

Sources of Exposure

Toxicokinetics and Biomonitoring

Biomarkers/Environmental Levels

General Populations

- The most important source of exposure to chlorodibenzofurans (CDFs) for the general population is food containing CDFs. The highest concentrations are found in meat, fish, and dairy products.
- Groups consuming high amounts of fatty fish may be exposed to higher levels of CDFs.
- Ambient air, drinking water, and consumer products are considered minor sources of CDF exposure.
- People living near incinerators or uncontrolled landfill sites with fires may be exposed to higher levels of CDFs.

Occupational Populations

- Workers in sawmills, textile industry, leather industry, certain chemical manufacturing, polychlorinated biphenyl (PCB) user industries (repairing transformers or capacitors, using casting waxes containing PCBs), and at incinerators may be exposed to higher than background levels of CDFs.
- Workers in the hazardous waste industry or first responders to incidents where CDFs may have been released (e.g., World Trade Center first responders) may be exposed to higher levels than the general population.

Toxicokinetics

- Over 90% of ingested CDFs is absorbed. CDFs are also absorbed following inhalation and dermal exposure; however, the percent absorption of CDFs for these exposure routes has not been quantified.
- CDFs are lipid soluble and tend to accumulate in tissues with high lipid content. The highest amounts are found in the liver and adipose tissue.
- CDFs are metabolized by the inducible CYP450 enzyme system.
- The major pathways of excretion of absorbed CDFs are feces and urine. Studies conducted in animals have shown that feces are the dominant pathway for excretion of absorbed CDFs via biliary excretion.

NHANES Biomonitoring

The weighted arithmetic mean of pooled blood samples (National Health and Nutrition Examination Survey [NHANES] 2009–2010) were 0.487–0.569 pg/g lipid for 2,3,7,8-tetraCDF, 1.23–9.52 pg/g lipid for 2,3,4,7,8-pentaCDF, 1.10–6.00 pg/g lipid for 1,2,3,4,7,8-hexaCDF, 1.47–5.43 pg/g lipid for 1,2,3,6,7,8-hexaCDF, 0.404–1.52 pg/g lipid for 2,3,4,6,7,8-hexaCDF, and 4.96–9.87 pg/g lipid for 1,2,3,4,6,7,8-heptaCDF. The proportions of results below the detection limit were too high to calculate means for 1,2,3,7,8-pentaCDF, 1,2,3,7,8,9-hexaCDF, 1,2,3,4,7,8,9-heptaCDF, and octaCDF.

Biomarkers

- Levels of CDF congeners can be measured in blood, body fat, and breast milk. Levels of CDFs in serum and adipose tissue are believed to be representative of body burden.

Environmental Levels

Air

- Between 1998 and 2004, air levels were 1.5–6.4 fg/m³ for 2,3,7,8-tetraCDF, 1,2,3,7,8-pentaCDF, 2,3,4,7,8-pentaCDF, 1,2,3,4,7,8-hexaCDF, and 1,2,3,4,7,8,9-heptaCDF and 21.9–27.3 fg/m³ for 1,2,3,4,6,7,8-heptaCDF and octaCDF.

Water

- The concentrations of CDFs in most waters are below the detection limit.

Sediment and Soil

- Total pentaCDFs, hexaCDFs, heptaCDFs, and octaCDFs in river sediment ranged from 12 to 30 ppt. 2,3,7,8-TetraCDF levels in river sediment ranged from 5 to 97 ppt.
- Soil levels of CDFs ranged from not detected to 180 ppt.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2023. Toxicological Profile for Chlorodibenzofurans. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

ToxGuide™ for Chloro- dibenzofurans (CDFs)

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Chemical and Physical Information

Routes of Exposure

Relevance to Public Health (Health Effects)

CDFs are Solids

- CDFs are a class of structurally similar chlorinated hydrocarbons containing two benzene rings fused to a central furan ring. Based on the number of chlorine atoms (one to eight) on the parent chemical, dibenzofuran, there are 135 possible types of CDFs, which are called congeners.
- CDFs are not manufactured commercially in the United States or any other country except on a very small scale for use in chemical laboratories or for toxicological studies.
- They are produced as undesired byproducts during the manufacture of various compounds. Thermal reactions, such as during municipal waste incineration and the incineration of industrial and hazardous waste, also result in the formation of CDFs.

- Inhalation – Minor route of exposure for the general population.
- Oral – Most likely route of exposure for the general population through ingestion of contaminated food.
- Dermal – Relevant route of exposure for the general and occupational populations.

CDFs in the Environment

- Biodegradation occurs slowly for higher chlorinated CDFs. They are considered to be persistent in the environment.
- CDFs have large soil adsorption coefficients and possess low mobility in soil surfaces.
- CDFs in water are predominantly adsorbed to suspended solids and sediment.
- The CDFs with more chlorine atoms are more likely to bioconcentrate in aquatic organisms.

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-, intermediate-, or chronic-duration inhalation MRLs were derived for CDFs.

Oral

- An intermediate-duration (15–364 days) oral MRL of 0.007 µg/kg/day was derived for 1,2,3,7,8-pentaCDF.
- An acute-duration (≤14 days) oral MRL of 5×10^{-4} µg/kg/day was derived for 2,3,4,7,8-pentaCDF.
- An intermediate-duration (15–364 days) oral MRL of 7×10^{-6} µg/kg/day was derived for 2,3,4,7,8-pentaCDF.
- A chronic-duration (≥365 days) oral MRL of 4×10^{-6} µg/kg/day was derived for 2,3,4,7,8-pentaCDF.
- An intermediate-duration (15–364 days) oral MRL of 0.005 µg/kg/day was derived for 1,2,3,6,7,8-hexaCDF.

Health Effects

- The toxicity of CDF congeners depends on the number and position of the chlorine atoms. Congeners with chlorines in the 2,3,7,8- position are the most toxic.

Health Effects (*cont'd*)

- Humans exposed to high levels of CDFs in contaminated cooking oil had numerous health effects including persistent acneiform eruptions, skin hyperpigmentation, increased susceptibility to respiratory infections, and neurological signs and symptoms.
- Most of the information on the toxicity of CDFs in laboratory animals comes from studies of 2,3,4,7,8-pentaCDF and 2,3,7,8-tetraCDF.
- Liver effects (increases in liver weight, lipid accumulation, and hypertrophy), pronounced decreases in thymus weight and/or thymic atrophy, decreases in serum thyroxine levels, fetal mortality, and birth defects (hydronephrosis and cleft palate) have been observed in animals orally exposed to CDFs.
- The International Agency for Research on Cancer (IARC) concluded that 2,3,4,7,8-pentaCDF is carcinogenic to humans (Group 1) and that 2,3,7,8-tetraCDF and 1,2,3,4,7,8-hexaCDF are not classifiable as to their carcinogenicity to humans (Group 3). The Department of Health and Human Services (HHS) and U.S. Environmental Protection Agency (EPA) have not conducted carcinogenicity assessments for CDFs.

Children's Health

- Children exposed to CDFs had similar effects as adults.
- It is not known if children are more sensitive to the toxicity of CDFs than adults.