WASHINGTON STATE DEPARTMENT OF ECOLOGY

Hazards of Dioxins

Hazardous Waste & Toxics Reduction Program *Publication Number #01-04-010*

What Are Dioxins?

The term "dioxin" refers to a group of chemical compounds sharing certain similar structures and biological characteristics (EPA, 2000a). Dioxin compounds are not created intentionally, but are formed inadvertently by a number of human and natural activities. These activities include combustion and incineration, forest fires, chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing, and other industrial processes (EPA, 2000a).

Burning materials that may contain chlorine such as plastics, wood treated with pentachlorophenol (PCP), pesticide-treated wastes, other chemicals such as polychlorinated biphenols (PCBs), and even bleached paper can produce dioxins (ATSDR, 1998). Cigarette smoke, some home-heating systems, and exhaust from vehicles using leaded and unleaded gasolines as well as diesel fuels also produce small amounts of dioxins (ATSDR, 1998; EPA, 2000b).

Background Information

Many forms of dioxin exist. One form, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) is considered the most toxic form. It is also the most studied form. Toxic equivalents (TEQs) are used to describe the toxicity of 16 other forms relative to 2,3,7,8-TCDD.

Dioxins and similar compounds are usually released in relatively low concentrations (e.g., parts per trillion or parts per quadrillion), but because they are very persistent, they remain in the environment and can accumulate in the tissues of animals. The environmental fate and transport of dioxins include many processes, including volatilization and long-range transport (ATSDR, 1998). Dioxins are everywhere in the environment. Industrialized urban regions usually have higher concentrations than less industrialized rural regions (ATSDR, 1998).

Dioxins strongly adhere to soils and sediments; their low vapor pressure, low water solubility, and strong ability to adhere to particulates generally ensures their immobility in soils and sediments (ATSDR, 1998). In a screening survey of Washington soils, mean dioxin concentrations were found to be 4.1, 2.3, 1.0, and 0.14 pptr TEQ for urban, forest, open, and agricultural soils, respectively (Rogowski & Yake, 1999). For comparison, EPA (2000c) recently reported mean dioxin concentrations of 3.6 pptr TEQ for rural soils and 11.9 pptr TEQ for urban soils in North America.

Dioxins and dioxin-like compounds are different from traditional contaminants regulated by the Department of Ecology (Ecology) because of their physical and chemical characteristics. Environmental regulations were originally designed to address pollutants that enter the environment in high concentrations and are diluted or broken down fairly quickly. Dioxins and other similar persistent, bioaccumulative, and toxic compounds usually enter the environment in small quantities and, because they don't break down, build up in the environment. Regulators are exploring different approaches to control these persistent, bioaccumulative, and toxic pollutants.

EPA estimates that most dioxin exposure occurs through the diet (EPA, 2000a). Small exposures occur from breathing air with trace amounts of dioxin on particles and in vapor form, from inadvertent ingestion of soil containing dioxin, and from absorption through skin contacting air, soil, or water. EPA believes the consumption of meat, fish, and dairy products is the primary pathway of human dioxin exposure (EPA, 1994).

Ecology's Proposed PBT Strategy

Persistent, bioaccumulative, and toxic chemicals (PBTs) are substances that can build up to levels that can be harmful to human and ecological health. These contaminants may travel long distances in the atmosphere and can move readily from land to air and water. They do not break down easily because of their persistence and tend to bioaccumulate in animals. PBT chemicals include man-made and naturally occurring substances.

Ecology has developed a PBT strategy that proposes to continually reduce, and where possible, eliminate releases of persistent, bioaccumulative and toxic chemicals into the state's environment (air, land, and water). Dioxins are included in the proposed strategy's list of PBT chemicals. (Gallagher, 2000)

Ecology recognizes that the decision to develop and implement this strategy is not one the department should or can make on its own. The decisions of how to reduce PBTs and what steps to take will involve many interested parties and encompass economic and public policy concerns.

Dioxins Persist in the Environment and Animals

Persistence is the resistance of chemicals to decompose. A measure of persistence is the time required for 50% of the compound to decompose or degrade through chemical, biochemical, and photochemical processes (half-life). Half-life estimates for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2, 3, 7, 8-TCDD) on surface soil range from 9-15 years, whereas the half-life in subsurface soil may range from 25 to 100 years (ATSDR, 1998).

For people, the average time to remove half of the 2,3,7,8-TCDD from the body is highly variable and may take from 7 to 12 years (ATSDR, 1998). Although 2,3,7,8-TCDD can be found in all tissues, highest concentrations are generally found in the liver and fat tissues (ATSDR, 1998).

Dioxins Bioaccumulate in Animals

Bioaccumulation is the accumulation of chemicals in organisms from the surrounding environment through absorption, ingestion, and inhalation (Environment Canada, 1994). Dioxins dissolve more easily or are more attracted to oily or fatty compounds than water. Because of this, they are more prevalent in animals with body fat, soils, and sediments than they are in water.

Dioxins may also be transported long distances in the global atmospheric circulation toward the polar regions of the earth, due to volatilization and cold condensation properties (Carey et al, 1998). In other words, warm air currents tend to rise, carrying the particles that vaporize easily in the warmer climates. The particles travel to the cooler climates, sinking back to earth as they arrive in the colder, polar regions.

Animals in cooler regions (e.g., oily, cold water fish such as salmon, cod, and halibut and mammals such as polar bears, seals, and whales) tend to have high levels of body fat to insulate themselves from the cooler temperatures and, therefore, bioaccumulate persistent organic pollutants, including dioxins.

Dioxin levels in the United States have been declining for the past 30 years due to reductions in man-made sources. However, they break down so slowly that dioxins from past releases will still be in the environment many years from now. Although dioxin levels in our bodies should continue to decline, levels are likely to remain elevated for years because of the significant role of the dioxins that remain in the environment from past releases (e.g., reservoir sources), (EPA, 2000b).

Dioxins are Toxic to Humans and Wildlife

Dioxins are very toxic to animals with the potential to produce a broad spectrum of adverse effects in humans. Dioxins can alter the fundamental growth and development of cells in many ways. For example (EPA, 2000a), dioxins may:

- cause cancer,
- disrupt the endocrine system, and
- cause reproductive and developmental effects.

Concerns about dioxins are often centered on immediate effects (acute) rather than long-term effects (chronic). Fetuses, infants, and children may be more sensitive to dioxin exposure because of their rapid growth and development. Data on risks to children are limited, however, and it is not known if children in the general population are experiencing adverse effects from dioxin (EPA, 2000a). Based on data from animal studies, exposure to low levels of dioxins over long periods (or high level exposures at sensitive times) might weaken the immune system (EPA, 2000b).

Cancer

EPA (2000c) characterizes 2,3,7,8-TCDD as a "human carcinogen" based on the weight of evidence of animal and human studies and characterizes other dioxin-like compounds (i.e., other dioxin-like chlorinated dibenzo-p-dioxins [CDDs] and chlorinated dibenzofurans [CDFs], and dioxin-like polychlorinated biphenyls [PCBs]) as "likely human carcinogens." The US Department of Health and Human Services determined that "it is reasonable to expect that 2,3,7,8-TCDD may cause cancer" (ATSDR, 1998). The International Agency for Research on Cancer determined that 2,3,7,8-TCDD is a "known human carcinogen" (IARC, 1997).

Endocrine, Reproductive, And Developmental Effects

The endocrine system is responsible for chemical communication and coordination throughout the body (ATSDR, 1998). Certain chemicals, such as dioxins, may disrupt this system. These chemicals are called "endocrine disruptors" because they may mimic natural hormones, inhibit the action of hormones, or alter the normal regulatory function of the immune, nervous, and endocrine systems (EPA, 1997).

Possible human health effects associated with endocrine disruption may include breast cancer and endometriosis in women, testicular and prostate cancers in men, abnormal sexual development, reduced male fertility, alteration in pituitary and thyroid gland functions, immune suppression, and neurobehavioral effects (EPA, 1997). Although birth defects have been observed in animals (developing animals are especially sensitive) exposed to higher than background levels of 2,3,7,8-TCDD, human birth defects resulting from exposure to dioxins currently cannot be confirmed (ASTDR, 1998).

Nursing human infants are potentially a highly exposed population. EPA (1994) noted that an infant nursing for one year *could* ingest higher dioxin concentrations than what the estimated adult normally ingests (e.g., background exposure). However, the total amount the infant may ingest during nursing would be small compared to the expected average lifetime dose.

Although breast milk appears to be a significant source of dioxin exposure to nursing infants, the overwhelming body of evidence supports the health benefits of breast feeding despite the potential presence of dioxin (EPA, 2000a; ATSDR 1998).

Possible wildlife health effects that may be due to endocrine disruption from dioxins and similar chemicals such as PCBs, DDT, and some pesticides include (EPA, 1997):

- decreased fertility in shellfish, fish, birds, and mammals;
- decreased hatching success in fish, birds, and reptiles;
- decreased offspring survival; and
- alteration of immune and behavioral function in birds and mammals.

Studies (Raloff, 1997; Zabel & Peterson, 1996) show that dioxins and similar substances can exert sub-lethal and lethal effects on very young lake trout, secondary to a disease called "blue sac syndrome," if present in lake trout eggs.

What is being done?

Concern about dioxins in the environment is receiving worldwide attention. The United Nation's Environmental Program has identified 12 persistent organic pollutants (POPS), including dioxins, and recently finalized global treaty negotiations to reduce and ban these pollutants. Several European countries were in the news in the last year because of dioxin contaminated food.

EPA has completed a draft strategy to reduce and eliminate dioxins and has listed dioxins in their list of targeted PBTs. They also recently completed a 12-year study on dioxins, concluding that dioxins are more toxic than previously thought.

Ecology's Hazardous Waste and Toxics Reduction Program has been working on many projects to reduce and eliminate dioxins. In the past few years, the program has sponsored or co-sponsored projects assessing dioxin in Washington State (*Dioxin Source Assessment and Waste in Fertilizer Study*). Current or future projects include the following:

- a plan for managing cement kiln dust
- standards for using steel mill flue dust in fertilizers
- dioxin screening of waste-derived and micronutrient fertilizers
- a plan for improved management of wood-fired boiler ash
- assisting dairy farmers with replacing mercury manometers with non-mercury manometers
- working with the agency's PBT Committees to reduce and eliminate these pollutants where possible.

It is anticipated that these strategies will support the overall goal of reduction of dixoins in the environment.

Contact Information

For additional information please contact Stacie Singleton at (360) 407-6753 (E-mail address *ssin461@ecy.wa.gov*) or Damon Delistraty at (509) 456-6362 (E-mail address *ddel461@ecy.wa.gov*). For information on the overall revision to the *Dangerous Waste Regulations*, contact Chipper Hervieux at (360) 407-6756 (E-mail address pher461@ecy.wa.gov). If you need materials in an alternative format, contact Stacie Singleton at (360) 407-6753 or (360) 407-6006 (TDD).

References

ATSDR, 1998. Draft Update Toxicological Profile for Chlorinated Dibenzo-*p*-dioxins. Prepared by Research Triangle Institute for U.S. Department of Health and Human Services, Agency for Toxic Substances Disease Registry (ATSDR), Atlanta, GA. 677 pp + appendices.

Carey, C., P. Cook, J. Giesy, P. Hodson, D. Muir, W. Owens, and K. Solomon (eds.). 1998. Ecotoxicological risk assessment of the chlorinated organic chemicals. SETAC Press, Pensacola, FL.

Environment Canada. 1994. Criteria for the Selection of Substances for Virtual Elimination: Final Report of the ad hoc Science Group on Criteria. September 15, 1994. 25 pp.

EPA, 1994. Estimating Exposure to Dioxin-like Compounds, Vol. 1. U.S. Environmental Protection Agency, Washington, D.C. EPA/600/6-88/055Ca.

EPA, 1997. Special Report on Environmental Endocrine Disruption: An Effects Assessment and Analysis. U.S. Environmental Protection Agency. EPA/630/R-96/012. Feb. 1996. Prepared for Risk Assessment Forum, EPA, Washington, D.C. 111 pp.

EPA, 2000a. Information Sheet 1: Dioxin: Summary of the Dioxin Reassessment Science. U.S. Environmental Protection Agency. Office of Research and Development. June 12. 2 pp.

EPA, 2000b. Questions and Answers About Dioxins, July 2000. Internet address: *<http://www.epa.gov/ncea/pdfs/dioxin/dioxin%20questions%20and%20answers.pdf>*

EPA. 2000c. Draft exposure and health reassessment of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and related compounds. EPA/600/P-00/001Ab-Ae, Ag. Environmental Protection Agency (EPA), Office of Research and Development (ORD), National Center for Environmental Assessment (NCEA), Washington, DC.

Gallagher, M. 2000. *Proposed Strategy to Continually Reduce Persistent, Bioaccumulative Toxins (PBTs) in Washington State*. Washington Department of Ecology. Publication #00-03-054. 65 pgs.

IARC. 1997. Polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurans. Vol. 69, IARC monographs on the evaluation of carcinogenic risks to humans. International Agency for Research on Cancer (IARC), World Health Organization (WHO), Lyon, France.

Raloff, J. 1997. Those old dioxin blues: some small fry are exquisitely sensitive models of dioxin vulnerability. Sci. News. Vol. 151. May 17. pp. 306-307.

Rogowski, D. and B.Yake. 1999. Addendum to Final Report: Screening Survey for Metals and Dioxins in Fertilizer Products and Soils in Washington State. Washington State Department of Ecology, Publication No. 99-333. 24 pp + appendices.

Zabel, E.W. and R.E. Peterson. 1996. TCDD-like activity of 2,3,6,7-tetrachloroxanthene in rainbow trout early life stages and in a rainbow trout gonadal cell line (RTG-2). Environ. Toxicol. Chem. Vol. 15, No. 12. pp. 2305-2309.