HUMAN SOURCES AND ACTIVITIES ASSOCIATED WITH DIOXIN-LIKE COMPOUNDS AND POPs IN THE ENVIRONMENT

MULTI-MEDIA INVENTORY OF PCDD/F RELEASES FOR NEW ZEALAND

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Introduction

There is considerable concern within the regulatory and scientific communities, as well as the wider community, about the potential adverse effects of exposure to polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/F). Until recently, most of the attention and nearly all of the research has focused on relatively few countries in the Northern Hemisphere. In 1995 the New Zealand Ministry for the Environment initiated the Organochlorines Programme to assess the level of risk posed by these chemicals to the environment and human health. The programme is currently developing regulatory standards and guidelines for PCDD/Fs and PCBs. Results of environmental[1] and population exposure monitoring[2] projects have been previously reported. The current project was designed to estimate the extent of on-going releases of PCDD/F to air, land and water, and the magnitude of PCDD/F reservoirs.

Methods

The study was designed to make maximum use of existing data and knowledge, and to include an important element of peer review throughout. International peer review provided access to overseas experience on inventories of PCDD/F, and local review ensured the input of industrial knowledge relevant to New Zealand. Importantly, the inventory was undertaken with the full support and cooperation of industry.

The study used the UK National Inventories of PCDD/F releases to air[3], land and water[4] as a template, and followed the 'emission factor approach', which is typical of other inventory compilations for these compounds[5]. For each source category, information was sought on processes, their characteristics and emission data. Activity statistics were assembled and emission factors developed from the best data available for the processes based on New Zealand tests and overseas emissions factors for similar processes. Field testing was initiated for selected sources to establish more reliable data, and to ensure that the New Zealand processes did indeed have similar emission factors to overseas processes. Where possible, the emission estimates were developed as a range to reflect the uncertainty in the activity statistics and emission factor data used.

The reference year for this inventory is 1998.

Results and Discussion

The complete inventory[6] is available at http://www.mfe.govt.nz/issues/waste/ocreports.http. The total release to air, land and water was estimated in the range 41 – 109 g I-TEQ yr^{-1}, Table 1.

Table 1. Annual release estimates of PCDD/F to air land and water

Source	Annual release estimate, (g I-TEQ yr^{-1})		
	Air	Land	Water
Incineration and combustion processes			
Clinical, pathological and quarantine waste incineration	0.38 – 3.5	0.43 – 3.2	**
Hazardous waste incineration	0.00054 – 0.0039	0.25×10^{-6} – 85×10^{-6}	**
Wastewater solids incineration	0.009	0.024	##
Crematoria	0.0080 – 0.45	##	**
Power generation	0.059 – 0.11	0.0016 – 0.12	##
Industrial, commercial and agricultural coal combustion	0.034 – 4.0	0.00047 – 0.32	##
Domestic coal burning	0.36 – 0.59	0.00072	**
Industrial wood combustion	0.85 – 2.4	0.33 – 1.9	##
Domestic wood burning	0.71 – 8.7	0.48 – 9.7	**
Domestic waste burning	0.54 – 6.4	5.7	**
Land transport (unleaded petrol and diesel fuels)	0.11 – 1.2	**	**
Uncontrolled fires (forest, scrub and grass fires; structure fires and vehicle fires)	0.45 – 3.9	##	##
Manufacturing and production processes			
Cement manufacture	0.10 – 0.65	0.000013 – 1.4	**
Lime manufacture	0.0030 – 0.16	0.0000050 – 0.15	**
Iron and steel production			
Primary steel production	0.10	0.67	0.015
Secondary steel production	0.017 – 0.063	1.4	##
Non-ferrous metal production	0.10 – 1.3	0.19 – 2.2	##
Aluminium production	0.0091 – 1.8		
Primary aluminium production	##	0.0017	##
Secondary aluminium production	0.0091 – 1.8	0.67 – 6.8	##
Glass production	0.00024 – 0.0038	##	##
Pulp and paper production	0.033 – 0.045	0.56	0.20 – 0.35
Miscellaneous activities			
Cigarette smoking	0.00029 – 0.0084	##	**
Used oil use and disposal	0.00068 – 0.024	0.012 – 0.53	##
Use of halogenated pesticides (2,4-D)	**	0.13 – 0.15	**
Landfills	-	20	0.0090 – 0.96
Landfill fires	10 – 15	-	-
Landfill gas (fugitive emissions/gas combustion)	0.078 – 0.16	-	-
Wastewater treatment	see wastewater solids incineration	0.61 – 5.2	0.34 – 2.6
Total annual estimate of emissions for 1998	**14 – 51**	**26 – 54**	**0.56 – 3.9**

= Insufficient information available to make an estimate. ** = No direct PCDD/F release occurs from this activity.

The major industrial emissions to air were from waste burning, either in clinical, pathological and quarantine waste incinerators, or from uncontrolled fires at landfills, coal and wood combustion, and secondary non-ferrous metal production. Lower emissions arise from the manufacture of cement and lime, pulp and paper (from recovery boilers) and iron and steel production, along with power generation and crematoria.

Non-industrial sources of PCDD/F include the domestic burning of wood and coal for home heating, the backyard burning of waste, uncontrolled fires such as building fires, and the use of petrol and diesel for land transport. The only natural sources considered in the inventory were uncontrolled forest, scrub and grass fires. The relative ranking of all sources is shown in Figure 1.

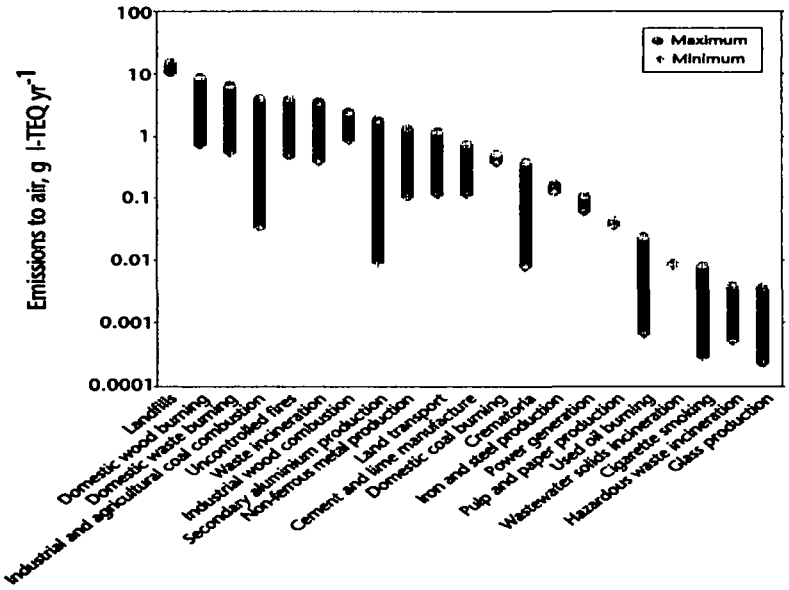

Figure 1. Relative ranking of PCDD/F emissions to air

Overall, the inventory estimated that approximately 60% of PCDD/F emissions to air were from industrial sources and 40% from non-industrial sources, which is notably different to inventories reported for northern hemisphere countries where generally industrial sources tend to dominate. This illustrates the importance of considering all potential sources of PCDD/F, and not expecting the ranking of sources to reflect those of highly industrialised country inventories.
There are other important differences between the New Zealand inventory and other countrywide inventories, most notably the absence of municipal waste incineration in New Zealand. Waste incineration in older and/or poorly controlled plants has been identified as a major source of PCDD/F emissions overseas. Similarly, primary steel production is by the Lurgi-Stelco process (a direct reduction process) from iron sand, for which there is no sintering stage, thereby removing a potentially significant source of PCDD/F emissions to air commonly found overseas.

The same processes that were identified as the highest emitters of PCDD/F to air were also identified as important sources to land, Table 1. In addition, domestic and industrial solid waste deposited to landfill and solid residues from waste water treatment may also be important.

Releases to water could be estimated for only a limited number of processes (Table 1), with other processes having either no direct aqueous discharge or insufficient data being available from which to make an estimate of releases. There are two bleached kraft pulp mills in New Zealand, both of which are elemental chlorine free, with chlorine dioxide being used in the bleach plant. No PCDD/F could be detected in their effluent discharges, with the estimate of releases made being based solely by *including half limit of detection values* in calculating the TEQ level.

PCDD/F reservoirs in contaminated soil from the historic use of PCP in the timber industry, the use of the herbicide 2,4,5-T and from coal gasification, as well as reservoirs at waste sludge dumps associated with the manufacture of bleached kraft pulp and from solid wastes deposited in landfills were estimated in the range 1,450 – 1,700 g I-TEQ, Table 2.

Table 2. PCDD/F reservoir sources

Reservoir	Magnitude (g I-TEQ)
Bleached kraft pulp manufacture	24
Waste within landfills	500
Historic use of 2,4,5-T	620 – 860 (2,3,7,8-TCDD)
Historic use of PCP	310
Coal gasification	0.028 – 6.4
Total estimate	1,450 – 1,700

Conclusions

A combination of understanding of local processes and conditions, international experience of emission factors, and targeted source testing has proved to be highly effective in producing a national inventory of PCDD/F emissions for New Zealand.

The inventory has estimated that the total release to air, land and water is in the range 41 – 109 g I-TEQ yr^{-1}. The main sources to air are landfill fires, the domestic burning of wood and waste, industrial coal combustion and clinical, pathological and quarantine waste incineration. These are also important sources for releases to land. It is critical that all potential sources of PCDD/F are considered, since non-industrial sources may be significant. For example, in the current study, it is estimated that non-industrial sources contribute about 40% of the total emissions to air. Estimates were also made of reservoirs of PCDD/F, primarily resulting from historic practices.

The inventory is one component of the New Zealand Government's initiative to reduce releases of PCDD/F to the environment, and to minimise human exposures, through the promulgation of regulatory standards for releases to air land and water and the implementation of other measures.

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