

## Sources of Exposure

## Toxicokinetics and Biomonitoring Levels

## Biomarkers/Environmental Levels

ToxGuide™

for  
Copper  
Cu

CAS# 7440-50-8

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### 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 1–2 mg/day.
- Excess copper in drinking water is more likely to occur in homes with copper pipes or corrosive (acidic) 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 and used as algacides in ponds.
- Oral exposure of copper may differ between children and adults due to differences in the consumption of various food groups.

### 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 Levels

- The geometric mean serum copper levels for all adults in the 2015–2016 NHANES was 1,146.6 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, range of means in U.S. samples, 2020–2022: 0.0182–0.0238 µg/m<sup>3</sup>

#### *Water*

- Groundwater, mean in U.S. samples, 2020–2022: 31.5 µg/L
- Surface water, mean in U.S. samples, 2020–2022: 21.9 µg/L
- Drinking water range: <5–53,200 µg/L

#### *Soil and Sediment*

- Soil, background levels: 2–50 ppm; mean in U.S. samples 2020–2022: 2,545 ppm
- Sediment, mean in U.S. samples, 2020–2022: 397 ppm

### Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2024. Toxicological Profile for Copper. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

U.S. Department of Health and  
Human Services  
Public Health Service  
Agency for Toxic Substances  
and Disease Registry  
[www.atsdr.cdc.gov](http://www.atsdr.cdc.gov)



**ATSDR**  
AGENCY FOR TOXIC SUBSTANCES  
AND DISEASE REGISTRY

## 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, and alloying ability, and is malleable.
- Copper occurs naturally in elemental form, is classified as a transition metal in Group 11 of the periodic table, 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 is 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.
- Soluble copper exists primarily in ionic form in water and is weakly associated with water molecules. In water, copper salts can dissolve or bind to particulate matter or various organic and inorganic chemicals in water depending on conditions such as temperature, pH, and solubility of the copper salt.
- 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, 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- ( $\leq 14$  days), intermediate- (15-364 days), or chronic-duration ( $\geq 365$  days) inhalation MRLs were derived for copper.

#### *Oral*

- An acute-duration oral MRL of 0.02 mg Cu/kg/day was derived for copper.
- An intermediate-duration oral 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.

- 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.
- Rats inhaling copper particles for acute and intermediate durations exhibited effects on the respiratory tract.
- Acute- and intermediate-duration oral exposure studies in animals report hepatic, renal, hematological, neurological, and reproductive effects.
- *In vivo* studies suggest that copper sulfate is genotoxic to mammalian cell lines.
- The Department of Health and Human Services (HHS), the International Agency for Research on Cancer (IARC), and the U.S. Environmental Protection Agency (EPA) have not classified copper regarding its carcinogenicity.

### Children's Health

- Children exposed to copper in drinking water may experience effects similar to those expected in adults.