FLUORIDE

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Background

- The word fluoride refers to the common salts of the element fluorine
- Naturally occurring fluorides, e.g. fluorspar, cryolite, and fluorapatite, account for .3 mg/kg of the earths crust and fluorides are found in all natural water sources.
- May be added to drinking water supplies in communities where the water supply is naturally low in fluorides.
- The US started adding fluoride to drinking water more than 50 years ago and today, more than 2/3 of the drinking water in the US is fluoridated.
- Roholm (1937), high fluoride intake corresponds to increased risk of skeletal fluorosis

Sources

- Breakdown of rocks and from volcanic eruptions
- Aluminum, steel, glass fiber industries
- Fertilizers and pesticides
- Household products: toothpaste, processed cereals(3.8-6.3 ppm), juices, sodas(>.6 ppm), tea(7-25 ppm), wines(.23-2.8 ppm), fluoridated salt(250 ppm)
- Average daily intake of fluorides is about 1 ppm, which goes up to about 2.7 ppm if the drinking water supply is fluoridated

Environmental levels

- Air- natural background concentrations of the order of 0.5 ng/m3. With anthropogenic emissions, it goes up to 3 ng/m3. Indoor concentrations can be nearly 50 µg/m3 where high fluoride coal is burnt.
- Water- fluoride levels vary according to source, with sea water>ground water>surface water. Freshwater levels vary from .05 ppm to 8 ppm, with the highest recorded natural level at 2800 ppm.
- Soils- levels vary from 200-300 ppm. Soil fluoride levels can go up with addition of fluoride containing fertilizers and pesticides. Crops grown on these soils often accumulate high levels of fluorides

Human Exposure

- Exposure depends upon geographical area
- Food accounts for 80-85% of daily intake
- Sources of exposure also affect intake
- 0.46-5.4 mg/day have been reported, but significantly higher levels have been reported in areas with high drinking water levels and where fluoride containing coal is burnt

Toxicokinetics

- Inhalation exposure
  - Occurs mainly in occupational settings, through inhalation of inorganic fluoride particulates
  - Results in a lower FEV and increased cough and sputum production
  - Mostly excreted through the urine
  - Chronic exposure results in skeletal fluorosis
- Dermal exposure
  - Route of exposure for inorganic fluorides only if skin is abraded
  - Causes local necrosis and edema

- Oral Exposure
  - Major route of fluoride intake
  - Water soluble fluorides almost completely absorbed by the GI tract
  - However, the amount reaching the bloodstream depends upon how much fluoride was ingested, whether food/drink was consumed recently and the type consumed
- High fluoride levels in food/drink induce vomiting, and this limits uptake

Metabolism and Storage

- Fluoride is believed to replace the hydroxyl ion and possibly the bicarbonate ion associated with hydroxyapatite, forming fluorapatite
- A portion of the absorbed fluoride is sequestered in bones and teeth, with virtually no storage in soft tissues.
- Fluoride that is not stored is excreted via the urine, sweat, saliva and feces within 24 hours
- Storage of fluorides in bones and teeth is reversible, with mobilization occurring after cessation of exposure
- Inorganic fluoride in the blood can form metal- fluoride-phosphate complexes, that interfere with enzyme processes requiring a metal ion co-factor

Health Effects

- Long term epidemiologic studies have established that fluoride primarily produces effects on skeletal tissues
- Fluoride levels of 0.5-2 ppm in drinking water can have a beneficial effect in that it prevents dental caries in children
- However, fluoride can have an adverse effect on dental enamel at concentrations of 0.9-1.2 ppm, causing mild dental fluorosis
- Elevated fluoride levels(3-6 ppm, >10 ppm) can cause skeletal fluorosis, which may be crippling
- There is some evidence that fluoride can increase the risk of arthritis
- People with decreased renal function are at greater risk from elevated fluoride levels

- Fuoride can cross the placental barrier, but there is insufficient evidence to show any link with congenital disorders
- Fluoride has also been linked to cancers in animal studies

Dental fluorosis

- Characterised by a mottling of the teeth.
- Severity of mottling increases with fluoride exposure
- Ranges from almost invisible opaque white spots to brown spots and pitting of the teeth
- Small white spots were observed in 20% of children exposed to fluoride levels of ~1ppm
- Mild dental fluorosis is considered a cosmetic effect, but may be an indicator of overexposure in children

Skeletal fluorosis

- Caused by the accumulation of fluoride in the bones
- Has a number of stages
  - First preclinical stage: biochemical abnormalities in the bones an blood
  - Second preclinical stage: histological changes observed in the bones
  - Early clinical stage: pain in the bones and joints, prickling and tingling in the limbs, muscle weakness, and fatigue. Changes can be observed in the pelvis and backbone
  - Second clinical stage: pain in the bones, calcification of ligaments, osteoporosis and osteosclerosis, formation of bone spurs
  - Advanced skeletal fluorosis: extremities weak, joint movements limited, vertebrae partially fused

- Exposure to over 20 mg/day of fluoride for over 20 years can cause advanced skeletal fluorosis. Similar effects are observed if a person is exposed to 8 mg/day for over 50 years
- Skeletal fluorosis can be caused even at levels of exposure as low as 4mg/day when aggravating conditions are present

Guidelines and Standards

- The WHO guideline recommends levels less than 1.5 ppm for drinking water
- The EPA drinking water standard is 4 ppm, with a secondary standard of 2 ppm

References

- IPCS (2002) Environmental Health Criteria No 227. Fluorides. WHO, Geneva
- http://www.fluorideaction.org/atsdr-fluoride.pdf
- http://www.who.int/docstore/water_sanitation_health/GDWQ/draftchemicals/fluoride2003.pdf
- http://education.vsnl.com/fluorosis/index.html