Dioxins and dioxin-like PCBs in the EU

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The Toxicity of Dioxins and PCBs

Dioxins and PCBs are among the most dangerous chemicals known to man. They are toxic, persistent, known endocrine disrupting chemicals (EDCs) and they can bioaccumulate up the food chain, putting humans and higher predators at increased risk.

Despite the downward trend in human exposure to dioxins, the risks posed by these substances are now considered to be greater than in the past because research shows effects at lower levels of exposure than previously suggested. Further, it is now appropriate, when assessing the risks of these substances, to group dioxins with certain PCBs (polychlorinated biphenyls) because they have a similar mechanism of action.

The World Health Organisation (WHO) has set a tolerable daily intake (TDI)[a] level for dioxin and dioxin-like PCB substances. However, comparison of this TDI with people's intakes of dioxins and dioxin-like PCBs shows that many people will regularly exceed this "safe" level.

The recent food scare in Belgium[b] has alerted people to health concerns related to dioxin exposure[c]. However, few people are probably aware that in industrialised European countries, even at the current "normal" levels of exposure to dioxins and dioxin-like substances, our children's development and mental ability are being compromised.[1 2 3]

Dioxins and PCBs are able to affect the body's chemical messengers or hormone system and are therefore considered to be endocrine disruptors. Exposure to these chemicals can particularly affect the thyroid hormones,[4] which regulate normal brain development and growth. In the light of this and other findings, WWF is concerned about the effects of exposure to even relatively low levels of dioxins and PCBs, and is pushing for the implementation of policies that seek to eliminate sources of releases.

After scrutinising all the evidence, experts have noted that "subtle effects may already occur in the general population in developed countries."[5]

Deficits in IQ and lower cognitive ability,[6 7 8] lower birth weight and growth,[9] and "floppy" muscle development[4] have all been found in children exposed to dioxin and/or dioxin-like substances at the upper range of the levels frequently found. Other behavioural effects, such as abnormal stress reflexes, have also been linked to raised PCB exposure through the ingestion of contaminated fish.[10] This has led many scientists to suspect that dioxins and certain PCBs contribute to learning disabilities, including attention deficit hyperactivity disorder and other neurological abnormalities.[11]

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[a] The TDI is an estimate of the amount of a contaminant, expressed on a body weight basis, which can be ingested every day over a whole lifetime without appreciable health risk.

[b] The dioxin contamination stemmed from the incidental introduction into the food chain of one lot of recycled fat, containing a high dioxin/PCB concentration. This was supplied to a limited number of fodder companies that incorporated it into animal feed, such that the animals fed on it became heavily contaminated. At September 1999, the precise circumstances under which the original dioxin contamination occurred was the subject of a judicial investigation (de Vylder, pers.comm 23/9/99).

[c] Contamination of meat and eggs were of the order of 700pg TEQ/g. If this contaminated Belgian food was consumed, this would have led to an additional intake of around 800-10,000 pg TEQ/day. Thus, a 70kg adult might have consumed around 30 times the upper range of the WHO TDI over the period January-June 1999 (for more details see www.who.dk/envhlth/dioxin/dioxin.htm)

In June 1998, in response to studies indicating the ability of dioxins to act as an endocrine disruptor and negative effects on neurological development, WHO reduced its tolerable daily intake (TDI) level to 1-4 picograms per kilogram body weight per day (pg/kg bw/day) [d]. The previous WHO TDI of 10pg/kg bw/day was based on a dioxin's liver toxicity and its ability to cause adverse effects on reproduction and the immune system[e]

With regard to the ability of dioxins to cause cancer, the International Agency for Research on Cancer has classified TCDD (the most toxic dioxin) as a known human carcinogen. People exposed to high levels of TCDD are at increased risk for all cancers combined. Similarly, people exposed to higher levels of TCDD or PCBs appear to be at increased risk of contracting non-Hodgkin's lymphoma, and it has been hypothesised that this may be connected with the adverse effects of these substances on the immune system and viral infection.[12] [13]

Other studies have linked dioxin exposure with endometriosis.[14] [15] Also, accidental exposure has been linked with an increased ratio of baby girls compared with boys.[16]

In wildlife, the reproductive effects of PCBs, along with other organochlorine contaminants, have been associated with the decline of the otter in European rivers, and the decline of dolphins and porpoises in the North Sea.[17] Furthermore, the detrimental effects of certain organochlorine compounds and PCBs on the immune system may have been a factor in the disease epidemics in marine mammals. In the North Sea alone, such epidemics have killed literally thousands of animals.[18]

Therefore it can be seen that mankind's continuous and permitted input of dioxin and dioxin-like chemicals into the environment has adversely affected not only wildlife but also our own children. This should spur governments into taking further effective action to try to eliminate exposures. However, although EU legislation has required reduced dioxin emissions from some industrial sectors, a great deal more remains to be done.

Dioxins and PCBs are POPs

Dioxins and PCBs are not only toxic, persistent, and bio-accumulative. They can also be carried long distances in air currents, thereby posing a threat to humans and wildlife living in remote places. Dioxins and PCBs therefore have all the properties of Persistent Organic Pollutants (POPs) and are two of the 12 agreed "worst" or "most toxic chemicals known to man" and will be subject to global controls under the UNEP (United Nations Environment Programme) POPS Convention presently being negotiated. EU Member States - all of them wealthy - must deal effectively with these substances. And because PCBs and dioxins can travel all over the world, the EU will have to take the lead in technically and financially assisting developing countries (and countries whose economies are in transition) to enable them to deal effectively with these pollutants. Otherwise, EU Member States will continue to be exposed to unacceptable levels of these very dangerous and mobile man-made chemicals.

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[d] A picogram is one million millionth of a gram (10^{-12}).
Picograms per kilogram are equivalent to parts per thousand million million by weight.

[e] For further details of the effects of dioxin see WHO website www. who.int/peh and see review by van Leeuwen and Younes, 1999

Routes of Human Exposure

Human exposure occurs mainly through food from animal origin due to the build-up of these chemicals in the food chain: milk and dairy products, fish and fish oils, and meat and animal fats are the main source of dioxins and PCBs in the diet. Because of the bioaccumulative capacity of these substances to concentrate in fat tissues, it is not surprising that both animal fats and human breast milk are particularly contaminated.

In the UK, for example, the latest breast milk study in 1993-94 showed that two-month-old infants receive around 40 times more than the WHO tolerable daily intake, and 10-month-old infants receive around 10 times more[f]. The intake of two-month-old babies was 170 pg TEQ/kg bw/day which dropped to around 39 pg TEQ/kg bw/day at 10 months.[19]

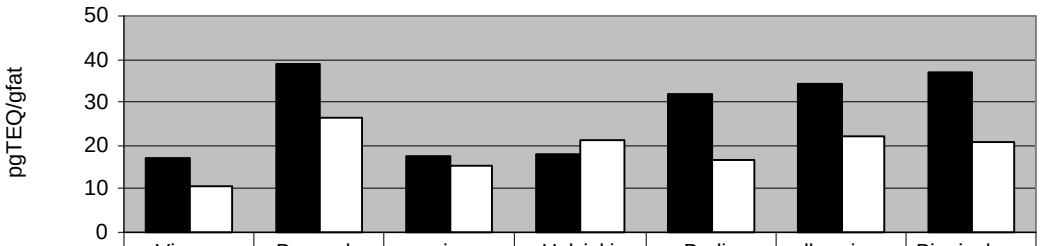
Figure 1 shows that breast feeding babies in many other EU countries are also receiving far in excess of the WHO TDI.[20] Breast milk analysed in Belgium and the Netherlands was even more contaminated than UK milk, although due to the relatively small numbers of women sampled and the limited number of locations, such data must be interpreted with care.

Even so, medical evidence indicates that, despite the presence of dioxins and dioxin-like substances in human milk, breast feeding should still be encouraged as this delivers benefits to the overall health and development of the baby. WWF agrees with this medical advice, but knowing the detrimental effects on the baby, this dangerous toxicity should not be present in the breast milk in the first place. Every EU Member State should be working to achieve this.

The unborn child (foetus in utero) is more sensitive than the breast feeding baby, so exposure in the womb is far more important than that of the infant.[21] This calls for special efforts to reduce the exposure of girls and young women prior to, and during, pregnancy.

[f] The term “dioxins” encompasses a whole group of 75 individual dioxins (that is PCDDs or polychlorinated dibenzo-p-dioxins) and some 135 individual furan substances (that is PCDFs or polychlorinated dibenzofurans).
Dioxin-like substances include some PCBs (polychlorinated biphenyls) which are known to exert their effects on the body in the same way as dioxins. For the purposes of evaluating the potential toxicity arising from any exposure to dioxins, the total exposure to both dioxins and dioxin-like PCBs needs to be taken into consideration
One particular dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), is known to be particularly toxic, and toxic equivalent factors (TEFs) have been derived to express the toxicity of other dioxins, furans and dioxin-like PCBs, relative to TCDD. This is to allow an assessment of the potential toxicity of complex mixtures of dioxins, furans and PCBs and to compare them with a tolerable daily intake (TDI) expressed as a toxic equivalent (TEQ) of TCDD per kilogram body weight per day (MAFF,1997).

Figure1: Comparison of dioxins in breast milk in EU countries in 1988 and 1993



	Vienna Austria	Brussels Belgium	various Denmark	Helsinki Finland	Berlin Germany	all regions Netherlands	Birmingham U.K.
■ 1988	17.1	38.8	17.8	18	32	34.2	37
□ 1993	10.7	26.6	15.2	21.5	16.5	22.4	21

The levels of contaminants in breast milk do provide a useful guide as to likely in-utero exposures - and if studies are undertaken over time, they provide a reliable insight into exposure trends.

In specific locations, emission sources may be responsible for high levels of contamination. For example, high levels of PCBs have been found in the breast milk of women living near a toxic waste site.[22] Similarly, high levels of dioxins have been found in the milk of cattle near a chemical waste incinerator and a smokeless fuels factory in Bolsover, England,[23] and high levels of dioxins and PCBs have been found in eggs from hens near a chemical waste incinerator.[24]

On the other hand, people consuming relatively modest amounts of certain foods can also exceed the WHO TDI. For example, a survey of 132 samples of marine fish found concentrations of dioxins and dioxin-like chemicals in the range 0.9 and 140 nanogram WHO TEQ/kg fat. This means that some of the EU fish-eating population would regularly exceed the WHO TDI, particularly pre-school children who eat at least an average amount of fish, and adults and school children who tend to eat more fish than most.[25]

It is a sad indictment of modern society that many foods known to promote human health have now become heavily contaminated with dioxins and dioxin-like substances. For example, oily fish provides a rich source of long chain polyunsaturated acids which protect against cardiovascular disease, yet eating two or more portions of this a week could result in someone exceeding the WHO TDI for dioxins on those occasions. Similarly, cod liver oil - the elixir of health for many post-war children - might now be better not taken regularly, as fish oils are often relatively highly contaminated, and could give rise to exposures above the WHO TDI.[26] Similarly, human breast milk itself is now one of the most contaminated of human foods.

Sources of dioxin-like PCBs

PCBs are industrial chemicals and are no longer manufactured in the EU, but they are still extensively used in transformers and capacitors. They are also found as hydraulic fluids in mining equipment, and in heat transfer installations. In the past, smaller amounts were also used in a number of applications, and in the EU it is believed that PCBs may still exist in many situations. These include some old construction and paint applications (for example polymer composite cement, grouting, chlorinated rubber paint and mastic), in some old refrigerators and

washing machines, and in some lights such as domestic strip light fittings and street lights. Many chemical products may also be contaminated by PCBs which can be formed unintentionally during their manufacturing process[27].

Large transformers are easily identifiable and will be found mostly in electricity generating locations, although some transformers containing PCBs may also be on offshore platforms. Capacitors are used to smooth out (shock) load fluctuations on industrial power supply systems, and for power factor correction. Factories are still likely to have banks of these, because between 1954 and 1979 almost all capacitor manufacturers in the world used PCBs as a dielectric fluid. Capacitors may also be located in shops, schools, hospitals and offices. As an indication of the extent of the problem, in 1997 in the UK alone, it was estimated that a significant proportion of PCBs was held in some 1,800 transformers and 450,000 capacitors.[28]

Identifying these capacitors is likely to present many difficulties, because these units are often small, unidentified and in unmarked boxes. Because some are also sealed, sampling to detect whether they actually contain PCBs is not a viable option. The assistance of trade associations and electricity companies would be very useful to help owners identify capacitors containing PCBs.

Sources of dioxins

Dioxins are not deliberately produced: they are "accidentally" manufactured during the synthesis or combustion of other chemicals. However, these "unintentional" amounts of pollution are not trivial. They are produced at levels threatening human and wildlife populations all over the world. The burning of organochlorine substances (for example PCBs and other industrial chemicals) is by far the largest source.

In Europe, a study[29] has estimated that 62 per cent of total dioxin emissions to air are accounted for by the following four sources:

- incinerators for domestic/municipal waste;
- iron ore sinter plants;
- incinerators for clinical waste; and
- facilities of the non-ferrous metal industry (including metal recovery works)

The remaining 38 per cent are believed to arise from other industrial sources, and particularly from the following non-industrial sources:

- domestic heating facilities (particularly wood combustion);
- accidental fires; and
- road traffic (mainly if leaded petrol is used).

At present there is much debate about the extent to which banning PVC would reduce dioxin emissions from municipal incinerators. While some environmental groups argue that PVC should be eliminated, the chemical industry suggests that there is no significant relationship between chlorine in incinerator feeds and dioxin emissions from waste incinerators. However, dioxins are the most toxic substances known to man and if all chlorinated substances could be eliminated from the feedstock, no dioxins could be formed.

Also, in the open burning of rubbish, [30] where PVC may be the most important man-made chlorine source and where low temperature and little mixing occurs, it seems likely that removing PVC would significantly reduce dioxin releases. Similarly, in incinerators burning medical wastes, virtually all available chlorine comes from PVC plastics. Therefore, WWF argues that there is a need for "materials policies" which chart a move away from the use of chlorine compounds, including PVC. Such policies would also address the formation of dioxins and PCBs during chemical synthesis, and products would be evaluated over their entire life cycle including raw material selection, production, use and end of life disposal. Alongside such materials policies, there is also a need to find mechanisms to reduce the amounts of waste generated and to stimulate recycling[g], reuse and composting programmes.

Several chemical processes (including incinerators) have the potential to release dioxins in solid wastes. Indeed, improved abatement of dioxin releases to atmosphere may result in increased releases to land in the fly-ash collected from incinerator filters. Coal-fired power stations and the burning of chlorine containing coal in homes may also be a significant source of releases of dioxins to both air and land, and this argues for a move away from such fuel.

The general solution for reducing dioxin release is to remove chlorinated compounds. In the metal industry for example, sorting and pre-treatment of scrap metal before reprocessing can cut dioxin emissions. This sorting would exclude materials containing chlorine and pre-treatment would strip plastic or PVC coatings. Similarly, several industries may also discharge dioxins to rivers or coastal waters. The pulp and paper industry is a significant source of releases to water. Such discharges should be eliminated by allowing only totally chlorine-free bleaching processes which are already in use in use in some paper mills.

Requirements for action on dioxins and PCBs by EU countries

Dioxins

At the Third International Conference on the Protection of the North Sea in 1990, ministers of the participating countries[h] agreed to achieve a 70 per cent reduction in all North Sea inputs of dioxins between 1985 and 1995. However, in 1995 a subsequent evaluation of the actions by individual countries suggested that only the Netherlands, Norway, Sweden and Switzerland would be successful.[31]

Further, in February 1993, in the Fifth European Program of Policy and Action, the Council of Ministers set the political goal to achieve a 90 per cent reduction of dioxin emissions from known sources by 2005 compared with the reference year 1985. It is clear that to achieve this goal, various metal working plants apart from incinerators will need to be brought under tighter controls.

Several years later, at the OSPAR (Oslo and Paris Commissions) meeting at Sintra in 1998, many EU countries still appeared to be unfocussed with regard to their legally binding obligations drastically to reduce dioxin emissions. PCBs and dioxins featured in the list of hazardous substances for priority action. For these substances OSPAR nations pledged that programmes and measures would be drawn up by 2003, to identify how the target of "cessation of emissions, discharges and losses by the year 2020" would be achieved. The OSPAR

[g] However, recycling programmes must be strictly regulated to ensure that waste is properly segregated, since recycling PVC plastics with other plastics can actually create more dioxins.
[h] Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, Switzerland, UK.

hazardous substances objective is to achieve near background values for naturally occurring substances and close to zero concentrations for man-made substances in the marine environment by 2020.

However, by mid-1999 no country had volunteered to take the lead on dioxins, which indicates a lack of political will to find strategies to ensure that reductions in emissions are achieved.

PCBs

At the Third Ministerial Declaration on the North Sea signed in1990, ministers agreed to take measures to phase out and destroy all PCBs (including the interim option of safe deep underground disposal of capacitors and empty transformers). Subsequently, in 1992 the Paris Commission (now OSPAR) agreed a Decision on PCBs, which confirmed the end of 1999 for phase-out for Iceland and all states bordering the North Sea. A more lax deadline of the end of 2010 was set for the other OSPAR countries. Although North Sea states have taken some steps, it is clear this goal will not be fully achieved.

All EU Member States should be brought into line by the EU Directive 96/59/EC on the disposal of PCBs and polychlorinated terphenyls. This sets down legal requirements for the preparation of inventories, labelling and treatment of all significant PCB holdings, as well as stricter regulation of PCB treatment facilities. The thresholds set out in the Directive for specific registration and consequent destruction are 5 dm^3 of overall filling capacity for equipment and 50ppm for contaminated substances within such equipment. Under the Directive, decontamination or disposal of these PCB materials must be carried out by 2010, although North Sea states should still be bound by the 1999 OSPAR deadline.

However, transformers and ancillary equipment with contamination levels below 500ppm are subject to the derogation that PCBs do not have to be removed until the end of the equipment's useful life. This means that the bulk of the electricity industry's costs will arise from registration and labelling and, to some degree, the retrofilling of equipment to levels allowed by the Directive. In contrast, the capacitors used by the manufacturing industry will need to be replaced, as de-chlorination and retrofilling are unlikely to be an option for this type of equipment.

Many countries have not taken their responsibilities regarding PCBs seriously enough. For example, Germany, Greece, Portugal, Spain and the UK are subject to legal action by the European Commission for failing to implement the 1996 EC Directive on the disposal of PCBs, which should have been transposed into national law by March 1998 at the latest.

The UN ECE Protocol on Persistent Organic Pollutants (POPs) similarly requires ratifying countries (whose economies are not in transition) to destroy or decontaminate PCB equipment containing over 500ppm (and liquid PCBs containing more than 50ppm) by 2015. In the case of dioxins this Protocol also requires ratifying countries continually to reduce annual emissions from a specified base year, by the use of a number of measures outlined, especially including the use of defined limit values (emission standards) and best available techniques. However, the Protocol acknowledges that the time may come when all such measures have been implemented and no further reductions can be achieved. In September 1999, although all EU countries had signed up to the Protocol, none had ratified it.

WWF's Recommendations

Policy measures

1. Human and wildlife exposure to dioxins and PCBs should be reduced to levels as low as possible. Therefore, the aim should be to eliminate dioxin and PCB releases to the environment.

2. More attention should be given to achieving the goal of eliminating dioxin sources. This will mean adopting a "materials policy" (see page 9) and finding alternative ways of dealing with certain chlorinated wastes already produced.

3. In line with a "materials policy", certain chlorinated industrial chemicals and pesticides which are contaminated with dioxins and/or PCBs, or which give rise to these substances during their life cycle (including disposal phase), should be phased out.

4. Significant dioxin emissions arise from the burning of leaded fuel, which should be phased out globally as a matter of urgency. Similarly, any dioxin emissions from heavy duty diesel engines should be quantified and eliminated.

5. To eliminate the release of PCBs, effective destruction technologies which do not themselves generate dioxins must be used to destroy existing stocks. Further, even relatively small sources of PCBs must be properly considered, particularly programmes for the safe disposal of PCB containing lights (such as street lights and domestic strip lights), as these substances will not fall within the PCB Directive 96/59.

6. In September 1999 Germany, Greece, Portugal, Spain and the UK were subject to legal action by the European Commission for failing to implement the EC Directive on the disposal of PCBs by March 1998. These countries should rectify this situation immediately.

7. In recognition of the harmful effects of exposure to PCBs, the implementation of the 1996 Directive on PCB disposal should be constantly evaluated in all EU countries. The experience gained from the implementation of this Directive, including how best to draw up inventories and conduct publicity campaigns to raise awareness of possible sources of PCBs and their hazards, and thereby ensure wide participation, should be made available to other non EU countries. This is because in future, all countries will have to deal with obsolete stocks of PCBs in line with the forthcoming UNEP Convention on Persistent Organic Pollutants.

8. In the OSPAR Convention a lead country on dioxins should be appointed.

9. All EU Member States have signed the UN ECE POPs Protocol, but they should now ratify it.

10. In negotiations on the forthcoming UNEP Convention on POPs there is a real danger that EU support for the aim of eliminating dioxins, as was evident at the negotiations in Geneva in September 1999, may weaken under pressure from the US delegation. Therefore, EU Member States should agree to call for:

    - elimination-directed control measures for dioxins (in D3, Annex III). For example, EU Member States should agree to negotiate for wording such as "with the aim of their continuing minimisation and ultimate elimination";
    - national inventories of emissions of dioxins and holdings of PCBs;
    - monitoring initiatives for PCBs and dioxins;
    - PCBs to be included in Annex A, which lists chemicals whose production and use are prohibited; and

- adequate financial assistance for developing countries to deal effectively with dioxins and PCBs.

11. Companies should be made liable for the chemicals and products they produce, and should not be able turn their backs on clean-up costs, or the costs of monitoring their pollution. Mechanisms should therefore be found, at least in part, to enable the PCB disposal costs to fall to the producers.

12. An alternative to incineration for the destruction of PCBs must be found. Dioxins can be formed during incineration, and other methods of destroying PCBs will be potentially more efficient.

13. A public awareness campaign about the dangers of dioxins and PCBs must be carried out. Consumers should be informed that the following measures can reduce the body burden of dioxin and dioxin-like PCBs:

    - trimming fat from meat;
    - consuming low-fat (rather than high-fat) dairy produce;
    - switching from animal fats to vegetable fats; and
    - a balanced diet (including adequate amounts of fruits, vegetables, and cereals - thus avoiding excessive exposure from a single source).

Regulatory measures

14. For dioxins and dioxin-like PCBs, EU Member States should set and adopt an EU-wide TDI, as well as Maximum Admissible Concentrations or at least guideline levels in specified foodstuffs. Also, food contamination monitoring systems should be put in place to ensure compliance. Such measures would seek to impose a common standard of human health protection.

15. Dioxins are unintentionally produced, but added measures are needed to reduce emissions further. Ultimately the goal is elimination (see [2] above), but in the interim, and as a matter of urgency, tough EU-wide standards should be *imposed and enforced* for industrial processes such as iron ore sinter plants, metal reclamation facilities, aluminium and other metal works, fossil fuel combustion plant, cement kilns, crematoria and incinerators. Legal restrictions on domestic and open waste burning operations are also needed. Small facilities may be responsible for a disproportionate amount of dioxin emissions, so there is a need to bring small and medium sized enterprises under tighter control.

Monitoring and Surveillance

16. Monitoring of the environment should continue in order to detect trends in exposure and unauthorised releases. Such monitoring may be particularly important to deter illegal disposal of PCBs.

17. Inventories of releases of dioxins should be improved so that all sources are identified and quantified as far as practicable. All environmental and human exposure routes should be identified including potential sources such as milk cartons, coffee filters and releases from pentachlorophenol (PCP) treated wood.

18. There is a need to harmonise methods of sampling and analysing stack emissions and residues in water, soil, biota and food. Minimum sampling requirements should also be agreed.

19. Contaminated sites should be cleaned up without delay.

20. Further studies are needed on the possible long-term health hazards to infants from exposure in the womb to dioxins and dioxin-like PCBs and other pollutants, as well as from the intake of contaminated breast milk. The long-term effects of exposure to chemical pollutants can only be clarified by continued surveillance.

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