

Sources of Exposure

Toxicokinetics and Biomonitoring

Biomarkers/Environmental Levels

General Populations

- Everyone is exposed to copper daily in food, water, and air.
- Copper is an essential nutrient to humans and low levels must be consumed daily. The average daily dietary intake in humans is estimated to be 2 mg/day.
- Excess copper in drinking water is more likely to occur in homes with copper pipes or corrosive water.
- Regular consumption of oysters or clams may substantially increase dietary copper intake.
- Consumption of dietary supplements, multivitamins, or fortified foods can increase dietary copper intake.
- Individuals may accidentally ingest or inhale copper powders, dusts, or crystals that are available for consumer and commercial purchase.

Occupational Populations

- Individuals who work in facilities that process, recycle, or mine copper may be exposed by inhalation or dermal contact.
- Agricultural workers can inhale herbicide or pesticide sprays that contain copper salts.
- Workers in these industries are at higher risk of exposure than the general population.

Toxicokinetics

- After ingestion, copper is absorbed into the gastrointestinal tract, primarily by the small intestine. To maintain copper homeostasis, the body will absorb less dietary copper as ingestion increases. No studies examined absorption from inhalation exposure.
- Distribution of copper is a two phase process: (1) 75% of copper distributed by the portal vein is taken up by the liver, and (2) copper from the liver is released to the blood circulation systems and distributed into various organ tissues. After inhalation, copper distributes to the liver, plasma, lungs, and kidneys.
- Copper metabolism is regulated by APT7A and ATP7B. Cu(II) is reduced to Cu(I) for transport through cellular membranes.
- Bile excretion through feces is the major excretion path for copper. Copper is also found in urine and breastmilk. The rate and extent of excretion from inhalation exposure is unknown.
- Copper half-lives in rat tissues are: 3.9-21 days in the liver, 5.4-35 days in the kidney, 23-662 days in the heart, and 457 days in the brain. In rats, the half-life in the lungs is 7.5 hours.

NHANES Biomonitoring

- The geometric mean serum copper levels for all adults in the 2015-2016 NHANES was 1146.6 µg/L.

Biomarkers.

Copper can be measured in blood, urine, hair, and nails to indicate exposure. When elevated, these may indicate excess copper exposure or disrupted copper homeostasis. There are no biomarkers of effect specific to copper toxicity. Tracking gastrointestinal symptoms and measuring liver enzyme levels can be used to monitor and manage the toxic effects of copper on tissues.

Environmental Levels

Air

- Outdoor, mean range: 0.02–0.79 µg/m³

Water

- Ground water range: 0.2–98.4 µg/L
- Surface water range: 0.021–69,000 µg/L
- Drinking water range: 0.009–2,450 µg/L

Soil and Sediment

- Soils range: 0.005–200,000 ppm
- Sediment range: 0.001–150,000 ppm
- Soil and sediment median: 30 ppm

Food

- Mean range: 0–135 mg/kg
- Baby food mean range: 0.02–1.6 mg/kg

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2022. Toxicological Profile for Copper (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

ToxGuide™

for

Copper

Cu

CAS# 7440-50-8

April 2022

U.S. Department of Health and
Human Services
Public Health Service
Agency for Toxic Substances
and Disease Registry
www.atsdr.cdc.gov



Chemical and Physical Information

Routes of Exposure

Relevance to Public Health (Health Effects)

Copper is a reddish metal

- Copper is a metallic solid that has high thermal conductivity, high electrical conductivity, low corrosivity, alloying ability, and is malleable.
- It occurs naturally, is a group 11 element (noble metals), and is an essential nutrient. Copper is odorless with a lustrous reddish color and exists in a solid state.
- Copper is insoluble in water. In contrast its salt, copper (II) sulfate, is soluble in water.
- Copper (II) sulfate is produced by treating hot copper with sulfuric acid. It is a white-green solid when anhydrous, and blue crystallized when hydrated. It has a pleasant odor.
- Copper (II) chloride is produced by a reaction of metallic copper with chlorine. It is a yellow-brown powder in the anhydrous form. It is odorless, and soluble in acetone and ethanol.

- Inhalation – The general public inhales copper in the atmosphere as it is typically bound to particulates. Inhalation can occur in workers who handle copper dusts, powders, or sprays. Communities living near facilities that process or mine copper can be exposed via inhalation.
- Oral – The general public is exposed daily to copper in water and foods. Copper is primarily ingested via drinking water.
- Dermal – Dermal contact is a potential route of exposure for workers. Children may also be exposed if playing in contaminated soils.

Copper in the Environment

- Copper occurs naturally in air, water, soil, and sediments.
- In the atmosphere, copper is in the form of particulate matter or adsorbed to it. It can travel long distances away from its original source.
- Copper is not stable in water due to its solubility but its salts, such as copper sulfate, are typically measured in water.
- In water, copper can dissolve or bind to particulate matter.
- Copper binds to soils and sediments especially those with high organic content. Its mobility is dependent on soil composition.
- Plants and crops uptake copper from soils since it is necessary for growth.
- Copper does not bioconcentrate in fish but may in mollusks such as clams, oysters, and squids, where concentrations may be relatively high.

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

Minimal Risk Levels (MRLs)

Inhalation

- No acute- (≤ 14 days), intermediate- (15-364 days), or chronic-duration (≥ 365 days) inhalation MRLs were derived for copper.

Oral

- An acute-duration oral provisional MRL of 0.02 mg Cu/kg/day was derived for copper.
- An intermediate-duration oral provisional MRL of 0.02 mg Cu/kg/day was derived for copper by adopting the acute-duration oral MRL.
- No chronic-duration oral MRL was derived for copper.

Health Effects

- Studies in humans show that gastrointestinal symptoms of vomiting, nausea, diarrhea, and abdominal pain are the most reported effects following oral ingestion of high concentrations of copper.
- Similar gastrointestinal symptoms have been expected in children orally exposed to high concentrations of copper, especially in drinking water.

Health Effects

- Jaundice, liver impairment, and renal failure are reported in cases where individuals ingested high lethal doses of copper sulfate.
- Copper is a respiratory irritant. Workers who use copper dusts or sprays report lung damage, nose, and throat irritation.
- Skin discoloration and eye irritation is reported in workers who had dermal contact with copper dusts.
- Intermediate-duration oral exposure studies in animals report alterations in hematological parameters, neurological impairments, and damage to male and female reproductive organs.
- Offspring of animals orally exposed to copper during pregnancy show delayed or altered development.
- *In vivo* studies suggest copper sulfate is genotoxic to mammalian cell lines.
- Neither the Department of Health and Human Services (HHS), the International Agency for Research on Cancer (IARC), nor the EPA have classified copper regarding its carcinogenicity.

Children's Health

- Children exposed to copper in drinking water may experience effects similar to those expected in adults. It is unknown if developmental effects seen in animals are expected to be seen in humans.