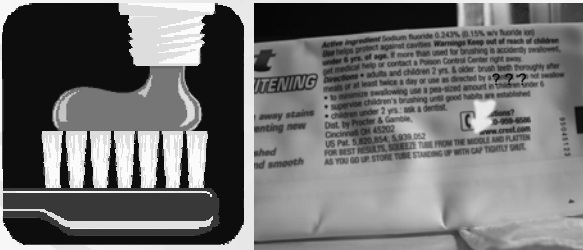


## The Colgate Crisis: Fluoridation and Health



## Fluorine: some initial comments

In pure form, fluorine, is a very reactive gas (found in exceedingly small amounts in nature)

But fluoride also exists widely in minerals--bound to metals as fluorides (e.g., sodium fluoride).

Whether or not fluorine is a trace element essential to human health is still debated, but in tiny amounts it protects teeth from bacterial decay and promotes bone growth.

## Uses of fluoride compounds

When used in very *low* concentrations (on the order of parts per million), fluorides are used in human health applications.

Fluorides such as sodium fluoride (NaF), sodium fluorophosphate (SMFP), and tin fluoride (SnF<sub>2</sub>), are common ingredients in toothpaste. Some dentists also give their patients semiannual fluoride treatments.

Many North American municipalities also fluoridate their water supplies, citing effectiveness in reducing tooth decay, safety of fluoridation, and the low cost to do so. The World Health Organization (WHO), and some other health organizations recommend fluoridation of municipal water supplies to a level between 0.7 and 1.2 ppm (so average of about 1 ppm).

## Uses of fluoride compounds

When used in very *high* concentrations (on the order of 10% by volume or higher), sodium fluoride may be found in rat poisons, insecticides, and wood preservatives.

Hydrofluoric acid (HF), a very strong acid, is used in the etching of glass and other industrial applications, including integrated circuit manufacturing.

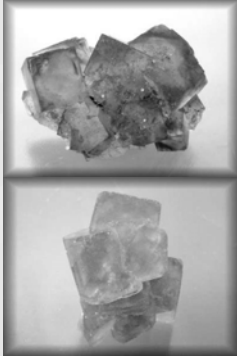
Fluorine joins with carbon to form a class of compounds known as fluorocarbons. Some of these compounds, such as dichlorodifluoromethane (CF<sub>2</sub>Cl<sub>2</sub>), were widely used in air conditioning and refrigeration systems and in aerosol spray cans, but have been phased out due to the damage they were causing to the earth's ozone layer.

### Where does our fluoride come from ?

Fluoride for industrial applications is sourced from the common mineral fluorite (calcium fluoride or  $\text{CaF}_2$ )

Common in hydrothermal deposits hosted in igneous and sedimentary rocks

1. From last fluids of plutonic intrusions (crystallize in cavities and fractures in pegmatites)
2. From warm brines that invade sedimentary rocks (crystallize in dissolution cavities of limestone)



### Where does our fluoride come from ?

Fluoride also occurs in natural waters and food (especially cereals, fruit, meat, fish, tea)

In some areas, water in hot springs is enriched in dissolved fluoride (note that this is consistent with the formation of fluorite in hydrothermal mineral deposits).

Also, groundwater that has interacted extensively with fluoride-bearing bedrock (marine deposits and especially those hosting hydrothermal deposits) can be enriched in dissolved fluoride.

### How does fluoride treatment prevent tooth decay ?

Human teeth (and bones) are primarily composed of the mineral calcium hydroxyapatite

Calcium hydroxyapatite has the chemical formula:  
 $\text{Ca}_5[(\text{PO}_4)_3\text{OH}]$

One of the main components of this mineral is the hydroxyl ion (an ion of oxygen and hydrogen with a charge of  $-1$ )

Fluoride (also an ion with a charge of  $-1$ ) substitutes for the hydroxyl ion, producing calcium fluoroapatite, with the chemical formula:  
 $\text{Ca}_5[(\text{PO}_4)_3\text{F}]$

### How does fluoride treatment prevent tooth decay ?

Calcium fluoroapatite is chemically stable than calcium hydroxyapatite in acid environment of the mouth

Calcium fluoroapatite dissolves at pH of 4.5  
Calcium hydroxyapatite dissolves at pH of 5.5.

This means that a higher concentration of calcium fluoroapatite in tooth enamel decreases tooth dissolution, and therefore can decrease the incidence of tooth decay.

Note: low-dose fluoride supplementation is also being used, on an experimental basis, to reduce the incidence of bone fractures in people affected by osteoporosis (fluoride strengthen bones for the same reason as in teeth).

### But too much fluorine is bad

Excessive intake of fluorine (above about 1 ppm) can lead to dental and skeletal fluorosis (disorders of tooth and skeletal development related to too much fluorine)

Excess intake of fluorine can also lead to thyroid conditions.

The most common cause of fluorosis is high fluorine intake via water (generally groundwater).

Supplementation of already high fluoride concentrations in water can exceed acceptable doses of fluoride (about 1 ppm)

### Dental fluorosis

Excessive intake of fluoride damages enamel forming cells called ameloblasts, leading to abnormal development of teeth.

Dental fluorosis is of particular concern during childhood when teeth are actively formed.

Leads to increase in the porosity of enamel and a decrease in mineral content.

Fluoridation of water must be undertaken with caution (taking into account natural concentrations of fluoride in the water supply).

### Degrees of dental fluorosis



Very mild to mild  
(slight mottling of teeth)

Moderate  
(obvious mottling of teeth)

Severe  
(severe mottling of teeth)

### Is fluoridation of water the best solution to reducing tooth decay?

Fluoridation of water must be undertaken with caution (taking into account natural concentrations of fluoride in the water supply)

Also, the incidence of cavities is not wholly related to the need for fluoride

For example, saliva can be more acidic in some individuals than others (leading to predisposition to tooth decay). Acidity of saliva is largely controlled by acid-producing bacteria feeding on sugars.

So fluoridation is not always the best solution toward reducing tooth decay

### Skeletal fluorosis

Excess fluoride intake also interferes with normal bone development

The early stage of skeletal fluorosis, is characterized by joint pain, sensations of burning, pricking, and tingling in the limbs, muscle weakness, chronic fatigue, and reduced appetite.

In the more advanced stages, pains in the bones become constant and some of the ligaments begin to calcify. Abnormal crystalline structure of the bones becomes apparent, and bony spurs begin to appear in joint areas.

In the most advanced stage, the extremities become weak and moving the joints is difficult. The vertebrae partially fuse together, crippling the patient. Bones also become brittle.

### Mass fluoridosis

Widespread fluoridosis has been documented in developing nations (particularly China, India, and South Africa). In these places, people regularly ingest fluoride at concentrations of 8-10 ppm (remember, accepted level is on order of 1 ppm)

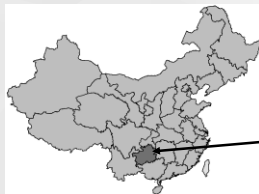
Often related to high intake of fluoride from groundwater sources, but also from the burning of coal, and coal-clay briquettes.

Incidences of fluoridosis are closely allied with incidences of arsenic poisoning.

### Guizhou Province, China

It is estimated that 30 million people suffer from chronic dental and skeletal fluorosis in China (10 million in Guizhou Province alone) where the custom of burning fluoride-rich coal.

At the same time, at least 3,000 people in Guizhou Province in southwest China are suffering from severe arsenic poisoning (also due to coal burning).



Guizhou Province

### Guizhou Province, China

Remember the comments made on this situation at the beginning of the course. These are repeated here (with some additional facts):

1. The primary fuel source here is coal (which in this region is naturally enriched in fluoride and arsenic)
2. Coal dust is combined with fluoride-rich clay to make briquettes.
3. The briquettes are burned in poorly ventilated huts (so, fluorine is inhaled from the air).
4. Food (including chili peppers and corn) are dried over coal burners (so, fluorine is also ingested through food).
5. Groundwater interacts with soil and bedrock in the area, which is rich in fluoride (so, fluorine is also ingested from water supply)

### Guizhou Province, China

Residents of Guizhou Province, China that have been most severely affected by fluoridosis have developed thick, bony overgrowths, skeletal deformities, darkly mottled teeth and gastric disorders.

It is also possible that fluoride toxicity affects the pineal gland and kidneys



### Could fluorosis be affecting North Americans ?

Early symptoms of fluorosis can mimic arthritis

It therefore makes one wonder whether increasing rates of arthritis in North America US, is related to the increase ingestion of fluoride that has occurred over the past 5 decades years via artificially fluoridated water.

The question is important, especially because is no known cause (other than 'aging') for common forms of arthritis

...and arthritis appears to be impacting adults at younger ages

Systematic studies are badly needed to investigate this.

Note: London water appears to be well within safety levels of fluoride (about 0.5 to 0.8 ppm).

*END OF LECTURE*