Volume X. Appendices

G. Dioxin: Environmental Occurrence, Exposure, & Effects on Human Health, Fact Sheet

Dioxin: Environmental Occurrence, Potential Exposures, and Effects on Human Health

1. What are dioxins?

The name dioxin is used for the family of structurally related chemicals called polychlorinated dibenzo-para-dioxins (sometimes referred to as PCDDs or chlorinated dioxins or dioxins) and polychlorinated dibenzofurans (sometimes referred to as PCDFs or chlorinated furans or furans). This family includes 75 individual compounds referred to as dioxin congeners, and 135 individual compounds referred to as furan congeners. The most toxic chemical in this family, called 2,3,7,8-TCDD, is widely recognized as the most toxic of the dioxins.

Throughout this Fact Sheet, the term "dioxins" refers to the family of chemicals known as PCDDs and PCDFs.

2. Do all dioxins possess similar environmental and toxicological properties?

No. There is general agreement among scientists that the environmental fate of dioxins and their toxicity in humans and animals vary widely. The degree to which dioxins persist in the environment varies with the different congeners. The higher chlorinated dioxins and furans, such as those that occur in Sierra-Crete®, are generally less persistent than 2,3,7,8-TCCD and other less chlorinated dioxin congeners. Furthermore, there is a significant body of scientific information indicating that some of the most common dioxins and furans found in the environment are significantly less toxic than 2,3,7,8-TCDD. While most toxicological studies focus on 2,3,7,8-TCDD, the few studies focused on the congeners that occur in Sierra-Crete® indicate that these higher chlorinated furans are less capable of eliciting toxic effects in humans and animals.

3. What are dioxin TEQs, and why is this important?

Among the 210 congeners that comprise the family of dioxins, 17 of these congeners are generally recognized by scientists as capable of eliciting a toxic response in animals and people. The structure of each of the 17 dioxin congeners includes a basic chemical ring structure with one or more chlorine atoms attached. The toxicity of the different dioxins is largely determined by the position and number of chlorine atoms on the molecule.

Because the majority of toxicological studies have been conducted with 2,3,7,8-TCDD and relatively few studies have been conducted for most of the other congeners, the toxicity of different dioxins are calculated using a toxic equivalency (TEQ) system. The World Health Organization (WHO), and the U.S. Environmental Protection Agency (USEPA) have adopted the TEQ system to estimate the potential effects of environmental samples that contain individual dioxin congeners.

Each of the seventeen 2,3,7,8-substituted dioxin congeners has been assigned a toxicity equivalence factor (TEF) value by the WHO. TEFs are estimates of the toxicity of different dioxin congeners *as compared to* the toxicity of 2,3,7,8-TCDD, which has been assigned a TEF value of one. For example, some of the most common dioxin congeners found in Sierra-Crete®, are considered to be 10,000 times less toxic than 2,3,7,8-TCDD, and hence have a TEF value of 0.0001.

Laboratories report the concentrations of dioxins in environmental samples as total dioxin toxic equivalents (sometimes referred to as "Total TEQs"). The total TEQs in an environmental sample are determined by a dioxin testing laboratory in three simple steps. First, the laboratory measures the concentration of each individual dioxin congener using sophisticated analytical instruments. Then, the laboratory multiplies the measured concentration of the individual congener by its corresponding TEF to produce a TEQ for each congener. Finally, the laboratory adds together the TEQs for each of the 17 dioxin congeners to determine the total dioxin TEQ concentration in the sample.

4. Where do dioxins come from?

Dioxins are formed by a variety of man-made and natural processes. Dioxins are by-products of a wide range of industrial processes formed when thermal processes produce chlorine-containing organic substances. Such processes include smelting, bleaching of paper pulp and the manufacturing of some herbicides and pesticides. Other major sources include production of iron and steel, backyard burning of household waste, wood burning, burning fuel for home heating, and electrical power generation. In terms of dioxin release into the environment, municipal solid waste incinerators are among the largest sources. Dioxins are formed during wastewater and drinking water treatment. Dioxins also result from natural processes, such as volcanic eruptions and forest fires.

5. What happens to dioxins when they enter the environment?

Dioxins are persistent, long-lived chemicals and do not readily degrade in the environment. When released into the air bound to particles, dioxins may be transported long distances, even around the globe. When released to rivers and streams through wastewater discharges, dioxins attach to particulate matter and settle to bottom sediments. When deposited to soil or bottom sediments, dioxins may build up in the food chain (e.g., in fish, beef cattle, chickens, dairy cows and other farm animals), resulting in measurable levels in a variety of foods and beverages.

6. What does it take to identify and measure dioxins in the environment?

The analysis of dioxins requires sophisticated methods that are available only in a limited number of laboratories around the world. The U.S. EPA has established a laboratory testing protocol to ensure that appropriate and consistent test procedures are followed. About 100 laboratories are able to analyze dioxins in environmental samples (e.g. ashes, soil, or water) and in food, but about 20 laboratories in the world are able to reliably measure dioxins in biological materials (e.g. human blood or milk). The costs for dioxin testing vary according to the type of sample, but costs of testing typically range between $1,200 and $2,000 per sample.

7. How might a person be exposed to dioxins?

Dioxins are ubiquitous in the environment, and can be found virtually everywhere. These substances work their way up the food chain by dissolving and remaining stored in the body fat of fish and animals. Because of this, the single largest source of exposure to dioxins is through the consumption of food, primarily meat, dairy products, and fish. According to the U.S. EPA, more than 90% of a person's average daily intake of dioxins is from the diet. Other sources include breathing dioxin-containing particles from the air and drinking unfiltered water. Skin contact with certain pesticides and herbicides can be another source of exposure. Living near solid waste incinerators releasing dioxins is another recognized sources of exposure.

8. How can dioxins effect a person's health?

The health risks from exposure to any chemical substance depends on a number of factors, including the dose, the duration of exposure, how a person is exposed, a person's general health condition, behavior and eating habits, smoking preference, and whether other chemicals are present.

According to the latest available scientific information, current levels of dioxins in the food supply, air, water and soil are so low that they pose no health threat to most people.

The most noted health effect in people exposed to large amounts of the most toxic form of dioxins, 2,3,7,8-TCDD, is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8-TCDD include skin rashes, discoloration, and excessive body hair. Changes in blood and urine that may indicate liver damage also are seen in highly exposed people.

A wide range of health effects have been observed in laboratory animals that have been exposed to dioxins. However, it is widely recognized by scientists that experimental animals appear to be more seriously effected by exposure to dioxins than are people.

9. How likely are dioxins to cause cancer?

Several studies suggest that exposure to the most toxic form of dioxins, 2,3,7,8-TCDD, increases the risk of cancer in people. Animal studies have also shown an increased risk of cancer from exposure to 2,3,7,8-TCDD. To date, few studies have been conducted to determine if exposure to dioxins other than 2,3,7,8-TCDD increases the risk of cancer in people. Based on human epidemiology data, the World Health Organization (WHO) has determined that only 2,3,7,8-TCDD is a human carcinogen. In the United States, the Department of Health and Human Services (DHHS) and U.S. EPA have determined that 2,3,7,8-TCDD may reasonably be anticipated to cause cancer. However, it is widely recognized by scientists, WHO, and U.S. EPA that dioxins do not affect genetic material and there is a level of exposure below which cancer risk would be negligible.

10. How can dioxins affect children?

Very few studies have examined the effects of dioxins on children. Chloracne has been seen in children exposed for short periods of time to high levels of dioxins. Scientists don't fully understand if dioxins affect the ability of people to have children or if it causes birth defects.

11. How can families reduce the risk of exposure to dioxins?

Though speculative at best due to the variable nature of dioxin's occurrence in the environment, families may reduce their risks of exposure through trimming fat from meat, consuming low-fat dairy products, and cooking food. Limiting the amount of fish, particularly fatty fish, in the diet also may eventually decrease a person's body burden of dioxins. Eating a balanced diet (including adequate amounts of fruits, vegetables and cereals) will help to avoid excessive exposure from a single source. In addition to diet, families should discourage their children from eating dirt or putting plastic and painted toys or other objects in their mouths. Everyone should wash their hands frequently if playing or working outdoors, handling household pesticides and herbicides, paints, and other chemicals.

12. Is there a medical test to show whether a person has been exposed to dioxins?

Tests are available to measure dioxin levels in body fat, blood, and breast milk, but these tests are not routinely available and are very expensive. Most people have low levels of dioxins in their body fat and blood. According to the U.S. EPA and scientists involved in monitoring for dioxins and other several other chemicals commonly found in the human body, the concentrations of dioxins in blood and body fat in the U.S. population can be as high as 30 to 40 parts per trillion. The average background concentration of dioxins in blood in adults in the United States is 22 parts per trillion. Although dioxins stay in body fat for a long period of time, medical tests cannot be used to determine when exposure occurred.

13. Has the federal government made recommendations to protect human health?

The U.S. EPA has set a limit of 0.00003 micrograms of 2,3,7,8-TCDD per liter of drinking water (0.00003 µg/L). The Food and Drug Administration (FDA) recommends against eating fish and shellfish with levels of 2,3,7,8-TCDD greater than 50 parts per trillion (50 ppt). For residential properties where dioxin is a chemical of concern in soil, the U.S. EPA and the California Department of Toxic Substances Control (DTSC) have required cleanup when levels exceed 1,000 ppt.

14. Where can a person learn more about dioxins?

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. Toxicological Profile for Chlorinated Dibenzo-p-dioxins (CDDs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Control Registry (ATSDR). 1999. ToxFAQs™ for Chlorinated Dibenzo-p-dioxins(CDDs). February. http://www.atsdr.cdc.gov/tfacts104.html

Health Canada. 2001. It's Your Health – Dioxins and Furans. November. http://www.hc-sc.gc.ca/english/iyh/dioxins.html

U.S. EPA and The InterAgency Working Group on Dioxins. 2000. Questions and Answers About Dioxins. July. http://www.epa.gov/ncea/pdfs/dioxin/dioxin%20questions%20and%20answers.pdf

U.S. EPA. 2001. Summary of the Dioxin Reassessment Science, Information Sheet 1. May. http://www.epa.gov/ncea/pdfs/dioxin/factsheets/dioxin_short2.pdf

U.S. EPA. 2001. Scientific Highlights from Draft Reassessment (2000), Information Sheet 2. May. http://www.epa.gov/ncea/pdfs/dioxin/factsheets/dioxin_long2.pdf

U.S. EPA. 2001. The Dioxin Reassessment Process, Information Sheet 3. May. http://www.epa.gov/ncea/pdfs/dioxin/factsheets/dioxin_proc2.pdf

U.S. EPA. 2000. Dioxins: Summary of Major EPA Control Efforts, Information Sheet 4. June. http://www.epa.gov/ncea/pdfs/dioxin/factsheets/dioxin_regs.pdf

U.S. EPA. 2000. Draft Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. http://www.epa.gov/ncea/pdfs/dioxin/part1and2.htm

World Health Organization (WHO). 1999. "Dioxin and Their Affects on Human Health' Fact Sheet 225. June. http://www.who.int/inf-fs/en/fact225.html