# DIOXINS

**Dioxins and furans can occur as a result of natural combustion processes (e.g. forest fires, volcanoes) and from human activities (e.g. waste incineration, iron and steel production, coal burning and some industrial processes involving chlorine). They accumulate in fatty tissues and can be carried long distances through air from the source of emission. Dioxins first gained widespread public notoriety after the Vietnam War ended in 1975 when it was found that the defoliant Agent Orange used by the US military was heavily contaminated with dioxin. International regulatory bodies accept that the chemical industry today is a minor contributor to environmental emissions of dioxins. In some industrialised countries, the main source is improper waste incineration. For example, in Japan, technological improvements and closure of several old incinerators have dramatically reduced emissions.**

## WHAT ARE DIOXINS?

Dioxins comprise a group of 210 organochlorine compounds with varying properties. Of these, 75 are polychlorinated dibenzo-para-dioxins (PCDDs) and 135 are polychlorinated dibenzofurans (PCDFs). Important factors are the chlorine content – which varies from 24-76% - and positions of chlorine atoms within the dioxin molecule. Only 17 dioxins have potential health effects. The most toxic is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD); the other 16 are 10-10,000 times less toxic than TCDD. Dioxins are colourless, odourless solids, which are readily soluble in fats, but not in water. They tend to bind to organic matter in sediments and soils and to accumulate in fatty tissues of living organisms. In humans, dioxins have a half-life of about seven years. Dioxins are persistent, toxic and bioaccumulative (PTB) chemicals and because they can travel long distances from the source of emission they are also POPs (persistent organic pollutants).

## SOURCES

Dioxins are formed when organic matter burns - particularly without adequate air supply and at temperatures below 850 °C- in the presence of chlorine. A European survey for 1998 revealed that the major environmental releases occur in air through various incineration and combustion processes. Four sources account for 74% of the total air emissions. These are legal municipal waste incineration (26%), sinter plants (18%), residential wood combustion (boilers, stoves, fireplaces, 16%) and incineration of hospital waste (14%). The incineration of hazardous industrial waste contributes less than 1%. Amounts of dioxins formed in incinerators do not depend on chlorine levels, but primarily on the design and operating temperatures of the facility.

A few chemical processes also generate small quantities of dioxins. Production and use of certain chlorophenols was historically a significant source. Other potential sources were production of chlorinated solvents and PVC plastics. None is significant today due to use of BAT with improved process technology and emission controls. Dioxins are destroyed by high-temperature incineration. There is no evidence that dioxins occur above environmental background levels in chemical or plastic products.

Dioxins are unintentionally formed during many everyday activities, for example by wood-burning stoves, petrol engine vehicles and even garden bonfires. It is estimated that up to 14% of dioxin air emissions in the UK occur around Guy Fawkes' night (5 November, celebrated with bonfires and fireworks). An annual six-fold rise in dioxin emissions between mid-September and mid-November also suggests links with domestic heating.

Dioxins also occur in nature and have been found in clay deposits thousands of years old. PCDDs have been identified in 8,000-year-old Japanese sediment. In 150-year-old UK soil and vegetation samples, PCDDs and PCDFs were measured at around one-third of levels found today.
Until the 1930s, environmental dioxin levels were fairly constant, but rose steeply up to the 1960s before falling again sharply after efforts were made to minimise industrial emissions. Today, dioxin levels have generally returned to those found pre-1930 and are still falling.

## EXPOSURE

Levels of dioxins in the natural environment are generally too low to be a significant source of human exposure (typically 1 pg/$m^3$ in air and 0.1 pg/g in soil). Some 95-98% of human exposure is attributable to the food we eat. Since dioxins bioaccumulate in fats, key dietary sources are fish, meat and dairy products. A report, *Compilation of EU dioxin exposure and health data* (November 1999), prepared by AEA Technology (UK) for the European Commission DG Environment found that dietary exposure has decreased over time in all European countries where data are available. In the UK for example, exposure has fallen by 71% between 1982 and 1992 and in Germany it has fallen by 45% between 1989 and 1995. In the US, TCDD lipid levels have fallen 90% between 1972 and 1999.

In 1998, the World Health Organisation (WHO) adopted an acceptable lifetime daily intake for the general population of 1-4 picograms of total dioxins and polychlorinated biphenyls (PCBs*) per kilogram body weight. This level is unlikely to be exceeded in Europe. This was confirmed by a 1998 survey by the French food safety agency AFSSA, estimating average exposure of French adults at 1.3 pg/kg body weight/day. Exposure levels for children and adolescents were higher, but even the most highly exposed 5% of people were below the maximum recommended WHO level of 4 pg.

## HEALTH AND ENVIRONMENTAL EFFECTS

In laboratory animals, certain dioxins have been shown to cause cancer and effects on reproduction, skin and liver. There is little data on human health effects except at very high doses after industrial accidents (notably the 1976 Seveso incident in Italy). Short-term effects such as skin disease, chloracne and changes in liver enzyme levels are reversible. Following Seveso, the incidence of blood related cancers in the general public exposed to dioxins showed a slight increase over a period of 20 years. The same trend was also found in exposed workers. Possible effects of long-term exposure to very low doses has been postulated as a hypothesis by a few scientists but remains to be demonstrated. Based on experimental data for animals and on limited human evidence TCDD has been classified as a human carcinogen (category I, IARC).

Some studies have reported sex ratio effects, but these were contradictory. Sometimes the results showed a preference for female births, sometimes for male births, but some studies showed no preference at all. Debate by scientists continues on possible risk to newborn breast-fed infants whose daily intake could exceed WHO lifetime levels for a short period. WHO's position, however, is that at current exposure levels, known health benefits of breast-feeding outweigh any potential risks

In laboratory studies, there is evidence of adverse effects on fish and wildlife at high doses and in historically contaminated areas of the world there is some effect on bird reproductive success rates. However, field observations generally are inconclusive due to many confounding factors, such as the presence of mixtures of pollutants and the lack of controls.

*PCBs are a family of chemically stable, fire resistant organochlorine chemicals, some of which have dioxin-like properties. They are no longer manufactured or marketed, but continue to persist in the environment. Use of existing electrical equipment containing PCBs is permitted until 2025 under the United Nations Environment Programme (UNEP) treaty adopted in May 2001.

## CONTROL MEASURES AND REGULATIONS

Covered by extensive legislation on emissions, dioxins are among the most stringently regulated chemicals. At EU level, maximum air emissions from major industrial sources are set at 0.1 ng TEQ/$m^3$ and this is increasingly a target for other developed regions of the world. Dioxins are priority substances for marine commissions such as the Oslo and Paris Marine Commission (OSPAR). They are regulated as POPs under the UN/ECE Convention on Long-range Transboundary Air Pollution and covered by the global UNEP treaty (May 2001) known as the Stockholm Convention.

## ADDITIONAL INFORMATION

Sources of further information on dioxins are numerous including regulatory authorities, universities, public libraries and organisations representing various industrial sectors. Here is a selection:


Euro Chlor
Dolf Van Wijk, Science Manager
Avenue E Van Nieuwenhuyse 4, box 2
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Email: eurochlor@cefic.be
www.eurochlor.org

European Centre for Ecotoxicology & Toxicology of Chemcials (ECETOC)
Francis Carpanini
Avenue Van Nieuwenhuyse 4, box 6
B-1160 Brussels, Belgium
Email: francis.carpanini@ecetoc.org

International Agency for Research on Cancer (IARC)
150 cours Albert Thomas
69372 Lyon Cedex 08, France
Tel 04-72738485

IPCS
World Health Organisation (WHO)
CH-1211 Geneva 27,
Switzerland

United Nations Environment Programme (UNEP)
11-13 chemin des Anémones
CH-1219 Châtelaine, Geneva, Switzerland.
Email: chemicals@unep.ch
www.chem.unep.ch/pops


*KEY SCIENCE INFORMATION SHEET*

Third information sheet in a series Euro Chlor is publishing to improve understanding by non-scientists of scientific issues. Each publication focuses on health or environmental aspects of the production, use and disposal of chlorine and its derivatives. *DIOXINS* can be found on the Internet at *Chlorine Online* (http://www.eurochlor.org) where subsequent information sheets will be posted as and when they become available.

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