

Sources of Exposure

Toxicokinetics and Normal Human Levels

Biomarkers/Environmental Levels

ToxGuide™

for Fluorides, Hydrogen Fluoride, and Fluorine

September 2003

U.S. Department of Health and
Human Services
Public Health Service
Agency for Toxic Substances
and Disease Registry
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General Populations

- The general population may be exposed to fluoride through consumption of drinking water, foods, and fluoride-containing dental products.
- Populations living in areas with naturally high fluoride levels in the water and soil may be exposed to high levels in water.
- Populations living near industrial sources of hydrogen fluoride, including coal burning facilities, may be exposed to higher levels of hydrogen fluoride in air.
- The major natural source of hydrogen fluoride emissions to the atmosphere is volcanoes whereas the largest anthropogenic source is electrical utilities.

Occupational Populations

- Occupational exposure to hydrogen fluoride or fluorine by inhalation exposure may occur in industries involved in the production of fluorine-containing chemicals, pharmaceuticals, high-octane gasoline, aluminum, and fluorescent light bulbs.
- Aqueous hydrogen fluoride is used for stainless steel pickling, glass etching, and metal coatings.

Toxicokinetics

- Almost 100% of inhaled hydrogen fluoride is absorbed through the upper respiratory tract; it is likely that fluorine will also be well absorbed.
- Soluble fluoride compounds are well absorbed (80–100%) through the gastrointestinal tract. Insoluble fluoride compounds are poorly absorbed (<10%).
- Hydrofluoric acid is absorbed through the skin.
- Once absorbed, fluoride is distributed throughout the body, with the highest concentrations found in calcified tissues.
- Fluoride is not metabolized and is eliminated via the urine.

Normal Human Levels

- In adults, plasma fluoride levels appear to be directly related to fluoride intake.
- Humans exposed to fluoride-treated water have plasma fluoride levels in the range of 1 to 4 mcmol/L.
- Adults who drink water that does not contain fluoride have plasma levels < 1 mcmol/L.

Biomarkers

- Serum and urinary fluoride levels are the most useful biomarkers of fluoride exposure; measurement should be taken shortly after exposure due to the rapid elimination of fluoride

Environmental Levels

Air

- Hydrogen fluoride levels in ambient air ranged from 1.0 to 7.5 $\mu\text{g}/\text{m}^3$.

Sediment and Soil

- Concentrations of fluoride in soil range from <10 to 3,700 ppm with a mean of 430 ppm.

Water

- Average fluoride concentration in rivers is approximately 200 $\mu\text{g}/\text{L}$.
- Fluoride concentration in groundwater generally ranges from 20 to 1,500 $\mu\text{g}/\text{L}$. The highest levels are found in the southwest; where the levels can exceed 1,500 $\mu\text{g}/\text{L}$.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine (Update). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Chemical and Physical Information

Routes of Exposure

Relevance to Public Health (Health Effects)

Fluorides are Solids; Hydrogen Fluoride and Fluorine are Gases

- Fluorides are naturally-occurring components of rocks and soil. They enter the atmosphere through volcanic emissions and the resuspension of soil by wind.
- Hydrogen fluoride and some fluorine gas are also emitted by volcanoes.
- Fluorine is a highly reactive element and readily hydrolyzes to form hydrogen fluoride and oxygen.

- Inhalation – Minor route of exposure for the general population. Predominant route of exposure for workers.
- Oral – The predominant route of exposure for general population.
- Dermal – Minor route of exposure.

Fluorides, Hydrogen Fluoride, and Fluorine in the Environment

- Gaseous hydrogen fluoride will be absorbed by atmospheric water forming an aerosol or fog of aqueous hydrofluoric acid. It will be removed by wet deposition.
- Particulate fluorides in the atmosphere will be removed by dry and wet deposition.
- Upon entering water, fluorides will gravitate to the sediment.
- Fluorides are strongly retained by soil.
- In water, fluoride forms strong complexes with aluminum.
- Fluoride accumulates in some plants and in the skeletal system of terrestrial animals that consume fluoride-containing foliage.

Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.

Minimal Risk Levels (MRLs)

Inhalation

- No inhalation MRLs were derived for fluorides.
- An MRL of 0.02 ppm has been derived for acute-duration inhalation exposure to hydrogen fluoride (≤ 14 days).
- No intermediate- or chronic-duration MRLs were derived for hydrogen fluoride.
- An MRL of 0.01 ppm has been derived for acute-duration inhalation exposure to fluorine (≤ 14 days).
- No intermediate- or chronic-duration MRLs were derived for fluorine.

Oral

- No acute- or intermediate-duration oral MRLs were derived for fluorides.
- An MRL of 0.05 mg fluoride/kg/day has been derived for chronic-duration oral exposure (≥ 1 year).
- No oral MRLs were derived for hydrogen fluoride.
- No oral MRLs were derived for fluorine.

Health Effects

Fluorides

- Excess fluoride can result in dental fluorosis and an increased prevalence of bone fractures in the elderly (due to increased bone mineral density and fragility). Skeletal fluorosis (brittle bones and decreased bone tensile strength) can result from exposure to high levels of fluoride.

Hydrogen Fluoride

- The primary effects of hydrogen fluoride are tissue damage resulting from direct contact. Observed effects include bronchiolar ulceration, pulmonary hemorrhage, and burns to the eyes and skin.

Fluorine

- Fluorine gas is extremely irritating; acute exposure can result in nasal and eye irritation at low levels and death due to pulmonary edema at high levels.

Children's Health

- Dental fluorosis can occur only while the teeth are forming, thus children under the age of 8 years are susceptible to this effect.
- It is not known if children are more susceptible to other adverse effects of hydrogen fluoride, or fluorine than adults.