Compilation of EU Dioxin Exposure and Health Data

Task 2 – Environmental Levels

Report produced for

European Commission DG Environment

UK Department of the Environment, Transport and the Regions (DETR)

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Executive Summary

Many analyses have been carried out across the world in order to determine the concentrations of polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF), which are often collectively termed ‘dioxins’, in environmental media and other matrices, including soils, sediments, air, vegetation, wildlife, sewage sludge, residues and consumer goods. This report provides a summary of the overall findings of dioxin analyses undertaken within Member States of the European Union.

Early results date back to the 1970s and many countries, such as Austria, Finland, Germany, the Netherlands, Sweden and the United Kingdom, have carried out monitoring activities or research programmes to either update their existing databases or to gain further insight into sources, fate and transport of dioxins in the environment. For Ireland, Luxembourg, and Greece there is only limited information available from a few or single studies. For Italy, there is little information available, and for Belgium and Spain data which are available relate to only one part of the country, namely Flanders and Catalunya, respectively. Portugal is in the process of initiating dioxin-related programmes, France is intensifying its efforts to obtain more data, especially in the neighbourhood of incinerators and other combustion units, and Denmark is proposing to carry out an overall re-evaluation of dioxins in the country to update and enlarge the database.

It has not been possible to carry out any statistical analysis of available data, as countries or individual reports provided aggregated data covering varying numbers of samples, time periods and locations. From an analysis of the data it was, in most cases, impossible to distinguish significant differences in background concentrations of dioxin in rural and urban locations. In several locations, seasonal trends have been observed, with lower air concentrations of dioxin in summer and higher concentrations in winter. The cause for these differences is not fully understood: some authors indicate additional combustion sources whereas others relate the differences to meteorological conditions with lower air mixing heights in the colder season.

Most data are available for dioxin concentrations in soils and, to a lesser extent, sediments and air. Biomonitors, such as vegetation or cows’ milk, have been successfully applied to identify or monitor ambient air concentrations in the neighbourhood of potential point sources, although a linear correlation between dioxin concentrations in vegetation and air samples cannot be established. Due to public concern regarding dioxins, many studies have been aimed at identifying potential ‘hotspots’ of contamination. As a result, such locations have been more intensively sampled and analysed than background or baseline locations.

In most countries a broad range of dioxin concentrations has been detected in all media. The table below presents the range of reported typical concentrations and maximum concentrations measured in locations with known contamination**.**

Despite the limitations mentioned above, this study provides a valuable overview of the present status of dioxin contamination in the Member States of the European Union. The results from this study will help countries to rank their own situation with respect to that of

neighbouring countries and may direct the focus of further programmes. For the European Commission, the results of this study, together with the source characterisation and inventory programme led by the Landesumweltamt Nordrhein-Westfalen, will help to set future priorities for dioxin reduction measures and identify needs for further information gathering or research programmes.

Finally, in the international context, with negotiations presently underway within the United Nations Environment Programme (UNEP) for a Convention on Persistent Organic Pollutants (POPs), which includes dioxins and furans as two of the twelve POPs [1], there is a need to know about sources and environmental occurrence of PCDD and PCDF in the EU Member States. For such a purpose, this study represents a sound basis and a state-of-the-art report for the European Union.

Concentrations of dioxin measured in EU Member States

Environmental Matrix	Measured Typical Range	Maximum Concentration Contaminated Sites	Units
Soil	<1 – 100	100,000	**ng I-TEQ/kg d.m.**
Sediment	<1 – 200	80,000	**ng I-TEQ/kg d.m.**
Air (ambient) **(bulk deposition)**	<1 – 100s <1 – 100s	14,800	**fg I-TEQ/m^3** **pg I-TEQ/m^2 d**
Sewage Sludge	<1 – 200 (average 15 – 40)	1,200	**ng I-TEQ/kg d.m.**
Spruce/Pine Needles (biomonitors)	0.3 – 1.9	100	**ng I-TEQ/kg d.m.**

Two main recommendations arise from this study. However, other issues, relating to environmental sampling, analysis and data collection, are also relevant to a number of the other component Tasks within this project, and are addressed in a separate report on Generic Issues.

- For monitoring purposes, cows' milk has proved to be an appropriate monitor for air quality and human exposure. A substantial database of dioxin concentrations in EU Member States is available and guideline concentrations for human consumption. Thus, it is recommended that the use of cows' milk for monitoring purposes should be further applied and extended within the European Community;
- It is clear from this study that there are many data on environmental concentrations of dioxin, which cover many environmental compartments and other matrices, including consumer goods and residues. However, the information is not easily accessible and is very scattered, especially in countries with a long dioxin history. In such cases, the relevant government agencies do not necessarily own the data or maintain a comprehensive database containing the results generated in the country. This fact is due to the widespread interest in issues relating to dioxins and shared responsibilities within

[1] Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene, hexachlorobenzene, polychlorinated biphenyls, dioxins and furans

each country. It is recommended that, for compliance with future European Commission Directives, all relevant data from public and private organisations should be reported to the local or federal authorities and, thus, be accessible to governments and the general public.

Contents

1 Introduction

Many analyses have been carried out across the world in order to determine the concentrations of polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF), which are often collectively termed ‘dioxins’, in environmental media and other matrices. This report provides a summary of the overall findings of dioxin analyses undertaken within Member States of the European Union.

The data reported in this study have been collected through an extensive literature search of both printed and electronic documentation, and many contacts with research and government organisations within EU Member States. All concentrations reported are normalised to I-TEQ and, for the Nordic countries, N-TEQ. The data have been derived from the original sources. Generally, within the context of this study, it has not been possible to verify the quality of the data. However, in a few cases, where data seemed to be contradictory or unclear, attempts have been made to resolve this in order to present consistent information.

Early results date back to the 1970s and many countries, such as Austria, Finland, Germany, the Netherlands, Sweden and the United Kingdom, have carried out monitoring activities or research programmes to either update their existing databases or to gain further insight into sources, fate and transport of dioxins in the environment. For Ireland, Luxembourg, and Greece there is only limited information available from a few or single studies. For Italy, there is little information available, and for Belgium and Spain data which are available relate to only one part of the country, namely Flanders and Catalunya, respectively. Portugal is in the process of initiating dioxin-related programmes, France is intensifying its efforts to obtain more data, especially in the neighbourhood of incinerators and other combustion units, and Denmark is proposing to carry out an overall re-evaluation of dioxins in the country to update and enlarge the database.

Certain data collected during the course of this study can further be evaluated for trends. For selected media, such evaluations may give an indication as to whether measures taken to reduce releases of dioxin have been successful, and these are discussed in a separate report on Time Trends.

When evaluating concentrations of dioxin in the environment, it should be taken into account that some matrices are sensitive to short-term inputs, *e.g.* ambient air or short-lived vegetation, whereas other matrices, such as sediments and soils, are relatively insensitive to temporal variation. Further important factors for the interpretation of results are season (*e.g.* winter *vs.* summer), length of the sampling or exposure (*e.g.* few hours *vs.* weeks), location (*e.g.* urban *vs.* rural), the sampling method (*e.g.* high volume sampling *vs.* particulate deposition), sampling depth (*e.g.* surface *vs.* core), *etc.* The paragraphs below describe some of the most important findings to consider when analysing environmental samples.

Section 2 of this report outlines a number of important factors relating to the various environmental matrices within which dioxins may be detected. These are described in greater detail in a separate report on Environmental Fate and Transport. The results of the evaluation of concentrations of dioxin in the environment are summarised in Section 3, with a more detailed description of data relating to each Member State and associated discussion being provided in the Technical Annex. The implications for further measures which might be required to control and/or reduce human exposure to dioxins are presented under the heading Conclusions and Recommendations.

2 Environmental Matrices

2.1 SOIL

Soils are natural sinks for persistent and lipophilic compounds such as dioxins, which adsorb to the organic carbon of the soil and, once adsorbed, remain relatively immobile. Soil is a typical accumulating matrix with a long memory; in other words, dioxin inputs received in the past will remain and, due to the very long half-lives of dioxin in soils, there is hardly any clearance. Soils can receive inputs of environmental pollutants *via* different pathways of which the most important are: atmospheric deposition, application of sewage sludge or composts, spills, erosion from nearby contaminated areas. Once dioxin contamination is detected in soils, a historic evaluation has to be performed to determine which might have been the predominant input pathway (sometimes pattern analysis might provide further evidence). In general, it is difficult to determine when a soil contamination occurred. The concentrations in soil tend to reflect the baseline contamination of a region. Thus, urban areas exhibit higher concentrations than rural.

Sampling depth and use patterns play an important role when reporting soil concentrations. In most sampling programmes, agricultural soils are sampled to a depth of 30 cm in cases of arable land and 2-10 cm in cases of pasture land. Contained soils are sampled according to their composition in layers (on optical inspection). Forest soils are separated into litter and the various horizons of the mineral soil.

2.2 SEDIMENT

Sediments are the ultimate sink for dioxins (and other persistent and lipophilic organic substances). As with soils, sediment samples are accumulating matrices for lipophilic substances and can receive inputs *via* different pathways: atmospheric deposition, industrial and domestic effluents, stormwater, spills, *etc.* Sediment samples can be collected as grab samples or as cores, which allows for time adjustment. A special case of sediment sampling is determination of suspended particles, which reflects the current deposition in the water column.

2.3 AIR

Today, dioxins can be detected ubiquitously and have been measured in the Arctic, where almost no dioxin sources are present. It became clear that the lipophilic pollutants, such as dioxins, at the North and the South Pole originated from lower (warmer) latitudes. Emission of most dioxins from combustion sources into the atmosphere occurs in the moderate climate zones; dioxins then undergo long-range transport towards the North Pole, condensing in the cooler zones when the temperatures drop. This process of alternating re-volatilisation and condensing, also named the "grasshopper effect", can carry pollutants thousands of kilometres in a few days. Thus, the air is an important transport medium for dioxins. Reporting ambient air concentrations reflects the concentration during the sampling period but, due to the rapid transport and fast mixing of pollutants in air, dioxin concentrations will change quite rapidly. It has been shown in many cases that ambient air concentrations exhibit a strong seasonal trend.

Ambient air concentrations are determined either directly or as deposition samples. To measure dioxins in ambient air samples, typically, a high volume sampler is used, consisting of a glassfibre filter, to collect particulates, and a cartridge containing polyurethane foam (PUF) or XAD-2 raisin, to absorb the finest particulates and any gaseous dioxins. In Europe the Bergerhoff method is frequently used to collect dry and wet deposition, according to a method established by the German VDI (Association of German Engineers). The results from both methods are directly correlated to the time of exposure and the sampling location.

2.4 VEGETATION

An indirect method of determining ambient air concentrations is the use of biomonitors, such as vegetation. The outer waxy surfaces of pine needles, kale or grass absorb atmospheric lipophilic pollutants and serve as an excellent monitoring system for dioxins. The advantage of biomonitors, such as pine needles, is that they are widely spread over Europe and samples can be easily obtained. As there is a database of measurements taken from a wide range of locations over long periods of time, the analytical results from different locations or years can be compared. However, a linear correlation between dioxin concentrations in pine needles, or any other vegetation, and the high volume samplers or deposition samples cannot be established. The concentrations in biomonitors reflect the ambient air concentrations during the time of exposure (growth period) of the plant. With pine needles, accumulating effects over several years can be determined.

3 Results

3.1 OVERVIEW

The results of the evaluation of concentrations of dioxin in the environment, consumer goods, and residues are summarised in this section of the report and are presented according to these matrices. More detailed information, with the data available for each country, is presented in the Technical Annex.

A summary of the matrices where dioxin concentrations have been determined is shown in Table 1. Most countries have investigated dioxin concentrations in soil and, to a lesser extent, in sediments and air. Intensive monitoring programmes have been performed in Germany and the United Kingdom; fewer data were available from Austria, Sweden, Spain, Denmark, and Finland; no data were available from Portugal. For cows' milk, Table 1 lists only the countries which have performed dioxin analyses for environmental impact assessment or source monitoring.

Table 1: Overview of environmental matrices analysed by EU Member States

	A	B	DK	D	E	F	FIN	GR	I	IRE	L	NL	P	S	UK
Soil	X	X	(x)	X	X		X	X	X	X	X	X		X	X
Sediment				X	X		X		X		X	X			X
Air	X	X		X					X		X	X		X	X
Vegetation	X			X		X**	X								X
Wildlife				X			X							X	
Cow milk *	X**					X**				X					
Fish *				(x)			X							X	
Water														X	
Consumer Goods			X	X											
Sewage sludge	X		X	X	X										X
Wastes				X											X

* biomonitor; ** biomonitor close to point source,
(x) few data or data of poor quality

3.2 SOIL

Most data are available for dioxin concentrations in soils, as a number of intensive surveys have been carried out. In almost all countries a broad range of dioxin concentrations was detected, as illustrated in Table 2, with the lowest concentrations below 1 ng I-TEQ/kg d.m. and the highest around 100 ng I-TEQ/kg d.m. In the Netherlands, particularly, most soil samples have been taken in the neighbourhood of municipal solid waste incinerators, where concentrations up to 252 ng I-TEQ/kg d.m. have been detected.

In contaminated locations measured concentrations range from several hundred to around 100,000 ng I-TEQ/kg d.m. The highest concentrations reported are shown in the last column of Table 2. As the extent of measurement programmes varies considerably from one country to another, it is not possible to identify any individual country with dioxin concentrations in soils which are significantly higher or lower than any other.

Table 2: Summary of dioxin concentrations in soil from EU Member States (ng TEQ/kg d.m.)

	Other types	Forest	Pasture	Arable	Rural	Contamin.*
Austria		<1-64	1.6-14			332
Belgium	2.7-8.9				2.1-2.3	
Finland						>90,000
Germany		10-30	<1-30	<1-25	1-5	30,000
Greece	2-45					1,144
Ireland	<1-8.6	4.8	<1-13			
Italy	<1		<1-43	1.9-3.1		
Luxembourg	1.8-20	6.0			1.4	
The Netherlands					2.2-16	98,000
Spain	<1-24.2				<1-8.4	
Sweden					<1	11,446
United Kingdom	<1-87				<1-20	1,585

* maximum measured concentration at contaminated sites.

3.3 SEDIMENTS

Dioxin concentrations in sediments from EU Member States are summarised in Table 3 and range from below 1 ng TEQ/kg d.m. up to around 200 ng TEQ/kg d.m. However, contaminated locations were identified in many countries where concentrations from several hundred ng TEQ/kg d.m. up to 80,000 ng I-TEQ/kg d.m. have been measured.

Table 3: Summary of dioxin concentrations in sediments from EU Member States (ng TEQ/kg d.m.)

	Finland	Germany	Italy	Lux.	Netherl.	Spain	Sweden	UK
Background	<1-100	1.2-19	<1-10		1-10		<1-208	
Urban		12-73	<1-23	2.4-16		<1-57		2-123
Contaminated	80,000	1,500	570		4,000		1692	7,410

3.4 AIR

Results for air samples were available for only eight Member States (Table 4). There are three basic approaches to determine the dioxin concentrations in air: high volume samplers which will collect particle-bound and gas-phase dioxins, Bergerhoff or similar samplers which will collect dry and wet deposition, and biomonitors such as kale, spruce needles or grass, which preferentially absorb the gas-phase dioxins. As far as was possible to determine, very similar methods have been applied to generate these results.

Table 4 shows that the concentrations in ambient air range from below 1 fg I-TEQ/m³ to several hundred fg I-TEQ/m³ and in deposition a similar range was found for the concentrations in pg I-TEQ/m²·d.

The extremely high concentration of 14,800 fg I–TEQ/m³ was measured at the Pontyfelin House site, in the Panteg area of Pontypool in South Wales, which is very close (~150 m) to an industrial waste incinerator.

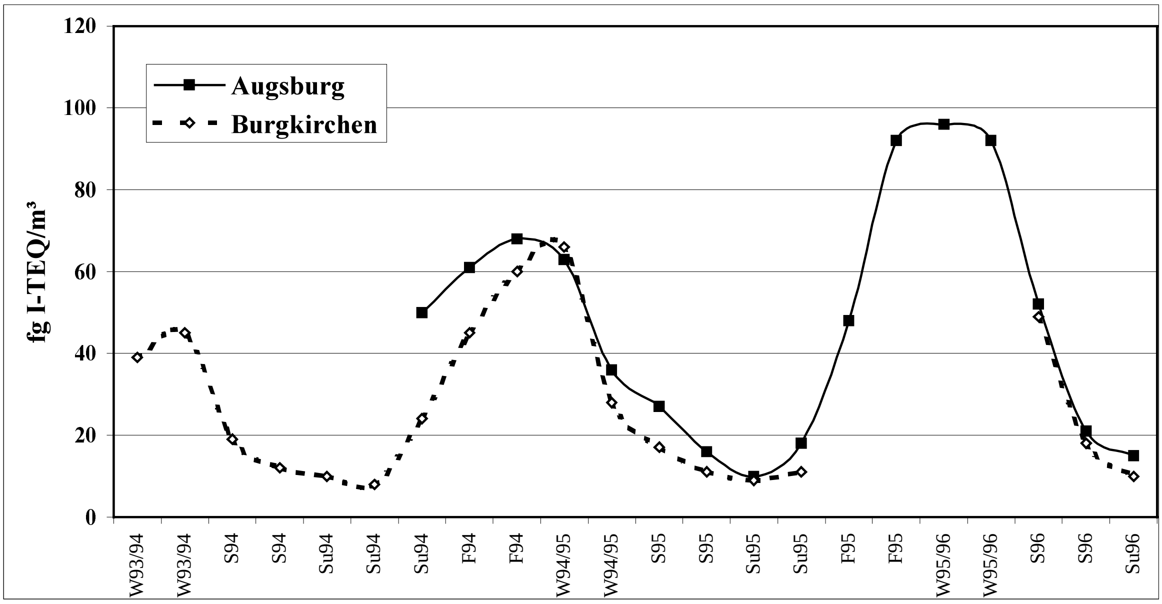
Table 4: Summary of air concentrations from EU Member States. Concentrations of ambient air samples (fg TEQ/m³) and deposition (pg TEQ/m²·d)

	Ambient Air				Deposition	
	Unspecified	Urban	Rural	Contaminated	Urban	Rural
Austria	1.3-587					
Belgium		86-129	70-125		<1-12	<1-3.1
Germany	2-812				<1-464	
Italy		48-277				
Luxembourg		54-77	30-64			
Netherlands		4-99	9-63	6-140		
Sweden	5.4-53.7	<1-29				
UK		0-810	1-24	14,800	<1-312	0-517

In several countries strong seasonal trends have been determined for ambient air concentrations. A typical seasonal trend is displayed in Figure 1 for the cities of Augsburg and Burgkirchen in southern Germany. Whereas Augsburg represents an urban industrial location, Burgkirchen is located in a more remote part of Bavaria with some industrial activities in the neighbourhood (modern municipal waste incinerator, chemical industry). In general, dioxin concentrations in winter are much higher than in summer and, on a TEQ basis, concentrations measured in the winter in Germany were up to 10 times higher than concentrations in summer. A graphical representation of the median concentrations measured in two networks during 2 ½ years is displayed in Figure 1.

The cause for these variations is not fully understood: whereas in some regions additional combustion activities, such as heating of private homes, might be responsible for higher emissions, other authors find that meteorological conditions, with more frequent inversion layers and lower mixing heights in the air column, might explain the differences.

Figure 1: Seasonal trend of ambient air concentrations of dioxin in southern Germany. Median concentrations obtained from the networks around the MSWIs at Augsburg and Burgkirchen (n=223)



3.5 BIOMONITORS

3.5.1 Vegetation

Vegetation has been used by many countries to monitor ambient air concentrations. The use of these biomonitors was found useful for both routine programmes on a long-term basis and to identify potential hotspots around point sources of emissions. The use of kale was successfully implemented around a steel producing plant in Luxembourg, where mean concentrations up to 106 ng I-TEQ/kg d.m. were detected; in Germany 12.6 ng I-TEQ/kg d.m. were determined close to combustion sources. In Austria, spruce needles were used as biomonitors: the background concentrations were in a very narrow range between 0.3 and 1.9 ng I-TEQ/kg d.m. Normally, baseline concentrations were around 0.5 ng I-TEQ/kg d.m. in rural areas and around 1-1.7 ng I-TEQ/kg d.m. in urban areas. Studies from Bavaria and Hesse in Germany reported that mean dioxin concentrations in pine needle ranged from 0.53 to 1.64 pg I-TEQ/g d.m. However, in the neighbourhood of the Brixlegg copper reclamation plant in Austria, between 51 and 86 ng I-TEQ/kg were determined. In Welsh Rye grass, which is typically exposed for four weeks during the summer, concentrations were between 0.5 and 1 ng I-TEQ/kg d.m. However, as mentioned above, a linear correlation between dioxin concentrations in vegetation and the high volume air samplers or deposition samples cannot be established.

3.5.2 Animals

Fish and shellfish have frequently been used as biomonitors for the aquatic environment. As can be seen from Table 5, fish are highly bioaccumulative for dioxins and concentrations of several hundred pg TEQ/g fat have been detected. These concentrations are much higher than those found in terrestrial animals, such as cattle, pigs, or chickens.

Top-predators, like sea eagles or guillemots, also showed high concentrations of dioxin: as an example, in Finland 830 to 66,000 pg TEQ/g fat were found in white-tailed sea eagles. The Swedish Dioxin Database reported a wide range of dioxin concentrations in the blubber of ringed seal: 6.3 to 217 pg TEQ/g fresh weight.

Table 5: Summary of fish concentrations from EU Member States (pg TEQ/g fat)

	Finland	Germany	Sweden	United Kingdom
Range	75-200	40-51	9.1-420	16-700

Cows' milk has been used by several countries as a biomonitor for ambient air contamination around potential dioxin point sources. Based on experiences from The Netherlands and Germany, cows' milk concentrations around 1 to 3 pg I-TEQ/g fat should be considered as background for highly industrialised and densely populated countries. Both countries have set upper limits for the marketing of cows' milk which are at 5 and 6 pg I-TEQ/g fat, respectively. The German regulation states that if dioxin concentrations above 3 pg I-TEQ/g fat are detected, such concentrations should not be considered as background; a nearby dioxin source should be identified and, if possible, eliminated. In view of these experiences and guidelines, the numbers in Table 6 show data from hotspots that have been identified and subsequently monitored in Austria and France. In France the monitoring programme was performed for several municipal solid waste incinerators (MSWI), and not limited to the very bad and old plant; the case of the Brixlegg copper reclamation plant in Austria revealed a severe problem for the farmers in the neighbourhood. In Austria, it was more than five years before the dioxin concentrations returned to background levels. In France, only a few measurements of concentrations in cows' milk were above the German or Dutch guidelines concentrations. The surveys performed in Ireland were designed to obtain a general overview on concentrations in cows' milk and did not target any point source. All concentrations were very low, based on general European data for dairy products.

Table 6: Summary cows' milk concentrations as biomonitors around potential dioxin point-sources from EU Member States (pg TEQ/g fat)

	Austria	France	Ireland
Source	Copper reclamation plant	Various municipal solid waste incinerators	General surveys, no point source
Range	5-69.5	0.32-8.37	0.13-1.5

3.6 SEWAGE SLUDGE

In Austria and Germany, sewage sludge for application in agriculture has to be analysed for dioxins and comply with legal limit values . These countries have established a maximum permissible concentration of 100 ng I-TEQ per kg dry matter for sewage sludge applied to agricultural land. Additional data were available from Denmark, Spain, and the UK. As can be seen from Table 7, in general, the concentrations ranged from below 1 ng I-TEQ/kg d.m. to around 200 ng I-TEQ/kg d.m, with levels in Germany reaching over 1,000 ng TEQ/kg d.m. Average concentrations of dioxin in sewage sludge are quite similar for each country, lying between 15 and 40 ng I-TEQ/ kg d.m. These findings indicate that similar sources are responsible for the contamination in sludges. The results, mainly from Germany and Sweden, revealed that " normal" effluents from households, especially from washing machines, could explain these results. Additional inputs can originate from dishwashers but also run-off from streets and from roofs. Industrial inputs, where untreated effluents enter the municipal sewer systems, can cause very high contamination in sewage sludges. In such cases, more than 1,000 ng I-TEQ/kg d.m. have been detected.

Table 7: Summary of sewage sludge concentrations from EU Member States (ng TEQ/kg d.m.)

Country	Austria	Denmark	Germany	Spain	Sweden	UK
Range	8.1-38	0.7-55	0.7-1,207	64	0.02-115	9-192
Average	14.5	21	20-40		20	

3.7 CONSUMER GOODS

In Germany, chemical substances, mixtures, etc. have to comply with legally binding maximum permissible concentrations according to the ChemVerbots-Verordnung. In addition to measurements that have to be performed within the framework of this regulation, consumer goods, such as textiles, pulp and paper products, cork, leather, etc. have been analysed for dioxins. A detailed presentation of these results is shown in Section A5 of the Technical Annex to this report. The results can be summarised briefly as follows:

- raw textiles contained dioxin concentrations below 1 ng I-TEQ/kg with one exception, where 244 ng I-TEQ/kg were detected. In finished cotton, the median concentration was as low as 0.20 ng I-TEQ/kg;
- textiles bought in department stores in Germany (>140 pieces) showed that 90 % of the samples were (almost) uncontaminated with dioxins (<10 ng I-TEQ/kg). However, in cases where treatment with pentachlorophenol or application of chloranil-based dyestuffs were suspected, up to 370 ng I-TEQ/kg textile were determined. A survey of 24 T-shirts in Denmark did not detect any high contamination: the concentrations ranged from 0.02 to 2.6 ng N-TEQ/kg;
- wool was found to contain concentrations between 1 and 86 ng I-TEQ/kg. Some of the contamination in the finished products pointed at pentachlorophenol as the source of contamination;
- leather was contaminated with dioxins between 430 and 6,400 ng I-TEQ/kg. These concentrations were detected in wallets and shoes. Such high concentrations were confirmed even in samples from quite recent collections in 1996. For leather goods, the

PCP concentrations correlated with dioxin concentrations, at least qualitatively. This finding could not be confirmed for textiles (here, the more water-soluble PCP might have washed out before the textile entered the market);

- PCP-treated wood can be highly contaminated with dioxins; at the surface, concentrations of 1,500-19,000 ng I-TEQ/kg were analysed. Untreated wood typically had only around 5 ng I-TEQ/kg;
- corks for wine bottles were contaminated in the range 0.18-2.6 ng TEQ/kg; cork in wall coverings contained higher concentrations with 12.6 ng TEQ/kg;
- relatively intensive investigations of candles were performed in the mid 1990s in Germany, caused by a public fear that, during Christmas time, higher exposure of humans might occur when candles were burnt. The raw materials for the production of candles – paraffin and stearin – showed very low dioxin contaminations, namely 0.6 and 1.6 ng I-TEQ/kg, respectively. The natural product, bees' wax, contained the highest concentration (11 ng I-TEQ/kg). Wicks contained 0.08-0.18 ng I-TEQ/kg. Also the coloured products had low concentrations with a mean value of 0.33 ng I-TEQ/kg (median: 1.8 ng I-TEQ/kg);
- the highest concentrations detected in German pulp samples analysed in the 1990s was 1.65 ng I-TEQ/kg. In general, Swedish and Canadian paper products had contaminations below 1 ng I-TEQ/kg. The lowest dioxin contamination was found in samples using total chlorine-free bleaching (*e.g.* Organocell[2] or ASAM[3] processes) where all concentrations were below 1 ng I-TEQ/kg;
- higher concentrations than in papers from primary fibre were detected in papers, cardboards and cartons produced from recycling paper. In 1991, dioxin concentrations in the range from 0.83 and 11.53 ng I-TEQ/kg d.m. were determined.

[2] Bleaching sequence: Oxygen in alkaline medium added with hydrogen peroxide followed by peroxide

[3] Uses an alkaline sulfite step with anthraquinone, oxygen and ozone bleaching

4 Conclusions and Recommendations

During this project extensive amounts of quantitative data on dioxin concentrations in the various environmental media were collected from Member States of the European Union. All countries delivered information expressed as toxic equivalents (TEQ); some older data were on an homologue basis only, but were not used in this project. The amount of data for a given country and a given environmental matrix varied greatly. For some countries, such as Germany, the United Kingdom, Finland, and the Netherlands, there exist large databases on dioxin concentrations in the environment. However, the coverage per matrix varies from country to country: for example, there are many data on wildlife in Finland whereas there are only a few data for Germany. On the other hand, Germany and the United Kingdom focused many activities on ambient air monitoring. So far, there are no dioxin data available for Portugal, although there are several studies in progress and, in the near future, data will also be available from this country. Other countries will use advanced methodology to update and enlarge their database; *e.g.* Denmark will perform a dioxin program in the year 2001 and will also include Greenland and the Faroe islands.

However, due to public concern regarding dioxins, many studies have been aimed at identifying potential ‘hotspots’ of contamination. As a result, such locations have been more intensively sampled and analysed than background or baseline locations.

It has not been possible to carry out any statistical analysis of available data, as countries or individual reports provided aggregated data covering varying numbers of samples, time periods and locations. From an analysis of the data it was, in most cases, impossible to distinguish significant differences in background concentrations of dioxin in rural and urban locations. A seasonal trend, with higher air concentrations of dioxin in winter and lower concentrations in summer, was confirmed many times, irrespective of location.

It is clear from this study that there are many data on environmental concentrations of dioxin, which cover many environmental compartments and other matrices, such as consumer goods and residues. However, the information is not easily accessible and is very scattered, especially in countries with a long dioxin history. In such cases, the relevant governmental agencies do not necessarily own the data or maintain a comprehensive database containing the results generated in the country. This fact is due to the widespread interest in issues relating to dioxins and shared responsibilities within each country.

Research leading to new data on concentrations in the environment or products has sometimes been initiated and financed in the private sector and, thus, the data are not necessarily reported to the appropriate government agency, but may be found in the published literature. It should, therefore, be assumed that within the governments and agencies, but more in the private sector and research institutions, many more data exist that could not be accessed within the framework of this study. It is recommended that, for compliance with future European Commission Directives, all relevant data from public and private organisations should be reported to the local or federal authorities and, thus, be accessible to governments and the general public.

Other recommendations, relating to environmental sampling, analysis and data collection, are also relevant to a number of the other component Tasks within this project and are addressed in a separate report on Generic Issues. However, for monitoring purposes, cows' milk has proved to be an appropriate monitor for air quality and human exposure. A substantial database of dioxin concentrations in EU Member States is available and guideline concentrations for human consumption. Thus, it is recommended that the use of cows' milk for monitoring purposes should be extended within the European Community;

Despite the data limitations described above, this study provides a valuable overview of the present status of dioxin contamination in the Member States of the European Union. The results from this study will help countries to rank their own situation with respect to that of neighbouring countries and may direct the focus of further activities. For the European Commission, the results of this study, together with the source characterisation and inventory programme led by the Landesumweltamt Nordrhein-Westfalen, will help to set future priorities for dioxin reduction measures and identify needs for further information gathering or research programmes.

Finally, in the international context, with negotiations presently underway within the United Nations Environment Programme (UN EP) for a Persistent Organic Pollutants (POPs) Convention, which includes dioxins and furans as two of the twelve POPs [4], there is a need to know about sources and environmental occurrence of PCDD and PCDF. For such a purpose, this study represents a sound basis and a state-of-the-art report for the European Union.

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[4] Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene, hexachlorobenzene, polychlorinated biphenyls, dioxins and furans

Glossary

DG	Direction Génerale
d.m.	Dry matter
EU	European Union
MSWI	Municipal solid waste incinerator
PCDD	Polychlorinated dibenzo-*p*-dioxins
PCDF	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
POPs	Persistent Organic Pollutants
UNEP	United Nations Environment Programme
TEQ	Toxicity equivalent (I = International; N= Nordic)