HISTORY OF FLUORIDES

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BY DR. VARSHA SHARMA

Fluoride – fluore – to flow

- It is a highly reactive element
- Atomic number is 9
- The atomic weight is 19

THE ELEMENT FLUORIDE

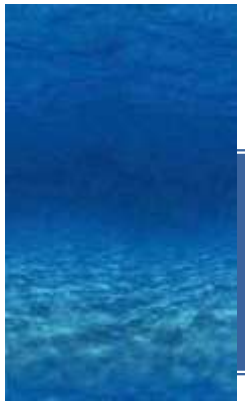
-The Federal Register of United States Food and Drug Administration describes fluoride as an essential nutrient.

-The WHO expert committee on trace elements included fluorine as one of the 14 physiologically essential elements.

-These essential elements are required for the normal growth and development of Human Beings.

Sources of Fluorides

either ingested or inhaled



Water – natural

Professionally applied

Sea foods

Vegetables

Volcanic eruptions

Tea

FLUORIDES

SYSTEMIC

- WATER FLUORIDATION PUBLIC SCHOOL
- SALT FLUORIDATION
- MILK FLUORIDATION
- SUGAR FLUORIDATION
- FLUORIDE SUPPLEMENTS

TOPICAL

PROFESSIONAL

- NaF
- SnF
- APF GEL/ SOLUTION
- FLUORIDE VARNISH
- SLOW RELEASING FLUORIDE DEVICES
- F CONTAINING PROPHYLACTIC PASTES

SELF

- F MOUTH RINSES
- F DENTIFRICES
- F CHEWING GUMS
- F GEL

FLUORIDE IN ENVIRONMENT

1. **IN LITHOSPHERE:**

- In *rock and soil-*
  - Fluorspar (fluorite CaF_2)
  - Fluorapatite $\{Ca_{10}F_2(PO_4)_6\}$
  - Cryolite (Na_3AlF_6)

- *In Soil,* the fluoride concentration increases with depth;

0-7.5cm ⟶ 20-500mg of Fluoride/kg

0-30 cm ⟶ 20-1620mg of fluoride/kg

WHO Expert Committee on Oral Health Status & Fluoride Use
Geneva, 22-28 November,1993

2. **IN WATER:**

- *Sea water* - 0.8- 1.4mg/L.
- *Lakes, rivers or artesian wells* - below 0.5mg/L.
- Concentrations as high as 95mg/L have been recorded in the United Republic of Tanzania.

3. IN AIR:

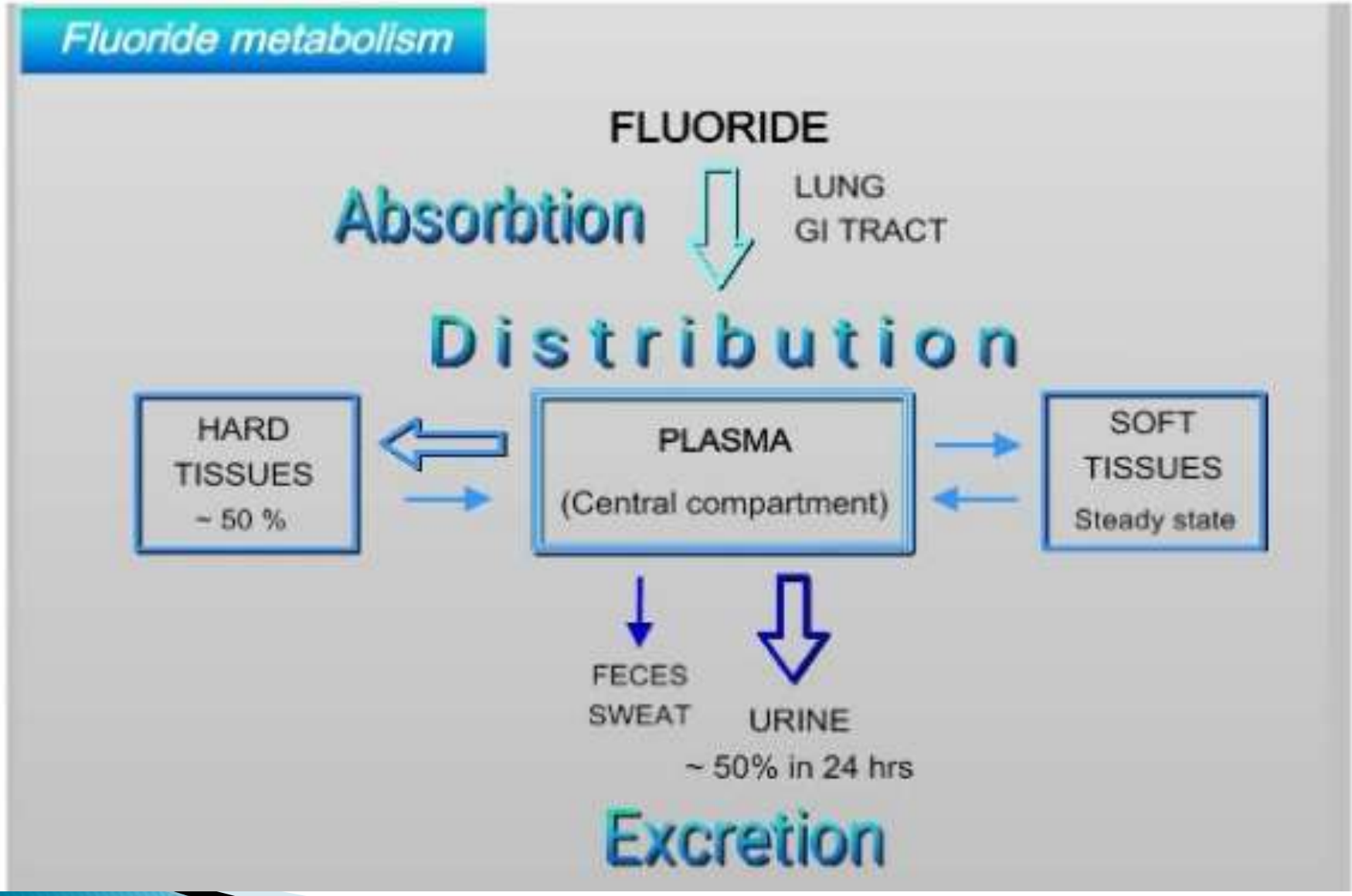
- Widely distributed in the *atmosphere*-
- dusts of fluorides-containing soils
- gaseous industrial waste
- domestic burning of coal fires
- gases emitted in areas of volcanic activity

4. IN FOODS AND BEVERAGES:

- *Unprocessed foods* -low (0.1-2.5 mg/kg).
- *In plants* - 2-20mg/g of dry weight.
- *Leafy vegetables* -11-26 mg on dry weight basis.
- *Fish* -20-40 ppm on dry weight basis.

METABOLISM OF FLUORIDE

- Major route of the fluoride absorption is ingestion via the GIT.
- The fluoride source may be organic and inorganic.
- Fluoride is generally ingested in a beverage, in food or as a pharmaceutical preparation such as NaF tablets.
- The principal source of Fluoride ingestion is WATER.


Fluoride metabolism
FLUORIDE
Absorbtion
LUNG
GI TRACT
Distribution
HARD TISSUES ~ 50 %
PLASMA (Central compartment)
SOFT TISSUES Steady state
FECES
SWEAT
URINE
~ 50% in 24 hrs
Excretion

ABSORPTION OF FLUORIDE

After ingestion of fluoride , such as drinking a glass of optimally fluoridated water

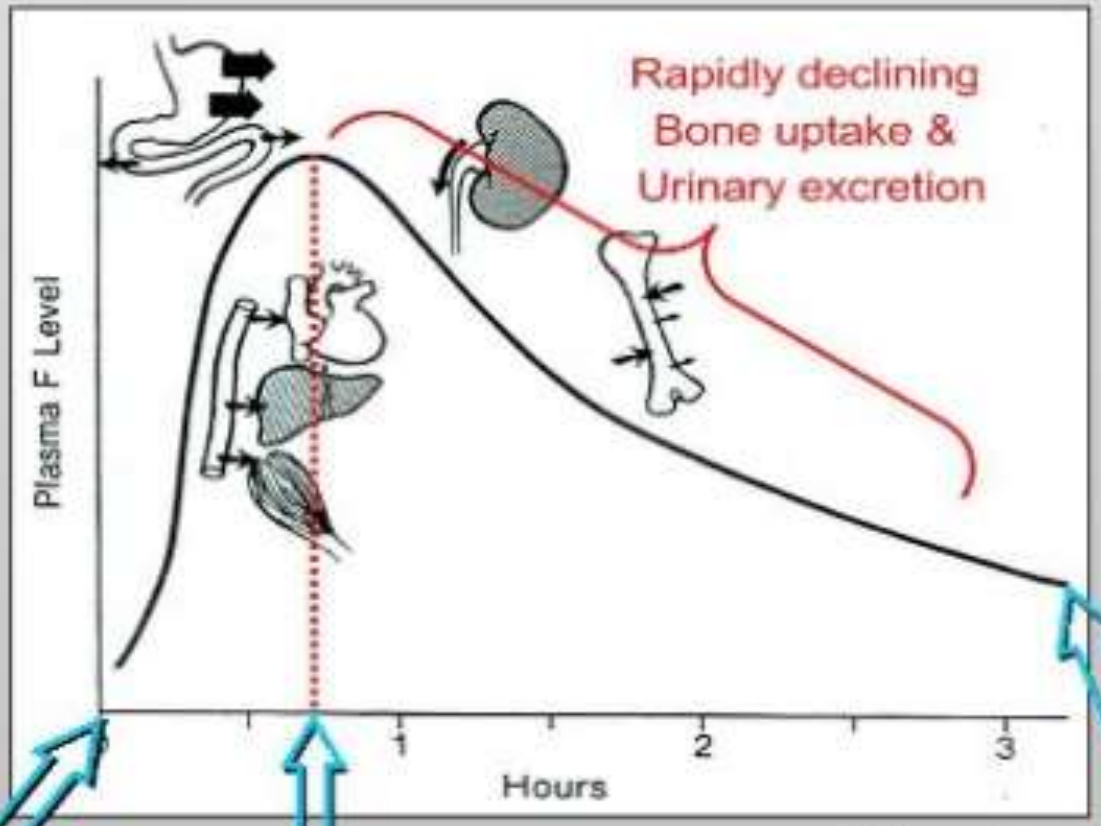
Majority is absorbed from stomach and small intestines

Into the blood stream causing short term increase in level of blood within 20-30 minutes

This conc. declines rapidly within 3-6 hours.

Absorption

How fast is the absorption and distribution?



Ingestion

Peak plasma level
< 30 min to an hour

Return to normal 3-6 hours
(If ingesting small amount)

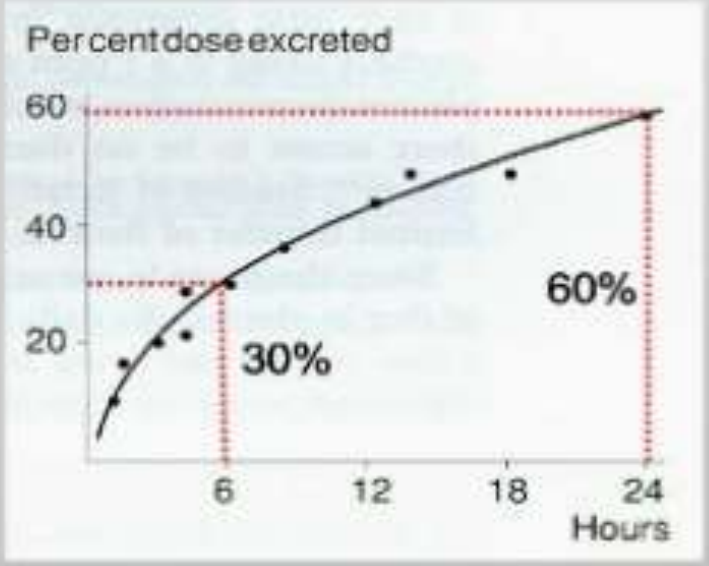
EXCRETION OF FLUORIDE:-

- Fluoride is excreted in urine and feces and lost through sweat.it occurs in traces in milk, saliva, hair and tears.
- Principal route of fluoride excretion is via the URINE .
- Kidney is the main pathway of fluoride excretion with an average fluoride intake of 3.9mg/day

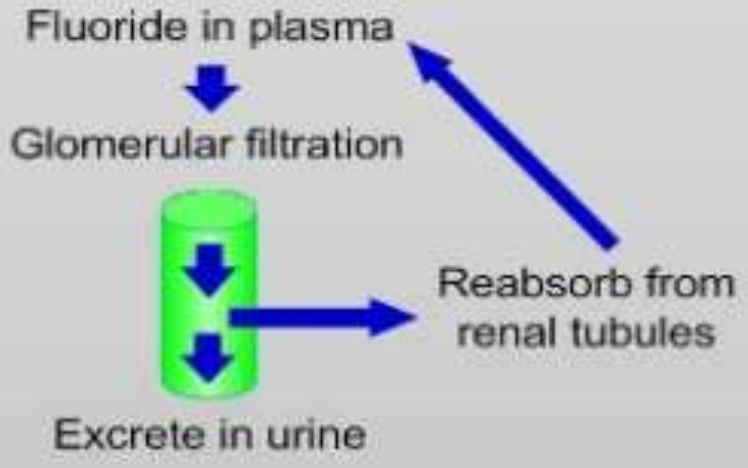
Excretion

Renal clearance of fluoride

Kidney is the major route of fluoride excretion



Amount of excreted fluoride vs time after ingesting



Adults: 40-60% of ingested fluoride

Children: Excrete a smaller % of ingested fluoride

STORAGE OF FLUORIDE :-

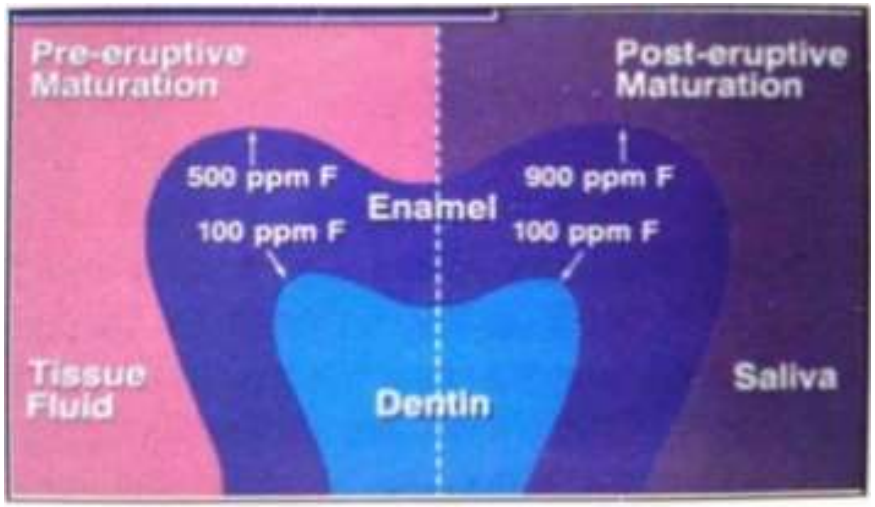
IN ENAMEL:

- Fluoride is deposited from the tissue fluid during pre-eruptive maturation phase.

- During initial stages of enamel formation the fluoride concentration is much higher than it is upon completion.

After a rise in the concentration, the level rapidly declines as the mineral density and degree of enamel formation increases

- Fluoride is acquired topically by enamel during post eruptive maturation and aging period.
- As a result the surface acquires much higher concentrations than the interior.



Fluoride Enamel Gradient

IN DENTIN & CEMENTUM:

- Fluoride concentrations are higher than in enamel probably because of greater porosity and the longer time during which they can acquire fluoride from tissue fluids.
- Where the tissue is in contact with circulating fluids, the fluoride concentration is high, but where the diffusion is hindered, the concentration is low.
- Fluoride concentration of cementum is higher than that of any dental tissues.

FLUORIDE IN BONE:-The distribution of fluoride with in bone is not uniform. It is highest in the areas of most active growth

***b)* FLUORIDE IN SALIVA-**

- Fluoride concentrations in human saliva are slightly less than those found in plasma, ranging from less than 0.01 to 0.05 ppm.

c)FLUORIDE IN MILK-

- Human breast milk provides less than 0.01mg/day.
- Ready-to-feed formulas contain less than 0.4 ppm
- Formulas reconstituted with optimally fluoridated water contain fluoride at 0.7 ppm or more.

- **D)Fluoride in blood:-**Approximately 3 quarters of total blood fluoride is in plasma and 1 quarter in RBCs. Regulation of plasma fluoride is due to large volume of extracellular body fluid

HISTORY

1. Discovery phase [1902-1931]
2. Epidemiological phase [1932-1945]
3. Demonstration phase [1945-1960]
4. Technology transfer phase [1960 onwards]

HISTORY OF EVOLUTION OF FLUORIDES IN DENTISTRY

- **1901- DR. FREDRICK McKAY**

  Permanent stains present on the teeth of local inhibitants of Colarado Spring, U.S.A. known as COLARADO STAINS noticed. He called the stain **Mottled Enamel**

- **1912 DR. J.M. EAGER**

  described similar stains present on teeth of certain italian emigrants embarking at Naples as " denti di chiaie.

- **1916, Dr Green Vardmin Black**

  supported MCKay work with histologic evidence reporting it as "an endemic imperfection of the enamel of the teeth

- **1925,Dr F McKay** change of water supply from spring water of the Great Salt Lake of Oakely, Idaho City, showed no brown stains in children.

- **1928,Dr McKay and Gromer Kempt**
  Similar observation found in Bauxite where changed water supply from a shallow well to foot well resulted in children with badly stained teeth.

- **1931,Mr HV Churchill** -A spectrographic analysis of Bauxite city water showed the presence of fluoride at the level of 13.7ppm.

- **1933,Dr H Trendley Dean**
  Shoe Leather Survey **(Dean's 22 city study)**

- **1939,Dean and McKay** -
  Came out with the most conclusive and direct proof that fluoride in domestic water is primary cause of human mottled enamel.

- **1939,Dr H Trendley Dean** -
  Hypothesis showing the inverse relationship between endemic dental fluorosis and dental caries emerged with survey of four illinois cities.

SHOE LEATHER SURVEY

- Conducted by Trendley H. Dean in 1931 for continuing the work of McKay.
- 22 cities in 10 states of U.S.A on a population sample of 5824 children.
- Following report was obtained:-
  - High concentration of fluoride is directly proportional to severity of enamel mottling
  - Enamel mottling was widespread in areas with water having fluoride content of 3ppm.
  - Mottling with discrete pitting of enamel- 4ppm.
  - Dull chalky white appearance- 2.5ppm to 3ppm.
  - No mottling, no changes- 1ppm.

- The term mottled enamel gave way to more exact term “DENTAL FLUOROSIS”.
- In 1934, ‘mottling index’ was developed by Dean.

21 cities study

- Similarly an extensive epidemiological study was done.
- 7,257 white children of 12-14yrs were examined, who had used local water since birth.
- In 21 cities, of 4 states of U.S.A. , where Fluoride concentration ranged from 0-2.6ppm.

- Results were:

1. DMFT ranged from 6-10 in areas with no fluoride.
2. DMFT ranged from 2 &3 in water containing 1ppm.

- Thus it was concluded that 1ppm fluoride in drinking water resulted in maximum reduction in caries (i.e 60%).

WATER FLUORIDATION

Water fluoridation is the **upward adjustment of the fluoride ions** in a public water supply in a way that the concentration of fluoride ion in the water may be consistently maintained at **1 ppm** by weight to prevent dental caries.

- Water fluoridation is the controlled addition of fluoride to a public water supply to reduce tooth decay. Fluoridated water has fluoride at a level that is effective for preventing caries this can occur naturally or by adding fluoride.

- Community water fluoridation is the process of adjusting the amount of fluoride in a community water supply to an optimum level for the prevention of dental caries.

CARIES INHIBITORY EFFECT THROUGH WATER FLUORIDATION

- **1944-1959 Francis Arnold, Philip Jay and John Knutson**
  -GRAND RAPIDS MUSKEGON STUDY.

- **1945-1955 David et al**
  NEWBURGH- KINGSTON STUDY 10 year study.

- **1967(1946-1960) Dr JR Blayney, TN Hill, Zimmerman**
  EVANSTON OAK PARK STUDY .

- **1951 Hutton et al and 1965 Brown and Poplove-** CANADIAN STUDY

- **1961, Backer Dirks et al** -DUTCH STUDY (Tiel-Culemborg

- **1965, Ludwig** - NEW ZEALAND STUDY.

MEASUREMENT OF DENTAL FLUOROSIS IN THE 20th CENTURY

1. ➡ Dean's Fluorosis Index- 1934
2. ➡ Community Fluorosis Index-1946
3. ➡ Thylstrup-Fejerskov Index-1978
4. ➡ The Developmental Defects of Enamel Index-1982
5. ➡ Tooth Surface Index of Fluorosis -1984 given by Horowitz et al
6. ➡ Fluorosis Risk Index-1990 given by Pendrys

DEANS FLUOROSIS INDEX

- Introduced by Trendley H Dean in 1934.
- It is also known as Dean's Classification System for Dental Fluorosis.

ORIGINAL CRITERIA (1934)-

- It was based on a 7- point ordinal scale: normal, questionable, very mild, mild, moderate, moderately severe, severe.

- **NORMAL:**

Enamel is translucent, semi-vitriform type of structure.
Smooth, glossy surface usually of a pale creamy white colour.

- ***QUESTIONABLE:***

Slight aberrations, ranging from a few white flecks to occasional white spots.
1-2 mm in diameter.

- ***VERY* MILD:**

Small, opaque, paper-white areas scattered irregularly or streaked on the labial and buccal surfaces
Involves <25% of the tooth surface.
Small pitted white areas are on the summits of the cusps.
No brown stains present.

- ***MILD:***

White, opaque areas involve at least half of the tooth surface.
Surfaces of molars, bicuspids and cuspids show thin white layers worn off .
Bluish shades of underlying normal enamel.

- ***MODERATE:***

No change in the form of tooth. All surfaces are involved.

Minute pitting on labial and buccal surfaces.

Brown stain is frequently a disfiguring complication.

- **MODERATELY SEVERE-**

Greater depth of enamel is involved.

A smoky white appearance is often noted.

Pitting is observed on all the tooth surface. Brown stain if present is generally deeper in hue.

- ***SEVERE-***

Hypoplasia is marked.

Form of teeth is at times affected.

Often manifests in older children as a mild pathologic incisal-occlusal abrasion.

Deeper pits and often confluent stains are widespread .

Range from chocolate brown to almost black in some cases.

Deans revised index (1942)

NORMAL (0) The enamel represents the usual translucent semivitriform type of structure. The surface is smooth , glossy and usually of a pale, creamy white colour.

QUESTIONABLE(0.5) The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white fleck to occasional white spots. This classification is used in those instances where a definite diagnosis of the mildest form of fluorosis is not warranted and a classification of "normal" not justified.

VERY MILD (1) Small, opaque, paper white areas scattered irregularly over the tooth , but not involving as much as approximately 25% of tooth surface. Frequently included in this classification are teeth showing no more than about 1-2 mm of white opacity at the tip of the summit of the cusps of bicuspids or second molars.

MILD (2) The white opaque areas in the enamel of teeth are more extensive but do not involves as much as 50% of tooth.

MODERATE (3)
All enamel surfaces of the teeth are affected and surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature.

SEVERE (4) All enamel surfaces of the tooth 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.

MECHANISM OF ACTION OF FLUORIDES IN CARIES REDUCTION

- Increased enamel resistance/ reduction in enamel solubility
- Increased rate of posteruptive maturation
- Remineralization of incipient lesions
- Fluoride as an inhibitor of demineralization
- Interference with microorganisms
- Modification in tooth morphology

1. INCREASED ENAMEL RESISTANCE:

- When enamel is exposed to pH of about 5.5 or lower, it will dissolve according to following equation.

$$Ca_{10}(PO_4)_6(OH)_2 + 8H^+ = 10\ Ca^{++} + 6HPO_4 + 2H_2O$$

- But fluoride application allows for a substitution reaction to produce FAP,

- $$Ca_{10}(PO_4)_6(OH)_2 + 2F^- = Ca_{10}(PO_4)_6F_2 + 2OH^-$$

Concentration of calcium, phosphate and other ions increases in solution.

When plaque stops producing acid, pH rises & amount of dissolved mineral diminishes.

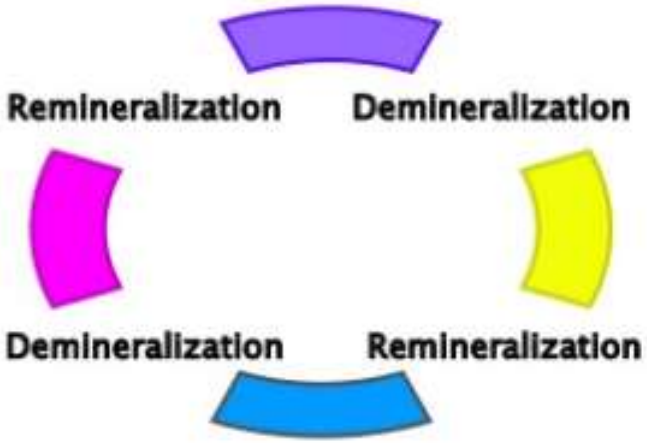
Results in precipitation of mineral.

2.INCREASED RATE OF POST-ERUPTIVE MATURATION:

- Newly erupted enamel is able to acquire more fluoride than older enamel.
- Topical application of fluorides when administered shortly after eruption has greater benefits.
- Newly erupted enamel has areas where mineral deposition is not entirely complete.
- These hypomineralised areas may become fully mineralized within only a few months after eruption and will be more resistant to acids.

- Its formation is therefore desirable during mineralization.

- Remineralization of etched surfaces is accelerated by as much as 4 to 5 times by only 1 ppm fluoride and that of white spot lesions by 2 folds.



3. ***REMINERALIZATION OF INCIPIENT LESIONS-***

- Fluoride accelerates the growth of enamel crystals that have undergone demineralization.

- Remineralization of enamel lesion occurs by deposition of crystalline hydroxyapatite.

- Apatite is the most stable and least soluble of biological calcium phosphate compounds.

4. INTERFERENCE WITH PLAQUE MICRO-ORGANISMS-

- Fluoride interferes with oral bacteria in 2 ways

- In high concentration ⟹ BACTERICIDAL
- In low concentration ⟹ BACTERIOSTATIC

- It helps control the growth of cariogenic bacteria without destroying them

- These inhibitory mechanisms are affected by the hydrogen ion concentration of plaque.

- A decrease in pH results in a greater inhibitory action on bacterial carbohydrate metabolism

which occurs due to

- Unionized hydrofluoric acid formed at lower pH values.

5. ***IMPROVED TOOTH MORPHOLOGY-***

- Areas of teeth like occlusal surfaces with deep fissures are most susceptible to dental caries.
- Effect of water fluoridation on tooth size and shape have suggested that fluoride tends to make teeth slightly smaller and provide them shallower fissures.

CONCLUSION

- Fluoride in recommended concentrations is definitely beneficial to health.
- In excess amount it is harmful to the body.
- Appropriate fluoride intake in different population groups in different areas has to be ascertained on the basis of fluoride concentration in food and water resources taken by the local population.

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- WHO Committee on Oral Health Status And Fluoride Use, Geneva, 1993.


Thank
You

Discovery phase [1902-1931]

Cause for mottled enamel.

1902-Dr. Frederick Mc Kay- noticed Colorado stain in the city Colorado in the US.

Colorado Stain.

Mottled enamel.

1912- Letter by G.M.Eager who called it Denti D Chiae

[Italian language]

1916-G.V.Black and Frederick Mc Kay detailed survey of the areas of Fluoride in Colorado. Endemic imperfection of enamel but there was no literature on it noted till then.

The areas affecting it were cosidered.

Now the cause of this was found that something in the water caused this mottling.

1925 – Oakley Idaho – changed water supply to confirm the cause for mottled enamel.

After 7 years the children were born with no stains of fluoride on the teeth.

1931 – scientist H.V.Churchill – chief chemist of the Aluminium company of Bauxite.

Spectrographic analysis of water.

There was 13.7 ppm in that area

Epidemiologic phase [1932-1945]

Trendley H Dean – analysis on the effect of F on dentition.

1934- Dean gave the seven point scale of DFIndex

1938-Dean has made a hypothesis of 1ppm fluoride is safe and beyond this there will be enamel mottling.

In UK

- 1933- Ainsworth

Results

1. 0-1ppm maximum reduction in prevalance of dental caries.
2. Beyond 1ppm F there wont be furthur reduction in dental caries
3. Above 1ppm fluoride in drinking water beginning of dental fluorosis starts

Water Fluoridation

Water fluoridation is the upward adjustment of the fluoride ions in a public water supply in a way that the concentration of fluoride ion in the water may be consistently maintained at 1 ppm by weight to prevent dental caries.

Demonstration phase [1945-1960]

- Artificial fluoridation of water supply era.
- Classified into

1945 - January 25 water fluoridation day

Grand Rapids

Muskegon

First city where there was first artificial fluoridation.

Grand Rapids [t]- Muskegon study [c]

- 10 years
- But after 6 years they had a gradual decrease in the fluoride concentration. Muskegon water was fluoridated.
- After 10 years – 50%

1951, Mean def of GR–M

AGE	GRAND RAPIDS		MUSKEGON	
	NO. OF CHILDREN	MEAN def	NO. OF CHILDREN	MEAN def
4	168	2.13	63	4.46
5	853	2.27	351	5.25
6	750	2.98	294	5.67

Newburgh [t] – Kingston [c]

Second study in the United States

2nd May 1945, David. B

10 years – 50%

Evanston [t] – Oakpark [c]

Third study –

January 1946

Blayney, I.N.Hill, Zimmerman

After 14 years – 50%

Canadian study on a world wide basis

Brantford [t] – Sarnia [c]

June, 1945

[Hutson, Linscott, Williams,1951]

17 years of water fluoridation – 55% reduction.

Dutch study[1953]

Tiel-Culemberg study

- Fluoride on different areas of the teeth.
- Free smooth surfaces - 80%
- 70% reduction in interproximal
- Only 30% reduction in the pits and fissures

Technology transfer


THANK
YOU

- Fluorine is a member of the halogen family with atomic weight of 19 and atomic number of 9.

- It is derived from the Latin word “fluore” meaning “to flow”.

- Is the most electronegative and reactive of all elements.

Dean's 21 city study

1942 - 1 ppm F

Methodology – 7257 children of the age group 12-14 years

Cities – Galesburg – 1.7ppm

Manmoth – 1.8ppm

Quincey – 0.2ppm

Macomb – 0.2ppm