Health effects of waste combustion products

Waste from homes, commerce and industry can be used to produce electricity by burning in modern waste incinerators. This process is not only energy-efficient but also reduces the amount of valuable land needed for refuse disposal. However, there are barriers limiting the widespread use of waste incineration. The most important of these barriers is public concern about the health effects of the pollutants in incinerator emissions.

This document gives background information on the potential health effects of ten key pollutants produced during the combustion of chemical, clinical, municipal and sewage waste. It also assesses current understanding of damage to the health of people actually living near waste incinerators. It is based on a report published by the Institute for Environment and Health (IEH, 1997).

This leaflet was originally published by the Institute in 1997. It was produced for ETSU/DTI as a concise summary for policy makers and decision makers of the IEH report *Health effects of waste combustion products* (Report R7). The report is now out of print, but can be downloaded as a pdf file from our Web site.
http://www.le.ac.uk/ieh

Institute for Environment and Health

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The ten key pollutants are:

five metals:

cadmium
mercury
arsenic
chromium
nickel;

three groups of organic substances:

dioxins
polycyclic aromatic hydrocarbons (PAHs)
polychlorinated biphenyls (PCBs);

plus:

fine particulate matter (PM_{10})
the gas, sulphur dioxide (SO_2).

In identifying the ten 'key' pollutants released during the incineration of waste, an initial list was compiled containing over 60 compounds or groups of compounds known to be present in emissions from the burning of municipal waste and also sewage sludge, chemical and clinical waste. Following a selection process based on both public concern and the levels estimated to be released, the number of compounds on the list was reduced to about 30. The ten considered to be of most significance regarding potential effects on human health were then selected using information on toxicity, persistence in the environment and whether or not the estimated level of the compound released was greater than existing or calculated air quality guideline values. The major route of human exposure to each of these ten pollutants, whether by inhalation or ingestion, was identified and the known human health effects reviewed.

General considerations

All ten key pollutants are present in the environment at background levels. They arise from various sources, of which waste incineration generally makes up only a small fraction. Future contributions from waste incineration are likely to fall as modern incineration technology becomes more widely used, and stricter pollution controls introduced by the UK Environment Agency in 1996 will reinforce this trend.

Although many of the pollutants considered here are classified as carcinogenic (able to cause cancer), these classifications are based on studies of laboratory animals or of people who have been exposed to high levels of pollutants at work or following accidental releases. The carcinogenic potential of these pollutants at the lower exposure levels found in the environment are difficult to determine and any effects are likely to be extremely small.

There is, however, evidence that exposure to some of the pollutants at environmental levels can cause health effects. For example, sulphur dioxide and the fine dust particles known as PM_{10} can worsen symptoms and increase mortality in people suffering from asthma and other diseases.

Most of the information about the health effects of specific pollutants comes from studies on single chemicals at relatively high levels of exposure — generally at work or as a result of accidents. Few studies have investigated the health effects of low-level exposures to these pollutants, either singly or in the chemical mixtures produced by waste incineration processes. While this document looks at the health effects of individual components, ideally one would determine the toxic properties of the actual mixtures of pollutants released in emissions. However, it is currently not possible to predict the overall effect of mixtures from information on individual components.

Some studies have attempted to show that incinerator workers have a higher mortality from cancer and other diseases than the population as a whole. Other studies have looked for health effects in people living near incinerators. None of these investigations has provided evidence of an increased risk of disease in populations living close to waste incinerators. However, all these studies have been relatively small. They may therefore not have been sensitive enough to identify small differences between populations exposed to environmental levels of pollutants and those exposed to the extra pollution from waste incineration.

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Health effects of the key pollutants

The IEH report discusses ten pollutants that may affect human health. In summarising health effects, particular consideration has been given to those which may occur at relatively low levels of exposure. The following sections summarise the major human health effects of these pollutants. Table 1 gives more information on levels and effects.

Cadmium

Exposure to high levels of cadmium in the workplace has been linked to an increased risk of lung cancer and a number of non-carcinogenic effects, particularly in the lungs and kidneys. It is not clear whether there is a level of exposure at which the less severe respiratory effects do not occur, so it is possible that such effects *could* occur at environmental exposure levels. However, effects on the kidney are not seen at levels below the exposure limits currently applied in UK work places, and so are unlikely to result from the lower levels encountered in the environment.

Mercury

The major health effects at low levels of exposure to mercury in the workplace are kidney damage and nervous system changes causing subtle behavioural effects. There appear to be exposure levels below which neither of these effects occur, but the likelihood of these effects occurring at environmental exposure levels remains uncertain.

Arsenic

Short-term and long-term exposure to high levels of inorganic arsenic can result in toxic effects in a number of organs including the respiratory tract, skin, liver and peripheral nerves. Long-term ingestion or inhalation of arsenic can result in cancer of the skin and lungs. As with other cancer-causing agents, the cancer risk resulting from very low levels of exposure, such as that arising from waste combustion, is likely to be small and difficult to determine.

Chromium

The major health effects reported to occur at high levels of exposure to the most toxic group of chromium compounds (hexavalent chromium) include damage to the inner tissues of the nose, inflammation of the skin, and lung cancer. Effects on the nose and skin are unlikely to occur at current environmental (or workplace) exposure levels, but a small risk of lung cancer cannot be excluded.

Nickel

Occupational and accidental exposures to nickel can cause effects in the lungs, gut and kidneys. The major concern in the workplace is the cancer-causing potential of inorganic nickel, and it is not possible to exclude a small increase in cancer risk resulting from low level exposure to inorganic nickel compounds. Allergic sensitisation to nickel and its salts, causing skin inflammation around areas of contact, is another recognised problem both in people who work with nickel and in the general population.

Dioxins

Exposure to dioxins at high doses can produce chloracne, a skin disease resembling acne. Dioxin exposure may also affect metabolism, reproduction and children's development — effects which have been reported to occur at levels less than ten times those of average background (mainly dietary) intakes or body-burden levels. Current evidence also suggests that dioxins may present a cancer hazard to humans.

PAHs

Some studies have shown an increased risk of lung, skin, and perhaps gut and bladder cancers in people exposed to mixtures of pollutants containing high levels of PAHs, such as emissions from coke ovens and tobacco smoke. Some PAHs have been shown to cause cancer in animals, and a number of regulatory authorities have classified certain PAHs as probably carcinogenic to humans. As no two sources of PAHs are likely to be the same, either in composition or the concentration of individual compounds, it is not possible to estimate the general risk of cancer resulting from environmental exposure to PAHs.

PCBs

Information on the human health effects of PCBs has come mainly from short-lived episodes when people have been exposed to serious contamination of their food or water. Some studies have also addressed concerns about PCBs in breast milk. As well as there being adverse effects from high-level episodic exposures, there is some evidence for a link between lower-level long-term exposures (at around ten times UK environmental levels) and certain subtle health effects. Although PCBs can cause cancer in animals and are known to persist in human tissues, there is no clear evidence that they cause cancer in humans.

PM_{10}

Exposure to these fine airborne particles has been associated with increases in both short-term and long-term health effects and in mortality in the general population. These effects are especially seen in susceptible groups such as the elderly and chronically sick people. There is no evidence of a level below which these effects do not occur, but the severity of the effects depends on the dose.

SO_2

Short-term exposure to high levels of SO_2 can irritate the upper airways. Exposure at levels found both in the workplace and the environment can produce narrowing of the airways in sensitive subjects. Population studies have shown that long-term exposure to SO_2 is associated with increases in heart and lung disease and mortality. Environmental exposure to SO_2 may also increase sensitisation to substances in the environment that cause allergies, such as pollen.

Reference

IEH (1997) *IEH Report on Health Effects of Waste Combustion Products* (Report R7), Leicester, Institute for Environment and Health

Table 1 Summary of background levels and major health effects of key pollutants

Pollutant	Background levels[a] Air[c]	Diet	Site of accumulation	Possible health effects[b]
Cadmium	0.0053µg/m^3 [0.11µg/person/day]	18µg/person/day	Liver and kidney	Workplace exposures associated with effects on lungs (including an increased risk of cancer) and kidneys. Environmental exposures are unlikely to result in these effects although a very small increase in risk of lung cancer cannot be excluded
Mercury	0.00025µg/m^3 [0.0050µg/person/day]	2µg/person/day	Mostly in the kidney for inorganic salts; mercury vapour also deposited in the brain.	Changes in kidney function and behavioural effects at low exposure levels in the workplace. The relevance of these effects to environmental exposures is uncertain
Arsenic	0.016µg/m^3 [0.32µg/person/day]	<70µg/person/day	Does not accumulate	Inorganic arsenic is toxic to respiratory tract, skin, liver, and peripheral nervous system at high exposure levels; the major health effect is cancer of the skin and lungs. Any increase in cancer risk at environmental exposure levels is likely to be small and difficult to determine
Chromium	0.0036µg/m^3 [0.072µg/person/day]	250µg/person/day	Cr(VI) does not accumulate; Cr(III), although poorly absorbed, can accumulate in liver, spleen and bone marrow	Occupational exposure to some Cr (VI) compounds is associated with damage to the inner tissues of the nose, skin inflammation and lung cancer. Effects on the nose and skin are unlikely at environmental exposures but a small increase in lung cancer risk cannot be excluded
Nickel	0.0012µg/m^3 [0.024µg/person/day]	170µg/person/day	Concentrated in liver and kidneys (and lungs following inhalation); in individuals without known exposure, highest levels are found in bone, lung, kidney, liver and heart	Workplace exposure to inorganic nickel compounds is associated with an increased risk of cancer of the lung and nose; a small increase in risk at environmental levels is possible. Nickel can cause allergy known as nickel sensitisation

Dioxins[d]	0.0000068µg/m^3 [140pg/person/day]	0.000069µg TEQ[e]/person/day	Accumulates in fat; can be detected in breast milk	Chloracne is associated with high levels of exposure. May affect metabolism, development and reproduction at levels less than ten times average levels in the body. Dioxins may also cause cancer
PAHs	0.13µg/m^3 [2.6µg/person/day]	3.7µg/person/day	Can accumulate in fat and breast milk	Some PAHs may cause cancer of the lung, skin and possibly bladder and gut at high levels of exposure; it is not possible to estimate cancer risk at environmental exposure levels
PCBs	0.00070µg/m^3 [0.014µg/person/day]	0.34µg/person/day[f]	Accumulates mainly in fat (and breast milk)	Few adverse effects definitely associated with long-term low-level exposure. Subtle developmental effects reported in children resulting from exposure in the womb or through breast feeding. Evidence for ability to cause cancer is inadequate
PM_{10}	20–34µg/m^3 [400–680µg/person/day]	Not applicable	Does not accumulate	Increased short- and long-term health effects and mortality in the general population, particularly in susceptible subgroups such as the elderly or sick
SO_2	1–50µg/m^3 [20–1000µg/person/day]	Not applicable	Does not accumulate	Short-term high-level exposure can irritate the upper airways; workplace and environmental levels can produce airway narrowing in sensitive subjects. Long-term environmental exposure is associated with increased heart and lung disease and mortality, and can increase sensitisation to allergens such as pollen

a Background air data taken from: *A to Z: A Directory of Air Quality Data for the United Kingdom in the 1990s* (1995), The Meteorological Office

b For non-cancer endpoints, thresholds may exist but the levels at which they occur are not well established

c The figure in square brackets is the calculated total daily background level per person via the air, based on a breathing volume of 20m^3/day

d Also includes polychlorinated dibenzo-*p*-furans

e TEQ, toxic equivalents

f Background data on dietary levels taken from MAFF Food Safety Directorate Food Surveillance Information Sheets 34 (1994), 71 (1995) and 89 (1996)

Conclusions

Some of the key pollutants released during incineration processes have been shown, in other circumstances, to cause diseases, including cancer. However, no studies to date have found significantly more disease, compared with the general population, in either incinerator workers or people living near incinerators. This has two possible interpretations:

there are really no effects on these populations; or

the studies have not been sensitive enough to identify any effects which are present.

For most of the pollutants, waste incineration emissions will only increase human exposure by a small fraction of the background environmental levels. People living close to incinerators may be exposed to slightly higher levels of pollutants than people living elsewhere and so may be at somewhat greater risk of damage to their health. Unfortunately these risks are difficult to quantify because very little information is available on the health effects of pollutants either at low environmental exposure levels or in mixtures.

At the end of 1996 the Environment Agency introduced stricter controls on the atmospheric release of many of the pollutants considered in this document. Together with the increasing use of modern incineration equipment, this is expected to reduce any risks of damage to health resulting from incinerator emissions to levels below those detectable by any practical study.

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