Dioxins levels in Australia: key findings of studies

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Introduction

The Australian Government established the National Dioxins Program (NDP) in 2001 to improve knowledge about levels of dioxins in Australia. The program aims to determine levels, assess the risks to Australians and the environment, and to consider appropriate management actions.

Starting in mid 2001and completed in 2004, the studies constituted the largest survey of dioxin levels ever undertaken in Australia. The findings will contribute to debate on how to deal with dioxins in Australia, as well as helping to meet obligations under the Stockholm Convention on Persistent Organic Pollutants, which Australia ratified on 20 May 2004. These studies will also contribute to a better understanding about dioxins in the southern hemisphere. This paper provides a summary of the key findings of these studies and the risk assessments[1].

Methods

The information studies were undertaken by leading Australian scientific organisations, with assistance from overseas experts, under contract to the Australian Government Department of the Environment and Heritage. The studies gathered information on level of dioxins by measuring emissions from sources such as bushfires, as well as dioxin levels in the environment, food and population. The findings of these studies were used to determine the risk dioxins pose to Australians and the environment.

For the purpose of the NDP, the term "dioxins" is used in the broader sense and is also taken to include the polychlorinated dibenzofurans (PCDFs) and co-planar polychlorinated biphenyls (PCBs) i.e. the 29 compounds considered by the World Health Organization to have significant toxicity.

Results and Discussion

Emission sources – bushfires

The 1998 inventory of sources of dioxin emissions estimated that bushfires may contribute up to 50 % of the total dioxins emissions to air in Australia, or between 72-1,700 g TEQ/year. This estimate was based on overseas data. The bushfire study aimed to reduce this uncertainty by measuring the levels of dioxins in smoke and samples of ash collected from 19 laboratory and 21 field burns.

The laboratory tests burned wheat straw, sorghum, sugarcane and forest litter. The study found that laboratory burns do not adequately simulate the combustion processes occurring in the field.

Dioxin emissions from the laboratory tests were up to ten times higher than those from field fires but were comparable to other laboratory tests. It is thought that the key difference between field and laboratory emissions may be the time that the smoke in laboratory burns remains at high temperature.

The total emissions of dioxins from field fires ranged from 0.1-2.9 pg TEQ/g of fuel. Based on these levels and the total area of land burnt in each year in Australia, the total emissions of dioxins to air from bushfires are estimated to be 31-494 g TEQ/year, or around 20-30% of all emissions to air. Savanna fires in northern Australia accounted for most of these emissions.

Emission sources – motor vehicles
For this study, motor vehicle emissions were determined using existing estimates and calculating the total emissions based on the total distance traveled by all Australian vehicles in 1998. This gave a range of 0.7-16.5 g TEQ/year or about 2 % of total emissions to air.

Emissions sources - all dioxin sources
Using the findings of the bushfires and motor vehicles studies, as well as publicly available data on emissions from industries, a new inventory was prepared for 2002. This inventory included dioxin emissions to air, water and land, based on guidelines developed by UNEP.

The new inventory estimates that total emissions to air in Australia are between 160-1,787 g TEQ/year with a best estimate being 500 g. Uncontrolled combustion, which includes bushfires, waste burning and accidental fires, is estimated to contribute nearly 70 % of total emissions to air and over 80 % of total emissions to land, with most being emitted from grass fires. Disposal and landfilling is estimated to be the largest source of dioxin emissions to water, contributing over 75 % of the total.

Dioxins level in the environment
Four studies were undertaken to measure the levels of dioxins in the environment (air, soils, aquatic environments and fauna). They were not designed to identify dioxin 'hotspots' such as contaminated industrial sites, but rather to get a picture of the background levels of dioxins in the Australian environment. For the purposes of these studies, Australia was divided into three geographic regions:

- northern - Northern Territory and Queensland
- south-eastern - New South Wales Victoria, South Australia and Tasmania
- south-western - south west Western Australia.

Samples were collected from locations in each region, representing four different land-uses (agricultural, urban, industrial, and remote areas).

Air
Air samples were collected at ten sites continuously over monthly intervals from September 2002 to August 2003 to establish seasonal variations in dioxin levels, related, for example, to emissions from sources such as domestic wood heaters and bushfires.

This study indicates an obvious seasonal cycle, with levels higher during winter in all cities, most likely due to smoke from domestic wood heaters. Despite the winter increase, overall mean annual levels in the major cities are still very low by world standards, with levels around 14-17 fg TEQ/m^3. Extremely low levels were observed in clean marine air at Cape Grim and in agricultural locations (typically less than 1.5 fg TEQ/m^3).

Soils

Soils samples were collected from 86 locations across the three regions and from remote sites in central and north-west Australia. Agricultural land-uses were classified according to the main agricultural practice (grazing, cotton, vegetables, sugarcane, forestry, cereals). Dioxins were found in most soils, with levels ranging from 0.05-23 pg TEQ/g dry weight. Levels across all land-use types in the northern and south-eastern regions were similar, but the levels in the south-western region were lower. Western Australia and inland areas recorded low levels.

Dioxins in soils from urban and industrial locations were substantially higher than levels in agricultural and remote locations. Across agricultural land-uses, dioxins levels were similar, with the exception of sugarcane districts. The higher level is not likely to be related to sugarcane cultivation since they are the same as found in non-sugar growing areas throughout coastal Queensland. These dioxins may be formed through natural processes.

Aquatic environment

Sediment samples were collected from 58 locations in freshwater, estuarine and marine locations. Samples of bivalves, such as oysters and mussels, were also collected. Fish from local commercial fisheries were included, with an emphasis on table species. Dioxins were found in all sediments, with levels ranging from 0.002-520 pg TEQ/g dry weight. Urban/industrial areas had significantly greater levels of dioxins than samples from remote and agricultural locations. The levels of dioxins in 18 bivalve samples ranged from 0.0043-0.2 pg TEQ/g wet weight. Levels in the 23 fish samples ranged from 0.0053-0.49 pg TEQ/g wet weight.

Fauna

Around 66 fauna samples were collected, mainly from dead animals, such as those near roads or stranded on beaches. The study found the highest levels in birds of prey, with a maximum level of 3,900 pg TEQ/g lipid. Marine mammals also had comparatively high levels, with PCBs more prevalent than dioxins or furans. Levels were generally much lower in herbivores such as kangaroos, galahs (bird) and dugongs. Levels in kangaroos ranged from 0.001-25 pg TEQ/g lipid. The levels in other marsupials (possums, koalas and bandicoots) were comparable to the kangaroos. Levels in the monotremes (platypus and echidnas), ranged from 9.3-60 pg TEQ/g lipid.

Dioxin levels in food

Food Standards Australia New Zealand examined dioxin levels in a range of foods to determine the level of dioxin exposure of Australians through food and to assess the human health risk. Levels were determined by analysis of 168 samples of 22 randomly sampled foods from Australian retail outlets which were prepared ready to eat. The survey found that Australian foods have low levels of dioxins. These results were then combined with dietary information from the Australian 1995 National Nutrition Survey to assess the population's dietary exposure.

Mean range of dioxin concentrations in food, in pg TEQ/g fresh weight

Food	*Concentration range*	**Food**	*Concentration range*
Bacon	0.025-0.083	Leg ham	0.0016-0.017
Baked beans	0.0012-0.016	Liver pate	0.0025-0.043
Bread, white	0.00067-0.026	Margarine	0.0025-0.058
Butter	0.028-0.27	Milk chocolate	0.0077-0.056
Chicken breast	0.0044-0.021	Milk, whole	0.0023-0.012
Eggs	0.0088-0.057	Minced beef	0.0054-0.048
Fish fillets	0.59-0.64	Orange juice	0.00018-0.007
Fish portions	0.019-0.039	Peanut butter	0.035-0.25
Hamburger	0.00050-0.027	Potatoes	0.00029-0.014
Infant formula	0.0036-0.018	Sausage	0.0096-0.058
Lamb chops	0.0044-0.045	Tuna, canned	0.029-0.041

Dioxin levels in agricultural commodities

The National Residue Survey, managed by the Australian Government Department of Agriculture, Fisheries and Forestry, analysed around 220 samples of meat, fish and milk. The study found dioxin levels in these commodities are low and compare favourably with overseas products.

In the absence of an Australian commodity standard for dioxins and furans, the levels were compared against the European Union (EU) standard. None of the samples contained dioxin and furans exceeding this standard. The EU standard only refers to dioxins and furans and does not currently include dioxin-like PCBs.

Body burden – levels in blood serum

Blood serum samples were collected through a national pathology laboratory from over 9,000 individuals. They were pooled into 96 samples based on gender, age (under 16, 16-30, 31-45, 46-60 and over 60 years), and the following five regions:

- north-east (Brisbane, Tweed and Gold Coast and major population centres in Queensland)
- south-east (Sydney, Canberra, Wollongong, Newcastle and other major population centres from New South Wales)
- south (Melbourne, Adelaide, Hobart and other major population centres from Victoria)
- west (Perth and other major population centres in Western Australia)
- one rural region (all States and the Northern Territory).

The levels in the Australian population are very low by international standards, with a mean of 10.9 pg TEQ/g of lipid. Dioxins levels between males and females showed no differences, except that slightly higher levels of dioxins were observed in females in the over 60 years age group. This result could not be explained on the basis of differences in the mean age between males and females in this group. The study found dioxin levels increased with age.

Body burden – levels in breast milk

In order to compare the results with previous World Health Organization studies, mothers were selected using the following criteria:

- first-time mother with a baby aged two to eight weeks
- exclusively breastfeeding
- willing to provide a minimum of 100 ml of milk over a six week period (two-eight weeks after birth)
- healthy pregnancy, mother and child
- a resident of the area for the past five years.

In total, 173 individual samples were collected from 12 metropolitan and rural regions (Brisbane, Sydney, Melbourne, Adelaide, Perth, Hobart, rural inland NSW, rural Queensland, rural Victoria, Newcastle, Wollongong and Darwin). These were pooled into 17 samples for dioxin analysis.

Dioxins were detected in all groups, with a mean of 9 pg TEQ/g of lipid. There were no significant differences observed in the levels collected from the different regions. These samples were compared with samples collected from Melbourne women in 1993 and showed levels almost halved from 1993 to 2003.

Risk assessment – ecological

Using the data from the fauna study an ecological risk assessment found that dioxins, furans and PCBs contributed equally to the load in birds and terrestrial mammals, while for marine mammals, PCBs contributed over 90 % of the load in dolphins and seals, and over 80 % in whales. There is a potential risk to birds of prey from exposure to dioxins. Terrestrial mammals are at a low risk when exposed to background levels of dioxins.

All risk assessments have uncertainties due to knowledge and data gaps, which require the adoption of assumptions to cover these gaps. This assessment was no exception because of the absence of data on the toxicity of dioxins to Australian marsupials and monotremes. The conclusions were based on the small number of fauna samples, comprising a limited number of species whose sensitivity to the toxic effects of dioxins is unknown. A conservative approach was adopted in this risk assessment to prevent underestimation of the risk. Inherent uncertainties should be taken into account when interpreting the results of the risk assessment.

Risk assessment – human health

An Australian Tolerable Monthly Intake value for dioxins of 70 pg TEQ/kg body weight/month, was recommended by the National Health and Medical Research Council and the Therapeutic Goods Administration[2] in 2002. This human health standard was based on the most sensitive reproductive effects of dioxins in animals. The risk assessment found that for Australians aged 2 years or older, the monthly intake of dioxins was between 3.9-15.8 pg TEQ/kg bw/month or between 6-23 % of the Tolerable Monthly Intake.

Using the findings of the blood serum study, body burdens and average lifetime daily exposures (ALDE) were calculated. The mean ALDE was estimated as 1.32 TEQ pg/kg bw/day (minimum of

0.13 pg/kg bw/day for ages under 16 years; maximum of 2.96 pg/kg bw/day for 60 years and older). The ALDE estimate is higher than the estimated dietary intake because it includes historical exposures, which are likely to have been higher than current exposures, as well as intake of dioxins from non-food sources.

The next steps

The reports conclude that dioxin levels in Australia are generally low and that the risks to human health and the environment are also low. Using the information contained in the reports, the Australian Government, in consultation with stakeholders, will be formulating a range of actions to keep dioxin levels low and further reduce the risks.

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- the Australian Government Department of Agriculture, Fisheries and Forestry, who assessed the levels of dioxins in agricultural commodities; and
- Food Standards Australia New Zealand and the Australian Government Department of Health and Ageing who assessed the levels of dioxins in foods and assessed the health effects of dioxins.

References

1. Full reports of these studies and the risk assessments can be accessed through the DEH Internet address http://www.deh.gov.au/industry/chemicals/dioxins/index.html

2. National Health and Medical Research Council and Therapeutic Goods Administration (2002) *Dioxins: Recommendation for a Tolerable Monthly Intake for Australians*, Department of Health and Ageing, Canberra, Australia.