

Dioxins: Dutch/Western European control policy, impact on emission and on human exposure

Job A. van Zorge

Ministry of Housing, Spatial Planning and Environment,
P.O.Box 30945, 2500 GX The Hague, The Netherlands

1. INTRODUCTION

Dioxins are highly persistent chlorinated organic compounds, which because of their lipophilicity after exposure accumulate in the fatty tissues of organisms, including humans. Dioxins are micro contaminants from many industrial, combustion and incineration processes. Dioxins are ubiquitous pollutants and environmental levels are of anthropogenic origin. The most persistent dioxins, the 2,3,7,8-chlorinated congeners, are extremely toxic. They build up in the food chain and therefore present a hazard for predatory animals. Human exposure is mainly (ca. 95%) by food and is at a level of concern. The hazard of the most toxic dioxin has been recognized for about three decades now and a first Tolerable Daily Intake (TDI) was proposed in 1982 by the Dutch National Institute for Public Health and Environmental Protection. After it was realized that humans and the environment are exposed to a mixture of many polychlorinated dibenzo-p-dioxins (PCDD's) and dibenzofurans (PCDF's), usually together indicated as dioxins, an internationally accepted system was developed to express the toxicity of mixtures of these compounds [1-2]. This system of toxic equivalency compared to the most toxic dioxin 2,3,7,8-TCDD has been of great help in risk assessments and standard setting. Many countries have developed control policies for dioxins.

2. DEVELOPMENTS IN THE EUROPEAN UNION

2.1. Directives

As a result of an industrial accident in 1976 in Italy, in which 2,3,7,8-TCDD was released to the environment and the Seveso area was contaminated, a directive on major accident hazards of certain industrial activities was introduced [3]. This so-called Seveso-directive requires steps to be taken to prevent major accidents and to limit the consequences of those that do occur.

In the European Directive on the combustion of hazardous waste [4], which has been implemented at the start of this year, an emission limit for dioxins of 0.1 ng TEQ/m³ is set. This means that facilities for destruction of hazardous waste or facilities combusting hazardous waste as a source of energy, e.g. cement kilns, will have to meet this standard.

The Directive on integrated pollution prevention control (IPPC) [5] was adopted 24 September 1996. It imposes the application of best available techniques (BAT) for indicated categories of industrial activities in order to reduce the impact of on the environment.

The existing EC-directives on municipal waste incineration date back to 1989 and do not dictate an emission limit for dioxins. Installations for municipal solid waste incineration are included in the IPPC-list of activities for which BAT must be introduced.

2.2. Dioxin emission

In February 1993 the Council of Ministers of the European Union agreed upon the 5th European Community Environmental Program in which a reduction target for emissions dioxins of 90% was set for the year 2005 as compared to the reference year 1985. Therefore an inventory of all relevant dioxin sources in the member states is required. A special research project was commissioned by DG XI (the directorate-general for the environment) to the LUA NRW (the North Rhine Westphalia State Environment Agency). The aim of this project is to obtain detailed information about the European dioxin emissions. It was started in January 1995 and is planned to comprise two phases.

Phase 1: inventarization of results of dioxin measurements in EU-member states, to be completed in 1996.

Phase 2: measurements of relevant dioxin sources in EU-member states in order to achieve a comparable level of information, to be started in 1997.

Table 1

Dioxin emissions in some European countries (g TEQ/year) [6]

COUNTRY	REFERENCE YEAR	EMISSION g TEQ/year
United Kingdom	1989	4013
	1994	560 - 1058
	future	315
Sweden	1987	218
	1993	12.4 - 93
Netherlands	1990	612
	1996	90
	2000	63
Germany	1987	1651
	1994	355 - 659
	future	79 - 100

The data collected in phase 1 is very different in quality. For several countries no data are available at all, other countries have estimated their dioxin emissions based on statistical information and on emission factors from the literature, some countries only have data from old measurements and only a few countries have complete inventories for which the estimates are based mainly on measurements and extrapolations. Some results are presented in table 1.

These figures indicate a large reduction in dioxin emissions during the last decade and moreover the prognostic figures show a substantial ongoing decrease for future

emissions.

2.3. Dioxin concentrations in air

The reduction of dioxin emissions is substantiated by a reduction of air concentrations. Dioxin concentrations in air have been halved in North Rhine Westphalia, a heavy industrialized state of Germany, in the period 1987/88 till 1993/94 [7].

2.4. Dioxin levels in humans

Also a reduction in body burdens of humans is observed. The human milk studies coordinated by WHO/EURO show a decrease of dioxin levels in the period 1988 till 1993 [8]. In fig. 1 this decrease is presented as an annual reduction percentage compared to the levels of 1988. This shows that there is a positive correlation between the magnitude of the decrease and the levels in 1988.

Trends in dioxin levels of human milk and human blood in individual countries confirm these results [9-11].

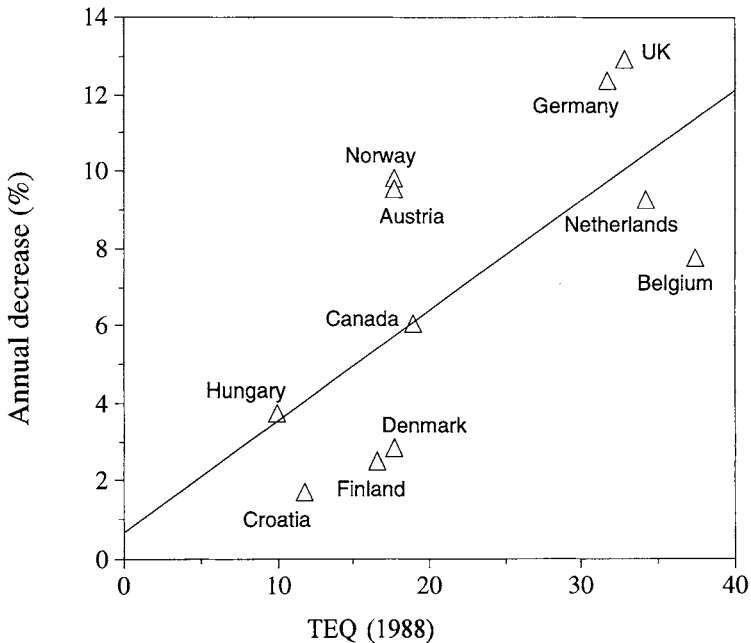


Figure 1. Results of human milk studies WHO/EURO 1988/1993

2.5. Dietary intake

In the framework of the SCOOP program (a scientific cooperation program of the European Union) mid 1997 a project will be started to collect data on dietary exposure of dioxins in the member states. A commission report of these data will be presented to the Scientific Committee which has to advise on the need of standard setting for food.

A more detailed, but less updated review of emission sources, ambient concentrations, dietary exposure and regulations has been presented by Liem and Van Zorge [12].

3. DEVELOPMENTS IN THE NETHERLANDS

The government of The Netherlands has intensively sponsored dioxin research during the past years. The research program was initiated in 1989 by the detection of high levels of PCDD/PCDF in cow's milk in the surroundings of several municipal solid waste incinerators (MSWI's). This program now has been finalized. The main goal of the program was the detection of dioxin sources, quantification of their emissions and use of these data for an emission reduction strategy.

3.1. Emission measures

Because of the milk problem near MSWI's in August 1989 a guideline on incineration of municipal solid waste and related processes, like incineration of hazardous waste, hospital waste and sludges, was published. In this guideline an emission standard for dioxins of 0.1 ng TEQ/m³ was set for new incinerators. Existing incinerators had to meet this standard the first of December 1993. In February 1993 the guideline was transformed into law and because of problems with the accommodation of the existing incinerators the date of enforcement was delayed to the first of January 1995. In practice it took until the start of 1997 before all the MSWI's complied with the standards. For other dioxin emitting processes no standards have been set until now. License providing authorities however have been instructed to ask for maximum acceptable emission reduction. If necessary for certain sources, emission maxima will be presented in the

National Emission Guideline.

The dioxin emission of MSWI's has to be monitored at least twice a year. As the result of a round robin study an instruction for sampling, sample treatment and analysis was published in 1993, in which also detection limits for the different congeners were dictated [13].

Six old MSW incinerators have been closed, two of them were replaced by new ones and another two new incinerators have been build. Action was taken to reduce the amount of waste which has to be incinerated. Separated collection and composting of the organic fraction of municipal waste now is widely introduced in the country.

3.2. Dioxin emission in The Netherlands

The results of the study on sources and emissions indicated that for The Netherlands MSWI's were by far the most important source (ca. 80%) of dioxin emission into the air. In figure 2 the emissions in 1991 of dioxin sources are presented together with the estimates for the year 2000. Figure 3 presents the proportional contribution of these sources to the total emission in these years. It clearly shows that municipal solid waste incineration changes from a major to a minor source of dioxin emission. In the future wood combustion for house heating, industrial processes and the use of pesticides are expected to be major sources. The latter one is dominated by the extensive former use of pentachlorophenol (PCP) as a wood preserver. The use of PCP, which contains relatively large concentrations of dioxins, was terminated at the start of 1991.

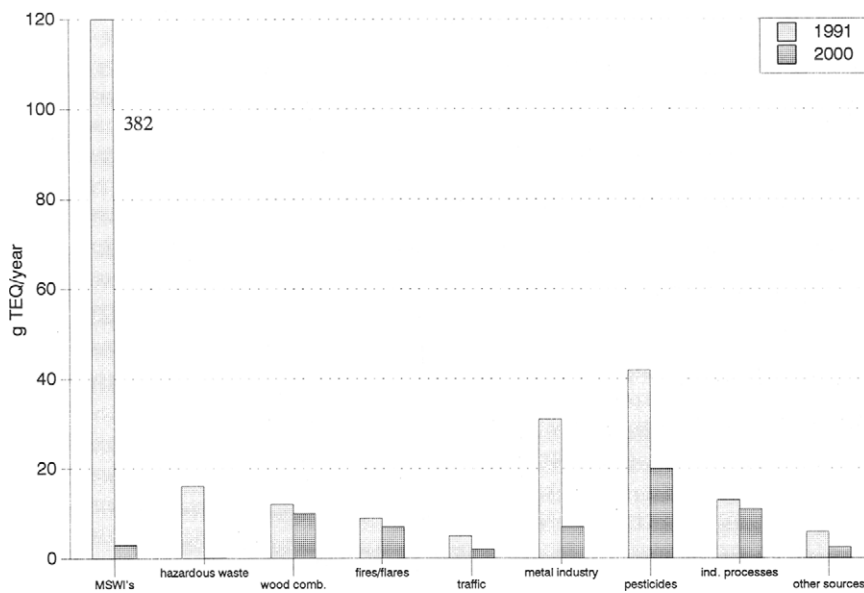


Figure 2. Sources of dioxins in The Netherlands

Table 2 shows the estimated total dioxin emissions and the emissions of MSWI's in The Netherlands from 1985 till 2000 together with the reduction percentage in comparison to the reference year 1989. For MSWI's a more than 99% reduction already has been achieved. For the total emission the reduction percentage compared to the estimated 1985 emission, the European reference year, is given also. It is clear that the European target of 90% reduction in member states in 2005 will be reached much earlier in The Netherlands and in fact already has been achieved.

3.3. Effects of emission measures for MSWI's

As mentioned the detection of high levels of PCDD/PCDF in cow's milk near MSWI's gave the impulse for the emission reduction policy. In order to prevent the consumption of milk with high dioxin levels in 1989 a standard of 6 pg TEQ/g fat was set for dairy

products. Milk of dairy farms near MSWI's was monitored and in areas where the standard was exceeded the milk was taken out of the consumption chain. As an illustration of the effectivity of emission reduction measures Figure 4 shows the dioxin levels in milk from reference farms in the Lickebaert area situated near the MSWI AVR, which with a capacity of ca. 1 million tons of waste per year is the biggest MSWI in the country. The retrofitting of this incinerator was completed in 1994 which was clearly reflected in the dioxin levels in milk. Moreover the levels in milk were in good agreement with the calculated values from a chain model that was developed to relate emissions to levels in cow's milk [14].

Table 2
Dioxin emissions in The Netherlands

YEAR	MSWI's g TEQ/year	REDUCTION % *	TOTAL g teq/year	REDUCTION % *
1985			840	
1989	697		899	
1990	410	41	612	32 (27)
1991	382	45	516	43 (39)
1995	13	98	122	86 (85)
1996	5	99.3	90	90 (89)
2000	3	99.6	63	93 (92)

* compared to 1989 emission
(compared to 1985 emission)

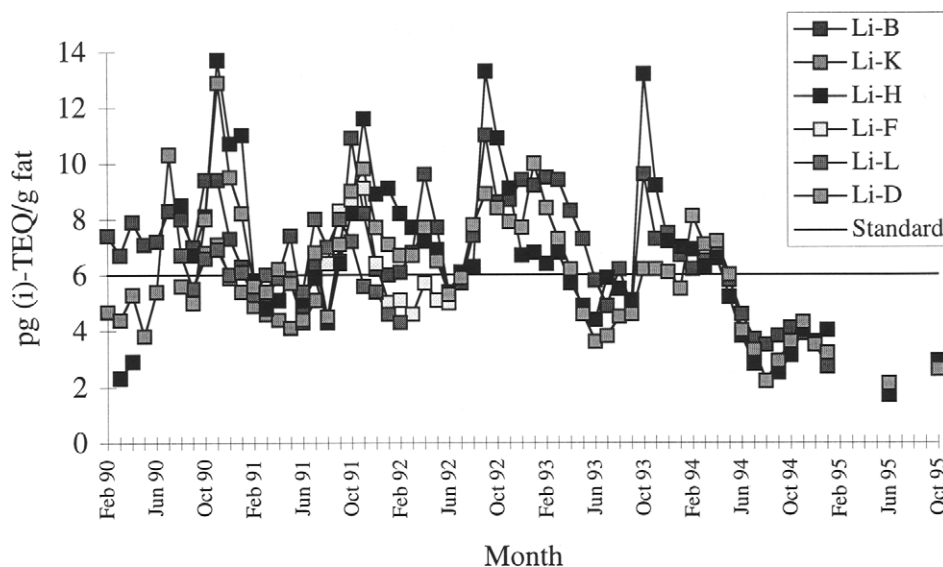


Figure 3. Dioxin levels in cow's milk from the Lickebaert area (1990-1995)

3.4. Dietary intake

Much effort has been put into investigations of dietary exposure. In 1982 a TDI of 4 pg 2,3,7,8-TCDD/kg body weight was introduced [15] and almost unnoticed this was changed into the same value for TEQ's. In 1991 the TDI of 10 pg 2,3,7,8-TCDD/kg b.w. which was proposed in 1990 by WHO [16] was adopted and again this value was interpreted as TEQ's. In spite of this raise of the TDI the policy remained to reduce dioxin levels as far as possible. In 1996 the Health Council of The Netherlands as a result of a reevaluation of dioxin toxicity data advised to reduce the health based exposure level to 1 pg TEQ/kg b.w. [17]. Besides that it was advised to include dioxin like PCB's in risk evaluations and standard setting. Herefore the use of the toxic equivalency factors proposed by WHO/EURO [18] was recommended.

Two tracks were followed in the investigations into dietary exposure:

- i analysis of duplicate diets for dioxins and related compounds,
- ii analysis of food categories and calculation of exposure by use of the consumption

data from the National Food Consumption Inquiry.

The latter approach has the advantage that information is obtained for different age categories and for gender. The results of both investigations were well in line with each other. Figure 4 shows the contribution of food categories to the dietary intake [19]. In this figure dioxin like PCB's are presented separately.

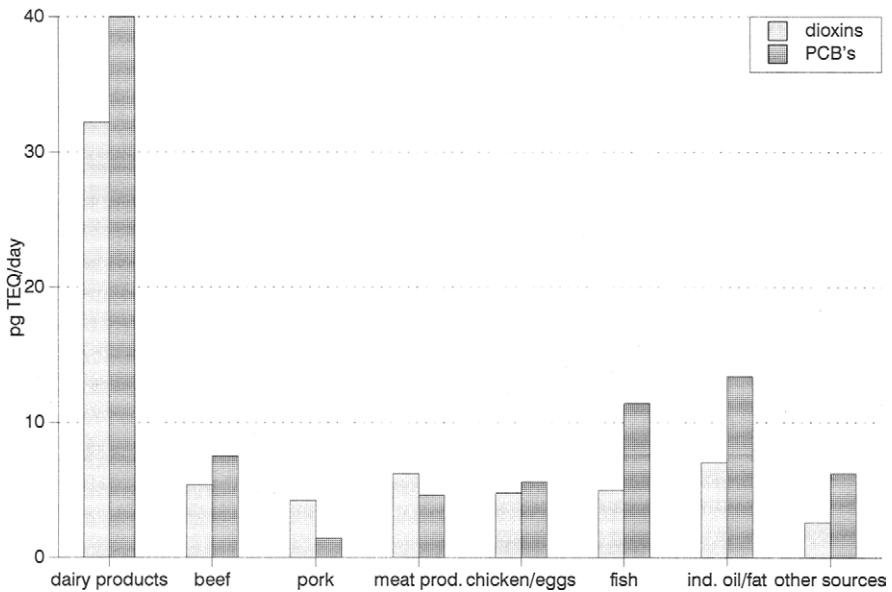


Figure 4. Median contribution of food categories to the dietary intake

The results of duplicate diet studies are given in figure 5. It is clear that there has been a remarkable decrease in the dioxin levels in food from 1978 till 1994. In this study the mean intake of PCDD's, PCDF's and dioxin like PCB's has decreased to 1.5 pg TEQ/kg b.w./day [20]. In view of the fact that after 1994 still important emission repressing measures were introduced it is expected that this downward trend will continue and that a daily intake of 1 pg TEQ/kg b.w. is well within reach as a result of all the measures which have been taken now.

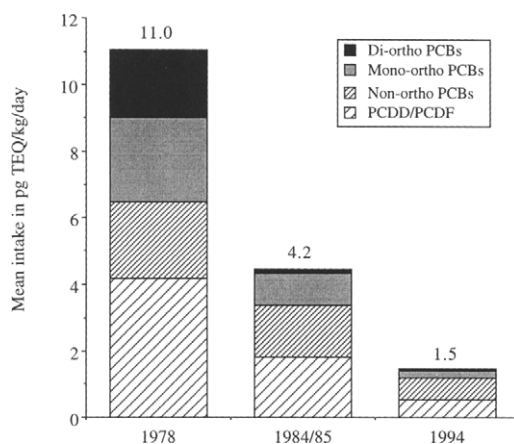


Figure 5. Results of duplicate diet studies in The Netherlands

3.5. Human body burdens

Dioxin body burdens will respond much slower to emission reduction measures. The long halflife in humans causes an accumulation that reaches an equilibrium only after several decades. So past high exposures will work on for a long time. Nevertheless a reduction is observed in human milk which is an indicator of body burden. In The Netherlands the mean levels in human milk decreased from 34.2 to 23.5 pg TEQ/g fat between 1988 and 1993 [21]. An additional study is planned for 1998.

4. CONCLUSION

It is clear that all the efforts and money spend on emission reduction of dioxins have caused a drop in human exposure. It can be expected that human body burdens will decrease below a level that rises concern. A condition for an ongoing downward trend is the maintenance of the measures which have been taken. Because of the transborder transport of dioxin emissions an international approach is necessary. Therefore the EU approach, as laid down in the 5th Environmental Program, is promising.

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