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## Health Impacts of Incineration, with particular reference to the Toxicological Effects of Ultrafine Particulate Aerosols and Organo-Chlorines

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Town and Country Planning Act 1990 Appeal by Mercia Waste Management Ltd  
for "Integrated Waste Management Facility"  
at British Sugar Site, Kidderminster, Worcestershire.  
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### Table of Contents

1	Introduction
4	1.1 Scope of the Evidence
4	1.2 About the Author
4	2 Background - Basic Concepts.
6	2.1 Fundamental Approached to Waste Management
6	2.2 The Nature of the Waste Stream has Changed
6	2.3 Changing Policy
6	2.4 Matter cannot be Destroyed
6	3 The Generation of Persistent Organic Pollutants (POPS), including dioxins
8	3.1 The Nature of POPS
8	3.2 What makes Compounds Persistent
8	3.3 Origin of Organo-Chlorines
8	3.4 Products of Incomplete Combustion
8	3.5 Breakdown of Organo-Chlorine Compounds is Very Slow
10	3.6 CFCs and Solvents
10	3.7 Transportation of Organo-Chlorines
10	3.8 Organo-Chlorines Bio-Accumulate
10	3.9 Organo-Chlorines are Ingested Through Air and Food
11	3.10 Organo-Chlorines are Stored in Body Fat
11	3.11 No Protection for the Fetus
11	3.12 Human Body Burdens Already Too High
11	3.13 Body Burden is a More Appropriate Metric
11	3.14 Dioxin Produced by Combustion of Waste
12	3.15 Other types of Dioxins and PICs
12	4 The Inadequacy of the Use of Incremental Dose Models in Risk Assessments for Persistent Bio-Accumulative Pollutants.
13	4.1 Simplistic Approach
13	4.2 Deficiencies with the Model
14	4.3 Tightened Standards?
14	5 The Relevance of Recent Research on the Health Effects of Respirable Particulate Aerosols on Health
15	5.1 Nanoparticles
15	5.2 Atomic Structure of Nanoparticles
15	5.3 Highly Reactive Surfaces
15	6 Health Effects of Ultrafine Particulate Aerosols
16	6.1 Effects of Particle Mixtures
16	6.2 Deaths from Air Pollution
16	6.3 Threshold Levels
16	6.4 Ingress of particulates
16	6.5 Most dangerous particles
17	6.6 Number of Particles in Air

17	6.7	Particle Size is Critical
17	6.8	Fine Particles Linked to Human Deaths
17	6.9	Biological Mechanism for Heart-Related Diseases and Death
18	7	Relevance of Particulate Aerosols to Incinerators
19	7.1	Incinerators Emit Vast Quantities of Ultra-Fine Particles
19	8	Health Impacts of NO <sub>2</sub> and other emissions:
20	8.1	An acceptable Risk?
22	9	Epidemiology
24	10	Summary
28		APPENDIX

1 - Comments by Dr C.V. Howard on the: Review by Professor R Harrison of "Incineration and Human Health" by Michelle Allsopp, Pat Costner and Paul Johnston. 29 11 References 33 1  
Introduction Statement by Dr C V Howard MB, ChB, PhD, FRCPath.

1.1 - Scope of the Evidence - I have been asked by Wyre Forest Friends of the Earth group to examine the potential health impacts of the proposed incinerator at the Integrated Waste Management Facility proposed for the British Sugar site, Kidderminster. My evidence will address the effects of the most problematic particulate and gaseous emissions, in the light of the latest scientific knowledge. I will also discuss the inappropriateness of incremental dose as a metric for judging the effects of persistent organic pollutants in environmental risk assessments. I will also address various material points made by the Environment Agency in the decision document on the IPPC permit and particularly in relation to the critique by Professor Harrison of the Greenpeace report 'Incineration and Human Health' that is included in that decision document.

1.2 - About the Author I qualified in Medicine in 1970 at the University of Liverpool and after registration with the General Medical Council, started a career in research at that institution. The central theme of my research has always been centred on the development of the fetus and neonate. I am currently a Senior Lecturer and Head of the Developmental Toxicology-Pathology Group at the University of Liverpool. I am a Fellow of the Royal College of Pathologists. In 1983, I obtained the degree of Doctor of Philosophy at the University of Liverpool for research into the development of the immature brain, using 3-D microscopy techniques. At this time I was appointed an Editor of the Journal of Microscopy, which is an internationally recognised publication and the official journal of the Royal Microscopical Society. In 1985 I was appointed General Editor in overall charge, a post that I held until 1992. I have developed a number of assays (tests) for measuring biological tissues with microscopes, which come under the general heading of stereology. These tests are now becoming used in the pharmaceutical industry as very sensitive toxicological tests to detect minimal change. They are of particular importance in developmental pathology. There is an International Society for Stereology with some 500 members world-wide. I was elected President of this society from 1991-95. I was President of the Royal Microscopical Society from 1996-8. I was awarded the 150th Anniversary Gold Medal of the Royal Microscopical Society for services to microscopy. I am a member of the British Society of Toxicological Pathologists. Over the past decade years, the Developmental Toxicology-Pathology Group at Liverpool has developed an international reputation for its work on fetal development and the insight that has been gained in detecting the permanent damage that the fetus can sustain if its growth is perturbed. More recently the group has been working on the developmental toxicology of chemical mixtures. I have appeared as an expert witness in a number of previous planning inquiries in relation to public health implications which arise from emissions from waste combustion plants, with particular reference to the unborn and newly born child and long-term health effects.

2 - Background - Basic Concepts.

2.1 - Fundamental Approached to Waste Management

There are two fundamental approaches to handling waste, either try to reduce inputs to the waste stream or attempt to deal with wastes once they have been produced. Clearly there is scope to combine the two.

## 2.2 - The Nature of the Waste Stream has Changed.

The nature of the waste stream has changed profoundly over the past 100 years. The majority of the combustible portion of the waste stream originally consisted of wood products, including paper, and fabrics made from natural fibres. Subsequently the content of toxic materials, including heavy metals and plastics, has inexorably risen in both proportion and volume. This change has made what was originally a waste mixture that would probably have been no more dangerous to burn than any other fossil fuel, into a much more hazardous proposition.

## 2.3 - Changing Policy.

The policy of the waste industry over many decades has been to 'dispose' of waste in a way that put it out of sight and hence out of mind. Until recently in the UK, this has been achieved primarily by using landfill, an activity that has already left a toxic legacy for future generations. The waste management industry is now being forced to substantially reduce this activity, due to the Landfill Directive 1999/31/EC. The industry's response is to fall back on an old fashioned technology, incineration, that is no longer suited to the modern waste streams.

## 2.4 - Matter cannot be Destroyed

The process of incinerating waste does not destroy anything, 'matter cannot be created or destroyed'. Incineration is a method of waste dispersion, which superficially gives the impression that a process of disposal has been performed. Thus when waste is combusted, it is transformed into gases, particles and ash. The gases are dispersed to the air, the particles either go to air or are arrested on filters as 'fly ash', and the 'bottom ash' or clinker remains inside the combustor. All of the heavy metals that are in the waste find their way into one of these phases. In addition, toxic organic compounds formed during the combustion process are also emitted as gases, on particles, or in ash. Thus all of the effluvia from waste incinerators pose problems for human and environmental health as well as for disposal. The evidence of Alan Watson includes a calculation of the permitted emissions from the Kidderminster proposals which are included in the Environmental Statement and the IPPC permit. This shows that, assuming the incinerator was operating at the stated emission level throughout the operating period, the total emissions would be:

Emission Proposed level g/sec Annual kg(Dioxin =g) 25 year Contract Period tonnes(Dioxin =g)

Particulates 10 mg/m<sup>3</sup> 0.308 8,316 207.9

Carbon monoxide CO 50 mg/m<sup>3</sup> 1.54 41,580 1,039.5

Volatile Organic Compounds VOC 10 mg/m<sup>3</sup> 0.308 8316 207.9

Hydrogen Chloride HCl 10 mg/m<sup>3</sup> 0.308 8316 207.9

Hydrogen Fluoride HF 1 mg/m<sup>3</sup> 0.0308 831.6 20.79

Oxides of Sulphur SO<sub>x</sub> 50 mg/m<sup>3</sup> 1.54 41,580 1,039.5

Oxides of nitrogen NO<sub>x</sub> 200 mg/m<sup>3</sup> 6.16 166,320 4,158

Mercury Hg 0.05 mg/m<sup>3</sup> 0.00154 41.58 1.0395

Cadmium Cd and Thallium 0.05 mg/m<sup>3</sup> 0.00154 41.58 1.0395 As Cr Co Cu Mn Ni Pb Sb V\* 0.5 mg/m<sup>3</sup> 0.0154 415.8 10.395

Ammonia NH<sub>3</sub> 10 mg/m<sup>3</sup> 0.308 8,316 207.9

Dioxins and Furans 0.1 mg/m<sup>3</sup> 3.08 x 10<sup>-9</sup> 83.16 x 10<sup>-6</sup> 2.079 x 10<sup>-6</sup>

\*Arsenic As, Chromium Cr, Cobalt Co, Copper Cu, Manganese Mn, Nickel Ni, Lead Pb, Antimony Sb, Vanadium V

Note that this includes 166 tonnes per year of Nox, over 8 tonnes per year of particulates, etc.

These estimated quantities are, in my opinion, high enough to have the potential to cause health effects on the most vulnerable members of the local population and to add significant amounts of pollutants to the general background levels in the environment.

### 3 - The Generation of Persistent Organic Pollutants (POPS), including dioxins

#### 3.1 - The Nature of POPS (Persistent Organic Pollutants)

An outline of the nature of POPS and the industrial processes that lead to their formation is essential for a complete overview of the incineration debate (Howard et al, 2000). The main problem substances are made from carbon and chlorine, so-called organo-chlorine compounds. However, the volume of organo-bromine wastes is increasing and leading to many of the same problems associated with organo-chlorines (Howard & Staats de Yanes, 2001).

#### 3.2 - What makes Compounds Persistent

The body can normally break down naturally-occurring biochemical substances, with the use of enzymes that have evolved over many millions of years. The industrial production of organic (i.e. carbon-based) chemicals has led to the widespread dissemination of pollutants that are not easily biodegraded and therefore become persistent in the environment. This indicates that the enzymes necessary to achieve their rapid breakdown are not present, as might happen with novel compounds not found in nature. When such chemicals also are preferentially fat-soluble (lipophilic), they tend to build up in animal tissue, a process termed bioaccumulation. For the more persistent compounds, the concentration will increase more in those animals higher up in the food web; a process termed bio-magnification. Humans are positioned high up in the food web.

**3.3 - Origin of Organo-Chlorines** Organo-chlorines are substances containing chemically-combined chlorine and carbon. They first emerged as by-products of the expanding chlor-alkali industry in the 1930's. The manufacture of caustic soda by the electrolysis of brine leads to the production of chlorine gas, which is highly toxic and cannot be allowed to be released into the environment. Therefore by-products that were less acutely toxic had to be made with the gas. This was and continues to be largely achieved by combining chlorine with carbon compounds from the oil and coal industries. The chemical properties of organo-chlorines, include low flammability, chemical stability and initially an apparent lack of immediate toxicity to humans. This makes them very desirable for industrial use. As a result, there are now some 11,000 organo-chlorine compounds which are known to be produced and used commercially for products as diverse as pesticides, plastics, solvents, lubricants and refrigerants. Currently, global production of chlorine gas is 40,000,000 tons/year. About 35% of this is used to manufacture polyvinylchloride (PVC) plastic.

**3.4 - Products of Incomplete Combustion** There is no natural organo-chlorine chemistry in any higher animal life forms. Some organo-chlorines do occur naturally in the environment but only at very low levels. When organo-chlorine substances become involved in combustion, then certain products of incomplete combustion (PICs) can be formed. These include the dioxin-like substances, which are a family of highly persistent organo-chlorine compounds that are unwanted by-products of either the industrial production of carbon-chlorine chemicals or their subsequent combustion. The recent USEPA review confirms that the dioxin-like substances are amongst the most toxic substances known (USEPA, June 12th, 2000). The range of PIC emissions from municipal waste incineration is huge. The flue gas will contain hundreds and possibly thousands, of pollutants - many of which it will not be possible to identify but which will often be carried adsorbed onto the finest respirable particulates. Kay and Steigltz published a paper in Chemosphere listing just some of these emissions. Normally they would remain unidentified by the operator or the regulator. They identified the following volatile organic chemicals emitted from a municipal waste incinerator: pentane; trichlorofluoromethane; acetonitrile; acetone; iodomethane; dichloromethane; 2-methyl-2-propanol; 2-methylpentane; chloroform; ethyl acetate; 2,2-dimethyl-3-pentanol; cyclohexane; benzene; 2-methylhexane; 3-methylhexane; 1,3-dimethylcyclopentane; 1,2-



dimethylcyclopentane; trichloroethene; heptane; methylcyclohexane; ethylcyclopentane; 2-hexanone; toluene; 1,2-dimethylcyclohexane; 2-methylpropyl acetate; 3-methyleneheptane; paraldehyde; octane; tetrachloroethylene; butanoic acid ethyl ester; butyl acetate; ethylcyclohexane; 2-methyloctane; dimethyldioxane; 2-furanecarboxaldehyde; chlorobenzene; methyl hexanol; trimethylcyclohexane; ethyl benzene; formic acid; xylene; acetic acid; aliphatic carbonyl; ethylmethylcyclohexane; 2-heptanone; 2-butoxyethanol; nonane; isopropyl benzene; propylcyclohexane; dimethyloctane; pentanecarboxylic acid; propyl benzene; benzaldehyde; 5-methyl-2-furane carboxaldehyde; 1-ethyl-2-methylbenzene; 1,3,5-trimethylbenzene; trimethylbenzene; benzonitrile; methylpropylcyclohexane; 2-chlorophenol; 1,2,4-trimethylbenzene; phenol; 1,3-dichlorobenzene; 1,4-dichlorobenzene; decane; hexanecarboxylic acid; 1-ethyl-4-methylbenzene; 2-methylisopropylbenzene; benzyl alcohol; trimethylbenzene; 1-methyl-3-propylbenzene; 2-ethyl-1,4-dimethylbenzene; 2-methylbenzaldehyde; 1-methyl-2-propylbenzene; methyl decane; 4-methylbenzaldehyde; 1-ethyl-3,5-dimethylbenzene; 1-methyl-(1-pro-penyl)benzene; bromochlorobenzene; 4-methylphenol; benzoic acid methyl ester; 2-chloro-6-methylphenol; ethyldimethylbenzene; undecane; heptanecarboxylic acid; 1-(chloromethyl)-4-methylbenzene; 1,3-diethylbenzene; 1,2,3-trichlorobenzene; 4-methylbenzyl alcohol; ethylhexanoic acid; ethyl benzaldehyde; 2,4-dichlorophenol; 1,2,4-trichlorobenzene; naphthalene; cyclopentasiloxanecamethyl; methyl acetophenone; ethanol-1-(2-butoxyethoxy); 4-chlorophenol; benzothiazole; benzoic acid; octanoic acid; 2-bromo-4-chlorophenol; 1,2,5-trichlorobenzene; dodecane; bromochlorophenol; 2,4-dichloro-6-methylphenol; dichloromethylphenol; hydroxybenzonitrile; tetrachlorobenzene; methylbenzoic acid; trichlorophenol; 2-(hydroxymethyl) benzoic acid; 2-ethylnaphthalene-1,2,3,4-tetrahydro; 2,4,6-trichlorophenol; 4-ethylacetophenone; 2,3,5-trichlorophenol; 4-chlorobenzoic acid; 2,3,4-trichlorophenol; 1,2,3,5-tetrachlorobenzene; 1,1-biphenyl (2-ethenyl-naphthalene); 3,4,5-trichlorophenol; chlorobenzoic acid; 2-hydroxy-3,5-dichlorobenzaldehyde; 2-methylbiphenyl; 2-nitrostyrene(2-nitroethenylbenzene); decanecarboxylic acid; hydroxymethoxybenzaldehyde; hydroxychloroacetophenone; ethylbenzoic acid; 2,6-dichloro-4-nitrophenol; sulphonic acid m.w. 192; 4-bromo-2,5-dichlorophenol; 2-ethylbiphenyl; bromodichlorophenol; 1(3H)-isobenzofuranone-5-methyl; dimethylphthalate; 2,6-di-tertiary-butyl-p-benzoquinone; 3,4,6-trichloro-1-methyl-phenol; 2-tertiary-butyl-4-methoxyphenol; 2,2'-dimethylbiphenyl; 2,3'-dimethylbiphenyl; pentachlorobenzene; bibenzyl; 2,4'-dimethylbiphenyl; 1-methyl-2-phenylmethylbenzene; benzoic acid phenyl ester; 2,3,4,6-tetrachlorophenol; tetrachlorobenzofuran; fluorene; phthalic ester; dodecanecarboxylic acid; 3,3'-dimethylbiphenyl; 3,4'-dimethylbiphenyl; hexadecane; benzophenone; tridecanoic acid; hexachlorobenzene; heptadecane; fluorenone; dibenzothiophene; pentachlorophenol; sulphonic acid m.w. 224; phenanthrene; tetradecanecarboxylic acid; octadecane; phthalic ester; tetradecanoic acid isopropyl ester; caffeine; 12-methyltetradecanecarboxylic acid; pentadecanecarboxylic acid; methylphenanthrene; nonadecane; 9-hexadecene carboxylic acid; anthraquinone; dibutylphthalate; hexadecanoic acid; eicosane; methylhexadecanoic acid; fluoroanthene; pentachlorobiphenyl; heptadecanecarboxylic acid; octadecadienal; pentachlorobiphenyl; aliphatic amide; octadecanecarboxylic acid; hexadecane amide; docosane; hexachlorobiphenyl; benzylbutylphthalate; aliphatic amide; diisooctylphthalate; hexadecanoic acid hexadecyl ester; cholesterol.

### 3.5 - Breakdown of Organo-Chlorine Compounds is Very Slow.

The same properties that made organo-chlorines desirable to chemical industry have created widespread environmental problems. Once introduced into the environment, the stability of many organo-chlorines means they degrade very slowly. This is because the carbon-chloride bond in these chemicals is generally very strong and resists being broken down by normal biochemical and physical processes. Consequently, organo-chlorines may take 100 years to break down completely into harmless chlorides, while others do not degrade at all to any appreciable extent. Moreover, when organo-chlorines do break down, they usually produce other organo-chlorines - the carbon-chloride chemical bond remaining intact as part of another compound - and these are often more toxic and far more hazardous than the original substance. The number of unidentified organo-chlorines produced in this way is believed to be vast.

### 3.6 - CFCs and Solvents

Some organo-chlorines, including CFCs and solvents such as chloroform, are volatile and tend to evaporate into the atmosphere where they slowly break down. In the upper atmosphere, some organo-chlorines act as powerful ozone depleters, while others may degrade in the lower atmosphere.

### 3.7 - Transportation of Organo-Chlorines

All can be transported long distances by air currents and may eventually be deposited in the surface waters of rivers, lakes or seas. Other less volatile organo-chlorines, including PCBs, dioxins and many pesticides, can be transported in water currents or become bound up in soil or sediments. Since organo-chlorines can be transported by currents through the atmosphere and the rivers and oceans, many have become ubiquitous all around the world, from the deep sea bed to the stratosphere, from the Arctic to the Antarctic. The production of organo-chlorines from industry far outstrips the rate at which they are broken down in the environment to harmless chemicals. This means there is an ever-increasing load of organo-chlorines being added to in the environment each year.

### 3.8 - Organo-Chlorines Bio-Accumulate

The majority of organo-chlorines dissolve more readily in fats and oils than in water. Consequently, they tend to build up (bio-accumulate) in the fatty tissues of living organisms. For example, fish accumulate concentrations of some organo-chlorines in their tissues thousands of times greater than the level in the water in which they swim. Animals or birds which eat the fish concentrate the chemicals to even higher levels in their tissues. Thus animals at the top of the food chain such as dolphins and seals in the aquatic environment are exposed to and accumulate the greatest concentrations of organo-chlorines in their tissues. This process is called bio-magnification, since the chemicals that accumulate at one level of the food chain are further concentrated at the next level, when the predator eats contaminated prey.

3.9 - Organo-Chlorines are Ingested Through Air and Food Humans and terrestrial animals are exposed to organo-chlorines from breathing air which may be contaminated, but the major route of exposure is through food. Because organo-chlorines are fat-soluble, meat, fish and dairy products contain the highest levels of organo-chlorines.

### 3.10 - Organo-Chlorines are Stored in Body Fat

The vast majority of organo-chlorines are foreign to nature and living organisms have developed few methods to detoxify them. Once ingested with food, organo-chlorines are readily absorbed into body tissues. In general, the body deals with toxic substances either by detoxifying and excreting them or by sequestering them. In the case of organo-chlorines they are stored in fat.

### 3.11 - No Protection for the Fetus

The human body has a well-developed defence system to deal with many toxic chemicals it encounters in the course of living, but these systems and detoxifying enzymes do not mature until a few weeks after birth. However, no maternal protection from toxic chemicals present in the mother's body is given to the developing young. In fact, the developing fetus and newborn infant are exposed to organo-chlorine chemicals from the mother's body, both through placental transfer and from breast milk.

### 3.12 - Human Body Burdens Already Too High

There is now evidence that human populations have too much dioxin-like substance in their bodies. The sections of the population who are the most vulnerable to health effects are the fetus in the womb and the nursing child. These chemicals can have effects on the endocrine system, and can affect the development in the womb of many of the essential organs and systems, including the reproductive system, the immune system, the brain, kidneys, lungs etc. Some of these effects have been demonstrated to occur at current background levels. Effects on the intelligence, immune status and hormonal status of infants have been related quantitatively to the amount of dioxin-like substance

in the mother's body. *Kappe et al (2000)* reviews all the evidence for these effects. Exposure to dioxin-like substances has also been related to changes in the proportion of boys to girls being born (Williams 1992, Mocarelli 2000), there being a relative decrease in the number of boys. Studies of nursing mothers have shown that the organo-chlorine content of human milk declines significantly during the breast-feeding (lactation) period, which shows that mothers decrease their own body levels of these chemicals through lactation, by passing these chemicals to baby in the milk. This is also consistent with the finding that levels of organo-chlorines are lower during a second or third lactation than for the first lactation (e.g. Skaare and Polder 1990).

**3.13 - Body Burden is a More Appropriate Metric** The concept of body-burden of POPs such as dioxin-like substances is an important one. Dr Linda Birnbaum, a senior official in the US EPA, has confirmed that the total amount of dioxin-like substance in a person's body is a more appropriate measurement, than the tolerable daily intake (TDI), when attributing harm, Birnbaum (1998). The overall message is that the human race has too much background exposure to dioxin-like substances and that there is a need to reduce current body burdens urgently. This opinion is reinforced by the recent reports of the *Dutch Health Council (Sixma, 1996)*, *WHO (van Leeuwen & Younes, 1998)*, and the *UK Committee on Toxicity of Chemicals (COT), (COT, 2001)* which have all led to reductions in recommended tolerable daily intakes.

#### **3.14 - Dioxin Produced by Combustion of Waste**

Historically, a high proportion of the global contamination of the planet with dioxins has come about because of the combustion of organo-chlorines in the waste stream. It is pointless to quote emission rates for such substances in units per cubic metre of gas exhausted. The measurement of significance is the total mass of pollutant emitted that will end up in the environment.

**3.15 - Other types of Dioxins and PICs** Whilst there are only 210 possible dioxin and furan congeners of a single halogen, such as chlorine, there are about 4,600 discrete bromo-, chloro-, and mixed halogen derivatives possible. Some or all of these may be produced in municipal waste incinerators. Currently only 17 chlorinated dioxins are measured and then only usually twice each year after the first year's commissioning. It took nearly 20 years from first finding chlorinated dioxins in incinerator emissions to arrive at the point where limits were set for those emissions. The other halogenated dioxins, particularly the brominated species, were first found in incinerator emissions a decade ago but there is no indication in the application nor the IPPC permit that either the applicant or the Environment Agency intend testing for these chemicals. This is a significant concern because: • Levels of brominated compounds in breast milk have increased massively in the past two decades • There is growing evidence that these compounds are as toxic as the chlorinated species • Brominated and other halogenated dioxins are formed in municipal waste incinerators • The level of brominated pre-cursors that are included in municipal wastes are increasing (as fire retardants etc).



# Appendix B Human Health Impacts of Energy from Waste Processes

## Introduction

Most EfW plants are based upon incineration and studies of health effects have tended not to distinguish between older mass burn plants without energy recovery, and the more modern and better managed and controlled EfW plants. Care must therefore be taken in reviewing and interpreting the results of relevant research work. Pyrolysis and gasification technologies are relatively new and studies of health effects specific to plants using these technologies have yet to be undertaken.

There are two primary methods of evaluating the health effects of waste treatment plants. The first examines the prevalence of diseases that could plausibly be linked with emissions from the plant and looks for spatial patterns which would indicate a link with plant emissions. This method is termed spatial epidemiology. The other approach is to start from knowledge of the pollutant emissions from the plant and to calculate ground level concentrations and thus estimate both direct human exposures through inhalation, and where relevant indirect exposures through the food chain. From the magnitude of these exposures the magnitude of health outcomes can be calculated.

## Epidemiological studies

The vast majority of epidemiological studies have focused on older generations of incinerators and there are none specific to modern EfW plants. The studies have looked for spatial patterns in three categories of disease viz, cancer, respiratory and reproductive diseases. A typical approach is to construct concentric bands around an incinerator looking for differences in the prevalence of disease, with proximity used as a surrogate for pollutant exposure. There are a number of difficulties and drawbacks associated with this approach, not least of which is that there is frequently a gradient in the social make-up of populations such that there is a higher level of deprivation, itself associated with a higher frequency of disease irrespective of the presence of the incineration plant, closer to the plant compared with further away. Studies which have carefully controlled for so-called socio-economic confounding have generally failed to find any convincing evidence of an adverse health outcome associated with living in close proximity to an incineration plant.

## Calculation of impacts from emissions data

Incineration emits a wide range of typical combustion-generated pollutants in line with other major combustion plant. The main difference between modern incinerators and, for example, power stations is that incinerators tend to have more sophisticated pollution abatement technologies. The most important pollutant emissions include sulphur dioxide, oxides of nitrogen, particulate matter, hydrogen chloride, hydrogen fluoride, a range of trace metals, dioxins and furans. Estimation of the impact involves calculation of both short-term and long-term average ground level concentrations. If the short-term peak concentrations lie within health-based air quality standards it is unlikely that significant adverse health effects will occur. The long-term concentrations are nonetheless associated with adverse health effects which can be calculated using exposure-response functions which have generally been determined from air pollution epidemiology involving entire urban populations exposed to pollutants predominantly from road traffic. Such calculations demonstrate that an EfW plant will generally be associated with less than one additional hospital admission for respiratory or cardiovascular disease and less than one death brought forward per year. Calculation of population exposures to chemical carcinogens including arsenic, nickel, chromium and PAH shows a negligible impact on cancer rates. For dioxins and furans direct exposure through inhalation is a small contributor to exposure, which is dominated by exposure through foodstuffs. Calculation of dioxin and furan transfers through the food chain into home-grown produce indicates that the maximally exposed individuals around a modern incinerator receive well under 1% of their total dioxin intake as a result of incinerator emissions. Since the tolerable daily intake for dioxins is designed to be protective against both reproductive and cancer effects, it is unlikely that exposure as a result of incinerator emissions is a significant contributor to these diseases.