EMISSION OF DIOXINS FROM INDUSTRIAL WASTE INCINERATORS: HUMAN IMPACT

P. H.-Jones[A], J. de Gerlache[B], E. Martl[C], G. Mischer[D], M.C. Scherrer[E], W.J. Bontinck[F], and H.J. Niessen[F].

[A]Rechem Environmental Services, Hardley, Hythe, GB-Southampton SO4 6ZA
[B]Solvay S.A., rue de Ransbeek 310, B-1120 Bruxelles
[C]Ciba Geigy Ltd., K-127.5.56, Ch-4002 Basel
[D]Bayer Ag, WV-Umweltschutz, D-5090 Leverkusen
[E]Rhone-Poulenc, Av. Jean Jaures 24, F-69151 Decines Charpieu Cedex
[F]ECETOC, Av. E. Van Nieuwenhuyse 4, B-1160 Bruxelles

The major known sources of atmospheric contamination by polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) at the present time are municipal and hospital waste incinerators, metallurgical processes and possibly coal combustion. In contrast, industrial waste incineration has lower emissions, representing only about 1% of the total known sources (Table 1). Atmospheric PCDD and PCDF emissions from Industrial Waste Incinerators (IWIs) are strongly absorbed on particles, i.e. dust and fly ash. Yet, the levels of PCDDs and PCDFs in soil and grass close to IWIs in the UK and Germany are indistinguishable from urban background levels. (Deister and Pommer, 1991; Rechem International Limited, 1992).

Atmospheric PCDDs and PCDFs emitted from all sources are deposited on soil, grass, vegetation and surface water. Subsequent uptake by animals and bioaccumulation make the food chain the most important route of exposure (>90%) for man: fish, dairy produce, meat products, and vegetables all being important. Global human exposure to PCDDs and PCDFs has been estimated in various European countries as an average daily intake of about 120 pg/d, expressed as 2,3,7,8-TCDD toxic equivalents (TEQ) (Table 2). Conversion to an average body weight of 60 kg results in a daily burden of about 2 pg/kgbw/d. Because of mother's milk contamination, a higher food intake in respect to body weight, and the larger

proportion of dairy products consumed by children, values up to 10 pg/kgbw/d (TEQ) for their body burden may be expected.

Based on a combination of experimental toxicology and epidemiological data, an assessment was made of the health risk to man resulting from such exposure. The lowest effect level in animal studies is between 0.1 and 1 ng TEQ/kgbw/d, and recent studies on mechanism support the existence of a threshold level below which there is no toxic effect (ECETOC, 1992). In man, the only clearly established toxic effect of these compounds is chloracne. Data on other effects, including cancer, are inconclusive and remain a controversial issue. By applying a safety factor of 100, which is commonly used in Europe, it can be assumed that man would not be affected by a lifetime exposure to PCDDs and PCDFs corresponding to a daily intake of 1 to 10 pg TEQ/kgbw/d. Thus the total uptake of PCDDs and PCDFs from all known sources by man is within the range for this tolerable daily intake.

Only IWIs with outdated technology exhibit high levels of PCDDs and PCDFs for stack gas emission (ECETOC 1992). Although IWIs are a minor source of PCDD and PCDF emissions, further improvements are being sought. These include optimisation of waste preparation and loading rate, residence time, turbulence, temperature and waste/oxygen ratio. Better knowledge of the nature of the precursors and the mechanisms of formation of PCDDs and PCDFs are taken into consideration in designing modern IWIs, permitting the emissions of PCDDs and PCDFs to be reduced to 0.1 – 1 ng TEQ/m^3. Even more advanced technologies which are presently being evaluated may reduce these emissions still further, but the technical effort and cost will be considerable for relatively little benefit.

Incineration avoids dangerous dumping of industrial waste; the latter may result in leachate and landfill gas problems for many years. The risk to human health from exposure to PCDDs and PCDFs originating from industrial waste incineration processes using present state-of-the-art technology can be regarded as insignificant.

BIBLIOGRAPHY

Beck, H., Drob, A., and Mathar, W. (1992). *PCDDs and PCDFs, and related contaminants in the German food supply.* Chemosphere 25,1539

DoE – Department of the Environment (1989). *Dioxins in the Environment.* Pollution Paper No. 27. Her Majesty's Stationery Office, UK Central Directorate of Environmental Protection, London.

Deister, U. and Pommer, R. (1991). *Distribution of PCDD/F in the vicinity of a hazardous waste incinerator at Schwabach,* Chemosphere 23, 1643.

ECETOC (1992), *Exposure of Man to Dioxins: A Perspective on Industrial Waste Incineration,* Brussels, 1992.

Fiedler, H. and Hutzinger, O. (1991). *Sources and sinks of dioxins: Germany.* 11th International Symposium on Chlorinated Dioxins and Related Compounds, 23 – 27 September 1991, Research Triangle Park, North Carolina, USA. Abstract PD3.

HMSO (1992). *Dioxins in food.* Food surveillance paper No. 31. Her Majesty;s Stationery Office, Ministry of Agriculture, Fisheries

Kleijn, E.G.M. and van der Voet, E. (1991). *Dioxines in milieu en voeding in Nederland.* Coordinatie-Commissie voor de metingen van radioactiviteit en xenobiotische stoffen. Rijn, Bilthoven, NL.

Rechem International Limited (1991). Charleston Road, Hardley, Hythe, GB-Hampshire SO4 6ZA, unpublished results.

Theelen, R.M.C. (1991). Modelling of human exposure to TCDD and I-TEQ in the Netherlands: Background and occupational. In: Gallo, M.A., Scheuplein, R.J. and van der Heijden, K. (eds), *Biological basis for risk assessment of dioxins and related compounds,* Banbury Report No.35, Cold Spring Harbor Press, p.277.

TABLE 1
RELATIVE EMISSIONS OF DIOXINS FROM IWIs COMPARED TO TOTAL EMISSIONS

SOURCE	COUNTRY	YEAR	TOTAL AMOUNT OF PCDDS AND PCDFs EMITTED TO THE AIR FROM ALL IWIs IN g TEQ/y	RELATIVE EMISSIONS OF PCDDs AND PCDFS FROM IWIs %
DoE (1989)	UK	1989	11*	0.3*
Kleijn and v.d. Voet (1991)	NL	1991	12	1.2
Fiedler and Hutzinger (1991)	FRG	1990	0.5 - 72	1.8

* Recalculated by empirical comparison with a standard combustion pattern to express non-TEQ data in TEQ

TABLE 2
HUMAN DAILY EXPOSURE TO DIOXINS IN VARIOUS COUNTRIES (pg TEQ)

ROUTE/SOURCE	THE NETHERLANDS	UK	WEST GERMANY*
Air and Soil	3.2 (3%)		
Vegetable	18.5 (16%)	39.3 (31%)	6.3 (5.2%)
Meat and Eggs	22 (19%)	42.2 (34%)	39.0 (32.2%)
Dairy Products	43 (36%)	35 (28%)	41.7 (34.5%)
Fish	31.2 (26%)	7.7 (6%)	33.9 (28.0%)
Total Food	118	125	130*
REFERENCE	Theelen (1991)	HMSO (1992)	Beck et al (1992)

* calculated with German TEFs
** equivalent to 203 pg TEQ/d (recalculated with I-TEFs from German TEFs by HMSO, 1992).

TABLE 3

EMISSION OF PCDDs AND PCDFs TO AIR FROM INDUSTRIAL WASTE INCINERATORS (IWI)

LOCATION OF THE IWI	YEAR OF INSTALLATION	EMISSION TEQ ng/m³	LITERATURE	REMARKS
Schweinfurt, Germany	About 1965	2 - 4.5	Abfallwirtschafts Journal 1991	TEQ (NATO/CCMS)
Schwabach, Germany	1972	0.8 - 0.9	Abfallwirtshafts Journal 1991	TEQ (NATO/CCMS)
Ciba Geigy AG, Basel, K-224 Switzerland	1974	0.018	Meister et al. (1988)	Pilot Plant, multistage washing procedure
Nyborg, Denmark	1975	5.8	Demmich and Maurer (1987)	
Ebenhausen, Germany	1976	5.6 - 6.9[a] 3.1[b]	Abfallwirtschafts Journal 1991	1989[a]/1990[b] TEQ (NATO/CCMS)
Biebesheim, Germany	1981	0.37	Demmich and Maurer (1987)	Without PCB* charged
Bayer AG Brunsbuettel Germany	1982	0.66	Mischer and Schnabel (1989)	With add 8.4 kg/h PCB and 63.0 kg/h PCDM**
Kumla, Sweden	1983	15	Demmich and Maurer (1987)	Outdated technology
2 IWIs in the Netherlands	1987	1.2 - 2.3	Kleijn and van der Voet (1991)	Older technology both TEQ (NATO/CCMS)
Rechem International Ltd Pontypool, UK	1987	0.08	Rechem International Ltd (unpublished results 1991)	Approx. 4 tons per day PCB combustion new gas cleaning installed in 1987 on existing incinerator
Rechem International Ltd Fawley, UK	1990	0.06 - 0.15	Rechem International Ltd (unpublished results 1991)	Normal operation, no PCB combustion

* PCB Polychlorobiphenyl
** PCDM Polychlorodiphenylmethane