# national dioxins program

## dioxins in australia: a summary of the findings of studies conducted from 2001 to 2004

Australian Government
Department of the Environment and Heritage

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# background

The term "dioxins" describes a group of toxic organic chemicals that remain in the environment for a long time. These compounds can accumulate in the body fat of animals and humans and tend to remain unchanged for long periods. Several hundred of these compounds exist and are members of three closely related families:

- the polychlorinated dibenzo–p–dioxins (PCDDs)
- the polychlorinated dibenzofurans (PCDFs or furans)
- certain co–planar polychlorinated biphenyls (PCBs).

The National Dioxins Program (NDP) has focused on the 29 most toxic of these compounds which are recognised internationally as being harmful to humans and animals. To assist the reader, the term "dioxins" is used in this report to refer to the three families, but there are instances where specific mention is made to furans and PCBs.

The Australian Government established the program in 2001 to improve knowledge about dioxins in Australia. The program aims to determine levels, assess the risks to Australians and our environment, and to consider appropriate management actions.

Previously, limited Australian studies showed environmental levels were low, but a lack of information made it difficult to assess dioxin impacts on the environment and human health. The current studies are designed to fill this gap.

Starting in mid 2001, 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 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 our health and the environment.

Due to the high costs for laboratory analysis of dioxins, the number of samples collected for each study was limited and so caution is required when interpreting the findings. Nevertheless, these studies, completed in 2004, provide the largest survey of dioxin levels ever undertaken in Australia and provide information where no data was previously available. This document summarises the results of these studies and the conclusions of the risk assessments.

The findings will contribute to debate on how to deal with dioxins in Australia, as well as assisting Australia meet its obligations under the Stockholm Convention on Persistent Organic Pollutants (POPs). The Convention sets out a range of obligations for countries to reduce and, where feasible, eliminate releases of persistent organic pollutants, including emissions of by–product POPs such as dioxins.

The complete reports from the information studies and the risk assessment can be accessed on a CD–ROM attached to the inside back cover of this publication or from the Department of the Environment and Heritage website at http://www.ea.gov.au/industry/chemicals/dioxins/index.html. Hard copies of the reports are also available on request.

Note: the measured dioxin levels in this summary and the full reports use very small units such as nanograms, picograms and femtograms. Definitions of these and other technical terms are provided in the glossary on Page 16.

Note: The estimation of dioxin emissions (page 2 and 3) relies on data that is sometimes derived from laboratory studies and not actual measurements from facilities. This can create uncertainty in the figures which is reflected in the wide range of estimates. The 'best estimate' is the average between the highest and lowest emission factors. For more details, refer to Technical Report No 3 - Inventory of Dioxin emissions in Australia 2004.

# sources of dioxin emissions

## Dioxin emissions from bushfires

Dioxins are mainly unintended by–products of combustion processes. It has been estimated that 96 per cent of dioxins in the environment are from emissions to air. In 1998, an inventory of sources of dioxin emissions to air in Australia estimated that between 150–2,100 grams TEQ/year of dioxins are emitted each year. Wildfires, agricultural and prescribed fires were thought to be the major sources of these emissions.

Because no Australian data existed, the 1998 dioxins inventory used overseas studies and gave an estimate of between 72–1700 g TEQ/year from bushfires – a very wide range, reflecting the great uncertainty involved in the estimations. The bushfire study aimed to reduce this uncertainty by measuring the emissions of dioxins from fires in laboratories and from fires in several States and the Northern Territory. Emissions were analysed from 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 the smoke plume remains at high temperatures. In field burns, air in the smoke plume rapidly cools to temperatures not supportive of dioxin formation. In wood combustion heaters, where the gases are confined, they remain at temperatures suitable for dioxin formation. A similar situation probably occurs during laboratory burns.

The field burns comprised 13 prescribed fuel reduction fires in south–east Queensland, central Victoria and south–west Western Australia, two sugarcane burns in Queensland, four fires in tropical savanna woodlands in the Northern Territory and two wildfires in north–east Victoria.

The dioxin levels, particularly from south–east Queensland, were consistent with other studies of prescribed fires. 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, significantly lower than the 1998 estimate. Savanna fires in northern Australia accounted for most of these emissions.

A pump is used to collect smoke samples during a prescribed burn. Photo by C Meyer.

## Dioxin emissions from motor vehicles

Although motor vehicles are a source of dioxins, the level of their emissions remains uncertain. There are several reasons for this. Firstly, there is little data available on dioxins emissions from road traffic and tests on vehicles. Secondly, dioxin emissions can vary greatly due to factors including vehicle technology and age, fuel composition and ambient temperatures. Finally, in many cases, published information on dioxins emissions is contradictory. Determining dioxin emissions from motor vehicles must take account of these uncertainties.

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

Leaded petrol vehicles accounted for 40–45 per cent of this amount, due to the presence of chlorinated and brominated fuel additives in leaded petrol. The presence of these chemicals is believed to account for the higher levels of dioxins in leaded petrol vehicles. However, the banning of leaded

# sources of dioxin emissions

petrol from January 2002 is expected to have already substantially reduced dioxins emissions.

Diesel vehicles account for 35–50 per cent of total dioxin emissions from motor vehicles, with most from diesel trucks. Despite unleaded petrol vehicles accounting for 65 per cent of total kilometres travelled, they account for only 5–20 per cent of total dioxins emissions from motor vehicles.

## Emissions from all dioxin sources

Using the findings of the NDP studies on emissions from bushfires and motor vehicles, 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 the United Nations Environment Program. These guidelines identified nine major emission source categories. A summary, in decreasing order, for emissions to all media is shown in the table below.

The new inventory estimates that total emissions to air in Australia are between 160–1,788 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 65 per cent of total emissions to air and over 80 per cent 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 per cent of total emissions.

Prescribed burning and wildfires are likely to contribute at least 20–30 per cent of total dioxin emissions to the environment.

Dioxins from motor vehicles account for less than 2 per cent of total dioxins emissions to air.

View the full reports of the emissions studies on the CD–ROM at:

1. Dioxins emissions from Bushfires in Australia
2. Dioxins emissions from Motor Vehicles in Australia
3. Inventory of Dioxin emissions in Australia 2004

### Emission estimates by subcategory - top 25 emitters

| SOURCE CATEGORY | ANNUAL ESTIMATED RELEASE (G TEQ/ANNUM) | | | |
|---|---|---|---|---|
| | Air | Water | Land | Total* |
| Biomass burning | 240 | 0 | 1,020 | 1,270 |
| Pulp and paper production | 0.4 | 0.2 | 103 | 104 |
| Waste burning and accidental fires | 88 | 0 | 8.7 | 97 |
| Zinc production | 50 | 0 | 0 | 50 |
| Fossil fuel power plants | 14.3 | 0 | 27.7 | 42 |
| Aluminium production | 4.45 | 0 | 31.80 | 36.26 |
| Sewage and sewage treatment | 0 | 0.9 | 33 | 34 |
| Metal ore sintering | 32 | 0 | 0 | 32 |
| Medical waste incineration | 6.39 | 0.36 | 21.9 | 28.7 |
| Household heating and cooking with biomass | 20.2 | 0 | 1.6 | 21.8 |
| Iron and steel production plants | 20.3 | 0 | 0.03 | 20.3 |
| Copper production | 1 | 0 | 13 | 14 |
| Composting | 0 | 0 | 7.3 | 7.3 |
| Diesel engines | 5.4 | 0 | 0 | 5.4 |
| Other non-ferrous metal production | 4 | 0 | 0 | 4 |
| Heavy oil fired engines | 3 | 0 | 0 | 3 |
| Domestic heating and cooking with fossil fuels | 0.4 | 0 | 2.5 | 2.9 |
| Open water dumping | 0 | 1.5 | 0 | 1.5 |
| Ceramics production | 1 | 0 | 0 | 1 |
| Lead production | 0.5 | 0 | 0 | 0.5 |
| Cement production | 0.48 | 0 | 0 | 0.48 |
| Crematoria | 0.3 | 0 | 0.15 | 0.46 |
| 4-Stroke Engines | 0.3 | 0 | 0 | 0.3 |
| Landfills and waste dumps | 0 | 0.2 | 0 | 0.2 |
| 2-Stroke engines | 0.2 | 0 | 0 | 0.2 |
| Other | 0.06 | 0.05 | 0.7 | 0.9 |
| Total | 500 | 3.2 | 1,271 | 1,778 |

*Total may not exactly equal the sum of emissions to air, water and land due to rounding

# dioxins in our 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 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.

The ten sites representing the four land–uses were:

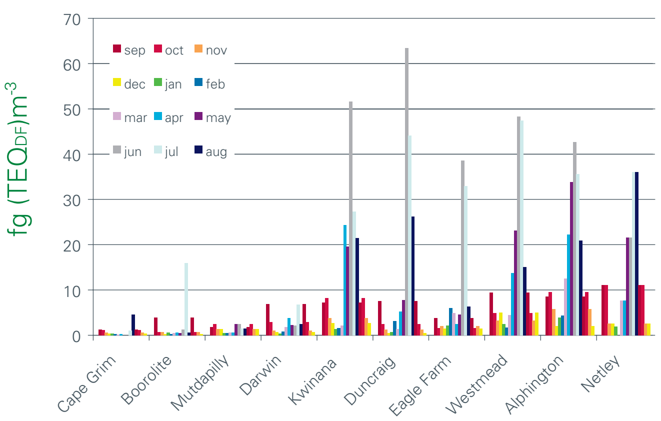
- Darwin, NT (urban)
- Eagle Farm, south–east Qld (industrial)
- Mutdapilly, south–east. Qld (agricultural)
- Westmead, Sydney, NSW (urban)
- Boorolite, lower north–east Vic agricultural)
- Alphington, Melbourne, Vic (urban)
- Cape Grim, Tas (remote – an Australian Baseline Atmospheric Pollution Station)
- Netley, Adelaide SA (industrial)
- Kwinana, Perth, WA (industrial)
- Duncraig, Perth, WA (urban)

The findings indicate an obvious seasonal cycle, with levels higher during winter in all cities, most likely due to smoke from domestic wood heaters.

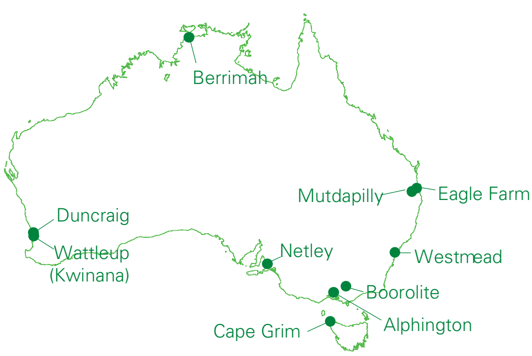
Despite the winter increase, overall mean annual levels in the major cities are still very low by world standards, with levels around 14–17 fg TEQ/m$^3$ compared with northern hemisphere cities with ranges of 20 to several hundred fg TEQ/m$^3$.

Seasonal cycles were also observed in rural Queensland and Victoria, although the cycles were weaker than in the cities.

Dioxins and furans increase over the winter months in the cities




Location of air sampling sites



# dioxins in our environment

A dry to wet season difference was observed in Darwin with levels in the dry season around six times higher than the wet season. Nevertheless, mean annual levels in Darwin are still very low (less than 4 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/$m^3$).

The relative contributions of dioxins, furans and PCBs vary across locations. The Netley site in SA has higher levels of dioxin–like PCBs compared with other sites, but these are still very low compared with other countries. Further testing is currently being undertaken to determine the source of these PCBs.

## Soils

Soils samples were collected from 86 locations across 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). Ten archived soils originally collected from a location near Adelaide since the 1920s were assessed for possible changes in dioxin levels.

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, with the highest levels found in soils near south–east coast population centres.

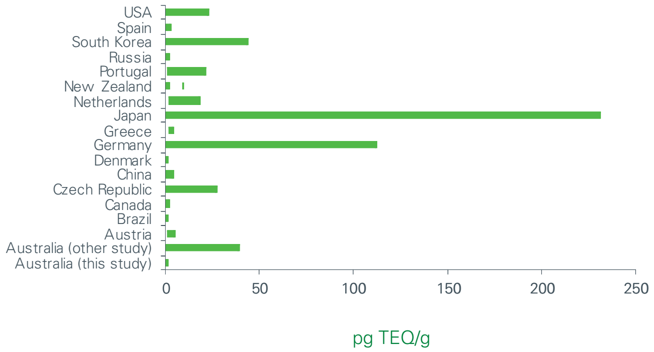
Across agricultural land–uses, dioxins levels were similar, with the exception of sugarcane districts. The higher levels are not likely to be related to sugarcane cultivation since they are the same as found in non–sugarcane growing areas throughout coastal Queensland. These dioxins may be formed through natural processes.

Archived samples contained detectable levels of dioxins, with levels in the 1925 sample greater than in the samples from the 1930s and 1940s. This may have been due to storage contamination so it is difficult to determine the causes for such variation.

Across all land–uses, dioxin levels in soils are on average much lower than those reported in many industrial countries.

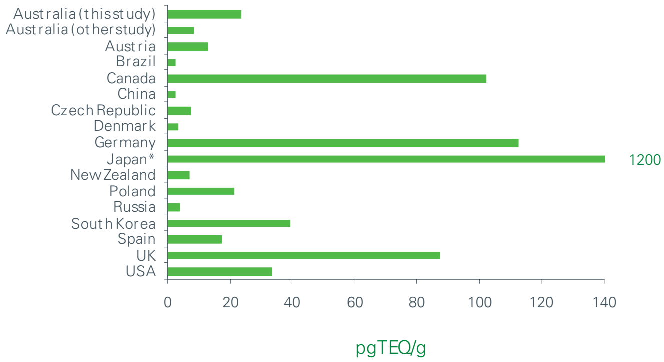
Dioxin levels in agricultural and remote soils in Australia compared with other countries

Note: the separate level for New Zealand represents a single sample




Dioxin levels in industrial and urban soils in Australia compared with other countries

* figure for Japan is 1200 pg TEQ/g



# dioxins in our environment

## Aquatic environment

As dioxins are insoluble in water, the most effective way of determining levels in aquatic environments is to analyse sediments and aquatic animals. 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.

Highest levels were found in the lower Parramatta River (100 and 520 pg TEQ/g) and the western section of Port Jackson (78 and 130 pg TEQ/g) in Sydney. These elevated levels may be due to historical contamination from former industrial sites near Homebush Bay. These sites are under going clean–up which will continue for the next five years.

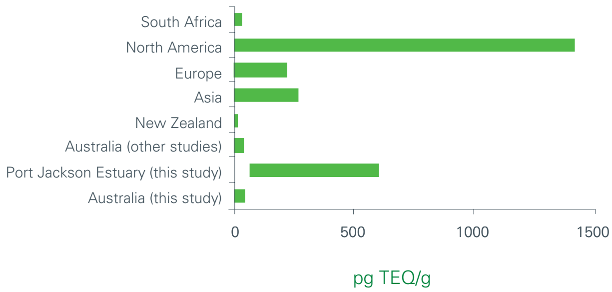
Elevated levels were found in other estuarine waters of Sydney (Botany Bay) as well as the estuaries in or near Brisbane, Melbourne, Hobart, Perth and Wollongong. Average levels across marine, freshwater and estuarine locations did not differ significantly.

The levels of dioxins in 18 bivalve samples ranged from 0.0043–0.2 pg TEQ/g wet weight, with highest levels from Port Jackson and the Yarra River, Victoria.

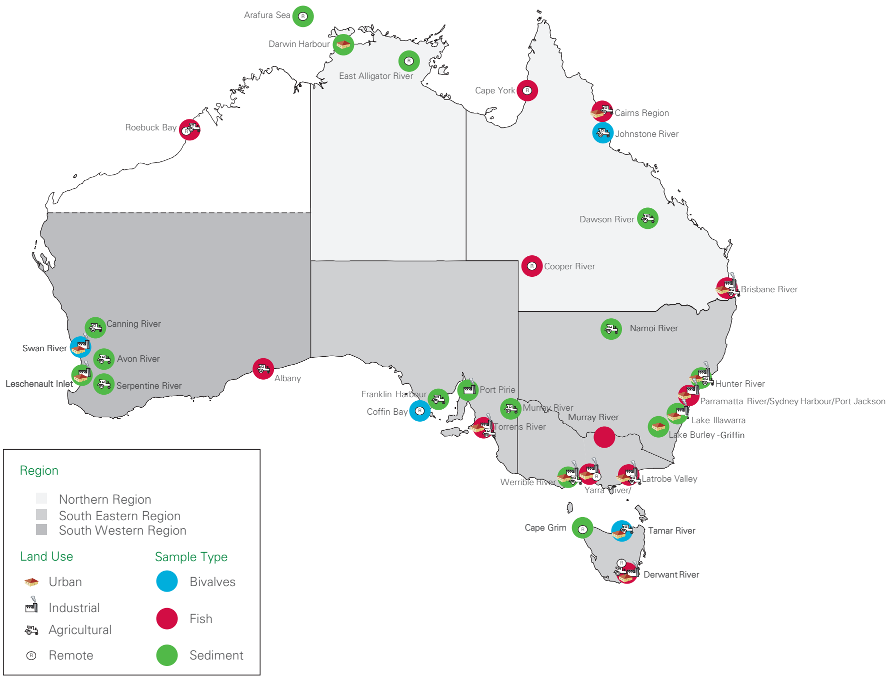
Dioxins in 23 fish samples ranged from 0.0053–0.49 pg TEQ/g wet weight. The level of dioxins was highest in fish sampled from the Sydney/Port Jackson area.

The results show dioxins levels in the aquatic environment are generally lower than for other industrialised countries but there are some sites where levels are elevated. Bivalve levels followed a similar pattern to the sediment levels. However, the fish had consistently low levels of dioxins.

### Dioxin levels in sediments in Australia compared with other countries




### Sampling locations for the aquatic study



# dioxins in our environment

## Fauna

Dioxins emitted to air can deposit on plant, soil and water surfaces. Dioxins can then enter the food chain when animals eat contaminated leaves, soils or sediments. The dioxins are then absorbed into animal fat. Dioxins increase in concentration as they move up the food chain, so that carnivores are more likely to have higher levels than herbivores.

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. However, compared with other countries, the levels in marine mammals are low.

Levels were generally much lower in herbivorous animals such as kangaroos, galahs and dugongs. Levels in kangaroos ranged from 0.001–25 pg TEQ/g lipid. The levels in other marsupials (possums, koalas and bandicoots) were low and comparable to the kangaroos. Levels in platypus and echidnas ranged from 9.3–60 pg TEQ/g lipid.

Compared with fauna from other countries the levels are generally lower. The levels in birds of prey were lower than comparable species from other countries. The levels in one kangaroo sample was higher than for caribou in Canada (0.7–6.4 pg TEQ/g lipid) but less than sika deer from Japan (3.2–330 pg TEQ/g lipid). The levels in kangaroo on a fresh weight basis are even lower due to the lean nature of kangaroo meat.

For an assessment of the risk that dioxins pose to fauna, see the section What is the risk to our environment?

View the full reports of the environment studies on the CD–ROM at:

4. Dioxins in Ambient Air in Australia
5. Dioxins in Soils in Australia
6. Dioxins in Aquatic Environments in Australia
7. Dioxins in Fauna in Australia

Dioxin levels:
– in the environment are generally very low compared with other countries
– increase in air during winter in cities and are most likely due to emissions from domestic wood heaters
– in soils and sediments are highest in urban and industrial areas
– are higher in birds of prey than in other animals.

# dioxins in our food

## Dietary exposure

Food Standards Australia New Zealand has examined the 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.

Dioxin exposure through food is determined by examining dioxin levels in various foods and combining this with information on the daily diet of the population. Foods likely to contain dioxins are those that contain animal fats, such as dairy products, meat and meat products, fish and eggs.

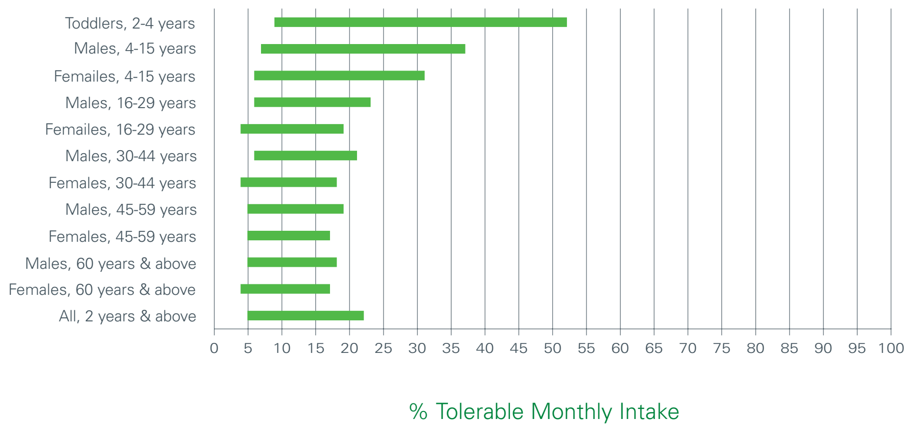
Dioxin levels in food were determined by analysis of 168 samples of 22 randomly sampled foods from Australian retail outlets which were prepared ready to eat. The mean range of dioxin concentrations found in the foods analysed are shown in the table on this page. The survey found that Australian foods have low levels of dioxins – similar to those reported in New Zealand and lower than other countries. These results were then combined with dietary information from the 1995 National Nutrition Survey to assess the population's dietary exposure.

As shown in the figure below, for all age groups from two years and over, the estimated monthly dietary levels of exposure to dioxins, for the average consumer, were well below the Australian Tolerable Monthly Intake (TMI) of 70 pg TEQ/kg body weight/month. Estimated monthly dietary exposures for high consumers were also below the TMI for all age groups.

Because of their high dietary intake relative to body weight, highest mean intakes for all age groups occur in infants and toddlers. In general terms, the estimated monthly level of exposure to dioxins for Australians (3.7–15.6 pg TEQ/kg body weight/month, lower to upper range) is similar to that of New Zealand (11.1 pg TEQ/kg body weight/month, middle value for adult males) and lower than that of other industrialised nations. For example, in the United Kingdom, the estimated exposure to dioxins for the population was 15–2pg TEQ/kg bw/month.

The major foods contributing to dioxin exposure for the Australian population over a lifetime were fish (including crustaceans and molluscs), milk and dairy products. For toddlers and children, the major foods contributing to dioxins exposure were milk and dairy products.

Mean range of exposures to dioxins for each population group in Australia, as a percentage of the Tolerable Monthly Intake.




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

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

# dioxins in our food

As there are limitations associated with the data used to characterise the risk associated with exposure to dioxins from food, in general, conservative assumptions were used to minimise the possibility that risks would be underestimated. On the basis of this analysis the public health and safety risk for all Australians from exposure to dioxins from foods is very low.

## Agricultural commodities

The National Residue Survey, managed by the Australian Government Department of Agriculture, Fisheries and Forestry, collected around 220 samples of meat, fish and milk during November and December 2002.

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, as shown in the table below. 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. It is expected a new EU standard will be developed in the next few years which will include dioxin–like PCBs.

View the full reports of the food studies on the CD–ROM at:

8. Dioxins in Agricultural Commodities in Australia FSANZ dietary study, Technical report No. 27.

Dioxin levels in food are low and pose a very low health risk for all Australians.

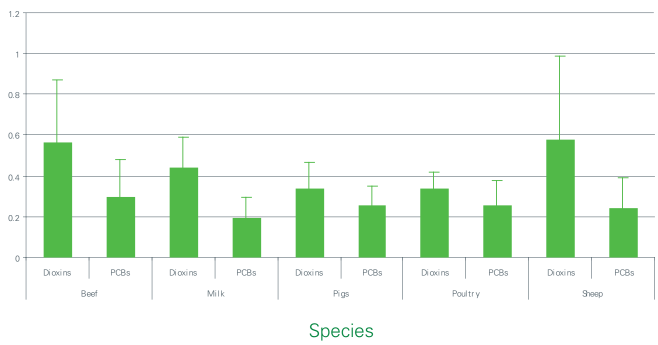
Dioxin levels in agricultural commodities compared with EU standards

| Species | Number of Samples | EU Standard Maximum pg TEQ/g* | Mean result from this study** pg TEQ/g | Australian results compared with EU standard % |
|---|---|---|---|---|
| Beef | 109 | 3 | 0.56 | 18.6 |
| Sheep | 45 | 3 | 0.57 | 19.1 |
| Pig | 20 | 1 | 0.33 | 33.1 |
| Poultry | 15 | 2 | 0.33 | 16.5 |
| Fish (salmonids) | 10 | 4 | 0.23 | 5.7 |
| Milk | 19 | 3 | 0.43 | 14.5 |

* on a fat basis except for fish where it is expressed on a fresh weight basis
** mean results for all upper bounds concentrations.

Mean dioxin and furan levels (pg TEQ/g fat) in all agricultural commodities except aquaculture fish

(T–lines indicate the highest level)



# dioxins in our bodies

Dioxins emitted to air can deposit on plant, soil and water surfaces. Dioxins can then enter the food chain when animals eat contaminated leaves, soils and sediments. In aquatic environments, filter–feeding animals can absorb dioxins when they filter sediments in the water. The dioxins are then absorbed into animal fat. Dioxins increase in concentration as they move up the food chain.

The consumption of animal products with high fat content, such as meat and dairy products, can increase human exposure to dioxins. Dioxins accumulate in body fat and the average concentration increases with age.

To determine dioxin levels in Australians, two studies were undertaken – one assessed levels in blood serum of the whole population and the other assessed levels in the milk of first–time mothers.

## 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 Qld)
- south–east (Sydney, Canberra, Wollongong, Newcastle and other major population centres from NSW)
- south (Melbourne, Adelaide, Hobart and other major population centres from Victoria)
- west (Perth and other major population centres in WA)
- one rural region (all States and the NT).

The levels in the Australian population are very low by international standards, with a mean of 10.9 pg TEQ/g of lipid. They are comparable with, although lower than, those in the New Zealand population.

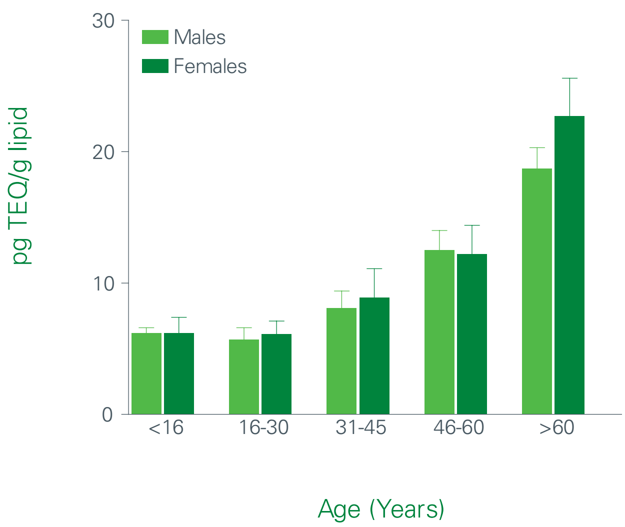
Dioxins levels between males and females showed no differences, except that slightly higher levels of dioxins were observed in females in the over 60 years age group. This result could not be explained on the basis of differences in the mean age between males and females in this group.

The study found dioxin levels increased with age. Reasons for this include on–going accumulation over a lifetime, the possibility that older people were exposed to much higher levels in the 1940s–1960s, and potential differences in metabolism and body fat.

Dioxin levels across the five regions were similar in each age range. Samples from the south–east region have slightly higher dioxin levels and females under 16 years have the highest levels of dioxins in rural regions.

As samples did not identify the donor, an assessment of any regional differences was complicated. The samples did not allow assessment of how long an individual lived in an area, their food intake or exposure to environmental contaminants.

Levels of dioxins in different age groups



# dioxins in our bodies

## Breast milk

Since breast milk is a rich source of fat, analysis of the levels of dioxins is valuable for estimating the total amount of dioxins in humans.

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 breast feeding
- 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 that levels had almost halved from 1993 to 2003.

Breast milk may contain low levels of dioxins because of its fat content, but all babies are exposed to dioxins even if they are not breastfed. Alternative foods for babies, such as infant formula, may also contain dioxins because of their fat content. Breast feeding is still the normal and most appropriate method for feeding infants, as supported by the World Health Organization.

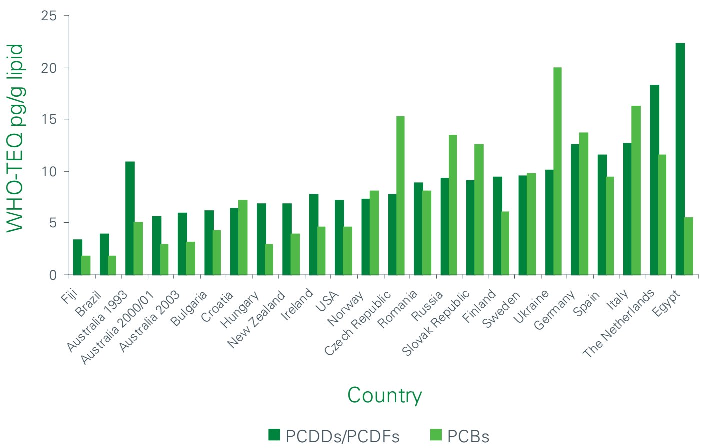
View the full reports of the studies of dioxins in our bodies on the CD–ROM at:

9. Dioxins in the Australian Population: Levels in Blood
10. Dioxins in the Australian Population: Levels in Human Milk

Dioxin levels in our bodies
– are low by international standards and have declined, reflecting similar world–wide trend over recent decades
– increase with age.

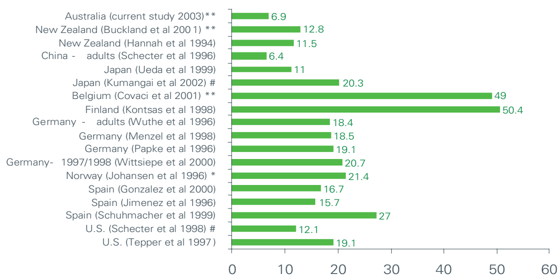
### Levels of dioxins in the breast milk of Australian women compared with other countries

All data is from a World Health Organization study in 2001 except for the "Australia 2003" figure, which represents the National Dioxins Program study.




### Levels of dioxins and furans in Australians compared with other countries

Note this figure does not include PCBs



# what is the risk to our environment?

Risk assessment is the process of estimating the potential impact of chemicals or other factors on people or on the environment, under a set of conditions and for a certain timeframe. Risk assessment identifies and characterises potential hazards, and determines the likelihood of their occurrence at the known levels of exposure.

Ecological risk assessment determines if chemicals will have adverse impacts on organisms in the environment. Unlike human health risk assessment, which seeks to characterise risks to individuals, ecological risk assessments aim to characterise risks to ecosystems, populations and species.

Dioxins can adversely affect many vertebrate species. At low levels they can disrupt the development of the endocrine, reproductive, immune and nervous systems of the offspring of fish, birds and mammals.

This ecological risk assessment has three main parts: the hazard assessment, the exposure assessment, and the risk characterisation. This hazard assessment used published studies examining the toxic effects of dioxins on a limited number of species. The data from these studies were adopted to assess the potential risk to native wildlife, for which no toxicity data is available. The exposure assessment was based on the data from the soil, aquatic environment and fauna studies. The risk characterisation was performed by combining information from the hazard and exposure assessments, to estimate the likelihood of harm.

The 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 per cent of the load in dolphins and seals, and over 80 per cent 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. However, the absence of data on the toxicity of dioxins to native marsupials and monotremes adds significant uncertainties to this assessment. The effect of different reproduction strategies between placental mammals and marsupials for dioxin exposure at sensitive life stages is not known
- Fish are at a low risk when exposed to the dioxin levels found in the Australian aquatic environment. This assessment is based on levels found in fish caught for the aquatic environment study
- Marine mammals living in the open oceans of Australia have no risk
- Based on the small number of samples collected in the fauna study, a potential risk is indicated for dolphins living in the vicinity of urban/industrial estuaries, which had higher levels of dioxins in their bodies than mammals living in the open ocean.

# what is the risk to our environment?

## Limitations of the assessment

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. The conclusions are 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 has been 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.

More reliable risk estimations would require information on the toxicity of dioxins to Australian wildlife. Animal ethics committees and current State legislation generally do not allow toxicity testing on native species. More targeted sampling of birds of prey and other species, in association with field observations of potentially exposed populations, would help to clarify whether dioxins are having a real impact on bird populations.

View the full report of the ecological assessment on the CD–ROM at:
11. Ecological Risk Assessment of Dioxins in Australia

Dioxins are higher in carnivorous animals such as birds of prey and lower in herbivores such as kangaroos. There is a potential risk to marine mammals living near urban areas and to birds of prey.

# what is the risk to our health?

## Dioxins in the general population

The human health risk assessment used data from the information studies and the findings of overseas studies.

For the general population, over 95 per cent of exposure to dioxins is through the diet, with foods of animal origin such as meat, dairy products and fish being the main sources. Based on the dietary study of dioxins, the intake of dioxins for the Australian population is lower than in most other countries.

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 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 per cent of the Tolerable Monthly Intake.

Intakes are lower in females than males for the same age, and decline with age in both sexes, the most rapid decline occurring after puberty. Infants and toddlers had a higher 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.

These intake figures are not a significant cause of concern and are lower than those in other developed countries.

## Exposure to dioxins from other sources

Dioxins enter the environment mainly from combustion processes.

Intake of dioxins through the skin, ingestion from soil and from breathing are minor contributors to exposure of the general population. Cigarette smokers are likely to have higher intakes of dioxins than non–smokers.

Australia has low dioxin levels compared to other industrialised countries. It is possible that the largest emitters to the environment are not the major contributors of dioxins contamination of food. Nevertheless, protection of land and aquatic environments used for food production is important to reduce the intake of dioxins.

This assessment, whilst not an occupational health and safety risk assessment, also briefly considered 'special' populations who may have been exposed to dioxins above background levels e.g. workers who used pentachlorophenol (PCP) for treating timber and dioxin–contaminated 2,4,5–T herbicide. In view of the relatively small number of occupationally exposed cases known or studied in Australia, as well as the lack of data on blood levels of dioxins in these workers, it has not been possible to draw clear conclusions about the health effects of such exposures. PCP and 2,4,5–T were withdrawn from use in Australia a number of years ago.

# what is the risk to our health?

## Dioxins in breast milk

Unborn children are exposed to dioxins in the womb, and nursing infants are exposed to dioxins in breast milk. Because of their high dietary intake relative to bodyweight, the highest mean intake of dioxins for all age groups occurs in infants and toddlers. These findings do not change the health advice that breast milk provides the ideal nutritional start to life. The intake in question is low and gets lower as the body develops to adult size.

## Dioxins and cancer

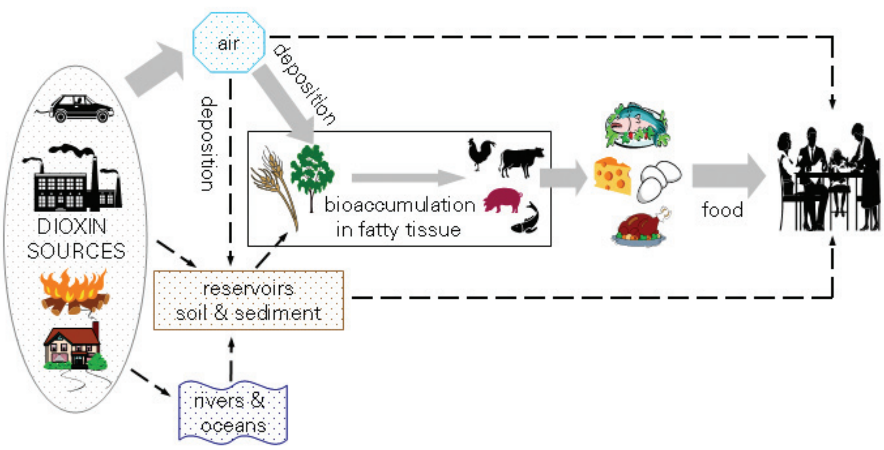
A number of agencies in other countries have tried to provide quantitative estimates of cancer risk, based on low–dose extrapolation from both animal and human data. The difficulties with estimating cancer risk include ongoing debate about the existence of a threshold level below which dioxins will not increase cancer risk and questions about the potency of the dioxins in causing cancer. Consequently, given the variability in quantitative risk estimates, this assessment has not attempted to make a quantitative risk conclusion.

The estimated intakes are below the Tolerable Monthly Intake, providing an adequate margin of safety for any possible increased risk of cancer. Furthermore, it is noted that the levels of dioxins in Australians are well below the levels associated with increased cancer risk in humans that has been seen in highly exposed industrial workers and communities exposed to industrial accidents in other countries.

View the full report of the health assessment on the CD–ROM at:
12. Human Health Risk Assessment of Dioxins in Australia

The monthly intake of dioxins from food for Australians older than 2 years was between 3.9–15.8 pg TEQ/kg bw/month or between 6–23 per cent of the Tolerable Monthly Intake. The risk to the health of Australians is very low.

Pathway for dioxins entering our bodies



# glossary

| | |
|---|---|
| Lipids | Lipids include fats and oils. |
| Limit of detection | Limit of detection, the lowest level at which a chemical can be measured in a sample by the analytical method used. |
| TEQ | Toxic Equivalents – allows the toxicity of a complex mixture to be estimated and expressed as a single number. A set of weighting factors has been determined for each type of dioxin, which expresses the toxicity of each type in terms of its equivalent mass of TCDD 2,3,7,8–Tetrachlorodibenzo–p–dioxin). Multiplication of the mass of the congener by its weighting factor (or toxic equivalency factor, TEF) yields the corresponding TCDD mass (or TEQ). The total toxicity of any mixture is the sum of the TEQs for each type of dioxin. |
| Upper bound | The maximum possible TEQ. |
| Units of measurement | |
| ng | nanogram $=10^{-9}$ gram (0.000 000 001g) |
| pg | picogram $=10^{-12}$ gram (0.000 000 000 001g) |
| fg | femtogram $=10^{-15}$ gram (0.000 000 000 000 001g) |
| Tolerable monthly intake | The amount of a substance which can be consumed over a month with no appreciable risk to health. |

Copies of the reports contained in this CD–ROM can be accessed electronically from:

http://www.deh.gov.au/industry/chemicals/dioxins/index.html