Background

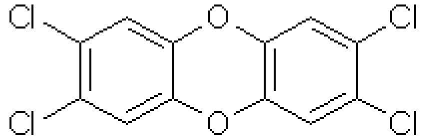
Umwelt Bundes Amt
For our Environment

Dioxins

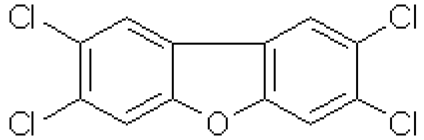
1. What are dioxins and dioxin-like PCBs?

1.1 What are dioxins?

Dioxin is the common term used to refer to a group of chlorinated dioxins and furans of similar chemical structure. The group of dioxins is made up of a total of 75 polychlorinated dibenzodioxins (PCDDs) and 135 polychlorinated dibenzofurans (PCDFs). Dioxins occur as mixtures in related compounds (congeners) in varying composition. The most toxic form of dioxin is **2,3,7,8-Tetrachlorodibenzodioxin** (2,3,7,8 TCDD), which is sometimes referred to as **Seveso poison** after the chemical accident which polluted the environment in Seveso, Italy, in July 1976. The other 2,3,7,8 chlorinated dioxins and furans which have additional chlorine atoms are also pertinent in a toxicological assessment of dioxins. These 17 compounds (7 dioxins, 10 furans) are used to assess toxicity, which is expressed as a toxic equivalent (TEQ) in relation to 2,3,7,8 TCDD.



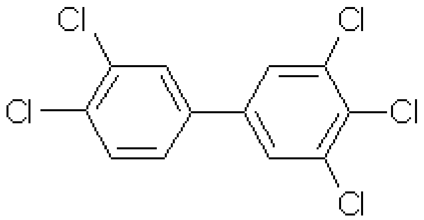
2,3,7,8-Tetrachlorodibenzodioxin (2,3,7,8 TCDD)



2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8 TCDF)

1.2 What are dioxin-like PCBs?

Polychlorinated biphenyls (PCBs) are also in the group of chlorinated hydrocarbons. They comprise a substance group that have a varying number of chlorine atoms attached to a biphenyl molecule. A total of 209 possible combinations exist (**congeners**). Of these 209 PCB congeners 12 which have a spatial and electronic structure similar to PCDD/PCDF (non ortho congeners PCB-Nr. 77, 81, 126, 169, and mono ortho congeners 105, 114, 118, 123, 156, 157, 167, 189), are known as dioxin-like PCBs. The most toxic form of dioxin-like PCB is PCB 126.



3,3',4,4',5-Pentachlorobiphenyl (PCB 126)

2. What are Toxic Equivalents?

It is generally assumed that the various dioxins have the same toxic effect mechanisms, differing only in the degree of their impact. These different degrees are given by a toxic equivalency factor (TEF) that expresses the toxicity of each individual compound in terms of the most toxic form of dioxin, 2,3,7,8 TCDD, which has a reference value of 1.

Toxicity is calculated and summed up on the basis of the contents of the individual compounds and their respective factor, and then expressed as a so-called toxic equivalent (TEQ). The TEQ value corresponds to the toxicity of a comparable volume of 2,3,7,8 TCDD. Toxic equivalency factors (TEF) have been derived from various studies and are updated as new knowledge is gained. Therefore different lists of these factors exist which must be taken into consideration when comparing data. The most common reference framework applied in **environmental** law to derive an I-TEQ is the 1988 I-TEF List (TEF by NATO/CCMS).

TEF values by the WHO represent a further development of this list. It is a TEF scheme that includes the 12 dioxin-like PCBs, which are similarly toxic as PCDD/PCDF and thus contribute to overall pollution by dioxins and dioxin-like compounds. WHO factors of 1998 are applied in laws governing **foodstuffs**. The last update of WHO factors was in 2005.

International toxicity equivalency factors by NATO-CCMS (I-TEF 1988) and World Health Organization (WHO-TEF, 1998 and 2005)

Polychlorinated Dibenzodioxins (PCDD)	I-TEF	WHO-TEF 1998	WHO-TEF 2005
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	**0.5**	**1**	1
1,2,3,4,7,8-HxCDD	0.1	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01	0.01
OCDD	**0.001**	**0.0001**	**0.0003**

Polychlorinated Dibenzofurans (PCDF)	I-TEF	WHO-TEF 1998	WHO-TEF 2005
2,3,7,8-TCDF	0.1	0.1	0.1
1,2,3,7,8-PeCDF	0.05	0.05	**0.03**
2,3,4,7,8-PeCDF	0.5	0.5	**0.3**
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01
OCDF	**0.001**	**0.0001**	**0.0003**

Polychlorinated Biphenyls	WHO-TEF 1998	WHO-TEF 2005
Non ortho PCB		
PCB 77	0.0001	0.0001
PCB 81	0.0001	0.0003
PCB 126	0.1	0.1
PCB 169	0.01	0.03
Mono ortho PCB		
PCB 105	0.0001	0.00003
PCB 114	0.0005	0.00003
PCB 118	0.0001	0.00003
PCB 123	0.0001	0.00003
PCB 156	0.0005	0.00003
PCB 157	0.0005	0.00003
PCB 167	0.00001	0.00003
PCB 189	0.0001	0.00003

Sources: North Atlantic Treaty Organization – Committee on Challenges of modern Society (NATO/CCMS) International toxicity equivalency factor (TEF) method of risk assessment for completely mixtures of dioxins and related compounds. Pilot study on international information exchange on dioxins and related compounds, report no. 176, 1988;
Van den Berg et al.: Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife Environmental Health Perspectives Volume 106, No. 12, 1998;
The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds; Toxicological Science Advance Access published July 7, 2006 (with slight modifications)

3. How are dioxins formed?

Dioxins were never industrially produced. In fact, they are the undesired by-product of all combustion processes in the presence of chlorine and organic carbon under certain conditions, e.g. certain temperatures. Dioxin is formed at temperatures of 300 °C and above and is destroyed at temperatures of 900°C and higher. Dioxins can also form as a result of forest fires and volcanic eruptions. Dioxins (but not furans) are also present in 200 million-year-old kaolin soils.

Dioxins are also formed in varying volumes in all chemical production processes which apply chlorine, and they may be contained as impurities in the finished products. Chlorophenols, for example, contain high levels of dioxin impurities, notably pentachlorophenol (PCP), which has been banned in Germany since 1989.

4. Where do dioxin-like PCBs occur?

PCBs were produced until the 1980s as technical mixtures of the 209 congeners and used mainly in transformers, electrical condensers, as hydraulic fluids, as well as a plasticiser in paints, sealing compounds, insulating materials and plastics. There are varying amounts of dioxin-like PCBs in these mixtures. PCBs have been banned in Germany since 1989, yet proper disposal that does not pollute the environment remains a global problem.

5. What are the main sources of dioxins in the environment?

Up until the 1980s volumes ranging in the kilograms were released to the environment via dioxin-laced chemicals such as pentachlorophenol, polychlorinated biphenyls (PCBs), and certain herbicides. In the meantime these substances have been regulated through legislation banning their use. The major sources of air pollution by these substances used to be metal mining and waste incineration systems. Thanks to ambitious limit values and advanced technology, dioxin emissions from waste incineration plants have been reduced dramatically. Today, the thermic processes in metal mining, metalworking and other small sources have become the main actors responsible for dioxin emissions.

The following table provides an overview of the dioxin emission sources and volumes in Germany.

Dioxin emissions sources in Germany, annual dioxin volume in g I-TEQ

Sources	Annual emissions in g I-TEQ		
	1990	**1994**	**2004**
Metallurgical industry	737	270	55
Sintering plants	576	168	41.5
Other iron + steel production	38	10	11.5
Non-precious metals	123	92	2
Thermic waste treatment	400	32	2
Household waste		30	1
Industrial /Hazardous waste		2[1]	1[2]
Sewage sludge		< 0.1	<0.1
Cement production	NE	NE	0.8
Pulp and paper industry	NE	NE	0.3
Coke and anode production	NE	3	2
Power plants and industrial firing installations (*GFA, TA-Luft)*	15	11	8
Small firing installations*	37	27	25
Transport	10	5	4
Crematories	4	2	0.1
Total emissions to air	1203	350	97

[1] hazardous waste, hospital waste
[2] incl. scrap wood

Source 1990 and 1994
Detzel, A., Patyk, A., Fehrenbach, H., Franke, B., Giegrich, J., Lell, M., Vogt, R. (1998): Investigation of emissions and abatement measures for persistent organic pollutants in the Federal Republic of Germany, research report 295 44 365, UBA-FB 98-115, UBA-Texte 74/98, Umweltbundesamt.
Berdowski, J.J.M., Baas, J., Bloos, J.P.J., Visschedijk, A.J.H., (1997): The European Atmospheric Emission Inventory of Heavy Metals and Persistent Organic Pollutants for 1990, research report 104 02 672/03, Umweltbundesamt.

Source 2004
Rentz, O., Karl, U., Haase, M., Koch, M. (2008): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), research report 205 67 444, Umweltbundesamt.

* **Source update:** Central System of Emissions of the Federal Environment Agency, 18/01/2011

6. Which measures are in place to reduce dioxin pollution?

Environmental pollution as well as exposure of foodstuffs and humans to dioxins have declined significantly in Germany since the late 1980s. This owes to a series of technical and legislative measures taken, in particular to limiting emissions in incineration processes and to banning the production of certain chemicals.

Dioxins and PCBs are persistent organic pollutants (POPs), a term used to designate organic chemicals that accumulate in the bodies of humans, animals and plants and that have the potential to be transported across long distances. As a measure to counteract the risk posed by POPs to man and the environment, a number of international environmental treaties have been agreed to in the past.

Negotiations on the Protocol on Persistent Organic Pollutants (POPs) to the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) were concluded on 24 June 1998, and the Protocol entered into force on 23 October 2003. The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted in May 2001 and entered into force on 17 May 2004. In contrast to the regional UNECE Protocol on POPs, the latter is a global treaty which requires Parties to end or reduce production, application and release of POPs. The Federal Republic of Germany was one of first signatory states to ratify both treaties and to transpose its regulations into national law (Law on the Stockholm Convention of 23 May 2001 on persistent organic pollutants (POPs Treaty) and the Protocol of 24 June 1998 to the 1979 Convention on Long-range Transboundary Air Pollution (POPs Protocol) of 9 April 2002 - Federal Gazette II p. 803 of 16 April 2002). In the first half of 2004 the European Union created the framework necessary for ratification of both agreements through adaptation and additions to existing Community regulations, (REGULATION (EC) No 850/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EC). The Regulation is binding and directly applicable in its entirety to all Member States.

Overview of key regulations in Germany

Legislation on emission caps

Act/Ordinance	**Date**	**Regulation of dioxins**
Federal Immission Control Act (*BImSchG*)	Version dated 26.09.2002 Last changed: 11.08.2009	Regulated by the Ordinances on the Implementation of the Federal Immission Control (*BImSchV*)
13th *BImSchV*: Ordinance on Large Combustion Plants and Gas Turbine Plants	20.07.2004	Emission limit value for dioxins: **0.1 ng I-TEQ/Nm^3**
17th *BImSchV*: Ordinance on Waste Incineration and Co-Incineration	23.11.1990 Last changed: 27.01.2009	Installations are to be built and operated such that no mean value determined over the respective sampling period exceeds the emission limit value of **0.1 ng I-TEQ/Nm^3** for the dioxins and furans set out in Annex I, expressed as total concentration (TE) in accordance with the procedure defined in Annex I.
19th *BImSchV* Ordinance on Chlorine Compounds and Bromide Compounds as Fuel Additives	17.01.1992 Last changed: 21.12.2000	Scavenger Ordinance – leaded petrol Ban on chlorine and bromide additives in petrol
27th *BImSchV* Crematories	19.03.1997 Last changed: 03.05.2000	Limit value for dioxin in waste gas **0.1 ng I-TEQ/Nm^3**
Technical Instructions on Air Quality Control *BImSchG* (*TA Luft*)	24.07.2002	Limit for dioxin in waste gas of **0.1 ng TEQ/Nm^3** Steel, iron and other metal production installations to seek to achieve concentration of 0.1 ng/Nm^3 in waste gas, with 0.4 ng/Nm^3 not to be exceeded.

DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 December 2000 on the incineration of waste sets limits to incineration plants which are already regulated in Germany by the Federal Immission Control Acts ordinances listed above. Thanks to these regulations dioxin emissions have been reduced from 1200 g per year in 1990 to below 70 g per year at present.

Legislation on ban of production, sale and application of certain chemicals and products

Act/Ordinance	Date	Regulation of dioxins
German Chemicals Act (*Chemikaliengesetz - ChemG*)	In version of 02.07.2008	
PCB, PCT, Vinyl Chloride Prohibition Ordinance	18.07.1989	Ban on production, sale and application of polychlorinated biphenyls, terphenyls (PCB, PCT) over 50 ppm, and vinyl chloride as aerosol
Pentachlorophenol Prohibition Ordinance (*PCP-V*)	12.12.1989	Ban on production, sale, and application of PCP, compounds with more than 100 ppm PCP, and individual items with more than 5 ppm PCP
Chemicals Prohibition Ordinance (*ChemVerbotsV*)	13.06.2003 Last amended 21.07.2008	Limits for dioxins and furans, including brominated dioxins and furans, not a TEQ total; instead classified in groups, according to toxicity and persistence, **of 1-100 µg/kg substance/product**

The ban and limitations set on certain substances, preparations and products by the Chemicals Act has prevented the occurrence of annual volumes ranging in the kilograms of pollution by dioxin-contaminated products.

Legislation and recommendations on soil and sewage sludge

Act/Ordinance	Date	Regulation of dioxins
Federal Soil Protection Act (*BBodSchG*)	17.03.1998 amended 09.12.2004	
Federal Soil Protection and Contaminated Sites Ordinance (*BBodSchV*)	12.07.1999 amended 23.12.2004	Action values for dioxins and furans: [ng TEQ/kg dry weight], for playgrounds: 100 For residential areas: 1,000 For parks and recreational areas: 1,000 For industrial and commercial properties: 10,000
AbfKlärV Sewage Sludge Ordinance	15.04.1992 amended 20.10.2006	Limit on application to soils used for agriculture and horticulture: **100 ng I-TEQ/kg dry weight sewage sludge**

The Federal Working Group on Dioxins proposed the following guidelines and recommendations for action in its 2nd report of 1993:

PCDD/F contamination ng I-TEQ/kg soil	Recommendations for action

dry weight	
<5	Target value; any application allowed without prior authorisation
5 - 40	Test orders and recommendations for action for agricultural and horticultural soil applications
> 40	Limitation to certain agricultural and horticultural soil applications; unlimited application on condition of minimal dioxin transfer

Legislation on animal feed and foodstuffs

Maximum limits on dioxin content in citrus pulp have been into force in the European Union since July 1998 (Directive 98/60/EC). Maximum levels of dioxin in other animal feeds have been laid down in Directive 2001/102/EC. Maximum levels of dioxins in foodstuffs and animal feed have been in effect throughout the European Union since July 2002.

The derivation of a maximum level for foodstuffs took into account which concentrations of dioxin and PCBs are normally present in various foods (background contamination). Maximum levels for dioxins and dioxin like PCBs are an appropriate tool to prevent intolerably high exposure of the human population and to prevent the distribution of intolerably heavily contaminated foodstuffs, e.g. from accidental pollution or exposure (see Recital 10 of Regulation (EC) Nr. 2375/2001. Any such maximum level is not an expression of toxicity.

Action levels have also been established in addition to maximum levels, and they are about 25% lower than corresponding maximum levels. If these levels are exceeded, the source of contamination must be detected. Target levels are concentrations at which no health risks are expected when complied with. They were due to be set by the European Commission in late 2008 but are still under debate. The tolerable daily intake (TDI) that was derived includes dioxins and all other substances that have a dioxin-like effect due to their chemical structure. Therefore, dioxin-like PCBs have been taken into consideration to determine a maximum level. Maximum levels for the total content of dioxins and dioxin-like PCBs in animal feed have been in force since February 2006 (Directive 2006/13/EC). Maximum levels of total dioxin and dioxin-like content in foodstuffs have been into force since December 2006 (Regulation (EC) No 1881/2006).

7. How do dioxins enter the environment?

Dioxins enter the environment through

- air
- products (chemicals, paper)
- solid residues (ash, slag, sewage sludge)
- wastewater (cellulose pulp mills, landfill leachate)

Even though dioxins were never produced on an industrial scale, they are widespread in the environment and have accumulated in soil. Dioxin enters the soil mainly via the airborne path, as well as through agriculture, e.g. by fertilisation with sewage sludge or other secondary raw material fertilisers.

Another major source of localised dioxin concentrations may also be the uncontrolled burning of varnished and treated wood or other wastes. With a half-life of several decades dioxin is very persistent in soil and is scarcely displaced. Tests have shown that, with few exceptions (e.g. courgettes), dioxins are rarely traced in vegetables but are instead attached to them or grass by soil particles. Dioxins in soil are largely transported to the food chain via these adherent soil particles. Use of contaminated soil as pasture or chicken runs is therefore particularly problematic, for dioxins are stored, and can also accumulate, in animal and human fat tissue long-term.

For decades, wastewater and rivers with high concentrations of dioxins have reached the oceans and seas. There, dioxins accumulate in the food chain, especially in the fat tissue of fish, mammals, and birds.

8. How is dioxin pollution manifested in the environment?

For the sake of public information about the contamination of man and the environment by dioxins, the Federal Environment Agency collects data on the concentrations of dioxins and others POPs in the Federation and *Laender* cooperation Dioxin Information Portal, which includes information on e.g. sampling site, sampling method, analysis method, laboratory data, etc. An online site with information and evaluation of the data is available. The data on concentrations in the environment and trends in Germany have been published (in German) in the 5th Report by the Government/Laender Working Group on Dioxins.

The introduction of dioxins to the environment has dropped significantly since 1990 thanks to dioxin reduction measures. That decline has slowed down in recent years and has even experienced a slight rise from time to time. Because dioxins are persistent, the issue has shifted from being an emissions problem to being an environmental problem. Therefore, in addition to measures to reduce emissions, other suitable precautionary measures must also be taken to minimise the entry of dioxins from the environment into the food chain.

Fish rich in fat such as some herring and salmon in the eastern region of the Baltic Sea have notably high dioxin contamination as a result of years of wastewater input and deposition. This is the reason why these fish can only be sold on the domestic markets of Finland and Sweden and may not be exported to other EU countries.

9. How are dioxins transferred to humans?

With 90-95%, nutrition is the main source of dioxins in humans. Nearly two-thirds of this dietary intake stems from consumption of meat and dairy products. Depending on the fat content, fish may also be more or less contaminated with dioxins, but in Germany, fish is consumed in small volumes only.

In contrast to dietary intake, intake via the air path is negligibly low for individuals not normally exposed through their occupation.

Dioxins accumulate primarily in the fatty tissue of organisms and are slow to biodegrade. The half-life of the most toxic dioxin (2,3,7,8 TCDD) in the body fat of a human is about 7 years. It takes nearly 20 years for half of the 2,3,4,7,8 pentachlorodibenzofuran, the slowest to biodegrade, to be eliminated from the body.

10. How high is the dioxin body burden in Germany?

An adult human in Germany takes in an average of about 0.7 pg (one picogram = one trillionth of a gram) WHO-TEQ per kilogram of body weight and day through dioxins (calculation based on 2000-2003 data). Added to dioxin-like polychlorinated biphenyls of 1.3 pg WHO-TEQ per kilogram of body weight and day, this results in an average daily intake of 2 pg WHO-TEQ per kilogram of body weight. Assuming that reductions of foodstuff will continue, it is assumed that burdens in Germany are currently somewhat lower. It must be noted that estimated dioxin intake is based on foodstuffs with average levels of contamination given typical human consumption habits. Differing eating habits may lead to considerably different results.

Table: Daily adult intake via nutrition of dioxin and dioxin-like PCBs in Germany, Source Mathar, BfR 2003

	WHO-TEQ-intake			
	Dioxins/ Furans	**Dioxin-like PCBs**	**Total**	**Share**
	pg/person and day			**%**
Meat				
Pork	4.8	2.4	7.2	5.2
Beef	4.9	12.2	17.1	12.4
Poultry	2.2	2.2	4.4	3.2
Milk	17.0	40.7	57.7	41.8
Eggs	4.5	6.0	10.5	7.6
Vegetable fats	5.2	5.2	10.4	7.5
Fish	6.0	17.9	23.9	17.3
Fruit/Vegetables	3.9	3.9	7.8	5.6
Food per day	**48**	**90**	**138**	
Food per kg of body weight and day	**0.7**	**1.3**	**2.0**	

Depending on maternal body burden dioxin absorption before and after birth is very high.. Studies have shown that new born are exposed to dioxins at half level of the mother’s fat concentration. There is also an uptake of pollutants through breast milk in infants. Figures from 1998 show dioxin uptake for an infant who was breasted (first four months) at a daily average of 57 pg I-TEQ per kg body weight. Surveys in Baden Württemberg revealed a 20% higher blood dioxin level in breastfed children than in bottle-fed children until 11th years of age (4th Report by Working Group on Dioxins, BMU 2002, PDF, 0.88MB). Nevertheless, the WHO and the National Breastfeeding Committee recommend breastfeeding as its positive effects outweigh any others.

The eating habits of small children are quite different to adults’. Children eat greater amounts in proportion to their body weight than an adult does and consume more dairy products, which are contaminated with organic pollutants in the animal fats. Studies have shown that small children have a dietary intake of dioxins that is twice to three times as high as that of an adult.

Breast milk is considered as an **indicator** of human body burden through dioxins. Breast milk is high in fat content and thus is a good indicator for dioxin residue in human fat tissue. Time-series studies have demonstrated that the success of reduction initiatives are reflected in breast milk. The breast milk dioxin content in Germany has dropped by 60% since the late 1980s.

Tolerable Daily Intake is an indicator of the amount of a substance that can be taken in daily over a lifetime without appreciable health risk. TDIs are calculated on the basis of laboratory toxicity data to which uncertainty factors are applied. The WHO has derived a tolerable daily intake of 1-4 pg WHO-TEQ/kilogram body weight but has emphasised that a precautionary level of under 1 pg WHO-TEQ/kg body weight per day should be set as a goal. The German position on this is similar. The Scientific Committee on Food (SCF) has derived a figure for a weekly intake of 14 pg WHO-TEQ/ kilogram body weight of dioxin and dioxin-like PCBs, or in other words, a daily intake of 2 pg. The Federal Environment Agency has published a critical comment on this matter.

11. What impact do dioxins have on humans?

Even the smallest amount of 2,3,7,8 TCDD (Seveso poison) is highly toxic. The acute toxicity of this substance is exceeded only by very few natural substances. In animal tests the diptheria toxin proves to be three times as toxic, tetanus toxin 10,000 times as toxic, and the botulinum toxin A 30,000 as toxic as TCDD. The Seveso dioxin is 10 times more toxic than the mycotoxin produced by fungi, 500 times more toxic than strychnine and curare, 1,000 more toxic than pure nicotine.

A comparison of the dose which produces 50 % mortality in animals (LD 50) reveals widely varying sensitivity among test animals (Data from EPA Report 2000).

LD 50 of 2,3,7,8 TCDD

Guinea pig	0.6 – 2.1 µg/kg body weight
Rat	10 - 340 µg/kg body weight
Rhesus monkey	70 µg/kg body weight
Hamster	1160 - 5050 µg/kg body weight

An acute effect of dioxin on humans is only to be expected upon exposure to very high volumes, e.g. through poisoning. In animal experiments there has been evidence of the so-called wasting syndrome, accompanied by severe weight loss, massive damage to the liver, and metabolic disorders that may be fatal within days' to weeks' time. Dioxins can cause skin damage (chloracne), disruption of the immune system, nervous system, endocrine system, reproductive functions, the enzyme systems, and all the associated complications. After the dioxin catastrophe in Seveso, there was a shift in the sex ratio at birth. Men who were very young at the time of the dioxin catastrophe fathered more girls later in life.

The risks posed by dioxins are that they are stored in body fat, where they accumulate and are eliminated at a very slow rate only. 2,3,7,8 TCDD was classified as a human carcinogen by the World Health Organization in February 1997. Other dioxins are also thought to be carcinogenic. Tests on animals have shown that the onset of disruptions of both the immune and reproductive systems already occur at very low dioxin concentrations. Children take in dioxins through the placenta and breast milk. Mother-child studies show that elevated dioxin concentrations in the mother which are still in the ‘normal’ range can lead to a number of developmental disorders or delays in the child.

12. What needs to happen in future to further reduce exposure to dioxin?

The dioxin burden on man and the environment must be reduced further as there are still large proportions of the population who have a daily intake of dioxin that is higher than the WHO precautionary value. In Sweden, for example, girls and young women are advised to limit their consumption of fatty fish from the Baltic Sea in order to have a low body burden of dioxins in the event of a pregnancy and so to burden the unborn child as low as possible. In its Strategy on Dioxins, Furans and polychlorinated biphenyls the European Commission has proposed both short-term and long-term reduction measures. Further measures must be taken beyond those which have already met with success so as to identify other dioxin sources and to reduce emissions at the source.

Since the dioxins present in the environment are spread across the globe and are very persistent, preventative measures must be taken to stop these substances from entering the food chain. Dioxin scandals of the past prove that contaminated animal feed has often been the cause of contaminated food, which is why monitoring of the former must be stepped up and production processes regulated in such a way as to minimize the risk of contamination. Limit values in animal feed and foodstuffs must ultimately be reduced to a level that enables the entire population to comply with the precautionary value recommended by the WHO.