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# Dioxins

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## Key facts

- Dioxins are a group of chemically related compounds that are persistent environmental pollutants (POPs).
- Dioxins are found throughout the world in the environment and they accumulate in the food chain, mainly in the fatty tissue of animals.
- More than 90% of human exposure is through food, mainly meat and dairy products, fish and shellfish. Many national authorities have programmes in place to monitor the food supply.
- Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer.
- All people have background exposure to dioxins, which is not expected to affect human health. However, due to the highly toxic potential, efforts are needed to reduce current background exposure.
- Prevention or reduction of human exposure is best done via source-directed measures, i.e. strict control of industrial processes to reduce formation of dioxins.

## Overview

Dioxins are environmental pollutants. They belong to the so-called dirty dozen – a group of dangerous chemicals known as persistent organic pollutants (POPs). Dioxins are of concern because of their highly toxic potential. Experiments have shown they affect several organs and systems.

Once dioxins enter the body, they last a long time because of their chemical stability and their ability to be absorbed by fat tissue, where they are then stored in the body. Their half-life in the body is estimated to be 7 to 11 years. In the environment, dioxins tend to accumulate in the food chain. The higher an animal is in the food chain, the higher the concentration of dioxins.

The chemical name for dioxin is 2,3,7,8-tetrachlorodibenzo para dioxin (TCDD). The name dioxins is often used for the family of structurally and chemically related *polychlorinated dibenzo para dioxins (PCDDs)* and *polychlorinated dibenzofurans (PCDFs)*. Certain dioxin-like polychlorinated biphenyls (PCBs) with similar toxic properties are also included under the term dioxins. Some 419 types of dioxin-related compounds have been identified but only about 30 of these are considered to have significant toxicity, with TCDD being the most toxic.

## Sources of contamination

Dioxins are mainly by-products of industrial processes but can also result from natural processes, such as volcanic eruptions and forest fires. They are unwanted by-products of many manufacturing processes including smelting, chlorine bleaching of paper pulp and the manufacture of some herbicides and pesticides. Uncontrolled waste incinerators (solid waste and hospital waste) are often the worst culprits of environmental release due to incomplete burning. Technology is available that allows for controlled waste incineration with low dioxin emissions.

Although formation of dioxins is local, environmental distribution is global. The highest levels are found in some soils, sediments and food, especially dairy products, meat, fish and shellfish. Very low levels are found in plants, water and air.

Extensive stores of PCB-based waste industrial oils, many with high levels of PCDFs, exist throughout the world. Long-term storage and improper disposal of this material may result in dioxin release into the environment and the contamination of human and animal food supplies. PCB-based waste is not easily disposed of without contamination of the environment and human populations. Such material needs to be treated as hazardous waste and is best destroyed by high temperature incineration in specialized facilities.

## Contamination incidents

Many countries monitor their food supply for dioxins. This has led to early detection of contamination and has often prevented larger impacts. In many instances dioxin contamination is introduced via contaminated animal feed, e.g. incidences of increased

dioxin levels in milk or animal feed were traced back to clay, fat or citrus pulp pellets used in the production of the animal feed.

Although all countries can be affected, most contamination cases have been reported in industrialized countries where adequate food contamination monitoring, greater awareness of the hazard and better regulatory controls are available.

## Effects on human health

Short-term exposure of humans to high levels of dioxins may result in skin lesions, such as chloracne and patchy darkening of the skin, and altered liver function. Long-term exposure is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions.

Chronic exposure of animals to dioxins has resulted in several types of cancer. TCDD was evaluated by the WHO's International Agency for Research on Cancer (IARC) in 1997 and 2012. Based on animal and human epidemiology data, TCDD was classified by IARC as a known human carcinogen. However, TCDD does not affect genetic material and there is a level of exposure below which cancer risk would be negligible.

Due to the omnipresence of dioxins, all people have background exposure and a certain level of dioxins in the body, leading to the so-called body burden. Current normal background exposure is not expected to affect human health on average. However, due to the high toxic potential of this class of compounds, efforts are needed to reduce current background exposure.

The developing fetus is most sensitive to dioxin exposure. Newborns, with rapidly developing organ systems, may also be more vulnerable to certain effects. Some people or groups of people may be exposed to higher levels of dioxins because of their diet (such as high consumers of fish in certain parts of the world) or their occupation (such as workers in the pulp and paper industry, in incineration plants, and at hazardous waste sites).

## Prevention and control

Proper incineration of contaminated material is the best available method of preventing and controlling exposure to dioxins. It can also destroy PCB-based waste oils. The incineration process requires temperatures over 850 °C. For the destruction of large amounts of contaminated material, temperatures of 1000 °C or more are required.

Prevention or reduction of human exposure is best done via source-directed measures, i.e. strict control of industrial processes to reduce formation of dioxins as much as possible. This is the responsibility of national governments. The Codex Alimentarius Commission adopted a Code of Practice for Source Directed Measures to Reduce Contamination of Foods with Chemicals (CAC/RCP 49-2001) in 2001. In 2006 a Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Food and Feeds (CAC/RCP 62-2006) was adopted.

More than 90% of human exposure to dioxins is through the food supply, mainly meat and dairy products, fish and shellfish. Therefore, protecting the food supply is critical. In addition to source-directed measures to reduce dioxin emissions, secondary contamination of the food supply needs to be avoided throughout the food chain. Good controls and practices during primary production, processing, distribution and sale are all essential in the production of safe food. Contaminated animal feed is often the root cause of food contamination.

Food and feed contamination monitoring systems must be in place to ensure that tolerance levels are not exceeded. It is the responsibility of feed and food producers to assure safe raw materials and processes during production, and it is the role of national governments to monitor the safety of food supply and to take action to protect public health. When contamination is suspected, countries should have contingency plans to identify, detain and dispose of contaminated feed and food. The affected population should be examined for exposure (for example, measuring the contaminants in blood or human milk) and effects (for example, clinical surveillance to detect signs of ill health).

## **What should consumers do to reduce their risk of exposure?**

Trimming fat from meat and consuming low fat dairy products may decrease the exposure to dioxin compounds. Also, a balanced diet (including adequate amounts of fruits, vegetables and cereals) will help to avoid excessive exposure from a single source. This is a long-term strategy to reduce body burdens and is probably most relevant for girls and young women to reduce exposure of the developing fetus and when breastfeeding infants later in life. However, the possibility for consumers to reduce their own exposure is limited.

# Measuring dioxins in the environment and food

The quantitative chemical analysis of dioxins requires sophisticated methods that are available only in a limited number of laboratories around the world. The analysis costs are very high and vary according to the type of sample.

Increasingly, biological (cell- or antibody based) screening methods are being developed, and the use of such methods for food and feed samples is increasingly being validated. Such screening methods allow more analyses at a lower cost, and in case of a positive screening test, confirmation of results must be carried out by more complex chemical analysis.

## WHO response

In 2015, WHO published the first estimates of the global burden of foodborne disease. Exposure to dioxins was shown to contribute significantly to foodborne disease burden globally, specifically on fertility and on thyroid function.

WHO has held a series of expert meetings to determine a tolerable intake of dioxins. In 2001, the Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA) performed an updated comprehensive risk assessment of PCDDs, PCDFs, and dioxin-like PCBs.

WHO, in collaboration with FAO, through the Codex Alimentarius Commission, established a Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Foods and Feed. This document gives guidance to national and regional authorities on preventive measures.

WHO has established and regularly re-evaluated toxic equivalency factors (TEFs) for dioxins and related compounds through expert consultations. The last update of the WHO TEF values was done in 2022. WHO-TEF values have been established which apply to humans, mammals, birds and fish.

- Exposure to dioxins and dioxin-like substances