Compilation of EU Dioxin Exposure and Health Data

Task 5 - Human Tissue and Milk Levels

Report produced for

European Commission Environment

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

October 1999

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Title	**Compilation of EU Dioxin Exposure and Health Data** Task 5 - Human Tissue and Milk Levels
Customer	European Commission DG Environment UK Department of the Environment, Transport and the Regions (DETR)
Customer reference	97/322/3040/DEB/E1
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File reference	j:/dioxins/t5_milkl/tsk5final.doc
Report number	AEAT/EEQC/0016.5
Report status	Final

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Executive Summary

Dioxins are known to be ubiquitous in the environment and the entire population of the EU has, to some extent, been exposed to dioxins, primarily through the ingestion of contaminated foodstuffs, although accidental and occupational exposure can also occur. Dioxins accumulate in the body and the average concentration increases progressively from year to year. Concentrations have been measured in human breast milk, blood and body tissue, and are an indicator of the exposure history of the individual or group of individuals concerned. It is recognised that dioxin concentrations can be influenced by a number of factors; some are directly associated with the various possible routes to exposure such as the location, occupation, living conditions and dietary habits of the individual; others include the number of breast-fed children and length of the nursing period; the age, sex and body weight of the subject concerned. However, within the scope of this study, it has proved impossible to identify comparable sets of data on which to base a quantitative assessment of the relative impacts of most of these factors. The only influencing factor which could be analysed in any detail was location; whether the subjects concerned lived in a rural, urban or industrial environment within each Member State.

This report presents the findings of work undertaken to assemble, compare and critically review the data on the concentrations of dioxin in human breast milk, blood and body tissue, measured within the Member States of the European Union. However, the only substantial source of comparable data relating to the majority of Member States is the WHO co-ordinated study of dioxin concentrations in human breast milk which, by definition, relates only to young women. There is very little comparable data relating to children, teenagers, men or older women.

Over the five-year period from 1988 to 1993 the average dioxin concentration in breast milk in European Member States decreased by around 35% (8.3% per year), with a slightly higher decrease in rural areas and slightly lower in industrial areas. Measurements taken in Germany over the eight year period from 1988 to 1996 showed that the average concentration of dioxins in the blood of adult males decreased by around 64% (12% per year), although the annual increase in dioxin concentrations in the body was estimated to be around 0.3 pg I-TEQ/g fat per year due, primarily, to the continuous ingestion of contaminated foodstuffs.

Although most data relating to the concentration of dioxins in the EU population are for nursing mothers, it is safe to assume that, for the population as a whole, the rate of accumulation of dioxins in the body has declined over the past two decades. It is for other Tasks within this project to determine whether that rate, if it continues, is sufficient to protect the population from the potentially harmful effects of dioxins. However, as the toxicology of dioxins is progressively better understood, it will continue to be important that concentrations in the body tissue and fluids of the population is monitored on a regular and consistent basis across the EU, and that ‘at risk groups’ are separately identified and monitored.

There are three main recommendations from this study:

- an EU-wide programme should be established for the routine monitoring of dioxin concentrations in the blood of males and females across all age groups, following similar

procedures to the WHO co-ordinated assessment of human breast milk, in order to assess and monitor any changes in the age-related increase in dioxin concentrations as a result of the measures implemented to reduce exposure;

- measurements are required of the actual rates of accumulation of dioxin in the body tissue of breast-fed infants, both for the first born and subsequent children;
- whilst recognising the wider benefits of breast-feeding infants, a better understanding is required of the importance of short periods of high exposure to dioxins on the neurological, immune system, reproductive system, endocrinological and intellectual development of such infants.

Contents

1. Introduction

Dioxins are known to be ubiquitous in the environment and the entire population of the EU has, to some extent, been exposed to dioxins primarily through the ingestion of contaminated foodstuffs, although accidental and occupational exposure can also occur. Dioxins accumulate in the body and the average concentration increases progressively from year to year. Concentrations have been measured in human breast milk, blood and body tissue, and are an indicator of the exposure history of the individual or group of individuals concerned. It is recognised that dioxin concentrations can be influenced by a number of factors; some are directly associated with the various possible routes to exposure such as the location, occupation, living conditions and dietary habits of the individual; others include the number of breast-fed children and length of the nursing period; the age, sex and body weight of the subject concerned. However, within the scope of this study, it has proved impossible to identify comparable sets of data on which to base a quantitative assessment of the impact of most of these factors. The only influencing factor which could be analysed in any detail was location; whether the subjects concerned lived in a rural, urban or industrial environment within each Member State.

This report presents the findings of work undertaken to assemble, compare and critically review the data on the concentrations of dioxin in human breast milk, blood and body tissue, measured within the Member States of the European Union. In the case of breast milk, data availability was good and the only countries for which no data sources could be identified were Greece, Ireland, Luxembourg and Portugal. However, data on dioxin concentrations in human blood and tissue have been compiled in only a few countries; in the case of blood data were identified for Finland, Germany and Spain, while for tissue only France, Germany, Spain and Sweden had suitable data sets. Detailed information and the data available from each country are given in the Technical Annex. This Summary Report presents an assessment of the concentrations of dioxin found in human breast milk, blood and tissue and any trends observed. The implications of these for the effectiveness of measures taken to reduce dioxin releases to the environment, as well as for future policy development, are presented under the headings of Conclusions and Recommendations.

The information presented in this report has been assembled through literature research, contact with the representatives of Government Departments and Agencies within individual Member States, as well as consultation with international experts actively involved in this field of research.

2. Analysis

2.1. HUMAN BREAST MILK

The main source of comparable data for the majority of Member States was the WHO co-ordinated assessment of dioxin concentrations in breast milk, the first round of which was conducted during the period 1986-1988 and the second during 1992-1993. Data on baseline concentrations of dioxin in breast milk samples were available from these assessments for Austria, Belgium, Denmark, Finland, Germany, the Netherlands, Spain, Sweden and the United Kingdom. In many cases, additional data were available from other sources and a limited amount of data were also available for France and Italy. The baseline concentration was taken to be that of the average (in this case female) population, which had not been subject to any known accidental or occupational exposure to dioxins.

In the case of the WHO assessments, analyses were performed on pooled milk samples, composed of varying numbers of individual samples, and the average concentration for the pool was reported. Many of the independent analyses were carried out on sets of individual samples, with the minimum, maximum and mean concentrations of dioxin being reported.

In most cases, the location within each country from which samples were collected was classified as rural, urban or industrial and this has facilitated a comparison of the average concentrations and trends observed across the EU for each type of environment. The years for which most data were available were 1988 and 1993. Table 1 shows the average of all reported measurements for those years, for rural, urban and industrial locations in EU Member States, and the percentage change observed over the five-year period.

In both 1988 and 1993 average measured concentrations were lowest in rural areas and highest in industrial areas, although it should be noted that very few measurements were reported for industrial areas. Concentrations decreased by around 35% (8.3% per year) over the five year period, with a slightly higher decrease in rural areas and slightly lower in industrial areas. A continuous series of measurements made in the urban area of Stockholm, Sweden, have shown a steady decrease in average dioxin concentrations of around 65% over the period 1972 to 1984/85 (8.4% per year), followed by only slight fluctuations to 1992. A further series of measurements made in the industrial region of Northrhine Westphalia, in Germany, have shown a steady decrease in concentrations of around 41% from 1992 to 1997 (10% per year).

Table 1 - Average reported concentrations of dioxin in human breast milk

	Average Concentration pg I-TEQ/g fat		
	1988	**1993**	**% Change**
Rural	28.2	17.7	37
Urban	29.5	19.2	35
Industrial	35.9	24.0	33

Within the data set for each location, there is a wide range in reported average dioxin concentrations. The maximum and minimum in each range is shown in Table 2, but it should be noted that each of these figures is an average of up to 176 pooled or individual samples. It should be expected that the range across all samples would be even greater.

Table 2 - Minimum and maximum average reported concentrations of dioxin in human breast milk

	Average Concentration pg I-TEQ/g fat			
	1988		**1993**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Rural	18.6 (Austria)	37.4 (Netherlands)	10.9 (Austria)	25.5 (Spain)
Urban	17.1 (Austria)	39.6 (Netherlands)	10.7 (Austria)	26.6 (Belgium)
Industrial	31.6 (Germany)	40.2 (Belgium)	20.9 (Germany)	27.1 (Belgium)

Figures 1 to 3 illustrate the average dioxin concentrations reported for 1988 and 1993 and the relative changes in concentration over the period for rural, urban and industrial areas respectively. Additional data for different years and other countries are given in the Technical Annex.

2.1.1. Infant Exposure

It is appropriate to consider here the implications of the concentrations of dioxin in human breast milk for the daily intake of breast-fed infants. On the basis that the average milk consumption of a 4 kg infant is around 800 ml/day at 3% fat content the figures presented in Table 1 suggest that the average dioxin intake by such infants in 1993 might range from 106 pg I-TEQ/kg/day in rural areas to 144 pg I-TEQ/kg/day in industrial areas. Similar estimates made in the UK derived a range of 110 pg I-TEQ/kg/day for an infant at 2 months of age falling to 26 pg I-TEQ/kg/day for an infant at 10 months, due to the move to a mixed diet and increase in bodyweight. However, these figures might represent a 'worst case'. In general, milk samples were collected from mothers only up to two months after delivery, and no account was taken of the fact that dioxin concentrations in human breast milk decline over the period of breastfeeding, by around 12% per month. In addition, concentrations become progressively lower for mothers feeding their second and subsequent children.

If the estimates of daily intake outlined above are compared with the new Tolerable Daily Intake (TDI) for the general population recommended by WHO, of 1 to 4 pg WHO-TEQ/kg/day (including PCBs), it appears that the exposure of infants up to 2 months old, to dioxins alone, could be a factor of between 27 and 144 times greater than this. However, the WHO recommended TDI is based on an average lifetime exposure and it might be assumed that the high levels of infant exposure are counter-balanced by lower levels of exposure in later life. This may be so, but consideration must also be given to whether the effects of short periods of very high exposure differ from those of prolonged periods of much lower exposure, particularly when the former occur during a critical period for infant neurological, physical and intellectual development.

The discussion above also illustrates how the female body-burden of dioxins can be influenced by the number of breast-fed children and the length of the nursing period, as the rate of elimination of dioxins from the mother's body during breast-feeding is greater than her rate of uptake via the various routes to exposure.

Figure 1 - Average dioxin concentrations in human breast milk:

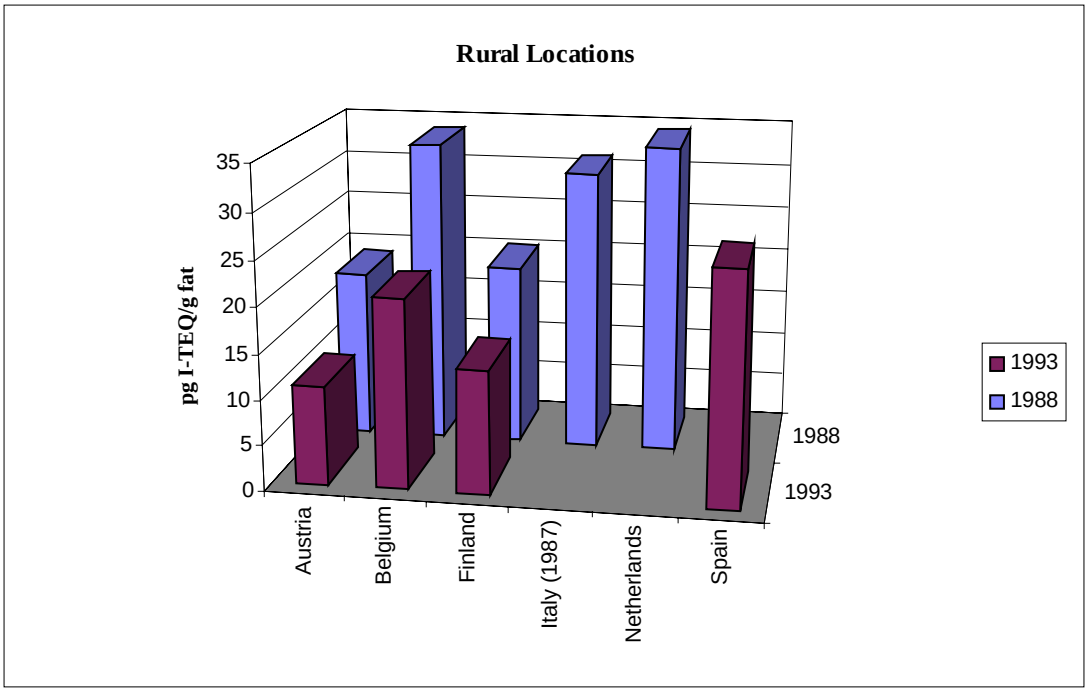


Figure 2 - Average dioxin concentrations in human breast milk:

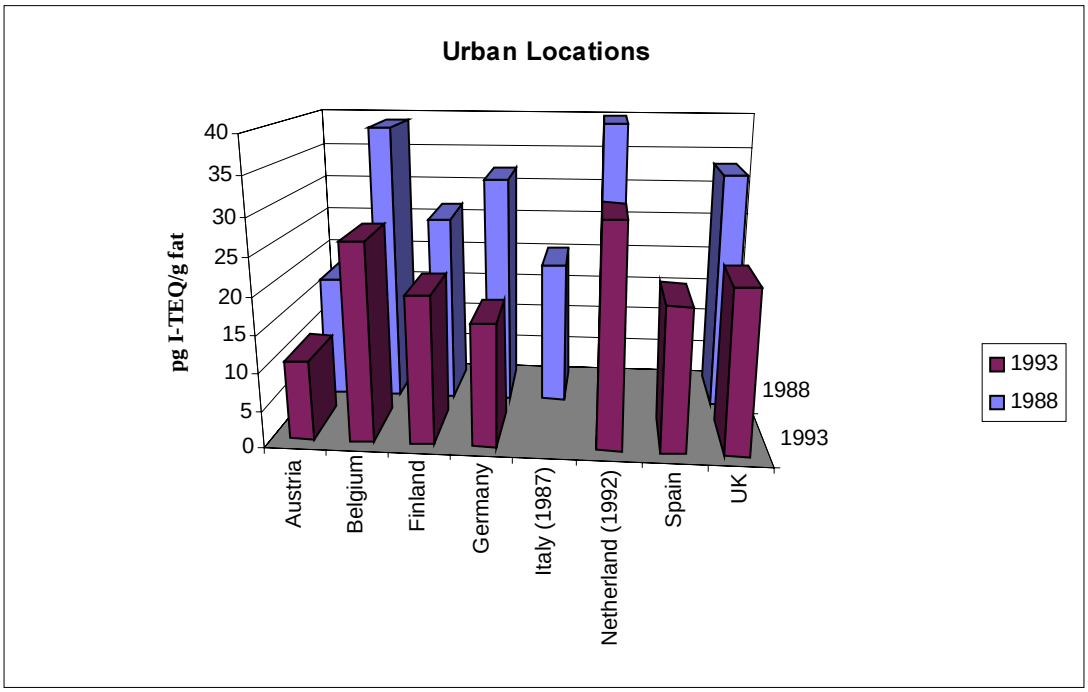
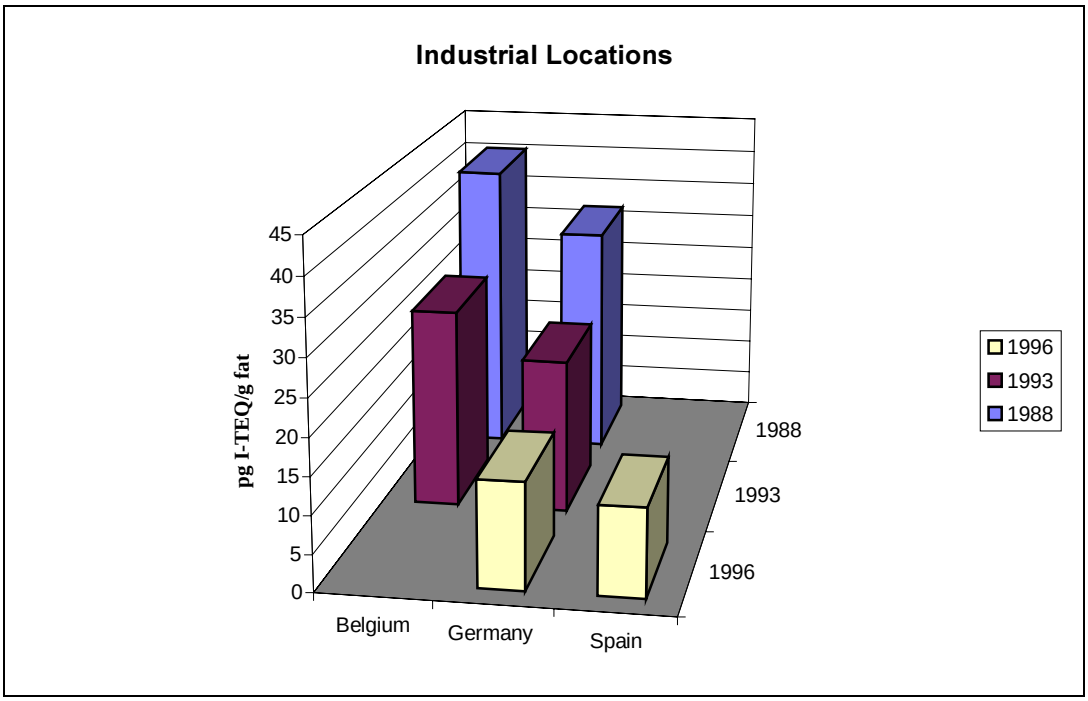


Figure 3 - Average dioxin concentrations in human breast milk:



2.2. HUMAN BLOOD

Insufficient comparable data were available to make a realistic assessment of how concentrations of dioxin in human blood have changed across EU Member States over recent years, although it is a relatively easy, non-invasive medium to sample and analyse. Data were identified for only Finland, Germany and Spain and are described in the Technical Annex. The most extensive set of data was collected in Germany, between 1988 and 1996, and shows an average decrease in dioxin concentrations of 12% per year for the adult male population as

a whole, with a mean concentration of 16.5 pg I-TEQ/g fat in 1996. However, the annual increase in dioxin concentrations in the body was estimated to be 0.3 pg I-TEQ/g fat, due to the continuous ingestion of contaminated foodstuffs and exposure via other, minor, routes.

2.3. HUMAN TISSUE

Only seven individual data sets, from four Member States, were identified in the course of this study and the concentrations of dioxin in human tissue measured in France, Germany, Spain and Sweden are described in the Technical Annex. Reported average concentrations range from 50 pg I-TEQ/g fat in the adipose tissue of German samples, in the late 1980s, to 18.6 pg I-TEQ/g fat in the abdominal tissue of hospital patients in Sweden, in 1994/95. However, as no standard method has been established for lipid determination, it is difficult to draw firm conclusions from a comparison of the limited amount of data relating to the individual Member States. In addition, the concentrations in adipose tissue are highly influenced by the age of the subject, as dioxins tend to accumulate in fatty tissue over time. Without detailed information on the characteristics of the tissue donor, it is difficult to make any meaningful comparison between the available data sets.

3. Conclusions

Concentrations of dioxin in human tissue and body fluids are an indicator of the exposure history of the individual or group of individuals concerned. The only substantial source of comparable data relating to the majority of European Union Member States is the WHO co-ordinated study of dioxin concentrations in human breast milk which, by definition, relates only to young women. There is very little comparable data relating to children, teenagers, men or older women.

Although it is recognised that a number of factors can influence dioxin concentrations in the human body, comparable sets of data are only available to make a quantitative assessment of the impact of geographical location, whether rural, urban or industrial, on the concentrations of dioxin in human breast milk.

Over the five-year period from 1988 to 1993 the average dioxin concentration in breast milk in European Member States decreased by around 35% (8.3% per year), with a slightly higher decrease in rural areas and slightly lower in industrial areas. Measurements taken in Germany over the eight year period from 1988 to 1996 showed that the average concentration of dioxins in the blood of adult males decreased by around 64% (12% per year), although the annual increase in dioxin concentrations in the body was estimated to be around 0.3 pg I-TEQ/g fat per year due, primarily, to the continuous ingestion of contaminated foodstuffs.

Data reported in Task 4 on Human Exposure to dioxins suggests that, over the past two decades, within EU Member States dietary exposure to dioxins has, on average, decreased by around 12% per year, depending upon the changing patterns of food consumption and the concentrations of dioxin in foodstuffs.

It is, therefore, clear that the actions taken to reduce human exposure to dioxins, whether by limiting and controlling the release of dioxins into the environment, restricting the movement of dioxins through the foodchain or establishing permissible concentrations in foodstuffs, have led to a reduction in the rate at which dioxins accumulate in the body of the ‘average’ citizen of the European Union.

4. Recommendations

This report relates, primarily, to the 'outcomes' of dioxin exposure rather than the 'inputs' and the following recommendations, therefore, address the need to clarify and interpret those outcomes more effectively, rather than any need to further limit and control the inputs.

Although the only comparable data relating to the concentration of dioxins in the population of EU Member States is for nursing mothers, it is safe to assume that, for the population as a whole, the rate of accumulation of dioxins in the body has declined over the past two decades. It is for other Tasks within this project to determine whether that rate, if it continues, is sufficient to protect the population from the potentially harmful effects of dioxins. However, as the toxicology of dioxins is progressively better understood, it will continue to be important that concentrations in the body tissue and fluids of the population is monitored on a regular and consistent basis across the EU, and that 'at risk groups' are separately identified and monitored.

There are three main recommendations from this study:

- an EU-wide programme should be established for the routine monitoring of dioxin concentrations in the blood of males and females across all age groups, following similar procedures to the WHO co-ordinated assessment of human breast milk, in order to assess and monitor any changes in the age-related increase in dioxin concentrations as a result of the measures implemented to reduce exposure;
- measurements are required of the actual rates of accumulation of dioxin in the body tissue of breast-fed infants, both for the first born and subsequent children;
- whilst recognising the wider benefits of breast-feeding infants, a better understanding is required of the importance of short periods of high exposure to dioxins on the neurological, immune system, reproductive system, endocrinological and intellectual development of such infants.

Task 5 – Human Tissue and Milk Levels

Technical Annex

CONTENTS

Annex 1
Human breast milk

CONTENTS

A1 Introduction

This Annex presents data assembled in EU Member States on the concentration of dioxins in human breast milk. The baseline concentration is taken to be that of the average population, which has not been subject to accidental or occupational exposure. No data were available for Greece, Ireland, Luxembourg or Portugal.

A number of countries have contributed to the WHO-coordinated assessment of dioxin concentrations in breast milk (Austria, Belgium, Denmark, Finland, Germany, the Netherlands, Spain, Sweden and the United Kingdom), the first round of which was conducted during the period 1986-1988 and the second during 1992-1993. For both rounds, analyses were performed on pooled milk samples, composed of varying numbers of individual samples from at least 10 nursing mothers. Donors had to be nursing their first child (primaparae) and breastfeeding only one infant. At least two different groups from each country were included in the studies, for example, expected high exposure and low exposure groups, and samples were collected from exactly the same locations for each round of the study. These assessments have proved to be the main source of comparable data for the majority of Member States.

Concentration values extracted from WHO (1989) were calculated using the Nordic Toxicity Equivalency Factors (N-TEF) model. This model differs from the I-TEF scheme in that the latter ascribes a TEF value of 0.05 to the 1,2,3,7,8-Cl_5DF congener, while in the Nordic scheme this is assigned a value of 0.01. However, this results in a negligible difference between the N-TEQ and I-TEQ values.

A1.1 Austria

Dioxin concentrations in breast milk measured in rural and urban areas of Austria were similar in 1988 and 1993. In both cases concentrations have decreased over the period, by approximately 40%.

Concentrations measured in 1993 close to the copper recycling plant in Brixlegg were found to be around 30% higher than in the rural and urban locations selected.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Tulin (rural)	pool	1988	18.6 *	51	WHO (1989)
Tulin (rural)	pool	1993	10.9	21	WHO (1996)
Vienna (urban)	pool	1988	17.1 *	54	WHO (1989)
Vienna (urban)	pool	1993	10.7	13	WHO (1996)
Brixlegg (close to point source)	pool	1993	14.0	13	WHO (1996)
Brixlegg (close to point source)	individual	1993	9.3-45.9	5	Riss (1993)

***** Calculated using N-TEF model.

A1.2 Belgium

The measured concentrations of dioxin in breast milk, in both 1988 and 1993, were highest in the samples collected in the industrial area and lowest in the rural area. The average decrease in concentrations from 1988 to 1993 was around 34%, with the greatest decrease being seen in the rural location, at 38%, while concentrations in urban and industrial locations decreased by 31% and 33% respectively.

The average concentration reported by Van Cleuvenbergen *et al*. for samples taken in 1992, in the Provinces of Brabant, Antwerp, W- Vlaanderen, and Limburg, was 34.7 pg I-TEQ/g fat, with a range of 28.9 to 43.2 pg I-TEQ/g fat. This was higher than any of the average concentrations reported by the WHO assessment for 1993. Van Cleuvenbergen *et al*. considered a smaller number of individual samples than the WHO assessments, and took them from mothers breastfeeding their first child, as well as those feeding their second or third child. Primaparae samples constitute only 33% of the total individual samples, whereas the WHO assessment included only primaparae samples. However, it is normally the case that the dioxin concentration in breast milk is lower for the second and subsequent children.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Brabant-Walloon (rural)	pool	1988	33.7 *****	na	WHO (1989)
Brabant-Walloon (rural)	pool	1993	20.8	8	WHO (1996)
Brussels (urban)	pool	1988	38.8 *****	na	WHO (1989)
Brussels (urban)	pool	1993	26.6	6	WHO (1996)
Liege (industrial)	pool	1988	40.2 *****	na	WHO (1989)
Liege (industrial)	pool	1993	27.1	20	WHO (1996)
4 Provinces in Flanders	individual	1992	34.7	9	Van Cleuvenbergen *et al*. (1994)

***** Calculated using N-TEF model.

na Not available

A1.3 Denmark

For the WHO assessment, milk samples were collected from seven individual cities across Denmark, which were considered to be representative of background concentrations of dioxin for the population as a whole. Samples were not categorised according to the type of location; whether rural, urban or industrial. A 15% decrease in the mean concentration of dioxin was observed between 1988 and 1993 in the pooled samples.

Four individual milk samples from the 48 used in the 1993 assessment were also analysed and showed a mean concentration of 17.1 pg I-TEQ/g fat. However, in view of the small number of samples selected, it is difficult to make any comparison with the analysis of pooled samples.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)			No of samples	Reference
			Mean	Min	Max		
7 cities	pool	1988	17.8 *	-	-	42	WHO (1989)
7 cities	pool	1993	15.2	-	-	48	WHO (1996)
7 cities	individual	1993	17.1	11.9	22.5	4	WHO (1996)

***** Calculated using N-TEF model.

A1.4 Finland

Taken overall, dioxin concentrations measured in breast milk samples collected in the rural area of Kuopio were lower than those collected in the urban area of Helsinki for both 1988 and 1993. Vartiainen *et al.* and Kiviranta *et al.* also observed a greater decrease in concentrations in the rural area over this period (32%) than in the urban area (24%).

The concentrations reported within the WHO assessment for Helsinki appear to increase from 1988 to 1993. However, this might be explained by the fact that different laboratories undertook the analysis of the samples from the two periods. Vartiainen *et al.* and Kiviranta *et al.* were able to use the same laboratories and procedures for each set of analyses.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Kuopio (rural)	pool	1988	15.5 *****	31	WHO (1989)
Kuopio (rural)	pool	1993	12.0	24	WHO (1996)
Kuopio (rural)	individual	1987	20.1	37	Vartiainen *et al.*(1997)
Kuopio (rural)	individual	1992-94	13.6	28	Kiviranta *et al.* (1998)
Helsinki (urban)	pool	1988	18.0 *****	38	WHO (1989)
Helsinki (urban)	pool	1993	21.5	10	WHO (1996)
Helsinki (urban)	individual	1987	26.3	47	Vartiainen *et al.*(1997)
Helsinki (urban)	individual	1992-94	19.9	14	Kiviranta *et al.* (1998)

***** Calculated using N-TEF model.

A1.5 France

Only one assessment of the concentration of dioxin in the milk of nursing mothers in France was identified during the course of this study. The age range of the 15 mothers taking part in the assessment was 25 to 40 years.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Paris (urban)	individual	1990	20.1	15	Gonzalez *et al.* (1996)

A1.6 Germany

Data from the WHO assessment of dioxin concentrations in breast milk suggest that, in 1988, the concentrations in samples from the selected urban and industrial areas of Germany were very similar and that, over the period 1988 to 1993, urban area concentrations decreased by around 48%. Very little information is available to allow comment on concentrations in the rural areas of Germany but measurements in 1990/91, reported by Alder *et al.* (1994), suggest that they may have been appreciably lower than in either the urban or industrial areas.

Fürst (CLUA 1992/1993, CVUA 1994/1997) recorded a steady decrease in dioxin concentrations measured in milk samples collected in the industrial region of Northrhine Westphalia of around 41% from 1992 to 1997.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)			No of samples	Reference
			Mean	Min	Max		
Germany-East (rural)	individual	1990/91	23	15	30	499	Alder *et al.* (1994)
Germany-West (urban)	individual	1991	30.6	5.6	87	728	Beck *et al.* (1992)
Berlin (urban)	pool	1988	32.0 *****	-	-	40	WHO (1989)
Berlin (urban)	pool	1993	16.5	-	-	10	WHO (1996)
Northrhine Westphalia (industrial)	pool	1988	31.6 *****	-	-	79	WHO (1989)
Northrhine Westphalia (industrial)	individual	1992	20.5	3.5	39	56	CLUA (1992)
Northrhine Westphalia (industrial)	individual	1993	20.9	5.3	37.6	78	CLUA (1993)
Northrhine Westphalia (industrial)	individual	1994	17.2	4.9	30.3	50	CVUA (1994)
Northrhine Westphalia (industrial)	individual	1995	16.1	6.0	30.3	38	CVUA (1995)
Northrhine Westphalia (industrial)	individual	1996	14.1	4.9	30.5	22	CVUA (1996)
Northrhine Westphalia (industrial)	individual	1997	12.0	9.7	16.9	9	CVUA (1997)

***** Calculated using N-TEF model.

A1.7 Italy

Results reported by Schecter *et al.* (1992) for samples taken from nursing mothers in four regions of Italy, both rural and urban, suggest that in 1987 concentrations of dioxin in breast milk were higher in rural than urban areas. This result is questionable and, indeed, the Schecter *et al.* study recommended that further work was required to provide representative baseline data for Italy.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Pavia (rural)	pool	1987	31	9	Schecter *et al.* (1992)
Rome (urban)	pool	1987	22	9	Schecter *et al.* (1992)
Florence (rural and urban)	pool	1987	29	27	Schecter *et al.* (1992)
Milan (urban)	pool	1987	18	14	Schecter *et al.* (1992)

A1.8 Netherlands

Results reported by Liem *et al.*(1989,1995) and WHO (1989, 1996) suggest that the average concentration of dioxin in breast milk in the Netherlands has decreased by around 33% between 1988 and 1993. Although 103 samples were collected for the WHO assessment in 1993, only 17 were analysed. Liem *et al.* derived a slightly higher average concentration by analysing all of the 103 samples.

Concentrations reported by the WHO assessment for 1988 appear to be slightly (5.5%) lower for the rural area than for the urban area, although this is not entirely consistent with the even lower concentration reported for all regions in 1988.

The assessments carried out by Tuinstra *et al.* and Kooperman-Esseboom *et al.* on milk samples from the Rotterdam/Groningen region are essentially the same, as they relate to the same cohort and samples, differing only slightly in the number of samples analysed.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)			No of samples	Reference
			Mean	Min	Max		
All regions	pool	1988	34.2	30.6	39.7	10 pools of 9-13 samples	Liem *et al.* (1989)
All regions	individual	1993	23.5	8.4	63.2	103	Liem *et al.* (1995)
All regions	pool	1988	34.2 *	-	-	10 pools of 10 samples	WHO (1989)
All regions	individual	1993	22.4	10.2	35.9	17	WHO (1996)
Rural area	pool	1988	37.4 *	-	-	13	WHO (1989)
Urban area	pool	1988	39.6 *	-		13	WHO (1989)
Rotterdam/ Groningen (urban)	individual	1992	30	-	-	168	Tuinstra *et al.* (1995)
Rotterdam/ Groningen (urban)	individual	1992	30.2	-	-	176	Koopmann-Esseboom *et al.* (1994)

***** Calculated using N-TEF model

A1.9 Spain

The data available on the dioxin concentrations in human breast milk for various regions of Spain are inconsistent with the patterns and variations observed in other countries. Data from the WHO assessment for 1993 suggest that concentrations in the rural area are higher than those in the urban area. Measurements reported by Gonzales *et al.* for the industrial city of Madrid and by Schumacher *et al.* for Tarragona, suggest that dioxin concentrations in urban areas are higher than those in industrial areas, but that concentrations in the latter may have decreased by around 11% over the period 1990 to 1996.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)			No of samples	Reference
			Mean	Min	Max		
Gipuzkoa (rural)	pool	1993	25.5	-	-	10	WHO (1996)
Bizkaia (urban)	pool	1993	19.4	-	-	19	WHO (1996)
Madrid (industrial)	individual	1990	13.3	-	-	13	Gonzalez et al. (1996)
Tarragona (industrial)	individual	1996	11.8	5.9	17.1	15	Schumacher *et al* (1999)

A1.10 Sweden

Data from the WHO assessment suggest that, in the period 1985/86, the concentration of dioxins in human breast milk in the rural area of Sweden was around 11% lower than the concentration measured in either the urban or industrial areas. There was no significant difference between the concentrations measured in the urban area, the industrial area and in the locality of a municipal solid waste incinerator (MSWI).

Measurements reported by Lundén and Norén show a steady decrease in concentrations measured in the urban area of Stockholm, with a reduction of around 65% over the period 1972 to 1984/85, followed by only slight fluctuations from 1984/85 to 1992. These measurements have been re-evaluated by Norén & Meironyté (1999) using the WHO-TEFs for PCDDs , PCDFs and PCBs, and the time-period extended to 1997. Under this scheme concentrations decreased by around 61% between 1972 and 1984/85, but between 1972 and 1997 by around 72% (an average of around 8% per year).

Around 55-75% of the milk in the pooled samples analysed by Lundén and Norén and later by Norén & Meironyté was from mothers nursing their first infant. The majority of the remainder was from mothers nursing their second child. The average age of the mothers donating milk for the study was 27-28 years in the period 1972-1985, 29-30 years in 1988-1992, and 30-31 years in 1997. The increase in age is consistent with the general increase of the age of the mothers giving birth in Sweden.

(See below for Table)

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Borlänge (rural)	Individual	1985-86	20.1 *	10	WHO (1989), Lindström pers. com.
Gothenburg (urban)	Individual	1985-86	22.8 *	10	WHO (1989), Lindström pers. com.
Sundsvall (industrial)	Individual	1985-86	22.6 *	10	WHO (1989), Lindström pers. com.
Uppsala (locality of MSWI)	Individual	1985-86	22.4 *	10	WHO (1989), Lindström pers. com.
Stockholm (urban)	pool	1972	43	75	Lundén & Norén (1998)
Stockholm (urban)	pool	1976	30	245	Lundén & Norén (1998)
Stockholm (urban)	pool	1980	20	340	Lundén & Norén (1998)
Stockholm (urban)	pool	1984-85	15	102	Lundén & Norén (1998)
Stockholm (urban)	pool	1990	17	60	Lundén & Norén (1998)
Stockholm (urban)	pool	1991	13	60	Lundén & Norén (1998)
Stockholm (urban)	pool	1992	18	40	Lundén & Norén (1998)
Stockholm (urban)	pool	1972	100**	75	Norén & Meironyté (1999)
Stockholm (urban)	pool	1976	77**	245	Norén & Meironyté (1999)
Stockholm (urban)	pool	1980	52**	340	Norén & Meironyté (1999)
Stockholm (urban)	pool	1984-85	39**	102	Norén & Meironyté (1999)
Stockholm (urban)	pool	1988-89	44**	140	Norén & Meironyté (1999)
Stockholm (urban)	pool	1990	42**	60	Norén & Meironyté (1999)
Stockholm (urban)	pool	1991	32**	60	Norén & Meironyté (1999)
Stockholm (urban)	pool	1992	40**	40	Norén & Meironyté (1999)
Stockholm (urban)	Pool	1997	28**	20	Norén & Meironyté (1999)

***** Calculated using N-TEF model.

** Calculated using the new WHO-TEFs for PCDDs, PCDFs and PCBs

A1.11 UK

Technical difficulties were experienced in the analysis of the data supplied for the second WHO assessment of dioxin concentrations in human breast milk. The samples were subsequently re-analysed, as part of separate study, and the results reported by MAFF (1996). It is, therefore, appropriate that comparison be made between the data presented in the table below for 1988, drawn from WHO (1989), and for 1993/94 from MAFF (1996). This suggests that dioxin concentrations in breast milk samples from mothers living in an urban environment have decreased by an average 33% over the period 1988 to 1993/94, to an average value of
22 pg I-TEQ/g fat.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Birmingham (urban)	pool	1988	37.0 *	40	WHO (1989)
Birmingham (urban)	pool	1993	17.9	20	WHO (1996)
Birmingham (urban)	pool	1993-94	21	20	MAFF (1996)
Glasgow (urban)	pool	1988	29.1 *	40	WHO (1989)
Glasgow (urban)	pool	1993	15.2	23	WHO (1996)
Glasgow (urban)	pool	1993-94	21	20	MAFF (1996)
Cambridge (urban)	pool	1993-94	24	20	MAFF (1996)

***** Calculated using N-TEF model.

Annex 2
Human Blood

CONTENTS

A2 Introduction

This Annex presents data assembled in EU Member States on the baseline concentrations of dioxin in human blood. Only three countries were able to supply data: Finland, Germany, and Spain. No data were available for Austria, Belgium, Denmark, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Sweden or the UK.

A2.1 Finland

In a study of workers in a pulp and paper mill in Finland (Rosenberg *et al*, 1995) an analysis was made of a control group with no known accidental or occupational exposure to dioxins. The results of the study are shown in the table below. It was concluded that there were no statistically significant differences between the concentrations found in the control group and the potentially exposed workers. The mean concentration for the potentially exposed groups was 60 pg I-TEQ/g. A similar study was carried out in 1993, to assess the exposure of workers at three sawmills to the impurities of chlorophenol-containing antistain agents (Kontsas *et al*, 1998). Dioxin concentrations were reported for a control group of workers without known accidental or occupational exposure. The mean concentration measured in the two studies differed by around 24%, suggesting that dioxin concentrations in the general population may be declining.

Sampling Year	No of Samples	Mean Age	Concentration (pg I-TEQ/g fat)				Reference
			Median	Mean	Min	Max	
1989-90	14	41	47	49	20	99	Rosenberg *et al* (1995)
1993	18	43	42	37	26	86	Kontsas *et al* (1998)

The National Public Health Institute in Finland is currently carrying out studies of dioxin concentrations in blood (Vartiainen pers. com.). Concentrations measured in the rural location of Kuopio are 10-15 pg I-TEQ/g fat, for people below the age of 30 years, and 30-40 pg I-TEQ/g fat for people above this age. These concentrations are approximately 5 pg I-TEQ/g fat lower than those measured in Southern Finland.

A2.2 Germany

The following table presents the dioxin concentrations in human blood samples from across Germany. Samples were mostly from male adults and the results derived from individual samples. The data show a decrease of around 64% in the mean concentration over the eight year period from 1988 to 1996.

Sampling Year	No of Samples	Mean Age	Concentration (pg I-TEQ/g fat)				Reference
			Median	Mean	Min	Max	
1988	10	-	-	46.3	-	-	Päpke *et al.*(1989)
1989	102	37	37.8	40.8	11.6	93.5	Päpke *et al.*(1992)
1992	44	37	24.1	26.0	12.0	61.0	Päpke *et al.*(1993)
1993	70	37	19.4	21.7	10.3	48.8	Päpke *et al* (1994)
1994	134	40.4	17.3	19.1	5.2	43.9	Päpke *et al* (1996)
1996	180	36.7	15.6	16.5	7.0		Päpke *et al* (1997)

The following table shows the data for 1996 divided into three age groups:

Age Group	No of samples	Min	95 Percentile	Mean	Median	Ref
18-30 years	59	7.3	20.4	13.0	11.9	Päpke *et al* (1997)
31-42 years	68	7.0	26.1	16.9	17.1	Päpke *et al* (1997)
43-71 years	53	9.6	30.8	19.9	18.4	Päpke *et al* (1997)
All	180	7.0	26.9	16.5	15.6	Päpke *et al* (1997)

The annual increase in dioxin concentration in the body was estimated to be 0.3 pg I-TEQ/ g fat, which is somewhat lower than the age-dependent increase of 0.4 pg I-TEQ/g fat calculated for the previous years, and considerably lower than the annual increase of 0.8 pg I-TEQ/g fat reported at the 1992 Toxicology Symposium, in Berlin (Toxicology Symposium 1993).

A2.3 Spain

Plasma samples were taken from 20 subjects, who had no known occupational exposure to dioxins, and who lived in the vicinity of a hazardous waste incinerator currently under construction in Tarragona, in the Catalonia region. Tarragona already has an important petrochemical industry, two oil refineries and a municipal solid waste incinerator.

The samples were obtained from 7 women and 13 men aged between 28 and 62 years.

Sampling Year	No of Samples	Mean Age	Concentration (pg I-TEQ/g fat)				Reference
			Median	Mean	Min	Max	
1997	20	42	-	27.0	14.8	48.9	Schumacher *et al* (1999)

Annex 3
Human Tissue

CONTENTS

A3 Introduction

This Annex presents data on the concentrations of dioxin in human tissue measured in France, Germany, Spain and Sweden

There is no standard method for lipid determination and it is, therefore, difficult to draw firm conclusions from a comparison of the data relating to each of the Member States. The concentration of dioxins in adipose tissue is highly influenced by the age of the subject, as dioxins tend to accumulate in fatty tissue over time. Again, without detailed information on the characteristics of the tissue donor, it is difficult to make any meaningful comparison between data sets.

A3.1 France

Huteau et al (1990) measured the PCDD/F levels in adipose tissue of eight persons living in Paris. Not all congeners were quantified for all samples. Around 34% of the mean dioxin concentration was found to be due to 2,3,7,8-TCDD. This was not considered to be surprising, in view of the fact that the samples were taken from people in the age range 54 to 82, and also corresponded to data from earlier studies carried out in the late 1980s.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Paris (urban)	individual	1990	32.1	8	Huteau *et al* (1990)

A3.2 Germany

Only two data sets, with limited background information, have been identified in Germany.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)			No of samples	Reference
			Mean	Min	Max		
Adipose tissue	individual	unavailable	50.0	25.4	107.4	28	Mücke, *et al.* (1990)

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g wet weight)			No of samples	Reference
			Mean	Min	Max		
Liver	individual	unavailable	9.8	2.3	24.8	28	Mücke, *et al.* (1990)

A3.3 Spain

Gonzalez *et al.* (1993) reported dioxin concentrations in the abdominal tissue of 17 subjects who died in Madrid of natural causes. The subjects included 12 women and 5 men, ranging in age from 48 to 89 years. The mean concentration of 41.8 pg I-TEQ/g fat was considered to be of the same order of magnitude as that measured in similar studies in Canada, France, USA and Japan. A high concentration of the more highly chlorinated PCDDs was found in the samples taken in this study, and the authors suggested that the major contributor to the contamination of this population was pentachlorophenol (PCP).

Schumacher *et al* reported dioxin concentrations in the adipose tissue of 15 individuals from Tarragona, who lived near to the construction site for a hazardous waste incinerator. The subjects varied in age from 28 to 83 years. The maximum concentration of 69 pg I-TEQ/g fat and the mean concentration 31 pg I-TEQ/g fat were significantly lower than those measured by Gonzalez *et al.* in 1990.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)			No of samples	Reference
			Mean	Min	Max		
Madrid (industrial)	individual	1990	41.8	4.1	82.9	17	Gonzalez *et al.* (1993)
Tarragona (industrial)	individual	1996	31.0	13.4	69.4	15	Schumacher *et al* (1998)

A3.4 Sweden

Measurements were made of dioxin concentrations in the body tissue of two groups of individuals, who were considered to represent control groups within the general Swedish population. The individuals in both groups were patients undergoing surgery who had no history of malignancy. Breast tissue concentrations were measures for a group of 19 women aged between 44 and 72 years. Concentrations were measured in tissue from the abdominal wall of 17 patients, aged between 32 and 78 years, with almost equal numbers of men and women. The mean concentration of dioxin in breast tissue was found to be almost 30% higher than in the abdominal wall.

Region / Source	Sampling method	Collection period	Concentration (pg I-TEQ/g fat)	No of samples	Reference
Various regions (breast tissue)	individual	1993-95	24	19	Hardell, *et al.* (1996)
Various regions	individual	1994-95	18.6	17	Hardell,

(abdominal tissue)					Lindstrom, *et al.* (1996)

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