
Male Literacy	81.81
Female Literacy	66.84
Literates	1,016,219
Male Literates	564,110
Female Literates	452,109

5. **Study Areas:** Batwarahalli, Thimmasandra and Maddinayakanahalli villages of Bangarpet taluk, Kolar district.

Figure-11: Map showing Kolar district⁶¹

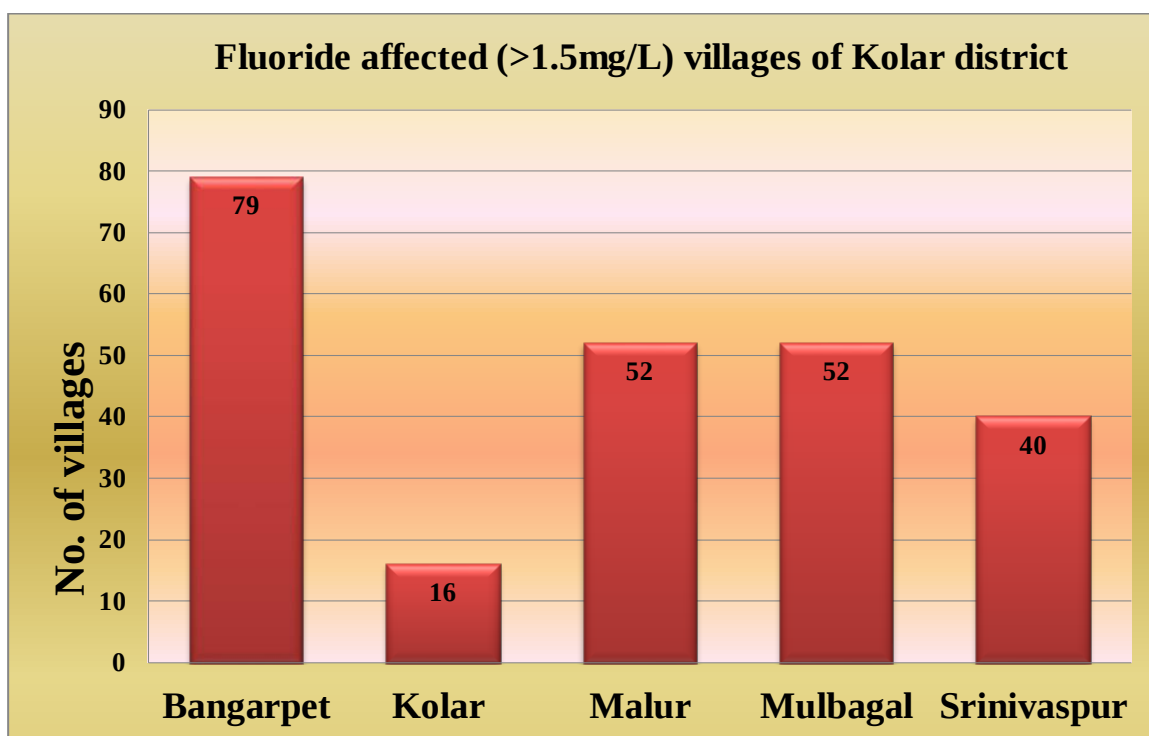


II. Method of Collection of Data:

1. Sample & Sampling Technique:

Fluoride estimation is being routinely done in Kolar district by the office of the executive engineer, Kolar in 10-15% of the drinking water sources. As per the report, Bangarpettaluk was selected as it recorded the highest number of villages i.e., 79 with fluoride level $> 1.5\text{mg/L}$ [Figure-12].

Figure-12: Report of estimated water fluoride levels by panchayatraj engineering
division Kolar – 2010⁶²



All the villages in Bangarpet taluk were listed in two groups. One group with fluoride level >1.5mg/L (Group 1) and another group with fluoride level <1.0mg/L (Group 2).

Firstly, the village in the group 1, Batwarahalli comprising of 133 population was randomly selected, secondly in group 2, Maddinayakanahalli comprising of 588 population was randomly selected. In order to have equal representation of population in two groups, one more village from group 1 i.e. Thimmasandra comprising of 471 population was randomly selected.

Study areas:**Group I:**

Batwarahalli village: It comprises of 25 houses with 133 population belonging to Oorgaumpet primary health centre, with bore well as the only source of water.

Thimmasandra village: It comprises of 84 houses with 471 population belonging to Bethamangala primary health centre, with bore well as the only source of water.

Group II:

Maddinayakanahalli village: It comprises of 101 houses with 588 population belonging to Bethamangala primary health centre, with bore well as the only source of water.

2. Study Subjects:

All the household members above 8 years of age in the selected study areas.

A 'household' is usually a group of persons who normally live together and take their meals from a common kitchen unless the exigencies of work prevent any of them from doing so. Persons in a household may be related or unrelated or a mix of both. However, if a group of unrelated persons live in a house but do not take their meals from the common kitchen, then they were not considered as constituent of a common household.⁶³

3. Study tool : Questionnaire:

The data were collected after informed consent, based on a pre-tested, validated, semi-structured questionnaire in the local verbatim by the interviewer through house to house survey. The proforma consisted of three parts- part one deals with socio demographic profile, part two and part three with household profile and individual profile with symptoms and questions on certain risk factors of dental, skeletal and non-skeletal fluorosis viz., source of water for drinking, cooking and

other domestic purposes, type of foods consumed and use of fluoride containing products and general physical examination and systemic examination of the individuals.[Annexure-1]

Intra & Inter-observer variability:

The survey was initiated, after obtaining hands on training from a dental specialist for one week to diagnose dental fluorosis and to differentiate from caries and other dental disorders. Ten percent of the sample were re-examined after blinding to the results of the initial examination by the same investigator for intra-observer variability and by the dental specialist for inter-observer variability.

4. a) Inclusion Criteria:

All the household resident members above 8 years of age in the selected villages of Bangarpet taluk, Kolar. The discolouration on the teeth is very evident in the permanent teeth by the age of 8years and above and hence the cut off as 8 years was considered.⁸

A resident member of the household is defined as someone who usually stays in the household, sleeps and shares meals, who has that address as primary place of residence, or who spends more than 6 months a year living there.

b) Exclusion Criteria:

Pregnant women, bed ridden patients who cannot perform the three simple diagnostic tests for skeletal fluorosis, persons with artificial teeth and the persons who were not available even after 2 visits were excluded from the study.

5. Investigations or Interventions to be conducted on patients or other humans or animals:

1. Water Analysis:

Water samples were collected in 1 litre plastic bottles, labelled, coded and analysed at Indian Institute of Science, Bangalore for fluoride levels by ion selective electrode method.

2. Radiological Evaluation:

Subjects unable to perform the three simple diagnostic tests for skeletal fluorosis due to pain or stiffness in the neck; or pain or stiffness in the shoulder joint and backbone respectively, were subjected for radiological evaluation for skeletal fluorosis and radiographs of the fore-arm were taken. The evaluating radiologist was blinded to the clinical symptoms of the subjects.

6. Operational Definitions :

a. Dental Fluorosis:

Oral examination was carried out with the subject seated in an ordinary chair in bright day light. The presence and severity of dental fluorosis was recorded using Dean's index.^{28, 30}

Dean's index:^{28, 30}

Classification	Weight	Diagnostic Criteria
Normal	0	The enamel represents the usual translucent semi vitriform type of structure. The surface is smooth, glossy, and usually of a pale creamy white color.
Questionable	0.5	The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots.
Very Mild	1	Small opaque, paper white areas scattered irregularly over the tooth but not involving as much as 25% of the tooth surface.
Mild	2	The white opaque areas in the enamel of the teeth are more extensive but do not involve as much as 50% of the tooth.
Moderate	3	All enamel surfaces of the teeth are affected, and the surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature.
Severe	4	All enamel surfaces are affected and hypoplasia is so marked that the general form of the tooth may be affected. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are widespread and teeth often present a corroded-like appearance.

Community fluorosis index (CFI) was calculated to identify whether dental fluorosis has been a common public health problem in that area.³⁰

CFI value range	Public health significance
0.0-0.4	Negative
0.4-0.6	Borderline
0.6-1.0	Slight
1.0-2.0	Medium
2.0-3.0	Marked
3.0-4.0	Very marked

b. Skeletal Fluorosis:

This was assessed by three simple diagnostic tests:

- a) Touching the toes without bending the knees;
- b) Touching the chest with the chin; and
- c) Stretching the arms sideways and folding the arms to touch the back of the head.

Pain or stiffness in the neck; or pain or stiffness in the shoulder joint and backbone, respectively, were noted.³¹

Patients complaining of pain or stiffness in the neck; or pain or stiffness in the shoulder joint and backbone, respectively and who were unable to perform these tests, were subjected to radiological evaluation for skeletal fluorosis at R.L. Jalappa Hospital. Radiographs of fore-arm were taken to look for interosseous membrane calcification.⁸

c. Socio-economic classification:

B.G. Prasad's socio-economic classification was adopted and modified as per all India whole sale price index.

All India whole sale price index for the month of October 2012 is 168.5.⁶⁴ As per the modified proposed classification by Agarwal et al, the all India whole sale price index [AIWPI] is to be multiplied by the hypothetical value 0.53 to derive the multiplication factor.⁶⁵

The income limits of classification have to be multiplied with a multiplication factor and the values should be rounded off to the nearest rupee. Therefore, the multiplication factor = value of AIWPI x 0.53 i.e., 168.5 x 0.53 = 89.3 ≈ 90.

The next step is to multiply Prasad's income limits by the multiplication factor.

Social class		Per-capita monthly income limits	Modified proposed classification
I	Upper high	100 and above	9000 and above
II	High	50-99	4500-8999
III	Upper middle	30-49	3150-4499
IV	Lower middle	15-29	1350-3149
V	Poor	5-14	450-1349
VI	Very poor/ below poverty line	<5	<450

d. Education:

The education status was classified as follows:

1. Illiterates: A person, who can neither read nor write or can only read but cannot write in any language, was considered as illiterate. All children of age 6 years or less, even if going to school and have picked up reading and writing, were considered as illiterate.⁶³

2. Literates: A person aged 7 years and above who can both read and write with understanding in any language has been taken as literate. There was no necessity for a person to have received any formal education or passed any minimum educational standard for being considered as literate. People who were blind and could read in Braille were considered to be literates.⁶³

They were further categorized as follows:

Sl no.	Category	Age	Class
1	Primary school	6-9yrs	1-4 th std
2	Middle school	10-12yrs	5 th -7 th std
3	Higher secondary school	13-15yrs	8 th -10 th std
4	Pre-University college	16-17yrs	11 th -12 th std
5	Graduation/Post graduation	>16yrs	- Bachelors in Arts/Science - Masters
6	Professional	>16yrs	Doctors/Engineers/Ph.D scholars

e. Occupation:

The occupation was categorized and defined as follows:

- Unemployed: persons with no employment or activity for their livelihood.
- Unskilled worker: Persons work requiring no intensive training or special skill. The workers who are engaged in field such as beedi, hotel, construction, mason, fishing, sales, rag picking, street vending, head load work, manual labourers, etc.
- Semi-skilled workers: Persons work requiring some type of skill like tailors, embroidery workers, weavers etc.

- Skilled workers: Persons work requiring some sort of regular training and skill which reflects in the quality of work done by them, like electricians, welders, fitters, turners, plumbers and drivers of different motor vehicles.
- Shop owner/businessmen, were categorized separately
- Semi - profession category included school teachers, class I and class II officers in Govt. services and companies.
- Professional category included doctors, advocates engineers, chartered accountants or such persons with professional qualification.

f. Measurements and assessments:

Pallor:

The study populations were also evaluated for pallor by inspecting the lower palpebral conjunctiva, nail bed and tongue for paleness in the sufficient day light.

Weight:

Measured using digital weighing scale of Salter make with an accuracy of 50 gm. The participant was asked to remove their footwear and to step onto scale with one foot on each side of the scale. The participant was instructed to stand still, face forward, place arms on the side and to wait until asked to step off. The weight was recorded in the kilograms.

Height:

Measured using flexible fibre tape with an accuracy of 0.1 centimeters. The participants were asked to remove their footwear, head gear (hat, cap, hair bows, comb, ribbons, etc). They were also instructed to stand against a wall with feet together, heels against the wall with knees straight and to look straight ahead and not tilt their head up. Care was taken to make sure that their eyes are at the same level as their ears. The flexible tape was fixed to the wall with the help of a plaster. Participant

and asked the participant to breathe in and stand tall. The height was recorded in centimetres (to the nearest 0.5cm).

Body Mass Index: ⁶⁶

Calculated as per the formula:

$$\text{BMI} = \frac{\text{Weight in Kilograms}}{\text{Height in meter}^2}$$

In children up to 19yrs have been further categorized based on standard deviations as shown below:

Overweight: >+1SD (equivalent to BMI 25 kg/m² at 19 years)

Obesity: >+2SD (equivalent to BMI 30 kg/m² at 19 years)

Thinness: <-2SD

Severe thinness: <-3SD

7. Analysis of Data:

The collected data were expressed in proportions and presented in the form of tables, figures and diagrams where ever necessary using standard statistical package. Proportion of fluorosis and the association of fluorosis with selected individual risk factor were analyzed with appropriate tests viz., chi-square, fisher's exact test, odds ratios and their 95% confidence intervals for the association of the predictor variables with the dependent variable. A p value of <0.05 was taken as statistically significant. The findings are discussed in the light of findings of other similar studies conducted elsewhere based on the objective of the study in the foregoing chapters.

Figure-13: Photos of house to house survey and measurement of weight and height



House to House survey



Measurement of height

Measurement of weight

Figure-14: Photos of children with dental fluorosis with different grades of severity



A. Questionable fluorosis
C. Mild fluorosis

B. Very Mild fluorosis
D. Moderate fluorosis

SECTION 5

RESULTS

“What we achieve inwardly will change outer reality.”

- Plutarch

5. RESULTS

Table-1: Age distribution of the study population

Age (years)	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
≤19	128 (26.3)	95 (22.8)	223 (24.6)
20-40	219 (45.1)	202 (48.4)	421 (46.7)
40-60	99 (20.4)	101 (24.2)	200 (22.2)
>60	40 (8.2)	19 (4.6)	59 (6.5)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. The two study groups with fluoride level >1.5mg/L and <1.0mg/L were constituted by 486 (53.8%) and 417 (46.2%) respectively.
2. Among the 486 study subjects in the study group with fluoride >1.5mg/L, 219 (45.1%) were in the age group 20-40years followed by 128 (26.3%), 99 (20.4%) and 40 (8.2%) were ≤ 19 years, 40-60 years and >60years respectively.
3. Among the 417 study subjects in the study group with fluoride <1mg/L, 202 (48.4%) were in the age group 20-40years followed by 95 (22.8%), 101 (24.2%) and 19 (4.6%) were ≤ 19 years, 40-60 years and >60years respectively.
4. Mean age of the study subjects, among the study group with fluoride>1.5mg/L was 33.0 ± 18.2years and in the other group with fluoride <1.0mg/L was 34.0±16.2years.

Figure-15: Age distribution of the study population among two study groups

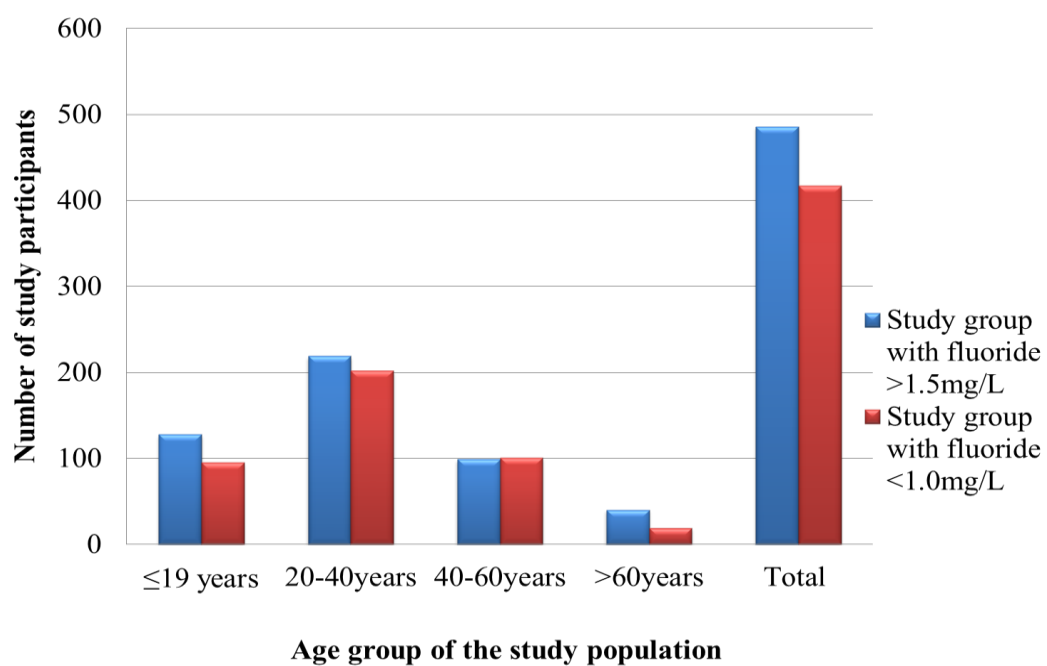


Table-2: Gender distribution of the study population

Gender	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Males	245 (50.4)	200 (48.0)	445 (49.3)
Females	241 (49.6)	217 (52.0)	458 (50.7)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. In the study group with fluoride level >1.5mg/L, 245(50.4%) of them were males and rest 241 (49.6%) were females.
2. In the study group with fluoride level <1.0mg/L, 200 (48.0%) were males and rest 217 (52.0%) were females.
3. Male to female ratio in the study group with fluoride level >1.5mg/L, was nearly 1:1 and in the study group with fluoride level <1.0mg/L, it was 1:1.1.

Figure-16: Gender distribution of the study population among two study groups

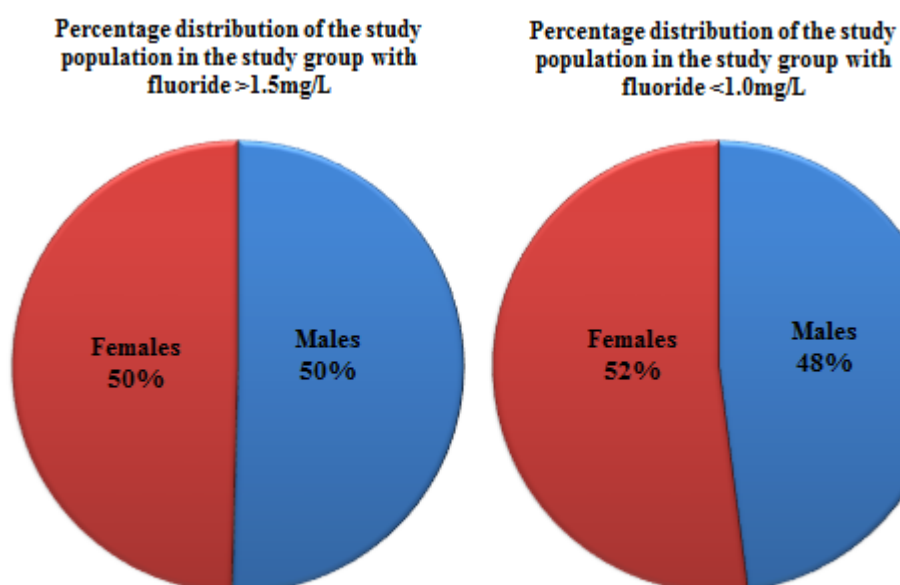


Table-3: Caste-wise distribution of the study population

Caste	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Scheduled Caste/ Scheduled Tribe	277 (57.0)	26 (6.2)	303 (33.5)
Other backward castes	189 (38.9)	365 (87.6)	554 (61.4)
General	20 (4.1)	26 (6.2)	46 (5.1)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. All the study subjects belonged to Hindu by religion in both the groups.
2. On caste-wise distribution, majority i.e., 554 (61.4%) of them belonged to other backward castes, followed by scheduled caste/scheduled tribe i.e., 303 (33.5%) and 46 (5.1%) belonged to general category.
3. Among the study group with fluoride level >1.5mg/L, most of them i.e., 277 (57.0%) belonged to scheduled caste/tribe.
4. Among the study group with fluoride level <1.0mg/L, 365 (87.6%) belonged to other backward castes.

Table-4: Utility of drinking water in the study population

Source	Utility	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Public Bore well	Directly	484 (99.6)	417 (100.0)	901 (99.8)
	Aqua guard	2 (0.4)	0 (0.0)	02 (0.2)
	Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. Main source of water for drinking and domestic purpose was public bore well in both the study groups.
2. Among the study group with fluoride >1.5mg/L, majority i.e., 484 (99.6%) of them used water directly from the source for both drinking and domestic purpose and rest i.e., 2 (0.4%) of them used aqua-guard for drinking purpose.
3. In the study group with fluoride <1.0mg/L, all the study subjects used water directly from the source for both drinking and domestic purpose.

Table-5 : Quantity of drinking water consumption among the study population

Consumption of drinking water per day in litres	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
≤ 2 Litres	255 (52.5)	177 (42.4)	432 (47.8)
>2 Litres	231 (47.5)	240 (57.6)	471 (52.2)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. In the study group with fluoride >1.5mg/L, 255 (52.5%) of them consumed ≤ 2L and 231 (47.5%) consumed more than 2L of water per day.
2. In the study group with fluoride <1.0mg/L, 240 (57.6%) of them consumed > 2L and 177 (42.4%) consumed ≤ 2L of water per day.
3. Mean consumption of drinking water among the study group with fluoride level >1.5mg/L was 1.9±0.5L and in the other group with fluoride <1.0mg/L, it was 2.0±0.5L.

Table-6 : Type of ration card possessed by the study population

Type of card	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
APL	18 (3.7)	28 (6.7)	46 (5.1)
BPL	458 (94.3)	357 (85.6)	815 (90.2)
Antyodaya	5 (1.0)	12 (2.9)	17 (1.9)
No Card	5 (1.0)	20 (4.8)	25 (2.8)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENT:

1. In the study group with fluoride level >1.5mg/L, most of them i.e., 458 (94.3%) had BPL cards and in the other group with fluoride <1.0mg/L, 357 (85.6%) of them had BPL cards.

Table-7: Socioeconomic status of the study population

SES (Modified B G Prasad Classification)	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Upper middle	4 (0.8)	0 (0.0)	4 (0.4)
Lower middle	38 (7.8)	30 (7.2)	68 (7.5)
Poor	396 (81.5)	168 (40.3)	564 (62.5)
Very poor/ below poverty line	48 (9.9)	219 (52.5)	267 (29.6)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. In the study group with fluoride level >1.5mg/L, maximum number i.e., 396 (81.5%) of them belonged to poor socio economic status, and in the other group with fluoride <1.0mg/L, most i.e., 219 (52.5%) of the study population belonged to very poor socio economic status according to modified B G Prasad classification.
2. Among the group with fluoride level >1.5mg/L, least i.e., 4 (0.8%) of them belonged to upper middle socio economic status, and in the other group with fluoride <1.0mg/L, minimum number i.e., 30 (7.2%) of the study population belonged to lower middle socio economic status according to modified B G Prasad classification.

Table-8: Occupational status of the study participants

Occupation	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Semi-professional	2 (0.4)	0 (0.0)	2 (0.2)
Shop-owner	5 (1.0)	1 (0.2)	6 (0.6)
Skilled	4 (0.8)	0 (0.0)	4 (0.4)
Semiskilled	2 (0.4)	0 (0.0)	2 (0.2)
Unskilled	333 (68.5)	323 (77.5)	656 (72.7)
Unemployed	140 (28.9)	93 (22.3)	233 (25.9)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENT:

1. Among the study group with fluoride >1.5mg/L maximum i.e., 333 (68.5 %) of them and in the other group with fluoride <1.0mg/L, 323 (77.5 %) of them belonged to unskilled group of occupation.

Table-9: Education-wise distribution of the study population

Educational Status	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Graduate/PG	12 (2.5)	7 (1.6)	19 (2.1)
Pre-university education	42 (8.6)	49 (11.8)	91 (10.0)
Higher secondary school	139 (28.6)	95 (22.8)	234 (26.0)
Middle school	88 (18.1)	75 (18.0)	163 (18.1)
Primary school	44 (9.1)	14 (3.4)	58 (6.4)
Illiterates	161 (33.1)	177 (42.4)	338 (37.4)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. Among the study group with fluoride level >1.5mg/L, majority i.e., 161 (33.1%) were illiterates and least i.e., 12 (2.5%) were graduates/post graduates.
2. In the other group, most i.e., 177 (42.4 %) of them were illiterates and minimum i.e., 7 (1.6%) were graduates/post graduates.

Table-10: Brushing habits of the study population

Material used for dental cleaning	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Neem bark	6 (1.2)	1 (0.2)	7 (0.8%)
Charcoal powder	76 (15.6)	38 (9.1)	114 (12.6)
Fluoridated tooth powder	8 (1.6)	50 (12.0)	58 (6.4)
Fluoridated tooth paste	396 (81.5)	328 (78.7)	724 (80.2)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. In the study group with fluoride >1.5mg/L, 396 (81.5%) of them and in the other group with fluoride <1.0mg/L, 328 (78.7%) of them used fluoridated tooth paste.
2. Among the study group with fluoride >1.5mg/L, 8 (1.6%) of them and in the other group, 50 (12.0%) of them used fluoridated tooth powder.
3. In the study group with fluoride >1.5mg/L, 481 (99.0%) and in the other study group with fluoride <1.0mg/L, all of them brushed once a day.

Table-11: Use of fluoride containing drugs among the study population

Fluoride containing drugs	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Antipsychotics (Fluoxetine)	01 (0.2)	01 (0.3)	02 (0.2)
Not consumed	485 (99.8)	416 (99.7)	901 (99.8)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENT:

1. In the study groups with fluoride >1.5mg/L and fluoride <1.0mg/L, only one participant in each group was consuming fluoride containing drug i.e., fluoxetine.

Table-12: Nutritional status of the study participants

Nutritional Status	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Underweight	98 (20.2)	134 (32.1)	232 (25.7)
Normal	343 (70.6)	263 (63.1)	606 (67.1)
Overweight	39 (8.0)	12 (2.9)	51 (5.6)
Obesity	2 (0.4)	3 (0.7)	5 (0.6)
Couldn't be assessed	4 (0.8)	5 (1.2)	9 (1.0)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENTS:

1. In the study groups with fluoride >1.5mg/L and <1.0mg/L, 343 (70.6%) and 263 (63.1%) of them were normal respectively.
2. Among the study group with fluoride >1.5mg/L, 98 (20.2%) and in the other group with fluoride <1.0mg/L, 134 (32.1%) were underweight.
3. Among the study group with fluoride >1.5mg/L, 39 (8.0%) and 2 (0.4%) were overweight and obese respectively.
4. In the study group with fluoride <1.0mg/L, 12 (2.9%) and 3 (0.7%) were overweight and obese respectively.

Table-13: Consumption of tobacco among the study participants

Consumption of tobacco	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Yes	62 (12.8)	39 (9.4)	101 (11.2)
No	424 (87.2)	378 (90.6)	802 (88.8)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENT:

1. Among the study participants with fluoride >1.5mg/L and <1.0mg/L, 62 (12.8%) and 39 (9.4%) of them consumed various forms of tobacco respectively.

Table-14: Consumption of areca nut among the study participants

Consumption of arecanut	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Yes	74 (15.2)	41 (9.8)	115 (12.7)
No	412 (84.8)	376 (90.2)	788 (87.3)
Total	486 (100.0)	417 (100.0)	903 (100.0)

Note: The figures in the parenthesis denote percentage

COMMENT:

1. Among the study participants with fluoride >1.5mg/L and <1.0mg/L, 74 (15.2%) and 41 (9.8%) of them consumed areca nut respectively.

Table-15: Prevalence of dental fluorosis in study population

Age group	Dental Fluorosis	Fluoride level >1.5mg/L			Fluoride level <1.0mg/L			Prevalence	Odds Ratio (CI)	χ^2 value	p-value
		Males (%)	Females (%)	Total (%)	Males (%)	Females (%)	Total (%)				
Children & Adolescents	Present	30 (51.7)	30 (42.8)	60 (46.8)	5 (12.8)	6 (10.7)	11 (11.6)	31.83%	6.7 (3.2-13.8)	31.30	0.0001
	Absent	28 (48.3)	40 (57.2)	68 (53.2)	34 (87.2)	50 (89.3)	84 (88.4)				
	Total	58 (100.0)	70 (100.0)	128 (100.0)	39 (100.0)	56 (100.0)	95 (100.0)				
Adults	Present	2 (1.1)	2 (1.2)	4 (1.2)	1 (0.6)	4 (2.5)	5 (1.6)	1.32%	0.7 (0.2-2.6)	0.25	0.61
	Absent	185 (98.9)	169 (98.8)	354 (98.8)	160 (99.4)	157 (97.5)	317 (98.4)				
	Total	187 (100.0)	171 (100.0)	358 (100.0)	161 (100.0)	161 (100.0)	322 (100.0)				

COMMENTS:

1. The prevalence of dental fluorosis in the study group with fluoride level $>1.5\text{mg/L}$ was 13.17% and in the study group with fluoride level $<1.0\text{mg/L}$ was 3.84%.
2. Among children and adolescents, the prevalence of dental fluorosis was 31.83%. In the study group with fluoride level $> 1.5\text{mg/L}$, the prevalence of dental fluorosis was 46.88% and in the study group with fluoride level $<1.0\text{mg/L}$ it was 11.58%.
3. Among adults, the prevalence of dental fluorosis was 1.32%. In the study group with fluoride level $> 1.5\text{mg/L}$, the prevalence of dental fluorosis was 1.11% and in the study group with fluoride level $<1.0\text{mg/L}$ it was 1.55%.
4. Among children and adolescents, in the study group with fluoride $>1.5\text{mg/L}$, the prevalence of dental fluorosis among males was 51.72% and among females, 42.85% whereas, in the other group, among males it was 12.82% and among females, 10.71%.
5. Among adults, in the study group with fluoride $>1.5\text{mg/L}$, the prevalence of dental fluorosis among males was 1.06% and among females, 1.16% whereas, in the other group, among males it was 0.62% and among females, 2.48%.
6. Odds ratio among children and adolescents was >1 , suggesting that the risk of dental fluorosis among the group with fluoride $>1.5\text{mg/L}$ was significantly 6.7 times more compared to the group with fluoride $<1.0\text{mg/L}$ ($p<0.01$). However among males and females, in children and adolescents and adults, among both groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$, the odds ratio was not statistically significant ($p>0.05$).

Table-16: Dean's index grading of dental fluorosis among study population

	Severity of Dental Fluorosis (Grading)	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)
Children and adolescents	Normal (0)	68 (53.1)	84 (88.4)	152 (68.2)
	Questionable (0.5)	10 (7.8)	5 (5.3)	15 (6.7)
	Very Mild (1)	20 (15.6)	1 (1.0)	21 (9.4)
	Mild (2)	9 (7.1)	1 (1.0)	10 (4.5)
	Moderate (3)	21 (16.4)	4 (4.3)	25 (11.2)
	Total	128 (100.0)	95 (100.0)	223 (100.0)
Adults	Normal (0)	354 (98.9)	317 (98.4)	671 (98.7)
	Questionable (0.5)	1 (0.3)	0 (0.0)	1 (0.15)
	Mild (2)	0 (0.0)	1 (0.3)	1 (0.15)
	Moderate (3)	3 (0.8)	4 (1.3)	7 (1.0)
	Total	358 (100.0)	322 (100.0)	680 (100.0)

COMMENTS:

1. Among children and adolescents, 152 (68.2%) had no dental fluorosis and the rest i.e., 71 (31.8%) had dental fluorosis of various severity among which most i.e., 25 (11.2%) had moderate and least i.e., 10 (4.5%) had mild grades of fluorosis.
2. Among adults, 671 (98.7%) had no dental fluorosis and the rest i.e., 9 (1.3%) had dental fluorosis of various severity among which maximum i.e., 7 (1.0%) had moderate and only one participant had questionable and mild grades of fluorosis.
3. Among children and adolescents with fluoride level $>1.5\text{mg/L}$, maximum number i.e., 21 (16.4%) had moderate grade and 20 (15.6%) had very mild grade of dental fluorosis whereas, in the study group with fluoride $<1.0\text{mg/L}$, 5 (5.3%) and 4 (4.3%) had questionable and moderate grades of fluorosis respectively.
4. Among the adults with fluoride level $>1.5\text{mg/L}$, 3 (0.8%) and 1 (0.3%) had moderate and questionable grades of dental fluorosis and in the other group, 4 (1.3%) and 1 (0.3%) had moderate and mild grades of dental fluorosis respectively.

Table-17: Community fluorosis index among study population

Community Fluorosis Index (CFI)	Fluoride level >1.5mg/L	Fluoride level <1.0mg/L	Total
Children and adolescents	0.8	0.1	0.9
Adults	0.03	0.04	0.07
Total	0.83	0.14	0.97

COMMENTS:

1. Community fluorosis index was 0.8 which is of slight public health significance among children and adolescents, in the group with fluoride >1.5mg/L. Among the other group with fluoride <1.0mg/L it was negative and had no public health importance.
2. Among adults, CFI was negative in both groups and had no public health significance.

Table-18: Prevalence of skeletal fluorosis based on three simple physical tests at the field level

Age group	Skeletal Fluorosis	Fluoride level >1.5mg/L			Fluoride level <1.0mg/L			Prevalence	Odds Ratio (CI)	χ^2 value	p-value
		Males (%)	Females (%)	Total (%)	Males (%)	Females (%)	Total (%)				
Adults	Present	9 (4.8)	9 (5.3)	18 (5.0)	10 (6.2)	5 (3.2)	15 (4.7)	5.0%	1.07 (0.5-2.1)	0.05	0.82
	Absent	178 (95.2)	162 (94.7)	340 (95.0)	151 (93.8)	156 (96.8)	307 (95.3)				
	Total	187 (100.0)	171 (100.0)	358 (100.0)	161 (100.0)	161 (100.0)	322 (100.0)				

COMMENTS:

1. The prevalence of skeletal fluorosis at field level in the groups with fluoride level >1.5mg/L was 5.02% and <1.0mg/L was 4.65%.
2. There were no cases of skeletal fluorosis in children and adolescents.
3. Among adults, in the study group with fluoride >1.5mg/L, the prevalence of dental fluorosis among males it was 4.81% and females it was 5.26% whereas, in the other group with fluoride <1.0mg/L, the prevalence of skeletal fluorosis among males it was 6.21% and females it was 3.10%
4. Odds ratio among adults was >1 suggesting that the risk of skeletal fluorosis among the group with fluoride level >1.5mg/L was higher compared to the group with fluoride level <1.0mg/L. However, it was not statistically significant ($p>0.05$).
5. Odds ratio in adults, among males and females, in both groups with fluoride >1.5mg/L and <1.0mg/L was not statistically significant ($p>0.05$).

Table-19: Skeletal fluorosis on X-ray confirmation

Age group	Skeletal Fluorosis	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)
Adults	Present	2 (11.1)	0 (0.0)	2 (6.1)
	Absent	16 (88.9)	15 (100.0)	31 (93.9)
	Total	18 (100.0)	15 (100.0)	33 (100.0)

COMMENT:

1. The skeletal fluorosis after x-ray confirmation was found among 2 (11.11%) adults in the study group with fluoride >1.5mg/L and no x-ray changes were seen in the study group with fluoride <1.0mg/L, and also among children in both the study groups.

Figure-17: X-rays of the skeletal fluorosis patients



Table-20: Prevalence of non-skeletal fluorosis based on symptoms

Age group	Non-Skeletal Fluorosis	Fluoride level >1.5mg/L			Fluoride level <1.0mg/L			Prevalence	Odds Ratio (CI)	χ^2 value	p-value
		Males (%)	Females (%)	Total (%)	Males (%)	Females (%)	Total (%)				
Children & Adolescents	Present	1 (1.7)	0 (0.0)	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	0.45%		0.045	0.83
	Absent	57 (98.3)	70 (100.0)	127 (99.2)	39 (100.0)	56 (100.0)	95 (100.0)				
	Total	58 (100.0)	70 (100.0)	128 (100.0)	39 (100.0)	56 (100.0)	95 (100.0)				
Adults	Present	11 (5.9)	15 (8.8)	26 (7.3)	7 (4.3)	1 (0.6)	8 (2.5)	5.0%	3.07 (1.3 – 3.8)	8.1	0.004
	Absent	176 (94.1)	156 (91.2)	332 (92.7)	154 (95.7)	160 (99.4)	314 (97.5)				
	Total	187 (100.0)	171 (100.0)	358 (100.0)	161 (100.0)	161 (100.0)	322 (100.0)				

COMMENTS:

1. Among children and adolescents, the prevalence of non-skeletal fluorosis was 0.45%. In the study group with fluoride level > 1.5mg/L, the prevalence of non-skeletal fluorosis was 0.78% and in the study group with fluoride level <1.0mg/L there were no cases.
2. Among adults, the prevalence of non-skeletal fluorosis was 5.0%. In the study group with fluoride level > 1.5mg/L, the prevalence of non-skeletal fluorosis was 7.26% and in the study group with fluoride level <1.0mg/L it was 2.48%.
3. Among children and adolescents, in the study group with fluoride >1.5mg/L, the prevalence of non-skeletal fluorosis among males was 1.72% and among females, there were no cases whereas, in the other group, there were no cases seen.
4. Among adults, in the study group with fluoride >1.5mg/L, the prevalence of non-skeletal fluorosis among males was 5.88% and among females, 8.77%

whereas, in the other group, among males it was 4.34% and among females, 0.62%.

5. Odds ratio among adults was >1 suggesting that, the risk of non-skeletal fluorosis among the adults in the study group with fluoride level $>1.5\text{mg/L}$ was significantly 3 times more compared to the group with fluoride $<1.0\text{mg/L}$ ($p<0.05$).

Table-21: Fluoride levels of the water samples in the study villages

Group	Villages	Source	Water fluoride levels
Group with fluoride >1.5mg/L	Thimmasandra	Borewell	4.31mg/L
	Batwarahalli	Borewell	2.59mg/L
Group with fluoride <1.0mg/L	Maddinayakanahalli	Borewell	0.61mg/L

COMMENTS:

1. The group with water fluoride >1.5mg/L comprised of Thimmasandra and Batwarahalli villages with a public bore well as the only source in both. The water fluoride levels analysed by ion-electrode method obtained from IISc were 4.13mg/L and 2.59mg/L respectively.
2. The other group with water fluoride <1.0mg/L comprised of Maddinayakanahalli with a public bore well as the only source. IISc reported the water fluoride levels to be 0.61mg/L.

Table-22: Relationship between socio-economic status with prevalence of dental fluorosis

Age group	Socio-economic status	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	p-value (Fisher's exact test)
Children and adolescents	Upper /Lower middle	26 (100.0)	0 (0.0)	26 (100.0)	0.0053
	Poor	34 (75.5)	11 (24.5)	45 (100.0)	
	Total	60 (84.5)	11 (15.5)	71 (100.0)	
Adults	Upper/Lower middle	1 (100.0)	0 (0.0)	1 (100.0)	1.00
	Poor	3 (37.5)	5 (62.5)	8 (100.0)	
	Total	4 (44.5)	5 (55.5)	9 (100.0)	

COMMENTS:

1. Among the children and adolescents with dental fluorosis, 26 (36.6%) of them belonged to upper /lower middle class and 45 (63.4%) of them belonged to poor class.
2. Among the adults with dental fluorosis, 1(11.1%) belonged to upper/lower middle class and 8 (88.9%) belonged to poor class.
3. In the study, among the children and adolescents with dental fluorosis, statistically significant difference was observed between socio-economic status and prevalence of dental fluorosis among the two groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ ($p<0.05$).
4. In the study, among the adults with dental fluorosis, there was no statistical significance observed between socio-economic status and prevalence of dental fluorosis among the two groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ ($p>0.05$).

Table-23: Relationship between castes with prevalence of dental fluorosis

Age group	Caste	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	Odds Ratio (CI)	p-value (Fisher's exact test)
Children and adolescents	Scheduled caste/ Other Backward Castes	58 (86.6)	9 (13.4)	67 (100.0)	6.4 (0.8-51.6)	0.11
	General category	2 (50.0)	2 (50.0)	4 (100.0)		
	Total	60 (84.5)	11 (15.5)	71 (100.0)		
Adults	Scheduled caste/Other Backward Castes	3 (42.8)	4 (57.2)	7 (100.0)	0.75 (0.03 – 17.5)	1.00
	General category	1 (50.0)	1 (50.0)	2 (100.0)		
	Total	4 (44.5)	5 (55.5)	9 (100.0)		

COMMENTS:

1. Among children and adolescents with dental fluorosis, 67 (86.6%) of them belonged to scheduled caste/other backward castes and 4 (4.4%) of them belonged to general category.
2. Among the adults with dental fluorosis, 7(77.8%) belonged to scheduled caste/other backward castes and 2 (22.2%) belonged to general category.
3. Odds ratio among children and adolescents with dental fluorosis, in the two groups, scheduled caste/other backward castes was >1. The risk of dental fluorosis was 6.4 times higher among scheduled caste/other backward class when compared to general category. However, it was not statistically significant ($p>0.05$).
4. Odds ratio among adults with dental fluorosis in the two groups, scheduled caste/other backward castes and general category was <1 and was not statistically significant ($p>0.05$).

Table-24: Relationship between quantity of drinking water consumed per day in litres with prevalence of dental fluorosis

Age group	Quantity of drinking water consumed per day in litres	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	Odds Ratio (CI)	p-value (Fisher's exact test)
Children and adolescents	≤ 2	49 (87.5)	7 (12.5)	56 (100.0)	2.5 (0.6 – 10.2)	0.22
	>2	11 (73.3)	4 (26.7)	15 (100.0)		
	Total	60 (84.5)	11 (15.5)	71 (100.0)		
Adults	≤ 2	2 (40.0)	3 (60.0)	5 (100.0)	0.6 (0.04 – 9.4)	1.00
	>2	2 (50.0)	2 (50.0)	4 (100.0)		
	Total	4 (44.5)	5 (55.5)	9 (100.0)		

COMMENTS:

1. Among children and adolescents with dental fluorosis, 56 (78.9%) of them consumed ≤ 2 litres and 15 (21.1%) of them consumed >2 litres of water.
2. Among the adults with dental fluorosis, 5(55.6%) of them consumed ≤ 2 litres and 4 (44.4%) of them consumed >2 litres of water.
3. Odds ratio among children and adolescents with dental fluorosis, in the two groups, who consumed ≤ 2 litres and >2 litres of water was >1. The risk of dental fluorosis was 2.5 times higher among the subjects who consumed ≤ 2 litres compared to the subjects who consumed >2 litres. However, it was not statistically significant ($p>0.05$).
4. Odds ratio among adults with dental fluorosis in the two groups, who consumed ≤ 2 litres and >2 litres of water was <1 and was not statistically significant ($p>0.05$).

Table-25: Relationship between items used for dental cleaning with prevalence of dental fluorosis

Age group	Items	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	p-value (Fisher's exact test)
Children and adolescents	With fluoride	56 (83.6)	11 (16.4)	67 (100.0)	0.23
	Without fluoride	4 (100.0)	0 (0.0)	4 (100.0)	
	Total	60 (84.5)	11 (15.5)	71 (100.0)	
Adults	With fluoride	1 (100.0)	0 (0.0)	1 (100.0)	0.44
	Without fluoride	3 (37.5)	5 (62.5)	8 (100.0)	
	Total	4 (44.5)	5 (55.5)	9 (100.0)	

COMMENTS:

1. Among children and adolescents with dental fluorosis, 67 (94.4%) of them used items with fluoride and 4 (5.6%) of them used items without fluoride for dental cleaning.
2. Among the adults with dental fluorosis, 1 (11.1%) of them used items with fluoride and 8 (88.9%) of them used items without fluoride for dental cleaning.

Table-26: Relationship between nutritional status with prevalence of dental fluorosis

Age group	Malnourished	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	χ^2 -value	Odds Ratio (CI)	p-value
Children and adolescents	Yes	29 (87.9)	4 (12.1)	33 (100.0)	0.53	1.6 (0.4 – 6.1)	0.46
	No	31 (81.6)	7 (18.4)	38 (100.0)			
	Total	60 (84.5)	11 (15.5)	71 (100.0)			
Adults	Yes	0 (0.0)	2 (100.0)	2 (100.0)			0.44 (Fisher's exact test)
	No	4 (57.1)	3 (42.9)	7 (100.0)			
	Total	4 (44.5)	5 (55.5)	9 (100.0)			

COMMENTS:

1. Among children and adolescents with dental fluorosis, 33 (46.5%) of them were malnourished and the rest 38 (53.5%) were of normal nutritional status.
2. Among the adults with dental fluorosis, 2 (22.2%) of them were malnourished and the rest 7 (77.8%) were of normal nutritional status.
3. Odds ratio among children and adolescents with dental fluorosis in the two groups with malnourished and of normal nutritional status was >1. The risk of dental fluorosis was 1.6 times more among malnourished compared to the subjects with normal nutritional status. However, it was not statistically significant ($p>0.05$).

Table-27: Relationship between socio-economic status with prevalence of skeletal fluorosis

Age group	Socio-economic status	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	p-value (Fisher's exact test)
Adults	Lower middle	7 (100.0)	0 (0.0)	7 (100.0)	0.009
	Poor	11 (42.3)	15 (57.7)	26 (100.0)	
	Total	18 (54.5)	15 (45.5)	33 (100.0)	

COMMENTS:

1. Among the adults with skeletal fluorosis, 7 (21.2%) of them belonged to lower middle class and 26 (78.8%) of them belonged to poor class.
2. In the study, among the adults with skeletal fluorosis, statistically significant difference was observed between socio-economic status and prevalence of skeletal fluorosis among the two groups with fluoride >1.5mg/L and <1.0mg/L ($p < 0.05$).

Table-28: Relationship between castes with prevalence of skeletal fluorosis

Age group	Caste	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	χ^2 - value	Odds Ratio (CI)	p-value
Adults	Scheduled Caste/ Other Backward Castes	11 (68.7)	5 (31.3)	16 (100.0)	2.52	3.1 (0.7 – 13.1)	0.1
	General category	7 (41.2)	10 (58.8)	17 (100.0)			
	Total	18 (54.5)	15 (45.5)	33 (100.0)			

COMMENTS:

1. Among the adults with skeletal fluorosis, 16 (48.5%) of them belonged to scheduled caste/other backward castes and 17 (51.5%) of them belonged to general category.
2. Odds ratio among the adults with skeletal fluorosis, in the two groups who belonged to scheduled caste/other backward castes and general category was >1. The risk of skeletal fluorosis among scheduled caste/other backward castes was 3 times more compared to general category. However, it was not statistically significant ($p>0.05$).

Table-29: Relationship between quantity of drinking water consumed per day in litres with prevalence of skeletal fluorosis

Age group	Quantity of drinking water consumed per day in litres	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	Odds Ratio (CI)	p-value (Fisher's exact test)
Adults	≤2	15 (57.7)	11 (42.3)	26 (100.0)	1.8 (0.3 – 9.8)	0.674
	>2	3 (42.8)	4 (57.2)	7 (100.0)		
	Total	18 (54.5)	15 (45.5)	33 (100.0)		

COMMENTS:

1. Among the adults with skeletal fluorosis, 26 (78.8%) of them consumed ≤ 2 litres and 7 (21.2%) of them consumed >2 litres of water.
2. Odds ratio among adults with skeletal fluorosis, in the two groups, who consumed ≤ 2 litres and >2 litres of water was >1 . The risk of skeletal fluorosis was 1.8 times higher among the subjects who consumed ≤ 2 litres compared to the subjects who consumed >2 litres. However, it was not statistically significant ($p>0.05$).

Table-30: Relationship between items used for dental cleaning with prevalence of skeletal fluorosis

Age group	Items	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	χ^2 -value	Odds Ratio (CI)	p-value
Adults	With fluoride	6 (54.5)	5 (45.5)	11 (100.0)	0.00	1.0 (0.2 – 4.2)	1.000
	Without fluoride	12 (54.5)	10 (45.5)	22 (100.0)			
	Total	18 (54.5)	15 (45.5)	33 (100.0)			

COMMENTS:

1. Among the adults with skeletal fluorosis, 11 (33.3%) of them used items with fluoride and 22 (66.7%) of them used items without fluoride for dental cleaning.
2. Odds ratio among adults with skeletal fluorosis, in the two groups, who used items with fluoride and without fluoride for dental cleaning, was equal to 1. Hence, there was no risk of skeletal fluorosis with the use of fluoridated items for dental cleaning. However, it was not statistically significant ($p>0.05$).

Table-31: Relationship between consumption of tobacco/areca nut with prevalence of skeletal fluorosis

Age group	Consumption tobacco/ Areca nut	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	χ^2 - value	Odds Ratio (CI)	p-value
Adults	Yes	7 (63.6)	4 (36.4)	11 (100.0)	0.55	1.7 (0.3 – 7.7)	0.45
	No	11 (50.0)	11 (50.0)	22 (100.0)			
	Total	18 (54.5)	15 (45.5)	33 (100.0)			

COMMENTS:

1. Among the adults with skeletal fluorosis, 11 (33.3%) of them consumed tobacco/areca nut and 22 (66.7%) of them did not consume tobacco/areca nut.
2. Odds ratio among adults with skeletal fluorosis, in the two groups, who consumed tobacco/areca nut and who did not consume tobacco/areca nut was >1 and risk of skeletal fluorosis was 1.7 times more among tobacco/areca nut consumers compared to non-consumers. However, it was not statistically significant ($p>0.05$).

Table-32: Relationship between nutritional status with prevalence of skeletal fluorosis

Age group	Malnourished	Fluoride level >1.5mg/L (%)	Fluoride level <1.0mg/L (%)	Total (%)	Odds Ratio (CI)	p-value (Fisher's exact test)
Adults	Yes	4 (44.4)	5 (55.6)	9 (100.0)	0.32 (0.05 – 1.84)	0.38
	No	10 (71.4)	4 (28.6)	14 (100.0)		
	Total	14 (60.9)	9 (39.1)	23 (100.0)		

COMMENTS:

1. Out of 33 individuals with skeletal fluorosis, height of the 10 individuals could not be assessed because of bent spine.
2. Among the adults with skeletal fluorosis, 9 (39.1%) of them were malnourished and the rest 14 (60.9%) were of normal nutritional status.
3. Odds ratio among the adults with skeletal fluorosis in the two groups with malnourished and of normal nutritional status was <1 and it was not statistically significant ($p>0.05$).

SECTION 6

DISCUSSION& LIMITATIONS

*“If you can ’t explain it simply, you don ’t understand it well
enough.”*

-Albert Einstein

6. DISCUSSION

Fluorosis has been a threat among children and adolescents of Kolar. The non-modifiable risk factors like dependency on ground water with fluoride above permissible limits as a sole source for drinking, semi-arid climate, drought prone and modifiable risk factors like consumption of drinking water directly without any treatment, use of fluoridated tooth paste for dental cleaning, fluoride containing medications, chewing tobacco/areca nut, smoking, failure in the community involvement in the maintenance of installed de-fluoridation units adds to this threat.

The present study was conducted to know the prevalence of dental and skeletal fluorosis and to compare some of the risk factors among the two groups with fluoride >1.5mg/L and with fluoride <1.0mg/L of Bangarpet taluk, Kolar district. Similarly, a comparative study has been conducted by Karthikeyan et al., in Tamil Nadu to know the prevalence of dental fluorosis among children and dental and skeletal fluorosis in adults by selecting two control areas with fluoride <1.0mg/L and three fluorosis areas, area 1 ranging 0.34 – 0.91mg/L, area 2, 1.20 – 2.90mg/L and area 3, 3.8 – 8.0mg/L.⁶⁷

The present study population was constituted by 903 members and included all the members above 8yrs of age. Similarly, Bhat et al., has conducted a cross-sectional community based study to know the prevalence of dental fluorosis among 588 residents in the age group 5-80+ of Hanumantharayanapalya, Ramnagar district, Karnataka where the water fluoride was 2.79 mg/L (>1.5mg/L).⁴⁶

The mean age of the study participants in our study among the study groups with fluoride >1.5mg/L was 33±18.2years and with fluoride <1.0mg/L was 34±16.2years. Similarly in a study by Xiang et al., in China in 2002-2003, the mean

age of the study participants in the high fluoride village was 52.36 years and in the low fluoride village was 48.11 years.⁴⁷

Our study comprised of 445 (49.3%) males and 458 (50.7%) females. Similarly in a study conducted by Murugan et al., in Tamil nadu, 45.2% of them were males and 54.8% were females. Male to female ratio in our study in the study group with fluoride >1.5mg/L was 1:1 and in the other group with fluoride <1.0mg/L it was 1:1.1. However, in a related study conducted by Xiang et al., in China in 2002 – 2003, among the study participants, male to female ratio was 1.28:1 in a high fluoride village with water fluoride level of 2.18 ± 0.86 mg/L) and 1.5:1 in low fluoride village with water fluoride level of 0.37 ± 0.09 mg/L.^{47, 52}

In our study, majority i.e., 554 (61.4%) of the study participants belonged to other backward castes followed by 303 (33.5%) belonged to scheduled caste/scheduled tribe and 46 (5.1%) belonged to general category.

In our study, majority i.e., 564 (62.5%) of them belonged to poor socio-economic status and in a study conducted by Jagan et al., in Kanyakumari in 2006, majority 46.2% of the participants belonged to lower socio-economic strata.⁵⁰

In the present study, majority i.e., 656 (72.7%) constituted group of unskilled workers like agricultural labourers and manual labourers and 338 (37.4%) belonged to group of illiterates. Similarly in a study conducted by Nirgude et al., in Nalgonda in 2008-2009, main occupation and source of income of the residents was manual labour and 35.1% of the participants were illiterates.⁴⁵

In our study public bore well was the major source for drinking water and domestic use, 471 (52.2%) of them consumed >2 litres of water.

We noted colgate tooth paste/powder as the most popular brand used by most of them i.e., 782 (86.6%) and 898 (99.4%) of them brushed once a day. Similarly in a study conducted by Jagan et al., in Kanyakumari in 2006, colgate was the most popular brand of tooth paste. 85% of them used tooth brushes and majority brushed once a day.⁵⁰

In the present study, 62 (12.8%) and 39 (9.4%) of them consumed various forms of tobacco among the groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ respectively. Nirgude et al., in Nalgonda in 2008-2009, has found 16.6% consumed tobacco in any form in his study.⁴⁵

In the present study, the prevalence of dental fluorosis in the study groups with fluoride level $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ were 13.17% and 3.84% respectively. Among children and adolescents, the prevalence of dental fluorosis was 31.83% whereas, in adults it was 1.32%.

Among the study groups with fluoride level $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$, the prevalence of dental fluorosis among children and adolescents were 46.88% and 11.58% respectively and among adults, 1.11% and 1.55% respectively.

In the present study, community fluorosis index (CFI) among children and adolescents, in the group with fluoride $>1.5\text{mg/L}$ was 0.8, suggesting slight public health significance whereas, in the other group with fluoride $<1.0\text{mg/L}$ it was negative (<0.4) with no public health importance. Among adults, CFI in both the groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ was negative (<0.4) with no public health significance.

In a comparative study conducted by Karthikeyan et al., in Tamil Nadu, to find the incidence of dental fluorosis and skeletal fluorosis among children aged 8 – 15yrs and adults found that in the study group with fluoride <1ppm had 30.1 % incidence of dental fluorosis among children and 39.6% among adults. CFI among children and adults were found to be 0.63 and 0.83 respectively. In the other group with fluoride ranged between 1 – 3ppm showed an incidence of 58% among children and 64.1% among adults. CFI among children and adults were found to be 1.71 and 1.85 respectively.⁶⁷

We did not find any cases of dental fluorosis among adults aged >36years. The reason may be that the exposure for higher fluoride content among the residents of Batwarahalli, Thimmasandra and Maddinayakanahalli would have been within 35 – 30 years and as people who are exposed to high fluoride level during 0 – 6yrs develop signs of dental fluorosis. However, cases of skeletal fluorosis were detected as it develops due to cumulative exposure of higher fluoride content at any age.

The prevalence of dental fluorosis was significantly higher among the children and adolescents compared to adults ($p < 0.05$) in the present study. Similarly, data from the National Health and Nutrition Examination Survey, 1999-2004 and the 1986-1987 National Survey of Oral Health in U.S. school children showed that the prevalence of dental fluorosis was higher in adolescents than in adults. Prevalence of dental fluorosis was higher among younger persons and ranged from 41% among adolescents aged 12-15yrs to 9% among adults aged 40-49 yrs.⁶⁸

A study done by Gopalakrishnan et al., in Alappuzha district, Kerala in 1998, showed 35.6% prevalence of dental fluorosis and community fluorosis index value was found 0.69 and also, water fluoride content > 1 ppm was associated with 1.85 fold elevated risk of prevalence of dental fluorosis, compared to the reference

group with a water fluoride content of < 1 ppm in contrast to this present study shows 46.8% prevalence of dental fluorosis and 0.86 as community fluorosis index value among children and the risk of dental fluorosis among the group with >1.5mg/L was significantly 6.7 times more compared to the group with <1.0mg/L.⁴⁴

In our study, among children and adolescents, in the study group with fluoride >1.5mg/L, the prevalence of dental fluorosis among males was 51.72% and among females, 42.85% whereas, in the other group with normal fluoride level, among males it was 12.82% and among females, 10.71%. Among adults, in the study group with fluoride >1.5mg/L, the prevalence of dental fluorosis among males and females were 1.1% and 1.2% respectively whereas, in the other group with fluoride <1.0mg/L, the prevalence of dental fluorosis among males and females were 0.6% and 2.5% respectively. Hence, among children and adolescents, males had a higher prevalence whereas, among adults, females had a higher prevalence compared to males. However, we did not find any significant difference in the gender and prevalence of dental fluorosis.

In a study conducted by Veeresh et al., in Bagalkot in 2007-2008, among children aged 5 – 14yrs, the prevalence of dental fluorosis among the males and females in the area with fluoride <1.5ppm were 23.97% and 32.9% and with fluoride >2.0ppm were 50.68% and 75.54% respectively. Statistical significance was observed between gender and prevalence of dental fluorosis.¹⁸

Saravanan et al., in his study in Chidambaram taluk in 2003-2004, among school children aged 5 – 12yrs, did not find any relationship between gender and prevalence of dental fluorosis.⁴²

We noticed that, among children and adolescents with fluoride level $>1.5\text{mg/L}$, maximum number i.e., 16.4% had moderate grade and 15.6% had very mild grade of dental fluorosis whereas, in the study group with fluoride $<1.0\text{mg/L}$ 5.3% and 4.3% had questionable and moderate grades of fluorosis respectively. Among the adults with fluoride level $>1.5\text{mg/L}$, 0.8% and 0.3% had moderate and questionable grades of dental fluorosis and in the other group 1.3% and 0.3% had moderate and mild grades of dental fluorosis respectively.

Bhat et al., among 588 residents in the age group 5-80+ of Hanumantharayanapalya, Ramnagar district had observed that 36.4% were affected with mild grade, 26.4% were affected with moderate grade and 4.7% were affected with severe grade of dental fluorosis.⁴⁶

The prevalence of skeletal fluorosis in both the groups of our study, with fluoride level $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ was 5.02%. Among adults, in the study group with fluoride $>1.5\text{mg/L}$, the prevalence of skeletal fluorosis among males was 4.81% and females, it was 5.26% whereas, in the other group with fluoride $<1.0\text{mg/L}$, the prevalence of skeletal fluorosis among males was 6.21% and females, it was 3.10%. There were no cases of skeletal fluorosis among children and adolescents. The skeletal fluorosis after x-ray confirmation was seen among 2 (11.11%) adults in the study group with fluoride $>1.5\text{mg/L}$ and no x-ray changes were seen in the study group with fluoride $<1.0\text{mg/L}$.

Choubisa et al., in villages of Banswara, Dungarpur, and Udaipur districts of southern Rajasthan, has noted that, at 1.5 ppm of fluoride, 6.1, 6.8, and 9.5% of adults in three selected villages showed evidence of skeletal fluorosis. 2-3 fluorotic subjects of each village showed increased bone mass and density as well as exostoses,

calcification of ligaments and inter-osseous membranes, and osteosclerosis. No children were found affected with skeletal fluorosis or skeletal deformities, the prevalence of which was higher in males and is in contrast to our study finding where in the study group with fluoride $>1.5\text{mg/L}$ there was higher prevalence among females.⁵³

We noted a higher prevalence of dental fluorosis with increase in water fluoride level however, the prevalence of skeletal fluorosis was same among both the groups with $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$. The reason for the dental and skeletal fluorosis to prevail in the study group with fluoride $<1.0\text{mg/L}$ may be due to the fluoride ingestion through food which needs further in-depth analysis.

Veeresh et al., in Bagalkot in 2007-2008, has concluded in his study that prevalence of dental fluorosis is associated with higher fluoride level similar to our study and Choubisa et al., in villages of Banswara, Dungarpur, and Udaipur districts of southern Rajasthan, has found the prevalence of skeletal fluorosis to increase with higher fluoride levels.^{18, 53}

In the present study, the prevalence of non-skeletal fluorosis among the children and adolescents and adults were 0.45% and 5.0% respectively. In the study group with fluoride level $>1.5\text{mg/L}$, the prevalence of non-skeletal fluorosis among children and adolescents was 0.78% and there were no cases in the group with normal fluoride. In the study group with fluoride $>1.5\text{mg/L}$, the prevalence of non-skeletal fluorosis among adults was 7.26% and 2.48% in the other group. Odds ratio among adults was >1 suggesting that, the risk of non-skeletal fluorosis among the adults in the study group with fluoride level $>1.5\text{mg/L}$ was significantly 3 times more

compared to the group with fluoride $<1.0\text{mg/L}$ ($p<0.05$). Susheela et al., had found 2% prevalence of non-skeletal fluorosis, in her study among the residents of Kurnool.⁶⁹

We observed that, the cases of dental and skeletal fluorosis were more among the subjects of poor socio-economic status i.e., 45 (63.4%) among children and adolescents, 8 (88.9%) among adults with dental fluorosis and 26 (78.8%) among adults with skeletal fluorosis.

In the present study, among the children and adolescents with dental fluorosis and adults with skeletal fluorosis, statistically significant difference was observed between socio-economic status and prevalence of dental fluorosis among the two groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ ($p<0.05$) but no statistical significance was observed between socio-economic status among adults with dental fluorosis ($p>0.05$).

We observed 100% literacy among the children and adolescent group with dental fluorosis, and there were more i.e., 39 (55%) cases of dental fluorosis among the group who had educational status lower than high school. In the adults with dental and skeletal fluorosis, there was higher i.e., 7 (77.8%) and 29 (87.9%) number of dental and skeletal fluorosis cases among literates and illiterates respectively. Among the adults with dental fluorosis, 7 (77.8%) of them were employed and 2 (22.2%) of them were unemployed. Among the adults with skeletal fluorosis, 24 (72.7%) of them were employed and 9 (27.3%) of them were unemployed. However, the association between prevalence of dental and skeletal fluorosis with education and occupation was not statistically significant ($p>0.05$).

In a study conducted by Nirgude et al., in Nalgonda in 2008-2009, has got more cases of dental and skeletal fluorosis among lower socio-economic status

(75.7%, 69.1%), illiterates (47.3%, 37.6%) and labourers and farmers (39.7%, 35.6%).⁴⁵

In the present study, among children and adolescents with dental fluorosis, most i.e., 38 (53.5%) of them were of normal nutritional status. Among the adults with dental and skeletal fluorosis, maximum i.e., 7 (77.8%) and 14 (60.9%) were of normal nutritional status respectively. Dental fluorosis among tobacco/areca nut consumers were nil in our study whereas, among the adults with skeletal fluorosis, 11 (33.3%) of them consumed tobacco/areca nut and 22 (66.7%) of them did not consume tobacco/areca nut. However, no statistical significance was observed with the use of tobacco or areca nut and nutritional status with the prevalence of dental and skeletal fluorosis ($p > 0.05$).

In contrast to the study by Choubisa et al., among adults of Udaipur and Dungarpur districts of Rajasthan, villagers with poor nutritional status showed the highest i.e., 61.6% and 23.9% dental and skeletal fluorosis incidence respectively. High incidence i.e., 80.0% and 13.8%, 75.0% and 30.4% of dental and skeletal fluorosis was observed among habitual users of tobacco and betel nuts respectively. Correlation coefficient between prevalence of dental and skeletal fluorosis in users was highly positive.⁵³

A study conducted by Sampaio F C et al., to investigate the relationship between nutritional status and dental fluorosis in areas with fluoride in the drinking water in Paraiba, Brazil found that malnutrition prevalence was approximately 20% in all fluoride groups, but was unrelated to dental fluorosis.⁵⁵

We did not observe any association of quantity of water consumed and use of fluoridated dental products for dental cleaning, similarly in a study conducted by Jagan

et al., in Kanyakumari in 2006, did not find significant association between various oral hygiene habits and dental fluorosis except for quantity of water consumed where in among the children who drank more than 4 glasses per day were found to be more prone for dental fluorosis. We did not find any studies for association of use of fluoridated medicine with prevalence of dental and skeletal fluorosis.⁵⁰

LIMITATIONS

1. The major risk factor in the development of dental fluorosis is drinking water. Fluorosis develops in an individual during the time of calcification of teeth, which takes place from early infancy. The fluoride content of the water which was consumed during that period is of critical importance, but could not be assessed. Hence, it is presumed that the children have been drinking water from the same source since their childhood (during the time of their teeth calcification).
2. The fluoride concentration in the ground water can fluctuate with the seasons and seasonal changes (sunshine, rainfall, humidity and temperature) and hence an annual average is a better indicator of fluoride levels in sources of drinking water.
3. Urinary fluoride levels, for the confirmation of consumption of fluoride rich water/food could not be analysed as we could not procure the instrument for the fluoride ion analysis due to constraints of time and logistics, as it was one person investigation.
4. Although we have taken history of use of fluoridated tooth paste, fluoridated mouth rinse, infant milk formulas, it needs an in-depth analysis of fluoride levels in the foods consumed in addition to detailed diet survey to confirm the cause of fluorosis could not be performed due to operational feasibility.

SECTION 7

CONCLUSION

“A fact is a simple statement that everyone believes. It is innocent, unless found guilty. A hypothesis is a novel suggestion that no one wants to believe. It is guilty, until found effective.”

- Edward Teller

7. CONCLUSION

- The prevalence of dental fluorosis in the study group with fluoride level $> 1.5\text{mg/L}$ was 13.17% and in the study group with fluoride level $< 1.0\text{mg/L}$ was 3.84%.
- Among children and adolescents, the prevalence of dental fluorosis was 31.83%. Among adults, the prevalence of dental fluorosis was 1.32%.
- Higher prevalence of dental fluorosis with higher water fluoride level was observed conversely, the prevalence of skeletal fluorosis was same among both the groups with $> 1.5\text{mg/L}$ and $< 1.0\text{mg/L}$.
- The prevalence of dental fluorosis was significantly higher among the children and adolescents compared to adults ($p < 0.05$) but, there were no cases of skeletal fluorosis among children and adolescents.
- Among children and adolescents, the risk of dental fluorosis among the group with fluoride $> 1.5\text{mg/L}$ was significantly 6.7 times more compared to the group with fluoride $< 1.5\text{mg/L}$ ($p < 0.01$).
- Among children and adolescents with fluoride level $> 1.5\text{mg/L}$, maximum number i.e., 16.4% had moderate grade and 15.6% had very mild grade of dental fluorosis whereas, in the study group with fluoride $< 1.0\text{mg/L}$ 5.3% and 4.3% had questionable and moderate grades of fluorosis respectively.
- Among the adults with fluoride level $> 1.5\text{mg/L}$, 0.8% and 0.3% had moderate and questionable grades of dental fluorosis and in the other group 1.3% and 0.3% had moderate and mild grades of dental fluorosis respectively.
- Community fluorosis index (CFI) was 0.8 suggesting slight public health significance among children and adolescents, in the group with fluoride $> 1.5\text{mg/L}$, and with fluoride $< 1.0\text{mg/L}$ it was negative and with no public

health importance. Among adults, CFI was negative in both groups and had no public health significance.

- The prevalence of skeletal fluorosis among adults during field evaluation in high ($>1.5\text{mg/L}$) and normal fluoride group was 5.02%. The skeletal fluorosis after x-ray confirmation was found among 2 (11.11%) adults in the high fluoride group.
- Among the children and adolescents, the prevalence of non-skeletal fluorosis was 0.45%. Among adults, the prevalence of non-skeletal fluorosis was 5.0%.
- The association between gender and the prevalence of dental and skeletal fluorosis was not statistically significant ($p>0.05$). There was no influence of occupation, castes and educational status observed with the prevalence of dental and skeletal fluorosis ($p>0.05$).
- In the study, among the children and adolescents with dental fluorosis and adults with skeletal fluorosis, we observed statistically significant difference between socio-economic status and prevalence of dental fluorosis and skeletal fluorosis among the two groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ ($p<0.05$) but there was no influence of socio-economic status among adults with dental fluorosis ($p>0.05$).
- The prevalence of dental and skeletal fluorosis association with risk factors like quantity of water consumed, use of fluoridated dental products for dental cleaning, use of fluoridated medicine, tobacco or arecanut and nutritional status was not statistically significant ($p>0.05$).
- The group with water fluoride $>1.5\text{mg/L}$ comprised of Thimmasandra and Batwarahalli villages with a public bore well as a source in both. The water

fluoride levels analysed in these sources by ion-electrode reported fluoride levels of 4.13mg/L and 2.59mg/L respectively.

- The other group with water fluoride <1.0mg/L comprised of Maddinayakanahalli with public bore well as the only source of water. The water fluoride levels analysed reported fluoride level of 0.61mg/L.
- Hence fluorosis is endemic in Bangarpet taluk, Kolar and there is an urgent need to take measures against this existing problem of fluorosis by setting up community defluoridation units.

SECTION 8

SUMMARY

“Develop success from failures. Discouragement and failure are two of the surest stepping stones to success.”

- Dale Carnegie

8. SUMMARY

Fluorosis is an endemic disease that results from excessive ingestion of fluoride. Ground water has been a rich source of fluoride and a dependent source for the residents of Kolar. There are very few epidemiological studies highlighting the problem of fluorosis. Hence this study was taken up to know the prevalence of dental and skeletal fluorosis, to compare some of the risk factors among two groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{ mg/L}$ and to estimate fluoride content in all the sources of water.

There were 486 study participants in the study group with fluoride $>1.5\text{mg/L}$ and 417 in the other group with fluoride $<1.0\text{mg/L}$, totally constituting 903 study participants.

Majority i.e., 45.1% of them belonged to the age group 20 – 40 yrs in the study groups with fluoride $>1.5\text{mg/L}$ and with fluoride $<1.0\text{mg/L}$, 48.4% of them belonged to 20 – 40yrs. Mean age among the study group with $>1.5\text{mg/L}$ was 33.0 ± 18.2 and in the other group with fluoride $<1.0\text{mg/L}$, it was 34.0 ± 16.2 .

In the study groups with fluoride level $>1.5\text{mg/L}$, 50.4% of them were males and rest 49.6% were females and with fluoride level $<1.0\text{mg/L}$, 48.0% were males and rest 52.0% were females. Male to female ratio among the study group with fluoride $>1.5\text{mg/L}$ was 1:1 and in the other group it was 1:1.1.

All the study subjects belonged to Hindu by religion in both the groups. Among the study groups with fluoride level $>1.5\text{mg/L}$, most of them i.e., 57.0% belonged to scheduled caste/tribe and with fluoride level $<1.0\text{mg/L}$, 87.6% belonged to other backward castes.

Among the study groups with fluoride level $>1.5\text{mg/L}$, maximum number i.e., 81.5% of them belonged to poor socio economic status and least i.e., 0.8% of them belonged to upper middle class and with fluoride $<1.0\text{mg/L}$, 52.5% of the study population belonged to very poor socio economic status and none belonged to upper middle class according to modified B G Prasad classification.

In the study groups with fluoride $>1.5\text{mg/L}$ maximum i.e., 68.5 % of them and with fluoride $<1.0\text{mg/L}$, 77.5 % of them belonged to unskilled group of occupation like agricultural or manual labourers.

Among the study groups with fluoride level $>1.5\text{mg/L}$, majority i.e., 33.1% were illiterates and least i.e., 2.5% were graduates/post graduates and with fluoride $<1.0\text{mg/L}$, 42.4 % of them were illiterates and 1.6% were graduates/post graduates.

Main source of water for drinking and domestic purpose was public bore well in both the study groups. Among both the study groups all of them used water directly from the bore-well except for 2 (0.4%) of them from the study group with fluoride $>1.5\text{mg/L}$ used aqua-guard. Mean consumption of drinking water among the study group with fluoride level $>1.5\text{mg/L}$ was 1.9 ± 0.5 and in the other group with fluoride $<1.0\text{mg/L}$, it was 2.0 ± 0.5 .

In the study groups with fluoride $>1.5\text{mg/L}$, 83.1% of them and with fluoride $<1.0\text{mg/L}$, 90.7% of them used fluoridated tooth paste/tooth powder. In the study groups with fluoride $>1.5\text{mg/L}$, 99.0% and with fluoride $<1.0\text{mg/L}$, all of them brushed once a day.

In the study groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$, 70.6% and 63.1% of them were normal, 20.2% and 32.1% were underweight respectively.

Among the study participants with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$, 12.8% and 9.4% of them consumed various forms of tobacco, 15.2% and 9.8% of them consumed areca nut respectively.

The prevalence of dental fluorosis in the study group with fluoride level $>1.5\text{mg/L}$ was 13.17% and in the study group with fluoride level $<1.0\text{mg/L}$ was 3.84%.

Among children and adolescents, the prevalence of dental fluorosis was 31.83%. In the study group with fluoride level $> 1.5\text{mg/L}$, the prevalence of dental fluorosis was 46.88% and in the study group with fluoride level $<1.0\text{mg/L}$ it was 11.58%. Odds ratio among children and adolescents suggested that the risk of dental fluorosis among the group with fluoride $>1.5\text{mg/L}$ was significantly 6.7 times more compared to the group with fluoride $<1.5\text{mg/L}$ ($p<0.01$).

Among adults, the prevalence of dental fluorosis was 1.32%. In the study group with fluoride level $> 1.5\text{mg/L}$, the prevalence of dental fluorosis was 1.11% and in the study group with fluoride level $<1.0\text{mg/L}$ it was 1.55%.

Among children and adolescents, in the study group with fluoride $>1.5\text{mg/L}$, the prevalence of dental fluorosis among males and females were 51.7% and 42.8% respectively whereas, in the other group with fluoride $<1.0\text{mg/L}$, the prevalence of dental fluorosis among males and females were 12.8% and 10.7% respectively.

Among adults, in the study group with fluoride $>1.5\text{mg/L}$, the prevalence of dental fluorosis among males and females were 1.1% and 1.2% respectively whereas, in the other group with fluoride $<1.0\text{mg/L}$, the prevalence of dental fluorosis among males and females were 0.6% and 2.5% respectively.

Among children and adolescents with fluoride level $>1.5\text{mg/L}$, maximum number i.e., 16.4% had moderate grade and 15.6% had very mild grade of dental fluorosis whereas, in the study group with fluoride $<1.0\text{mg/L}$ 5.3% and 4.3% had questionable and moderate grades of fluorosis respectively.

Among the adults with fluoride level $>1.5\text{mg/L}$, 0.8% and 0.3% had moderate and questionable grades of dental fluorosis and in the other group 1.3% and 0.3% had moderate and mild grades of dental fluorosis respectively.

Community fluorosis index (CFI) was 0.8 suggesting slight public health significance among children and adolescents, in the group with fluoride $>1.5\text{mg/L}$, and among the other group with fluoride $<1.0\text{mg/L}$ it was negative and suggested no public health importance. Among adults, CFI was negative in both groups with no public health significance.

The prevalence of skeletal fluorosis among adults during field evaluation in high and normal fluoride group was 5.02%. Among adults, in the study group with fluoride $>1.5\text{mg/L}$, the prevalence of skeletal fluorosis among males was 4.81% and females was 5.26%. In the fluoride $<1.0\text{mg/L}$, the prevalence of skeletal fluorosis among males it was 6.21% and females it was 3.10%.

The skeletal fluorosis after x-ray confirmation was found among 2 (11.11%) adults in the study group with fluoride $>1.5\text{mg/L}$ and no x-ray changes were observed in the study group with fluoride $<1.0\text{mg/L}$.

Among the children and adolescents, the prevalence of non-skeletal fluorosis was 0.45%. In the study group with fluoride level $>1.5\text{mg/L}$, the prevalence of non-

skeletal fluorosis among children and adolescents was 0.78% and there were no cases in the other group.

Among adults, the prevalence of non-skeletal fluorosis was 5.0%. In the study group with fluoride $>1.5\text{mg/L}$, the prevalence of non-skeletal fluorosis was 7.26% and 2.48% in the other group.

Odds ratio among adults suggested that, the risk of non-skeletal fluorosis among the adults in the study group with fluoride level $>1.5\text{mg/L}$ was significantly 3 times more compared to the group with fluoride $<1.0\text{mg/L}$ ($p<0.05$).

The group with water fluoride $>1.5\text{mg/L}$ comprised of Thimmasandra and Batwarahalli villages with a public bore well as a source in both. The water fluoride levels analysed in these sources by ion-electrode reported fluoride levels of 4.13mg/L and 2.59mg/L respectively.

The other group with water fluoride $<1.0\text{mg/L}$ comprised of Maddinayakanahalli with public bore well as the only source of water. The water fluoride levels analysed reported fluoride level of 0.61mg/L .

We noted a higher prevalence of dental fluorosis with increase in water fluoride level. But, the prevalence of skeletal fluorosis was equal among both the groups with $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$.

The prevalence of dental fluorosis was significantly higher among the children and adolescents compared to adults ($p<0.05$). However, there were no cases of skeletal fluorosis among children and adolescents. There was no influence of gender, occupation, castes and educational status observed in the prevalence of dental and skeletal fluorosis ($p>0.05$).

In the study, among the children and adolescents with dental fluorosis and adults with skeletal fluorosis, statistically significant difference was observed between socio-economic status and prevalence of dental fluorosis and skeletal fluorosis among the two groups with fluoride $>1.5\text{mg/L}$ and $<1.0\text{mg/L}$ ($p<0.05$) but there was no statistical significance observed between socio-economic status among adults with dental fluorosis ($p>0.05$).

The prevalence of dental and skeletal fluorosis association with risk factors like quantity of water consumed, use of fluoridated dental products for dental cleaning, use of fluoridated medicine, tobacco or arecanut and nutritional status was not statistically significant ($p>0.05$).

Fluorosis is a public health problem among the children and adolescents of Bangarpet taluk, Kolar. There is an urgent need for defluoridation of water sources.

SECTION 9

RECOMMENDATIONS

*“Experience is not what happens to you; it's what you do
with what happens to you.”*

- Aldous Huxley

9. RECOMMENDATIONS

- 1) There is a need to conduct studies in other taluks of Kolar to know the prevalence of fluorosis and also to elucidate the causative factors of fluorosis in the areas with water fluoride ranging within the permissible limits.
- 2) There is a need to identify the safe sources near the study areas and channelize people to use the safe source for drinking and domestic purpose.
- 3) There is an urgent need to set up community defluoridation units among the areas with water fluoride level above the permissible limits.
- 4) Studies on knowledge, attitude and practices should be conducted to know the existing knowledge, attitude and practices about effects and prevention of fluorosis.
- 5) There is a need to encourage the use of water only after purification by household defluoridation methods.
- 6) Involvement of the community in the maintenance of installed community defluoridation units needs to be promoted.
- 7) Need to improve the nutritional status among the population residing in the fluorosis prevalent areas by providing nutritional counselling.
- 8) Involvement of health planners, health administrators, engineers and health authorities to lower the burden of dental fluorosis in the community is a necessity.

SECTION 10

REFERENCES

*“A man who carries a cat by the tail learns something he
can learn in no other way.”*

- Mark Twain

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ANNEXURES

Annexure-1

Consent form and Proforma

IDENTIFICATION			
STATE: KARNATAKA			
DISTRICT: KOLAR			
Name of the Tehsil/Block/Police Station / Mandal: BANGARPET			
Name of the village/PSU:			
Selected HH Number (PSU wise code)			
Name of Head of the Household _____			
Address _____			

Name of the respondent _____			
INTERVIEWER VISITS			
NAME OF THE INTERVIEWER: Dr.Shruthi.M.N.			
DATE OF INTERVIEW	(DD / MM / YY) / / 		
TIME OF INTERVIEW	START TIME (HH / MM) / 		
	NAME	DATE	SIGNATURE
FIELD SUPERVISOR			
SCRUTINIZED BY			
DATA ENTRY BY			
RESULT OF THE INTERVIEW	Interview completed	1	
	Interview partially completed	2	
	Interview not completed	3	

CONFIDENTIALITY AND CONSENT:

Investigator's statement:

Introduction – My name is **Dr Shruthi M N**, post graduate in the department of Community Medicine, Sri Devaraj Urs Medical College, Kolar. We are carrying out a study on fluorosis. The study has been reviewed by the local ethical review board and has been started only after their formal approval.

Consent for the Study–Fluorine is the most electronegative element, distributed ubiquitously as fluorides in nature. Excess intake of fluoride (>1.5 mg/l) may cause dental, skeletal and non-skeletal fluorosis. The toxic effects of skeletal fluorosis are more severe in children with growing bones, women with children with their depleted bone and mineral reserves and in labourers with excessive drinking of water that can be up to 6 to 8 liters in summer. In this regard, I will ask you some questions about your household and the members staying at your household. You do not have to answer any questions that you do not want to answer and you may end this interview at any time you want to. However, your honest answer to these questions will help us better understand the health status of this area. We would greatly appreciate your help in responding to this survey. The survey will take about half an hour to ask the questions.

Participation in this study doesn't involve any cost for you. This study is not only beneficial to you but also to the community in large. The results gathered from this study will be beneficial in evaluating the services provided by the health care delivery system by the Government.

All the information collected from you will be strictly confidential and will not be disclosed to any outsider unless compelled by law. This information collected will be used only for research.

I kindly request you to give consent for the clinical examination and to perform three clinical tests to diagnose skeletal fluorosis. In case if you cannot perform any of the single tests among three, then you will be subjected for X-ray of the forearm for the confirmation of skeletal fluorosis and to differentiate skeletal fluorosis from age related arthritic changes and obesity which results in inability to perform those three clinical tests.

There is no compulsion to participate in this study. You will be no way affected if you don't wish to participate in this study. You are required to sign only if you voluntarily agree to participate in this study. Further, you are at a liberty to withdraw from the study at any time, if you wish to do so. Be assured that your withdrawal will not affect your treatment by the concerned physician in any way. It is up to you to decide whether to participate. This document will be stored in the safe locker in the department of Community Medicine in the college and a copy is given to you for information.

For any further clarification you are free to contact the principal investigator,

Dr. Shruthi M N; Mobile No: 9844303271

Respondent agreed for the interview, clinical examination and radiological examination (when required)	1	Administer the HH questionnaire and subject for radiological investigation (when required). Request the respondent to provide her/his written consent.
Respondent agreed for the interview and refused clinical examination	2	No interview to be carried out (Fill up the Result of the Interview)
Respondent refused for the interview and clinical examination but agreed for radiological examination (when required)	3	
Respondent refused for the interview, clinical examination and radiological investigation (when required)	4	

Respondent's informed consent I, understand that I remain free to withdraw from this study at any time. I have been read out/ explained in my local language i.e. in _____ and understand the purpose of this study and the confidential nature of the information that will be collected and disclosed during the study. I have had the opportunity to ask questions regarding the various aspects of this study and my questions have been answered to my satisfaction. I agree to participate in the survey, to undergo clinical examination, radiological investigation (when required) and authorize the collection and disclosure of my personal information as outlined in this consent form.	Signature/ Left Thumb Impression of the Respondent with date
If, the respondent does not agree to sign or give his/her Left Thumb Impression	Signature of interviewer certifying that informed consent has been given verbally by the respondent
Witness	1. 2.
Principal Investigator	Signature

CEÄÄ§AzsÄ-1

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⁻sÁUÄ^aÄ»,ÄÄ^aÄ □zsÄðgÄvÄ^aÄÄUÉ ©nÖzÄÄÝ. F
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SECTION -1 Household Composition

Line No.	1) Usual residents and visitors	2) Relationship to head of HH	3) Gender	4) Age	5) (IF AGE ≥5 YEARS) Education	6) Occupation	7) Income
	Please give me names of persons who usually stays in the household, sleeps and shares meals, has that address as primary place of residence, or spends more than 6 months a year starting with the head of HH	What is the relationship of (NAME) to the head of HH? Fill the respondent's code accordingly in the respective cell which is mentioned in the table below	Is (NAME) male (1) or female (2)?	How old is (NAME)? (in completed years)	What is the highest Class (Name) has completed? Illiterate....98 NA (if less than 7 years)...99	Fill if applicable	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
01		01					
02							

Line No.	1) Usual residents and visitors	2) Relationship to head of HH	3) Gender	4) Age	5) (IF AGE ≥5 YEARS) Education	6) Occupation	7) Income
	Please give me names of persons who usually stays in the household, sleeps and shares meals, has that address as primary place of residence, or spends more than 6 months a year starting with the head of HH	What is the relationship of (NAME) to the head of HH? Fill the respondent's code accordingly in the respective cell which is mentioned in the table below	Is (NAME) male (1) or female (2)?	How old is (NAME)? (in completed years)	What is the highest Class (Name) has completed? Illiterate....98 NA (if less than 7 years)...99	Fill if applicable	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
03							
04							
05							
06							
07							
08							
09							
10							
11							
Q 8	Total Income						
Q 9	Per Capita Income = $\frac{\text{Total Income}}{\text{Total no. of members in the family}}$						
Q10	Socio – Economic status (Modified B G Prasad Classification)						
CODES FOR COL.3							
Head of Household			01	Parent-in-law			07
Spouse (Wife or Husband)			02	Brother or Sister			08
Son or Daughter			03	Brother-in-law or Sister-in-law			09
Son-in-law or Daughter-in-law			04	Other Relative			10
Grand child			05	Adopted / Foster Child			11
Parent			06	Not related			12

SECTION – 2: Household Profile

No.	QUESTION	CODING CATEGORIES	CODE
11)	Duration of stay in the same place/house	Less than 1 month	1

		1 – 2 months	2
		2 – 3 months	3
		3 – 4 months	4
		4 – 5 months	5
		5 – 6 months	6
		More than 6 months	7
12)	What is the religion of the head of the household?	Hindu	1
		Muslim	2
		Christian	3
		Other (Specify_____)	77
13)	What is the caste of the head of the household? Specify Caste/tribe.....	SC	1
		ST	2
		OBC	3
		General	4
		No caste/tribe	5
14)	What is the main source of drinking water for members of your household?	Piped water in residence/yard/plot	01
		Public tap	02
		Hand pump in residence/yard/plot	03
		Public Hand pump	04
		Covered well in residence/yard/plot	05
		Open well in residence/yard/plot	06
		Public well	07
		Public Bore well	08
		Private Bore well	09
		Water supply schemes	10
		Lakes	11
		Rivers	12
		Springs	13
		Other (specify _____)	77
15)	If public hand pump is the main source then	Address	If No, Skip to Q16
		Distance in meters	
16)	How do you use that water for drinking?	Use directly from the source	01
		Use bleaching powder	02
		Use sedimentation techniques	03
		Use candle filters	04
		Aquagaurd / RO system/Kent	05
		Boiling	06
		Other (specify_____)	77
17)	Does the household have a ration card?	Yes (Card Shown)	1
		Yes (Card Not Shown)	2
		No	3
		Don't Know	8
18)	Record from the ration card whether the HH belongs to APL or BPL or Antyodaya category	APL	1
		BPL	2
		Antyodaya	3

19)	Instructions: Verify the economic status of the HH from different sources like: • Asking the colour of the Ration card • Rate of the ration purchased from PDS • From the Gram Panchayat records	APL		1
		BPL		2
		Antyodaya		3
		Not ascertained		4
20)	Modified BG Prasad Classification	I. Upper High	01	
		II. High	02	
		III. Upper Middle	03	
		IV. Lower Middle	04	
		V. Lower	05	
21)	Type of cooking salt purchased for your household to cook the last meal? Mention how many grams in the appropriate space provided		Code	No. of grams per day
		Iodised salt	01	
		Raw salt(non-iodised)	02	
		Black salt (Kala Namak)	03	
		Red Rock salt (Sindhi Namak)	04	
		Fluoridated salt	05	

SECTION - 3 Individual Profile (>7 years and above)

Name : _____

Age : _____

Gender : _____

No.	QUESTION	CODING CATEGORIES	CODE	SKIP
22)	How many litres of water do you drink per day?	$\frac{1}{2}$ L	01	
		$\frac{1}{2}$ - 1L	02	
		1 - 2L	03	
		2 - 3L	04	
		3 - 4L	05	
		>4L	06	
23)	What do you use to brush your teeth?	Finger	01	
		Neem bark	02	
		Any tree bark	03	
		Charcoal powder	04	
		Tooth powder	05	
		Fluoridated tooth paste	06	
		Non Fluoridated tooth paste	07	
		Other(specify _____)	77	
24)	How many times do you brush your teeth?	Once daily	01	
		Twice daily	02	
		Once in two days	03	
		Once a week	04	
25)	Do you use any mouth rinse?	Yes	01	SKIP to Q.34
		No	02	

26)	If yes, which brand do you use? Please specify with frequency					
27)	History of any medications including Multivitamins, Antipsychotics, Sodium fluoride for otosclerosis	Yes		01	SKIP to Q.36	
		No		02		
28)	If yes, which drug are you on? Mention the brand name and frequency (Multiple responses possible)	No.				Brand name of the Drug with frequency
		1	Multivitamins	Yes	01	
				No	02	
		2	Antipsychotics	Yes	01	
				No	02	
				No	02	
		3	Sodium Fluoride for otosclerosis	Yes	01	
				No	02	
		4	Others (Specify _____)		77	

29)	Diet (1 wk)	Type/brand	Quantity	Frequency/wk
01	Rice			
02	Ragi			
03	Vegetables			
04	Fruits			
05	Milk			
06	Tea			
07	Coffee			
08	Infant milk formulas (if applicable)			
09	Fish			
10	Egg			
11	Other non-vegetarian foods			
12	Fast foods (chat masala)			

30) Clinical Symptoms :

1) Symptoms of Dental Fluorosis :

Discoloration of Teeth (White/Yellow/Brown/Black) may be in spots or as streaks in horizontal orientation	Yes	01
	No	02

2) Symptoms of Skeletal Fluorosis :

No.	Symptoms		
1	Body pains	Yes	01
		No	02
2	Lethargy	Yes	01
		No	02
3	Tingling sensation of the extremities	Yes	01
		No	02
4	Stiffness of Neck	Yes	01
		No	02
5	Stiffness of Spine	Yes	01
		No	02
6	Stiffness of Joints	Yes	01
		No	02
7	Inability to Squat	Yes	01
		No	02

3) Symptoms of Non-Skeletal Fluorosis :

No.	Symptoms		
1	Dyspepsia with either Nausea/Vomiting/Pain abdomen/Constipation/Diarrhoea	Yes	01
		No	02
2	Muscle Weakness	Yes	01
		No	02
3	Fatigue	Yes	01
		No	02
4	Polyuria	Yes	01
		No	02
5	Polydipsia	Yes	01
		No	02
6	Repeated Abortions	Yes	01
		No	02
7	Repeated Still births	Yes	01
		No	02

31) General Physical Examination :

1) Anthropometry :

Weight in Kilograms and grams	
Height in Centimeters	
BMI = Weight in Kilograms/Height in Meter ² x 100	

2)

1	Pallor	Yes	01
		No	02
2	Icterus	Yes	01
		No	02
3	Cyanosis	Yes	01
		No	02
4	Clubbing	Yes	01
		No	02
5	Lymphadenopathy	Yes	01
		No	02
6	Edema (Pedal)	Yes	01
		No	02
7	Koilonychia	Yes	01
		No	02

32) Vital Signs

Temperature(febrile/afebrile)	
Pulse Rate per min	
Respiratory Rate per min	
Blood Pressure in mm of Hg	

33) Systemic Examination:

Cardiovascular System	
Respiratory System	
Per Abdominal Examination	
Central and Peripheral Nervous System	
Musculo-Skeletal system	

34) Dental Examination for Dental Fluorosis:

Dean's Criteria	Classification	Code (encircle the appropriate)
Smooth, glossy, pale creamy-white translucent surface	Normal	01
A few white flecks or white spots	Questionable	02
Small opaque, paper white areas covering less than 25% of the tooth surface	Very Mild	03
Opaque white areas covering less than 50% of the tooth surface	Mild	04
All tooth surfaces affected; marked wear on biting surfaces; brown stain may be present	Moderate	05
All tooth surfaces affected; discrete or confluent pitting; brown stain present	Severe	06

35) Clinical test for Skeletal Fluorosis:

No.	Tests	Performance	Code	If total score < 3 then the person will be subjected to Radiological examination
01	Touching the toes without bending the knees	Yes	01	
		No	00	
02	Touching the chest with the chin	Yes	01	
		No	00	
03	Stretching the arms sideways and folding the arms to touch the back of the head	Yes	01	
		No	00	
		Total Score		

36) Radiological Tests:

	CODE	RESULTS		
X ray (Score >3) Sl. No that is labeled accordingly	<table><tr><td></td><td></td></tr></table>			