Potential Health and Environmental Impacts

from Municipal Solid Waste Management

Summary

of a review by MKC Environmental Protection Team 2005

A. Introduction, impacts and treatment techniques

Introduction to the most recent research

A recent lengthy and 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".

The DEFRA report, after reviewing all the available evidence, concludes:

- burning municipal solid waste accounts for less than 1% of UK emissions of 'dioxins', while domestic sources such as cooking and burning coal for heating account for 18% ('bonfire night' alone is believed to account for 14% of annual UK 'dioxin' emissions);
- less than 1% of UK emissions of oxides of nitrogen, which reduce air quality, come from municipal solid waste management, while 42% come from road traffic;
- in some areas the science is less certain as there has been less investigation, including emissions to soil and water rather than air, and emissions from waste management techniques other than incineration and landfill, such as composting and mechanical biological treatment.

The report found no evidence of a link between the rates of cancer, respiratory diseases and birth defects and the current generation of incinerators, nor any "convincing" evidence that emissions from modern landfill sites harm health.

The report refers to one study which had reported a statistical link between birth defects and residence near landfill sites but that the study's authors themselves were clear the link they reported did not show that these health effects were caused by the landfill site.

Referring to the report's conclusions about incinerators the Environment Minister Elliot Morley said: " The report was not giving the green light for a new generation of incinerators to be built across the UK: it was simply saying that burning waste was at least no worse than burying it in landfills". He went on to say "This report is not a clear steer on incineration, but what it does is put incineration as an option in perspective. It's a fair assumption that there's no health reason why local authorities shouldn't opt for incineration, especially with energy recovery".

However, a review of the report by The Royal Society (the UK's premier scientific body) says that the final report addressed many of their concerns about the draft version but "we have stressed the need to clarify the uncertainties inherent in the data in this report and consider the implications this uncertainty has when evaluating the environmental and health effects of waste management" (Appendix 4 of the DEFRA report).

The National Society for Clean Air was welcoming, saying: "We hope the report will put an end to scaremongering over the health impacts of waste management facilities like incineration."

But Friends of the Earth, said: "This report fails to adequately consider the environmental benefits of recycling, or the wider global environmental impacts of the way we manage our waste, and must not be used as a green light for increased incineration." (Quotes from BBC News).

Clearly, in spite of this report being the most detailed and wide-ranging ever produced in the UK on the health and environmental impacts of waste management there is still a spectrum of views on this subject. Some of these views may be driven more by socio-political motives rather than any objective assessment of the scientific evidence. However, it is not necessarily the case that an objective scientific appraisal (assuming that is possible) is any more valid to society as a whole than the 'socio-political' conclusions reached by the general public and their representatives both from political organisations and environmental pressure groups.

How do scientists reach their conclusions about potential health and environmental impacts? Is there a universal scientific consensus about these impacts? (Part B below). How concerned should we citizens of Milton Keynes be about the potential health and environmental effects of dealing with the waste that we produce? (Part C below)

In an attempt to answer questions such as these a review of potential health and environmental effects of waste management techniques has been produced by the Environmental Protection Team of Milton Keynes Council (MKCEPT 2005). This review surveys the concepts used by scientists in reaching their conclusions and summarises the available evidence concerning potential health and environmental impacts of waste treatment techniques that might be used in Milton Keynes.

This chapter is a summary of that review which is available in full from ehept@milton-keynes.gov.uk.

Health and environmental impacts

What is an impact? Are they always negative?

Waste treatment tends to be thought of in an unremittingly negative way, it's dirty, dangerous and best kept as far away as possible. But there are positive impacts from treating our waste collectively. Without centralised collection and treatment the health and environmental impacts would be very severe. Waste is now treated as a resource; we can reclaim materials and energy from waste rather than just dump it in a hole in the ground.

Can environmental impacts be separated from health impacts?

It can be argued that any effect on the environment, for example global warming, will have an impact on human health, eventually. It is just a matter of time. Care has to be taken that actions to minimise short-term health risks do not produce a negative impact on the environment leading to a health risk in the longer term. For example, catalytic converters on cars reduce the level of nitrogen dioxide (a health hazard) in the air but increase the amount of nitrous oxide (a 'greenhouse gas'). We need to minimise all negative impacts.

Whose health is most at risk? Residents or workers in waste?

As shown by the DEFRA report there is little or no definitive evidence for direct health impacts from waste treatment sites on people who live near the sites. However, there is some evidence of significant health effects on workers in certain waste sites, which emphasises the need for strong occupational exposure limits to hazardous materials and the necessity for good personal protective equipment.

What potential health effects are of particular concern?

Landfill sites and incinerators have been investigated as possible causes of increased birth defects, cancers and respiratory illnesses including asthma, potentially associated with airborne emissions. 'Dioxin' emissions from incinerators have been particularly studied. Composting sites and Materials Recycling Facilities (MRFs) have been investigated for emissions of bioaerosols and odours and in connection with disease such as bronchitis. All the available research to date shows little, if any, causal connection between emissions from MSW treatment and health effects on nearby residents.

What potential environmental effects have raised concerns?

The main environmental effects of concern are that emissions might affect global warming or cause increases in acid rain. The global warming potential of MSW is estimated to be 2.32 tons of carbon dioxide per ton of landfilled waste. One ton of methane is equivalent to 25 tons of carbon dioxide in terms of 'greenhouse gas potential' and emissions of methane from MSW in landfill sites are believed to represent about 27% of total UK methane emissions. Acid gases, which might contribute to acid rain, are given off from all combustion processes, including transportation of MSW (combustion of petroleum products).

Municipal solid waste treatment

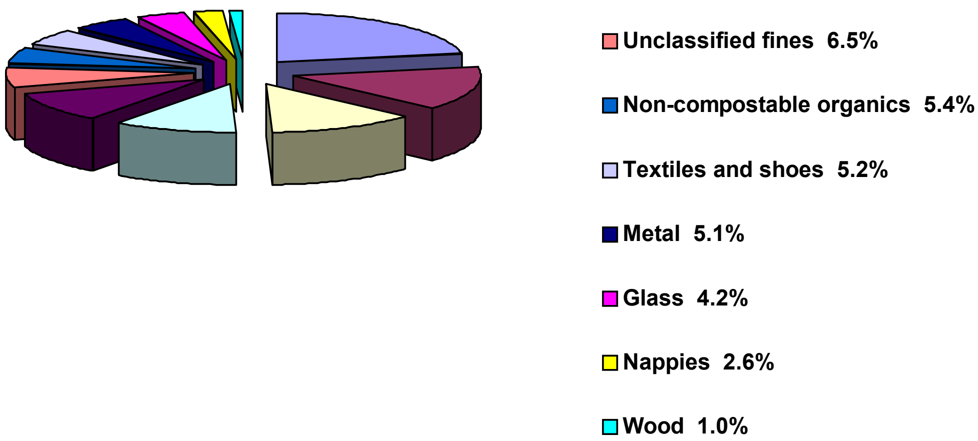
The composition and disposal of municipal solid waste

Municipal solid waste (MSW) comprises a variety of materials (see Figure 1 below). It is a very variable material, dependant on a range of factors, including where and when it is collected.

There is a lack of detailed information about the precise composition of MSW, which hinders assessments of potential impacts from its management. This variability and uncertainty can have effects on treatment methods and their emissions.

About three quarters of the UK's municipal solid waste is disposed of directly to landfill. Reuse and recycling (including composting) account for a further 13% of municipal solid waste. The remainder is pre-treated, mostly by incineration (approximately 9% of municipal solid waste). The remaining 1% is pre-treated using a variety of new or specialist methods which include gasification/pyrolysis; mechanical biological treatment (MBT); and anaerobic digestion.

Figure 1.
Composition of UK Municipal Solid Waste



A holistic approach to waste management and potential health impacts

Waste management is much more than the simple disposal of waste. It involves the generation, collection, transport and processing of waste, in addition to minimising waste production and incorporating the socially difficult concept of waste as a valuable resource. The current system of treating waste operates in isolation as the final stage in the materials flow cycle. This inevitably leads to the risk of negative impacts on health and the environment because many of the hazards that arise in this disposal stage of the materials flow cycle result from actions taken at the earlier stages of production, packaging and marketing.

The national waste strategy (DETR 2000) proposes a "waste hierarchy" which prioritises reduction, re-use, and recovery above disposal. Only when the options at the top are not appropriate should disposal of waste be the option of last resort. Use of such a holistic approach is a fundamental principle in the professional practice of Environmental Health and its adoption in the field of waste management would represent a significant advance in controlling and reducing any health risks associated with particular waste management options. Such an integrated waste management system requires separation of waste types for appropriate treatment and restrictions on certain production practices that introduce toxic materials into widely distributed household products.

However, there are major difficulties in adopting this approach. In order to avoid introducing toxic materials into household items it will require far-reaching changes to production systems, putting considerations about product end of life management at the beginning of the design phase rather than tacking it on as an afterthought. For example, the use of cadmium and other potentially toxic metals in printing inks and plastic stabilising agents. It is manifestly obvious that the most difficult and expensive method of reducing the risk of negative impacts from such toxic metals is to take action after waste processing techniques have dispersed the metals into the environment.

Clearly potential public health and environmental impacts are strongly influenced by the availability of safe, modern, well managed waste processing techniques within the overall waste management strategy adopted locally, regionally and nationally.

Techniques for treating MSW

Waste treatment techniques can be grouped into five categories:

(1) **Mechanical processes,** usually involving removal of objects, reduction in size, extraction of recyclables, possibly the production of refuse derived fuel (RDF) and organics for composting. It normally takes place in a dedicated facility.

(2) **Biological processes,** utilising the action of micro-organisms to break down organic wastes. This can be further divided into:

- ♦ **Composting** of 'green wastes' in the presence of air (aerobic), usually outdoors (windrow composting), the biogenic heat results in a stabilised and sanitised humic material rich 'compost';

- ♦ **Biological-thermal treatment** in enclosed vessels where the temperature and amount of oxygen can be controlled.

There are two types, aerobic and anaerobic:

- **In-vessel composting** (IVC) is aerobic and temperature can be sufficiently high and tightly controlled to also deal with food waste;
- **Anaerobic Digestion** (AD) takes place in the near absence of oxygen, leading to the production of a 'digestate' containing bio-solids and/or a liquid, and 'biogas', comprising methane & carbon dioxide, which can be used as a fuel to produce heat and/or electricity. Used for sewage sludges and agricultural waste but not widely for MSW in the UK.

(3) **Thermal processes,** essentially two types, open burning or enclosed burning:

- ♦ **Incineration with energy recovery,** the combustion of mixed waste under controlled conditions with energy used to generate electricity and occasionally heat. Reduces waste volume by about 70%, most of the ash can be re-used in building materials but it produces about 4% of fine ash from pollution control measures which needs to be disposed of as hazardous material to landfill. Used for 9% of UK waste.

- ♦ **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' (mainly carbon), the fuel can be burned to generate electricity;
  - **Gasification,** organic waste is heated in a high temperature (800-1200^{0}C) thermal process, similar to pyrolysis but involving breakdown of

hydrocarbons into a gas (carbon monoxide, hydrogen, methane) via partial oxidation under the application of heat. The 'syngas' produced can be burnt to generate electricity.

(4) **Mechanical-hybrid processes,** two types where the mechanical screening and separation of recyclables is combined with either a biological 'composting' technique or a heat treatment such as autoclaving:

- **Mechanical biological treatment (MBT)** normally the incoming waste stream is screened to extract and separate non-compostable fractions with particular end purposes in mind, with biological processing of the residual compostable waste and landfill of the reject fraction;
- **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 initially degrade the waste. Household bagged waste can be used directly in the vessel where it is exposed to pressure and steam at over 140^{0}C. The combination of the pressure, temperature and rotation of the vessel stabilises the organic fraction of the waste and steam cleans the inorganics.

(5) **Landfill** is now the option of last resort for dealing with waste, landfilling of bulk MSW is a thing of the past. Modern landfills are lined with impermeable material with advanced leachate (liquid) and gas control systems. Where biodegradable materials are landfilled natural bacteria produce landfill gas, principally methane and carbon dioxide. Landfill gas is now normally collected and burnt to recover energy but a significant proportion of the gas is lost to atmosphere as fugitive emissions. Landfill will probably always be used for the final disposal of the residual material from other treatment technologies.

Transport of waste and waste derived products

However MSW is treated it needs to be collected and transported, possibly via a waste transfer station, to a treatment facility. After processing any products have to be transported away and any residues taken to landfill. Almost all this transport is by road and this contributes to the emissions from road transport as a whole. In addition there will be some non-vehicle emissions from the waste materials during transport, for example dust, bioaerosols, odour and noise.

Part B: Concepts, Emissions and Control

Assessing risk from potential health impacts

This section outlines the underlying concepts and ideas used by scientists as they attempt to determine if chemicals are likely to have adverse impacts on health and the level, or dose, at which such effects may occur.

Toxicity, hazard, risk

Determining whether the potential environmental and health effects of a new waste management facility, or any new development, are acceptable is now founded on a scientific risk-based framework. This involves assessing and dealing with potential source-pathway-receptor linkages that embody the fundamental distinctions between toxicity, hazard and risk that are often a source of confusion and misunderstanding:

Toxicity: the potential of a material to produce injury in biological systems;
Hazard: the nature of the adverse effect posed by the toxic material;
Risk: the probability of suffering harm or loss under specific circumstances.

The relation of risk to hazard may be expressed as:

$$R = f\,(H \times E) = f\,(H \times D \times t)$$

where R is risk, f is function of, H is hazard, E is amount of exposure, D is dose and t is time.

Therefore, substances which pose only a small hazard but to which there is frequent or excessive exposure may pose as much risk as substances which have a high degree of hazard but to which only limited exposure occurs.

The concept of source-pathway-receptor linkages

Potential risks to human health and the environment can be regarded as comprising the three components that make up a source-pathway-receptor linkage:

Source: anything associated with a waste management facility with the potential to cause harm;
Pathway: a route by which a receptor can be exposed to, or affected by, the potentially harmful source;
Receptor: a particular entity that may be harmed or adversely effected by the emission.

Receptors include, people inside or outside the site boundary; properties outside the site boundary; ecosystems; surface water in the vicinity of the site; groundwater in the vicinity of the site; the atmosphere, (in terms of risk of climate change).

Hazards arising from exposure to a potentially harmful source are specifically characterised by the nature of the potential adverse effect, the pathway and the receptor they affect. They are only realised when there is a linkage between the source, the pathway and the receptor. If this linkage does not exist, or can be broken, then there is no hazard.

For example, consider a landfill facility for MSW situated on a non-aquifer (underlying geology does not hold substantial quantities of available water), with no local abstraction of groundwater for drinking water supplies and no local surface water receptors used as a source of drinking water. There would be no need to consider the human health impact of drinking water contaminated by this site as for this scenario there would be no potential for complete source-pathway-receptor linkages. This applies to a large part of Milton Keynes that is underlain by the Oxford Clay and specifically to the Bletchley landfill site.

Dose-response assessment

Dose-response assessment is an essential aspect of assessing possible health risks from chemicals. It involves the investigation of the relationship between the amount of the substance to which the subject is exposed and the frequency and severity of any adverse effects. For many types of adverse effects, such as organ-specific effects, neurological, immunological, reproductive, developmental and non-genotoxic carcinogenesis, there may be a **threshold dose**, below which no observed adverse effect will occur.

However, there is a generally held assumption that there is no threshold for safe exposure to substances that may cause cancer by mutation of the genetic information in DNA (genotoxic substances). This is because it is believed that there is some probability of effect at any given dose, no matter how low. In the absence of data in humans to the contrary, chemicals that can induce cancer in experimental animals are regulated as if they could induce cancer in humans.

Unfortunately there is not a consensus of opinion about which chemicals have, and which do not have, a threshold effect. Take 'dioxins' as an example. The US Environmental Protection Agency takes the view dioxins do not have a threshold for safe exposure, i.e. any dose could in theory cause cancer. In contrast the UK Department of Health Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) and the World Health Organisation (WHO) are of the opinion that there is a practical threshold of dioxin exposure below which there is no cancer risk. Thus they believe a Tolerable Daily Intake (TDI) can be established to set allowable levels in foods.

However, there is also a range of opinion about the level at which a TDI should be set. There is even disagreement about what effects low doses of toxic chemicals may have on human health.

Low dose effects

The fact that there is not a complete scientific consensus about the possible health effects of chemicals released into the environment is shown by the current controversy over so-called 'low-dose effects'. Some scientist hold that substances known as 'endocrine disrupters' (including 'dioxins', PCB's and some metals such as arsenic As, cadmium Cd, lead Pb, and mercury Hg and many other substances found in MSW) cause adverse health effects at doses much less than those considered in classical dose-response assessments. Thus they argue that the 'safe' levels determined by such experiments are not 'safe' at all.

Another group of scientists argues that many chemicals (including 'dioxins', As, Cd, Pb, Hg, etc.), which are toxic at high doses, actually cause beneficial health effects at low doses (the 'hormesis' effect). Thus they argue that by imposing unrealistically low limits on emissions of such chemicals we are actually harming public health. Are they mad? Can it possibly be true?

Before dismissing this idea out of hand consider alcohol consumption and vitamin A. There is good evidence to show that low or modest consumption of ethanol reduces total mortality in humans, whilst high ethanol consumption is a well-known cause of life-shortening disease. Similarly vitamin A is essential for good health, serious deficiency being a leading cause of blindness in children, but if taken in high doses it is toxic. Thus it could be said that both ethanol and vitamin A exhibit a hormetic effect.

Low-dose effects, whether negative or positive, are complex and to some extent contradictory, however, they do pose some serious questions in regard to dose-response, regulatory policy, and risk assessment in respect of potential impacts from

MSW management in particular and toxic substances in general. This is one of the areas where further research is needed as a matter of urgency in order to inform our assessment of potential impacts from MSW treatment.

Risk assessment

Risk assessment put simply is an evaluation of the probability of harm from a particular hazard. In the context of waste management facilities it is normally concerned with gathering and interpreting information on the characteristics of emission sources, pathways and receptors at specific sites and attempting to understand the uncertainties inherent in the assessment of these specific risks.

Risk assessment of potential human health impacts from MSW is critically reliant on the available data on human exposure. Much of this data comes from epidemiological studies investigating possible links between waste management sites and the incidence of various types of disease.

Epidemiological studies

Epidemiology is the study of the patterns and causes of disease in human populations. Unfortunately most such studies investigating links between waste management and health outcomes use unreliable evidence, usually that of residence or employment near the site. Only a tiny minority of studies is based on quantified ambient or personal measurements of pollutants taken at the time of potential exposure. In most studies, the waste management facility is just assumed to be a box emitting toxic compounds but no actual measurements are taken to use in the exposure assessment.

This means that even when an epidemiological study does find a statistical association between a waste management site and a health effect, it is difficult or impossible to decide if this is caused by emissions from the site. It may be just a chance association produced by random coincidence or it may be caused by factors unconnected with waste management.

Such factors include the pre-existing health of the people studied; their relative wealth or poverty; the standard of local health and social care services; lifestyle effects such as smoking, alcohol and drug use, diet, fitness; home and work exposure to hazardous substances; other past or present sources of pollution; population movements; genetic factors etc.

Risk management

Risk management involves evaluating alternative options within a political, regulatory, social, economic, scientific and technological framework, in order to determine the most appropriate and practical means of reducing risk to an acceptable level. Risk can never be reduced to zero. All human activity carries with it some risk. In practice the overriding principle is that risk is managed by breaking the source-pathway-receptor pollutant linkage(s). This may be done by such means as treating, removing or isolating emission sources, intercepting exposure pathways and/or by protecting or removing receptors. Risk management is based on the scientific output of the risk assessment procedures but takes into account other factors such as risk perception by the general public, planning constraints and the economic and technological feasibility of particular technologies.

Risk communication and the perception of risk

Individuals and regulatory bodies try to avoid or control activities they judge to be too risky and ignore or tolerate others. Conflict occurs when people form different judgements about the perceived risk of an activity. Disagreements about risk are inevitable because there is no way to define risk that does not include values, beliefs and assumptions.

Disagreement occurs especially when information about a particular activity is scarce. This leads to uncertainty, with judgements about risk being based on the qualitative aspects of a potential hazard using assumptions and mental strategies to help form a decision. When scientists make judgements about risk, the process is described as **risk assessment**. When members of the public make judgements about risk, the process is described as **risk perception**.

When there is a lack of good scientific data, as is sometimes the case with MSW management, and consequent uncertainty, scientists are as prone to the use of qualitative judgements as the general public. They are often under political or economic pressures which can bias their judgements either consciously or sub-consciously. They do not always get it ‘right’ and they frequently disagree with each other, they are, after all, only human.

Opposing positions regarding potential health impacts

It is manifestly obvious that waste management decisions have to be made and the health of the public has to be protected. In an ideal world decision-making would be based on a rigorous assessment of abundant high quality scientific evidence. In reality, waste management decision making takes place in a highly charged political environment, with different interest groups driven by conflicting values and belief systems as well as by contrary interpretations of the same, sometimes rather patchy, scientific evidence.

In effect informed debate has polarised into two apparently equally defensible positions:

The first position is essentially that there is little or no evidence of significant harm to human health from waste management operations. No human activity is completely safe but compared to other environmental health hazards (e.g. vehicle traffic) or compared to other causes of ill health (e.g. poor diet, lack of exercise, smoking, alcohol consumption, diseases), waste management operations are not a major public health concern. This position is exemplified by the (UK) National Society for Clean Air and Environmental Protection, in its recent report on incineration (Farmer & Hjerp 2001).

The second position takes as its starting point that lack of evidence is not the same as evidence of lack of health impacts. Waste management methods may have a major impact on health and the environment but the limitations of the research make it impossible to determine whether this is the case. This position is exemplified by the Friends of the Earth incineration report (FoE 2002).

Emissions from MSW treatment

Emission sources

Direct outputs of potentially hazardous substances in gaseous, liquid and solid materials leading to the pollution of air, water and land are the three most obvious categories of negative effect that might result from inadequately controlled emissions from a MSW management site.

However, less obvious but still potentially damaging emissions include those of indirect deposition from air to land of inorganic (dust) particulates and organic particulates (bioaerosols) leading to biological hazards, and also odour and noise emissions. All of these emissions have the potential to cause annoyance and health problems if MSW facilities are not managed in such a way as to control such emissions.

Most of the available information on emissions from MSW treatment concerns emissions to air. This is not necessarily because the impacts of emissions to air are more significant than other releases. It suggests that there is a lack of information on releases to other media. There is no information available which enables emissions from composting (other than particulate matter), MBT or anaerobic digestion to be properly quantified.

Some of the potentially hazardous substances are already in the waste and may be emitted when it is handled, some are produced or released when the waste is treated, others are leached into water which is then treated and discharged.

The specific emissions from a facility are dependent on the material being treated (e.g. whole MSW or particular fractions of MSW such as organic waste), the type of facility, the efficiency of the emission controls and to some extent the effectiveness of the management of the facility and its regulatory control. This means that a non-site specific review such as this can only give an approximate overview and comparison of what the emissions might be from particular MSW management facilities.

Emissions to air (Table 1)

The main emissions to air, from MSW treatment, which have the potential for significant health and environmental impacts are:

- **'Greenhouse gases'** with global climate altering potential, most significantly, carbon dioxide CO_2, methane CH_4, carbon monoxide CO and nitrous oxide N_2O;
- **Acidic inorganic gases** such as nitrogen oxides NO_X (mainly nitrogen dioxide NO_2, and nitric oxide NO), sulphur oxides SO_X (mainly sulphur dioxide SO_2), halides of hydrogen (mainly hydrogen chloride HCl, with much smaller amounts of hydrogen fluoride HF);
- **Volatile organic compounds (VOCs)**, the ten most abundant (by weight) non-methane volatile organic compounds (NMVOCs) emitted from waste treatment particularly landfill and composting are ethane, propane, formaldehyde, ethylene, benzene, ethanol, toluene, ethylbenzene, tetrachloroethene and hexane;

- **Organic chemical micro-pollutants**, primarily 'dioxins and dioxin-like compounds' such as some furans and some polychlorinated biphenyls (PCBs), most of these occur adhering to particulate matter;
- **Polycyclic aromatic hydrocarbons (PAH)**‡;
- **Volatilised metals**, such as As, Cd, Ni, Hg;
- **Particulate matter**, including dust and soot (see below).
- **Bioaerosols** (see below).

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).

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.

There is little available data about PAH emissions. Overall PAH emissions from MSW treatment are probably rather less than 3% of total national emissions to air (data from Dore et al. 2004), but 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, 10% for Cd, 1.65% for Hg and 0.2% for Ni (data from Dore et al. 2004; Enviros et al. 2004).

Emissions to water

Emissions to water are commonly associated with certain MSW treatments, particularly landfilling and, to a lessor extent composting. Some other processes use and discharge water, for example some thermal treatment involves using water which becomes contaminated and has to be treated and/or discharged in an appropriate manner, for example anaerobic digestion produces between 100 and 33 kg of liquid per tonne MSW processed. These emissions make up about 0.25% of total UK emissions to water.

Such waters are normally discharged to off-site sewage treatment works, usually after on-site treatment to a standard agreed by the regulatory controls and the sewage treatment company. Leachate may also be slowly released from a landfill, even in modern landfills with a fully engineered liner system there will still be some leakage through the system, which will enter groundwater.

The main emissions to water include:

- **Nitrogen** (mainly in the form of nitrates and ammonia NH_3), and phosphorus, which can 'over-fertilise' water causing unwanted growth of algae;
- **Metals** such as copper Cu, tin Sn and lead Pb;
- **Organic compounds** such as PAH, pentachlorophenol etc.

Emissions to land

Emissions to land fall into two categories indirect and direct:

- **Indirect:** emissions deposited from air to land. For example, acid deposition from gaseous emissions to air or as particulate deposition from dust emissions;
- **Direct:** such as by spreading composted material to land; recycling residues from incinerators, or pyrolysis/gasification processes; and landfilling of residual materials.

In contrast to inhalation of airborne emissions there are 'secondary' controls on water and food quality, which limit the potential for complete source-pathway-receptor linkages from MSW treatment via emissions to land and water resulting in ingestion by humans.

The main emissions to land include:

- **Metals** such as As, Cd, Pb, Hg etc. from most processes;
- **Dioxins** and furans e.g. in incinerator residue;
- **Organic** compounds such as PCB's in 'compost'.

Spreading of materials to land from composting or other processes is controlled through the application of standards such as British Standard BS PAS 100. This sets limits for human pathogens; potentially toxic chemicals, physical contaminants (e.g. glass, metal, plastic); substances toxic to plants; and weeds. However, this is an area where more research on possible emissions, particularly from composting, MBT and AD of MSW, is urgently required.

Emissions of particulate matter (PM)

All MSW treatment techniques are capable of generating particulate emissions either directly from the process itself or indirectly from transport to and from the facility. Airborne particulate matter includes a wide range of particle sizes and many different chemical constituents. It contains both primary components emitted directly into the atmosphere and secondary components, which are formed within the atmosphere as a result of chemical reactions. Airborne particulate matter is much more complex than most other common air pollutants. 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 (more or less synonymous with 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. The behaviour of bioaerosols is governed by the principles of gravitation, electromagnetism, turbulence and diffusion, which control all airborne particles. The size range is from 100 micrometer (μ, also know as microns, one millionth of a metre), through pollen spores 10 μ and bacteria 1μ to viruses 0.01 μ. Many millions of viruses or virions could fit within the cross-section of a pollen. 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.

Emissions of odour

Most MSW treatment techniques have the capacity to generate odour and complaints to Environmental Health departments about such odours are not uncommon. In many cases the complaints are primarily caused by occasions of abnormal operation when normal management control has failed.

There is a commonly held intuitive feeling that if something smells bad it may cause damaging health effects. In some cases this is undoubtedly true, for example hydrogen sulphide ('rotten eggs') smells bad and is highly toxic, even more so than hydrogen cyanide. However, in many, probably most, cases of odour there are no direct toxic effects.

Most reported problems with odour associated with MSW treatment relate to landfills and composting operations. There have certainly been occasions when these operations have generated complaints of odour in Milton Keynes. Odour complaints have also been recorded in respect of MBT facilities and waste transfer stations. However our experience in Milton Keynes shows that odour is only a problem with MSW treatment when the design and/or management of a site is not up to best practice.

Emissions of noise and vibration

All MSW management facilities generate noise and vibration, which if inadequately controlled can represent a hazard to health, particularly to workers engaged in the noisy activity. Noise is rarely considered as a health problem, however excessive noise can lead to definite negative health effects but this should not occur with properly managed MSW treatment facilities.

Regulatory control of emissions

All waste management sites are subject to regulatory control under the system of Integrated Pollution Prevention and Control (IPPC) by the Pollution Prevention and Control Regulations 2000, The Landfill Regulations 2002, and The Waste Incineration Regulations 2002. These regulations impose stringent controls on emissions to air, water (including discharges to sewer) and land, plus a range of other environmental effects,

Operators of installations carrying out prescribed activities must apply to the regulator for a permit which includes conditions based on the use of "Best Available Techniques" (BAT). This means that any emissions from waste management facilities will be controlled so as to be within what are considered to be ‘acceptable limits’. Therefore, in theory, no waste management facility should be giving out emissions that pose a significant threat to health or the environment.

Of course this is dependent on the regulatory ‘acceptable limits’ determined from risk assessment work being fully protective of health and the environment.

Comparison of emissions

Emissions of dioxins and furans per tonne of waste are higher from incineration than other MSW treatment techniques. However, emissions from incineration have dropped dramatically with a 99.8% reduction since 1990 due to new stringent regulatory limits.

Oxides of nitrogen emissions are greatest from incineration, followed by ATT pyrolysis/gasification and landfill.

Particulate emissions per tonne of MSW are highest from composting. Emissions from transport of waste are likely to be insignificant.

Bioaerosol emissions per tonne of MSW are highest from composting with significant emissions from MBT.

Sulphur dioxide emissions are similar for all processes that burn waste or processes involving the decomposition of waste. Emissions from transport of waste are likely to be insignificant.

Halides of hydrogen emissions are higher from processes where waste or waste derived gases are burnt. Incineration is the greatest source of hydrogen chloride.

Emissions of volatile organic compounds are likely to be higher from landfill, composting and MBT than from combustion processes.

Methane emissions derived from treatment of MSW come preponderantly from landfill.

Emissions to water, to surface water, sewer and groundwater are probably only significant from landfills, about which there is a great deal of data. Emissions to water from composting, MBT and AD of MSW is an area where data is lacking and research on the quantity, composition and control of liquid effluents from these processes is urgently needed. What evidence there is suggests composting facilities give rise to greater emissions of metals to sewers than do landfill sites (per tonne of MSW treated), but not all composting operations give rise to a liquid effluent.

Energy outputs. Incineration, landfill, anaerobic digestion and advanced thermal treatments all output energy which can be used to generate electricity. This represents a positive impact as that electricity need not be generated by burning coal, oil etc., processes that have negative impacts.

Other outputs. With the exception of landfill all the other processes produce other outputs. Composting and AD produce organic materials, which may be usable as soil conditioners. Ash from waste incineration may be used in place of geological aggregate resources. These may represent positive impacts but they all have the potential to release unwanted substances into the environment if they are not properly controlled. Materials recycling facilities produce materials that can be reprocessed into new useable products, thus avoiding use of raw materials. However, the energy used in this process is sometimes greater than that used by processing the equivalent raw materials.

Finally some of the residues from processes need to be disposed of to landfill, either because it has no beneficial use e.g. air pollution control residues; or because it is not up to a sufficiently high standard e.g. composted material which is not of a sufficient standard to be used on land.

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.

Part C: Health & Environmental Effects from MSW Treatment

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 and 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.

Many processes emit carbon dioxide, which will have a minor effect on global warming, but again MSW management is not a very significant source of CO_2. However, landfill is a very major source of methane emissions, which do have a significant effect on global warming. Thus avoiding the landfilling of the organic fraction of MSW will have a positive benefit in terms of global warming.

Results of research on potential health effects

The findings from epidemiological studies

Many studies have been carried out on possible health impacts from landfill sites and incinerators and there have been a few studies on materials recycling facilities and composting sites.

Particular concerns and investigations have focussed on three areas in connection with MSW:

- **Landfill sites** have been investigated as the possible cause of birth defects, cancers and respiratory illnesses including asthma;
- **Incinerators** have been investigated as to possible increases in cancer, birth defects and respiratory illnesses including asthma. Other studies have particularly concentrated on emissions of dioxins from incinerators;
- **Composting and materials recycling facilities** (MRFs) have been investigated for possible exposures to micro-organisms and odours, and lung diseases like bronchitis.

Studies on landfill sites

A recent study by the Small Area Health Statistics Unit is the only study that shows a consistent statistical relationship between living near MSW landfill sites and adverse health effects (Elliot et al. 2001). This study investigated the occurrence of birth defects in children born to families living within two kilometres of landfill sites in the UK. It included data on over eight million births in the UK between 1983 and 1999. The birth data were grouped into two categories: (i) where the mother lived within two kilometres of a landfill site; (ii) where the mother lived more than two kilometres from a landfill site.

The two categories were then compared to see if there was any statistical difference between the occurrence of birth defects in the two groups. The comparison showed slightly higher rates of birth defects in the group living closer to landfill sites. However, there are serious problems with interpreting the results of studies of this type including:

- the geographical location data was based on postcodes, which are broad indicators, this is the reason for using a 2 km distance cut-off point;
- the type of landfill site studied is unclear, it may be that it includes sites which have received hazardous waste in addition to MSW;
- even after attempting to allow for known ‘confounding factors’ it may be that the two groups differ due to residual confounding factors such as misclassification of socio-economic status, rather than a real difference in health (‘poor people’ have worse health than ‘rich people’);
- for some landfill sites which opened during the study, for some of the health effects studied, the group who lived nearer the landfill site suffered fewer birth defects than the group living further away (in other words living near the landfill site appeared beneficial to health). This indicates that factors other than residence near a landfill site may be the cause of the statistical differences;
- the very small scale of the incremental health risks identified in this study mean it is less likely that the reported effects are caused by any emissions from the landfill site.

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. In fact it is quite possible that if residence near municipal swimming pools were substituted for landfill sites then similar statistical differences might be found between the two populations due to residual confounding effects from socio-economic factors, such as the mother's diet, smoking and alcohol intake. Factors that include the mother's health and the child's genetic make-up are known to be causes of birth defects, but even so, the majority of birth defects are of unknown origin.

The independent expert Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment (COC) concluded "it is inappropriate to draw firm conclusions on the possible health effects of landfill sites from the results of this study".

There have been other studies on landfill sites, many of them on hazardous waste sites rather than sites for MSW. No study has shown unequivocal evidence that residence near a landfill site causes negative health impacts. In particular after an exhaustive investigation of the evidence the recent DEFRA report (Enviros et al. 2004) 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

Air pollution from all sources is known to have negative effects on the health of susceptible people, young children, the elderly and particularly people with pre-existing respiratory diseases. The UK Committee on the Medical Effects of Air Pollutants (COMEAP 1998) has shown that exposure to air pollution can bring forward death in a person with severe pre-existing disease, although the extent of life-shortening is of the order of a few weeks at most. However, there is little convincing evidence that current levels of air pollution in the UK cause adverse health effects on healthy individuals.

Most published studies of incinerators concentrate on the older generation of incinerators, which were phased out in the UK after the 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 studies of populations living near incinerators have not given clear indications of the presence, or absence, of negative health effects.

The fact that there is no good evidence of an association between living near an incinerator and adverse impacts on health could mean that incineration does not cause adverse health effects or it could mean that the health effects are not detectable using existing epidemiological methods and the available data. However, there is some research which showed that there is no difference in the amounts of dioxins and furans in blood samples from people living near to a modern incinerator and those living further away (Gonzalez et al. 2000).

Several studies have investigated possible associations between incinerators and the incidence of cancer. The most frequently studied cancers are those of the stomach, colorectal, liver, lung, larynx and non-Hodgkins lymphoma. Some studies have shown apparently significant correlations but the incinerators studied are often in areas close to other sources of potentially hazardous emissions, thus making it impossible to be certain of the source of any impact.

After considering all the available evidence the experts of the government's advisory 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".

It has been often asserted that emissions from incinerators make respiratory problems worse. There is little evidence of this, rather the contrary and it seems unlikely to be a major effect as in most cases the incinerator contributes only a small proportion of the local level of air pollutants.

Studies on composting sites

Hazards from bioaerosols have been shown to lead to a number of distinct health conditions such as allergic rhinitis and asthma, inflammatory diseases of the respiratory system, inflammation of the deep lung, and toxic pneumonitis (organic dust toxic syndrome). Studies have shown that levels of bioaerosols in a number of commercial scale composting facilities represent a distinct hazard, particularly to the on-site workers. However, there are insufficient studies to allow a quantification of these effects. In addition there are few studies of potential effects on residents near composting sites but they show that they could experience an increased rate of adverse health impacts such as bronchitis, coughing and eye irritation, but no link has been found with asthma.

In-vessel composting systems are capable of exerting a much greater degree of control on bioaerosol emissions and so are to be preferred to open 'windrow' composting operations but there is still a lack of information about these systems.

A few studies have examined the emission of VOCs from composting sites. One study has examined whether there is an increased risk of cancer due to exposure to emissions from these sites. No additional risk of cancer was found.

Further work is urgently needed to investigate, clarify and quantify the potential health impacts from composting sites of all types.

Studies on Materials Recycling Facilities

A few studies have been carried out on workers in these facilities. These show that the incidence of flu-like disease, eye and skin problems, fatigue and nausea are higher in these workers than in comparable groups. The most probable cause is exposure to high levels of bioaerosols. A significant problem is that there are no reported studies on the health of local populations living around MRFs.

In the absence of such studies we cannot assume that the impact of any emissions on local populations is negligible nor is it easy to use studies on worker's health as an indicator of possible effects on the local population both in respect of MRFs and composting sites.

This is because the general public is likely to include individuals of far greater susceptibility than the workforce. This is partly because of the well-known "healthy worker effect" which results in a workforce becoming a self-selecting population. Those who suffer ill health as a result of their work tend to leave for employment elsewhere, whilst those who are more resistant to the effects of occupational exposures are more likely to continue with that employment. This means that the workforce in MRFs, and composting sites, may be significantly more resistant to the negative effects of emissions such as bioaerosols than the general public. On the other hand they are exposed to much higher levels than the surrounding residents.

The conclusion must be that we cannot draw any useful conclusions about the potential for health effects on the population around MRFs, and composting sites, without further research.

Quantifying the health effects

How the investigation was carried out

The authors of the recent report on Environmental & Health Effects of MSW treatment (Enviros et al. 2004) carried out an exercise to assess quantitatively the health effects of MSW treatment and disposal facilities on a nation-wide basis. This section is based entirely on their findings.

Their assessment was restricted to emissions to air. Potential exposure to substances emitted to water or land is affected to a much greater extent by site-specific circumstances and by an individual's diet and lifestyle (we all have to breathe air, we don't all eat meat, smoke or drink alcohol etc.) and also by controls on water and food quality.

The health effects they considered were:

- 'Deaths brought forward', i.e. deaths occurring sooner than would otherwise have happened of vulnerable people such as the sick and elderly. This effect is a known result of elevated levels of air pollutants;
- respiratory hospital admissions;
- cardiovascular hospital admissions;
- additional cases of cancer.

The waste management facilities they considered were:

- incinerators, results from a previous study (Environment Agency 2003);
- six different types of landfill site;
- a pyrolysis/gasification planet;
- a composting plant;
- an anaerobic digestion plant;
- a mechanical biological treatment plant.

As they point out a number of assumptions had to be made in carrying out the evaluation due to lack of sufficient data. They were unable to estimate the potential health effects from composting sites because of a lack of quantitative information on emissions. A previous Environment Agency study on emissions of dioxins and furans from modern incinerators has shown that they amount to between 0.3% and 0.8% of the background exposure from other sources. On this basis they concluded, "the dioxin emission contribution to exposure of local populations is entirely negligible" (Environment Agency 2003).

The available data on emissions were used in a dispersion-modelling program, which produced a map of ground-level concentrations of the emissions in the vicinity of the modelled sites. These concentrations were then assessed in terms of their likely health impact on an assumed exposed population. They used the methodology prepared by the Committee on the Medical Effects of Air Pollutants (COMEAP 1998) to estimate the increase in mortality and hospital admissions using exposure-response coefficients derived from epidemiological studies. These coefficients represent the percentage increase in a baseline health rate in the population per unit rise in pollutant concentration.

Results of the evaluation

The results showed that on a national scale, allowing for the amount of waste currently managed by each process, emissions to air from MSW management are estimated to cause:

- Five hospital admissions for respiratory disease each year;
- less than one death brought forward per year;
- about one additional cancer case every seven hundred years.

The report says that more work on the possible health effects of composting is needed especially as there is some epidemiological evidence suggesting that health effects might occur in people living very close (within 250 metres) to MSW composting sites.

In terms of respiratory hospital admissions the available data does not definitely indicate that one option for managing MSW is better or worse than another. There is an indication that incineration may have a greater effect on health than landfill, in this regard, but the differences are very small.

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. This is especially the case when viewed in the context of the total number of admissions to hospital for respiratory disease caused by the action of two air pollutants (PM_{10} and SO_2, primarily produced by burning fossil fuel and transport) in urban areas of Great Britain which was estimated by COMEAP, on behalf of the Department of Health, to be 14,000 per year (COMEAP, 1998). Other influences on health are much more important than the management of MSW, even for people living near to sites handling MSW.

The DEFRA report (Enviros et al. 2004) concluded that the data does not allow them to say that one option for managing MSW is definitely better or worse than another in terms of deaths brought forward due to emissions to air. The estimate of less than one death brought forward pales into insignificance when compared to the COMEAP estimate of 11,600 deaths brought forward per year caused by overall PM_{10} and SO_2 air pollution alone in urban areas of Great Britain (COMEAP 1998).

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 estimated number of cancer cases caused by emissions to air from MSW management is so small that again it is impossible to say that one MSW management option is definitely better or worse than another.

If a comparison is made between the hazards of MSW management and other health hazards it helps to put them even further into context. For example, fireworks resulted in over 1000 hospital admissions in 2002; traffic accidents result in over 3,000 deaths and over 300,000 hospital admissions every year. This compares with less than one death brought forward and five hospital admissions every year, to people who are already elderly and/or ill, caused by emissions to air from MSW management.

<u>Conclusions from this review of potential health and environment impacts</u>

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. This is particularly true for the effects of 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, municipal solid waste 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 significant 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.

Metal emissions from MSW treatment (incineration and landfill sites) amount to about 0.1% for As, 10% for Cd, 1.65% for Hg 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 treatment facilities. But such impacts have not been shown to definitely 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 Cd emissions from landfills represent the vast majority of Cd emissions from MSW treatment which amounts to 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).

The population of Milton Keynes may or may not be convinced that these conclusions are valid. It is essential that every opportunity be taken to make freely available fair and balanced reviews of the available information on health and environmental impacts of MSW treatment, placing it in its proper context relative to other causes of impacts on health and the environment.

This will help to enable a properly informed debate to take place about any issue of health or environmental concern. This will help to avoid positions being taken based on inadequate information, fear of the unknown, information referring to old outdated processes, or allowing the debate to be dominated by narrow pressure groups whose main focus in not necessarily on what is best for the population of Milton Keynes as a whole.

Information and advice about environmental issues

Milton Keynes Council's scientists in the Environmental Protection Team are 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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Explanatory Notes

‡ Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, waste, or other organic substances like tobacco or grilled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as in soot. PAHs enter the air mostly as releases from fires, burning coal, and vehicle exhaust. PAHs can occur in air attached to dust particles. PAHs can break down by reacting with sunlight and other chemicals in the air, over a period of days to weeks. PAHs enter water through discharges from industrial and wastewater treatment plants. Most PAHs stick to solid particles and settle to the bottom of lakes or rivers. Micro-organisms can break down PAHs in soil or water after a period of weeks to months. In soils, PAHs are most likely to stick tightly to particles; certain PAHs may move through soil to contaminate underground water. PAH contents of plants and animals may be much higher than PAH contents of soil or water in which they grow. Human intake of PAHs is mainly from cigarette smoke, wood smoke, vehicle exhausts, asphalt roads, eating grilled or charred meats.

Some PAHs are believed to be carcinogens. People who have breathed or touched mixtures of PAHs and other chemicals for long periods of time have developed cancer. Some PAHs have caused cancer in laboratory animals when they breathed air containing them (lung cancer), ingested them in food (stomach cancer), or had them applied to their skin (skin cancer).