Toxicological Evaluation of Emissions from Modern Municipal Waste Incinerators

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Introduction

In the Federal Republic of Germany incineration is seen as an integral part of waste management which consists of avoiding, recycling and incineration to reduce the volume and destroy hazardous chemicals with the final goal to exclusively deposit inert material. Currently 49 municipal waste incineration plants (MWIP) are operating and about 20 are in the planning or construction phase.

Since combustion of waste is considered to emit a great number of known and unknown organic and inorganic compounds, dust, aerosols and gas there is great public fear of cancer, respiratory diseases and other health affects.

In this communication health risks, caused by emissions from a modern MWIP are evaluated by estimating additional air concentrations compared with the background air concentrations in rural areas, threshold levels, regulatory standard air concentrations and the background human exposure of the different compounds (1). For dibenzodioxins and dibenzofurans exposure via food are also estimated.

Estimation of Air Concentrations Around Proposed Municipal Waste Incineration Plants and Risk Assessment

Air concentrations around a modern MWIP are estimated by dividing the emission concentrations by 500,000. This dilution factor derives from the experience of calculating air concentrations near an emission source by mathematical models (2). The resulting air concentrations are compared with air quality standards which are based on the toxicologic evaluation of the different compounds. The concentrations are listed in the Technical Instructions on Air Quality Control (TA Luft) in the Federal Republic of Germany. The

1990

IW1-values have been developed for health protection in the case of long term exposure. Since these standards are only available for a few substances, risk assessment may also be based on the German Threshold Limit Values (MAK) for occupational exposure (3). Since these values are designed for healthy adults, exposed for 8 hrs daily and 40 hrs per week they are not suitable to control long term exposure of the general population. However, 1/100 of the respective MAK can be considered a concentration without adverse effects upon long term exposure.

Inorganic Compounds

The predicted air concentrations of the emitted inorganic compounds are much lower than the IW1 or the MAK (1:100). Moreover, concentrations of CO, SO_2 and NO_x are at least 25 times below those observed in rural areas within Germany (4). Consequently, they can be considered without toxicological relevance, and are not supposed to be of risk to human health.

Metals

Optimized procedures to remove dust from the emitted gas have drastically reduced emissions of metals. Air concentrations of the different metals in the neighbourhood of a modern MWIP which have been calculated as described above are at least 100 fold lower than the respective MAK-values (1:100). For only a few metals IW1-values are available. Calculated air concentrations of Cd and Pb are 40 and 20 times lower than the IW1. Consequently, similar to the inorganics, emissions of metals from a modern MWIP are not considered to be a risk to human health. However, most of these air concentrations are similar or only half the concentrations found in rural areas and would considerably increase this background exposure.

Organic Compounds

A matter of great concern to the public are the emissions of PCDD and PCDF. Modern MWIP *do not seem to emit more than 0.1 - 0.2 ng 2,3,7,8-TCDD/m³ and 1 ng/m³* TCDD-equivalents (TE). MWIP in the planning or construction phase are supposed to emit 0.1 ng TE/m³ only. Assuming flue gas emissions of 1 or 0.1 ng TE/m³ and a 500,000 fold dilution, air concentrations in a rural area would increase from an average of 10 fg/m³ to 12 or 10.2 fg/m³, respectively. This increases TE soil concentration from 1 to 1.1 ng/kg. Additional human TE exposure via the food chain amounts to 0.3 or 0.03 pg/kg body weight, respectively. In Table 1 the estimated TE-ingestion via the major fat containing human food components is given. Due to this exposure TE body fat concentration would increase from 40 to 50 or 41 ng/kg, respectively. These data have been calculated using a pharmacokinetic model assuming a half life of all PCDD and PCDF of 8 years and the amount of body fat to be 11 kg per adult person (5). Since toxic effects occur at fat concentrations exceeding 1,600 to 3,000 ng TE/kg fat (6) TE emissions of modern MWIP do not seem to create an additional hazard to human health.

However, a disturbing aspect of this consideration is the high background exposure of PCDD and PCDF to the human population including sucklings which ingest these components via human milk. There are various sources of this contamination. Recent estimates of the different sources in Germany, Sweden and Switzerland (6 - 8) indicate that MWIP seems to contribute considerably to the background levels. In the Federal Republic of Germany, currently operating MWIP are estimated to emit 40 - 400 g TE annually. This is calculated on the basis that 8 mil. t of municipal waste are incinerated, emitting 5,000 m³ stack gas per t of waste and 1 - 10 ng TE per m³ emitted air (7). According to rough estimates, industrial waste incineration plants and combustion processes also emit 40 to 400 g annually, motor-vehicles 50 g, while the percentage from the paper industry and domestic flue gas is not known. However, the major part of contamination seems to result from the previous production and use of pentachlorophenol and polychlorinated biphenyls.

Emissions of Unknown Chemicals

In addition to the PCDD and PCDF and other known hazardous chemicals the potential health hazards of, as yet unknown, material is also a matter of concern. Indeed, as with other combustion processes, a great number of unknown products are formed and released during municipal waste incinceration.

Analysing such complex mixtures is difficult and provides risk information on only the number of the chemicals detected. To overcome this problem, bioassy methods have been applied recently to evaluate the mutagenic and potential carcinogenic activity of the emissions. Such tests have been developed to quantify the mutagenic potential of ambient air, but did not detect mutagenicity that could be attributed to incinerator emissions (9). Additional tests are being developped to estimate biological effects (AHH-induction) of dibenzodioxins and dibenzofurans and cytotoxic effects of probes of stack gas or ambient air.

Such measures and improved pollution control equipment e. g. to guarantee emissions of 0.1 ng TE/m³ will further reduce the non definable risk.

Table 1: **Predicated Increase in Average Daily Ingestion of TCDD-Equivalents from Typical Waste Incinerator**

Stack Gas (ng/m³)	1	0.1
Ambient Air (fg/m³)	2	0.2
Exposure		
Air (fg/kg b. wt.)	0.6	0.06
Food (pg/kg b. wt.)		
- Dairy Products	0.07	0.007
- Beef (40 g Fat)	0.15	0.015
- 1 Egg	0.04	0.004
Total	0.3	0.03
Increase in Average Body Fat Concentration (40 ng/kg)	50	41

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