Potential Health and Environmental Impacts

from Municipal Solid Waste Management

Brief summary of a review by the Environmental Protection Team Milton Keynes Council
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The most recent research

A recent detailed report published by DEFRA (Enviros et al. 2004, “the DEFRA report”) concluded that on the evidence of scientific studies so far, Municipal Solid Waste (MSW) disposal has "at most a minor effect on human health and the environment". One of the main conclusions of the report was that burning waste was, at least, no worse than dumping it in landfills.

Techniques for treating MSW

Biological processes

Utilising the action of micro-organisms and biogenic heat to break down organic wastes, three main types**:**
(i) Composting of ‘green wastes’ in the presence of air (aerobic), usually outdoors (windrow composting);
(ii) In-vessel composting (IVC) is aerobic and temperature can be sufficiently high and tightly controlled to also deal with food waste;
(iii) Anaerobic Digestion (AD) in the near absence of oxygen produces a ‘digestate’ containing bio-solids and/or a liquid, and ‘biogas’. Used for sewage sludges and agricultural waste but not widely for MSW in the UK.

Thermal processes

Essentially two types open burning or enclosed burning:
(i) Incineration with energy recovery, the combustion of mixed waste with energy used to generate electricity. Used for 9% of UK waste.
(ii) Advanced Thermal Treatment (ATT) there is currently only one UK ATT MSW process using a combination of gasification and pyrolysis:
Pyrolysis, organic waste is heated to 400-700 ^{o}C in the near absence of oxygen producing a mixture of gaseous and liquid fuel and a solid ‘char’;
Gasification, organic waste is heated in a high temperature (800-1200^{0}C) thermal process, produces ‘syngas’ which can be burnt to generate electricity.

Mechanical-hybrid processes

Two main types where the mechanical screening and separation of recyclables is combined with either a biological technique or a heat treatment:
(i) Mechanical biological treatment (MBT) waste is screened to extract and separate non-compostable fractions, with biological processing of the residual compostable waste and landfill of the reject fraction;
(ii) Mechanical heat treatment (MHT), such as the application of steam and pressure to a mixed waste stream in a sealed vessel (autoclave or AC) to stabilise the organic fraction of the waste and steam clean the inorganics.

Landfill

The option of last resort for dealing with waste. Much landfill gas is now collected and burnt to recover energy but a significant proportion of the gas is lost to the atmosphere. Landfill will probably always be used for the final disposal of the residual material from other treatment technologies.

Emissions from MSW treatment

Emissions to water

Emissions to water are associated with landfilling and, to a lesser extent composting. Some other processes use and discharge water. These emissions make up about 0.25% of total UK emissions to water.

Emissions to air (Table 1)

With the exception of methane and cadmium (Cd) less than 2.5% of total UK emissions to air come from MSW management. However, 27 % of UK emissions of methane and 10% of emissions of Cd comes from MSW, in both cases very largely from landfill sites.

Overall PAH (polycyclic aromatic hydrocarbon) emissions from MSW treatment are rather less than 3% of total national emissions to air (data from Dore et al. 2004), the available data suggests emissions from incineration are unlikely to be significant. Road traffic will have a more significant effect on local levels of PAH than a MSW incinerator.

Data on metal emissions is mainly for incineration and landfill. Taken together metal emissions from incineration and landfill as a percentage of total national emissions amount to about 0.1% for As (arsenic), 10% for Cd, 1.65% for Hg (mercury) and 0.2% for Ni (nickel) (data from Dore et al. 2004; Enviros et al. 2004).

Emissions of particulate matter (PM)

All MSW treatment techniques are capable of generating particulate emissions. The available information suggests composting processes give out most particulate matter followed by incineration.

Emissions of bioaerosols

The main biological hazard associated with MSW treatment is related to the formation of bioaerosols (organic dust). These are airborne particles comprising large molecules or volatile compounds that are living or contain living organisms or were released from living organisms. Bioaerosols are considered to be the emission of most concern from all types of composting site and there are also significant emissions from MBT sites.

There is no information available which enables emissions from composting (other than particulate matter), MBT or anaerobic digestion to be properly quantified.

Table 1. Emissions to air from specific techniques
in weight per ton MSW treated
(grammes except where indicated otherwise)

	Cm	AD	In	TT	MB	Lf	Tr
Methane (CH_4)	Y	Y	19	Y	411	20kg	N
Carbon dioxide (CO_2)	Y	N	1 Mg	N	Y	0.3 Mg	Y
Nitrogen oxides (NO_x)	N	188	1.6kg	780	72.3	680	31
Sulphur oxides (SO_x)	N	3	42	52	28	53	0.11
Halides of hydrogen (HCl, HF)	N	<0.02	59	32.3	1.6	6	N
Non-methane VOCs	Y	Y	8	11	36	23	5.1
Dioxins & furans (ng TEQ)	N	N	400	48	40	140	0.04
Arsenic (As) mg	N	<0.5	5	60	?	1.2	?
Cadmium (Cd) mg	N	<0.1	5	6.9	?	71	?
Mercury (Hg) mg	N	<0.6	50	6.9	?	1.2	?
Nickel (Ni) mg	N	<0.3	50	40	?	9.5	?
Particulate matter PM	175	Y	38	12	Y	5.3	1.3
Polycyclic aromatic hydrocarbons	?	?	N	?	?	?	Y
Bioaerosols	Y	Y	N	N	Y	Y	N

Cm Windrow composting; **AD** Anaerobic Digestion; **In** Incineration; **TT** Advanced Thermal Treatment (pyrolysis/gasification); **MB** Mechanical Biological Treatment; **Lf** Landfill 25% of emissions as fugitive gases 75% from gas engines; **Tr** Waste related transport.
VOC volatile organic compounds; **?** no data; **N** not likely to be emitted in significant amounts; **Y** likely to be emitted unquantified. **Mg** megagramme, 1 million grammes; **kg** kilogramme, one thousand grammes; **mg** milligramme one thousandth of a gramme; **ng** nanogramme one thousandth of one millionth of a gramme. **TEQ** expressed as a concentration equivalent to the most toxic dioxin – 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

Emissions to land

This is an area where more research on possible emissions, particularly from composting, MBT and AD of MSW, is urgently required.

Conclusions about emissions

It is emissions to air that have the greatest potential for impact on health, as any impact would be more direct than impacts via water or solid materials. Whilst there is some good evidence about emissions to air, there are still gaps in our knowledge particularly about composting, mechanical biological treatment and anaerobic digestion (see Table 1).

However, with two exceptions (methane and Cd, both mainly from landfill) emissions to air from MSW treatment amount to only 2.5% of total UK emissions. Emissions to water from MSW treatment are negligible making up only 0.25% of the UK total. Emissions to land and in solid form are rather more difficult to assess.

Results of research on potential health effects

Studies on landfill sites

There is one recent study that shows a consistent statistical relationship between living near MSW landfill sites and adverse health effects (Elliot et al. 2001). There are serious problems with interpreting the results of studies of this type. The authors of this report are quite clear that there is no direct evidence of any cause and effect relationship between the identified health effects and living near a landfill site.

The recent DEFRA report says, ”we found that the weight of evidence is against any increased incidence of cancers in people living near to landfill sites”.

Studies on Incinerators

Most published studies of incinerators concentrate on the older generation of incinerators, which were phased out in the UK after the Integrated Pollution Prevention and Control (IPPC) regime introduced stricter emission controls. The level of emissions from these incinerators was very much higher than from modern incinerators, which makes any conclusions from these studies not directly relevant to the current situation. Not withstanding this, most of the epidemiological (health) studies of populations living near incinerators have not given clear indications of the presence, or absence, of negative health effects.

However, one study of a modern incinerator showed that there is no difference in the amounts of dioxins and furans in blood samples from people living nearby and those living further away (Gonzalez et al. 2000).

After considering all the available evidence the experts of the government’s independent advisory Committee on the Toxicity of Chemicals (COC) came to the conclusion that “any potential risk of cancer due to residency (for periods in excess of ten years) near to municipal solid waste incinerators was exceedingly low and probably not measurable by the most modern techniques”.

Studies on composting sites

Hazards from bioaerosols have been shown to lead to a number of distinct health conditions. Studies have shown that levels of bioaerosols in a number of commercial scale composting facilities represent a distinct hazard. Residents near composting sites could experience an increased rate of adverse health impacts such as bronchitis, coughing and eye irritation, but no link has been found with asthma. More research is needed in this area.

Results of research on potential environmental impacts

Potential environmental impacts

The two most important potential impacts are due to the emission of so-called 'greenhouse gases', with the potential to affect global climate, and the emission of acid gases which might contribute to acid rain (Table 2).

Table 2. The main environmental impacts

Technique	'Greenhouse gas' emissions	Acid gas emissions
Materials recycling facilities	**Slight overall benefit**	**Nil**
Composting	**Small effect due to CO_2 & possibly other emissions**	**Nil**
Anaerobic digestion	**Small effect due to CO_2**	**Minor adverse effect**
Incineration	**Small effect due to CO_2**	**Minor adverse effect**
Advanced thermal treatment	**Small effect due to CO_2**	**Minor adverse effect**
Mechanical biological treatment	**Small effect due to CO_2**	**Low or nil**
Landfill	**Large effect due to methane**	**Minor adverse effect**
Transport & waste transfer stations	**Minor benefit due to more efficient logistics**	**Minor adverse effect**

Conclusions on environmental impacts

With the exception of methane emissions from landfill sites, properly designed and managed MSW facilities have minimal effects on the environment. Although some processes do emit acid gases the amount and effect of these will be negligible compared to other sources of acid gases, such as combustion of fossil fuel and transport.

Quantifying the health effects

The DEFRA report included a quantitative assessment of the health effects of emissions to air from MSW treatment (summarised in Table 3).

Emissions of dioxins and furans from modern incinerators amount to between 0.3% and 0.8% of the background exposure from other sources. On this basis the “the incinerator dioxin emission contribution to exposure of local populations is entirely negligible” (Environment Agency 2003).

Table 3. Comparison of health effects

	Number per year in the UK due to:			
Health impact	**MSW management**	**Skin cancer (Mainly due to sunlight & sunbeds)**	**Lung cancer due to passive smoking**	**Health impacts due to overall air pollution**
Deaths brought forward	**0.55**			**11,600**
Hospital admissions	**4.9**			**14,000**
Cancers	**0.0014**	**6,000**	**hundreds**	
Data quality	**Poor**	**Moderate**	**Poor**	**Poor**

The report was unable to estimate the potential health effects from composting sites because of a lack of quantitative information on emissions. More work on the possible health effects of composting is needed, as there is some epidemiological evidence suggesting that health effects might occur in people living close (within 250 metres) to MSW composting sites.

Comparison of health effects from MSW management with other causes

The calculated total number of estimated extra hospital admissions at less than five per year is very small. Other influences on health are much more important than the management of MSW, even for people living near to sites handling MSW.

Conclusions from this review of potential health and environment impacts

The scientific position

There is disagreement amongst some scientists over the precise nature of technical points such as threshold and non-threshold chemicals and the low-dose effects of some toxic chemicals.

Further research urgently needs to be carried out in areas where there is a lack of good quality data; especially bioaerosol emissions in general, and most emissions from composting, MBT and Anaerobic Digestion.

In spite of the above there is now sufficient good quality research available to be able to say that, with the exception of landfilling, MSW treatment is

responsible for only a very small fraction of national emissions of hazardous chemicals. Furthermore, it does not lead to significant adverse health or environmental effects (with the exception of workers at some sites and open 'windrow' composting, see below).

Emissions from MSW treatment

All forms of MSW treatment give off potentially harmful emissions. There are strict controls on such emissions, which must be maintained and fully enforced.

'Dioxin' emissions from MSW incinerators make up between 0.3 and 0.8% of national 'dioxin' emissions. Domestic cooking and heating produce 18% of UK 'dioxin' emissions. Bonfire night and fireworks amount for about 14% of national emissions. Therefore, with respect to 'dioxins', it makes more sense to introduce strict controls on bonfires and fireworks than to ban MSW incinerators, which are already tightly controlled.

MSW treatment is responsible for less than 2% of national emissions of volatile organic compounds (VOCs excluding methane). The VOC benzene, a known carcinogen, is of particular concern but less than 0.02% of UK emissions are due to MSW treatment. The level of VOCs in domestic indoor air is ten times greater than outside (from furnishings, cleaners, etc.).

Nitrogen oxides (NO_x) are a significantly harmful air pollutant but less than 1% of national emissions arise from MSW management. Road traffic is responsible for 42% and electricity generation for 24% of these emissions. About 70% of our exposure to NO_2 occurs in the home, mainly from gas cookers.

Metal emissions from MSW treatment (incineration and landfill sites) amount to about 0.1% for As, 10% for Cd, 1.65% for Hg (mercury) and 0.2% for Ni as percentages of national annual emissions. Almost all the Cd comes from landfill sites. Crematoria give rise to 16% of national emissions of Hg.

Data in respect of PAH emissions to air is poor but MSW treatment probably accounts for less than 3% of total national emissions to air.

Bioaerosol emissions may be a concern with non-combustion waste treatment technologies, particularly at composting, MBT and anaerobic digestion sites and possibly at some materials recycling facilities.

Emissions of methane from landfill sites amount to about 27% of the national total emissions of methane. Agriculture accounts for about 40 % of the national emissions of this 'greenhouse gas'.

MSW management emits about 2.4% of the national total emissions of carbon dioxide.

Health impacts in the UK

There are adverse health impacts, especially from bioaerosols, for some workers at some MSW composting and MBT treatment facilities. Such impacts may affect residents near those sites. However, further research is needed with regard to the effects of bioaerosols in particular.

An exhaustive review has shown there is no definite evidence of a causal connection between living near a MSW landfill site and adverse health impacts.

MSW treatment is calculated to cause 4.9 hospital admissions per year compared to 14,000 for air pollution as a whole, (that is about 0.035%).

'Deaths brought forward' due to MSW treatment are calculated to be 0.55 per year as opposed to 11,600 due to air pollution as a whole (that is less than 0.005%).

Cancers caused by MSW treatment are calculated to be 0.0014 per year (one in seven hundred years) as opposed to some 6,000 skin cancers per year caused by sunlight and sunbeds and 'hundreds' of lung cancers per year caused by passive smoking from other people's cigarettes.

The implications for waste management in Milton Keynes

Biodegradable waste should not be landfilled because it leads to considerable emissions of methane, which contribute significantly to global warming.

Landfilling should be the option of last resort for any waste containing cadmium as landfills emit about 10% of national Cd emissions to air.

With the exception of landfilling and possibly composting, there are no compelling reasons, based on health or environmental impacts, to prefer one properly designed and managed MSW treatment technique over another.

With the exception of landfill sites and their emissions of methane and cadmium, provided MSW management sites are properly designed, managed and regulated, particularly with regard to emissions of bioaerosols, their overall impact on health and the environment is minimal, when compared to other causes of such impacts.

Open 'windrow' composting should be avoided close to where people live or work, especially if the boundary of the facility is within 250 metres of a workplace or the boundary of a dwelling, unless and until further research is able to show that potential health impacts near to composting sites are negligible.

There are no compelling reasons based on possible health and environmental impacts to rule out any form of modern thermal treatment of MSW, including incineration.

When deciding which MSW management techniques should be used comparing potential health and environmental impacts of one technique against another has no real meaning, as the impacts are so minimal compared to other sources and the differences between the techniques are small. Rather the choice of techniques should be based on the most efficient techniques representing the most economically attractive option. (With the exception of landfilling and 'windrow' composting as noted above).

Information and advice about environmental issues

The Environmental Protection Team is always willing to provide information and advice about these issues or any aspect of the Milton Keynes environment. They may be contacted through the Environmental Services helpline (01908 252570) or by e-mail on ehept@milton-keynes.gov.uk

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