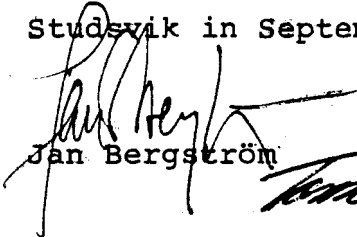



# MKS | Arbetsrapport - Technical Note

MILJÖKONSULTERNA

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Titel och författare - Title and author  HEALTH RISK EVALUATION OF FLUE GAS EMISSIONS OF CHLORINATED DIOXINS AND DIBENZOFURANS FROM A HAZARDOUS WASTE INCINERATION PLANT  Tomas Öberg		
  <p style="text-align: center;">SUMMARY</p> <p>The background to and database for health risk evaluation of the flue gas emissions from at Swedish hazardous waste incineration plant is presented. The data base is comprised of conservative assessments of known, toxicological, chemical and meteorological data. The conclusion is that no adverse significant influence on public health can be anticipated with emissions at their present levels.</p> <p>This report is a revised and translated version from a original in Swedish.</p>  <p style="text-align: center;">Studsвик in September 1984</p> <p style="text-align: center;"> Jan Bergström </p>		

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## 1 INTRODUCTION

In autumn 1983 the combustion of hazardous waste started at SAKABs plant in Norrortorp, Sweden. MILJÖKONSULTERNA I STUDSVIK AB (Environmental Consultants at Studsvik AB) have been appointed by the authorities to supervise the eighteen month test period of the plant.

In december 1983 high levels of chlorinated dioxins and dibenzofurans were measured in the flue gas emissions from the plant. When these emission data were reported it was immediately decided to start continuous measurements at the plant, and to carry out a test programme to find control parameters to limit these emissions. It was also decided to make an exhaustive evaluation of the health risks associated with these compounds, including the use of an air dispersion model.

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## 2 STANDARDS - HEALTH RISKS

Certain isomers of chlorinated dioxins (PCDDs) and dibenzofurans (PCDFs) are amongst the most toxic compounds known. The most thoroughly studied of these is 2,3,7,8-tetrachloro-p-dibenzodioxin (2,3,7,8-TCDD). Knowledge of the effect on humans, especially chronic effects, is incomplete or lacking for both TCDD and the other compounds. However on the basis of animal experiments some unofficial "standards" have been presented.

Starting from the No-Effect-Level in reproduction studies on animals, using a safety factor on 500, a "TLV" (threshold level value) for 2,3,7,8-TCDD of  $10 \times 10^{-12} \text{ g/m}^3$  ( $10 \text{ pg/m}^3$ ) was calculated (1). This "standard" refers to work place exposure (8 h/day, 250 days/year).

Extrapolating from cancer studies on animals, a very much lower "standard" for 2,3,7,8-TCDD was reached: 50 - 100  $\times 10^{-15} \text{ g/m}^3$  (50 - 100  $\text{fg/m}^3$ ) in ambient air (2, 3) and 1 ppb ( $\mu\text{g/kg}$ ) in soil (4). This calculation is based on the assumption that 2,3,7,8-TCDD is a complete carcinogen. Experimental data does not support this assumption (5).

For the discussion of chronic exposure the standards 50 - 100  $\text{fg/m}^3$  in ambient air and 1 ppm in soil will be used. It should be noted that this is a conservative assessment.

## 3 TCDD-EQUIVALENTS

The toxicological information concerning other isomers of PCDD, and PCDFs than 2,3,7,8-TCDD is very limited. A method to include these in a health risk evaluation is to recalculate the concentrations to "TCDD-equivalents". A TCDD-equivalent represents the effect of the same amount of 2,3,7,8-TCDD. The conversion is made by comparison of the acute toxicities (LD<sub>50</sub>-values) or ability to induce certain enzymes.

The method of calculation above can be criticized from many different directions, but lacking a better approach, it has been used in other real life situations, e g in clean-up after the PCB-fire in Binghamton (1, 6). In this case the relative toxicities of the different isomers were determined from the acute toxicity on guinea-pigs\*. Only those isomers with chlorine in positions 2,3,7,8 and six chlorine at the most gave a significant contribution to the total toxicity in the calculation of TCDD-equivalents.

The method used in the Binghamton-case can also be applied to SAKABs plant in Norrortorp. Calculations made on emission data there show that hexa-CDD and hexa-CDF can be neglected, as these isomers do not give a significant contribution to the total amount of TCDD-equivalents. The conversion factors, and an example of a calculation are shown below.

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\* Note If the calculations were to be made on the basis of the potency for induction of enzymes some deviations would arise.

However at present there is no scientific data that can show that such a model would give a better estimation of real risks.

Table 1

Isomers	Conversion factor
2,3,7,8-TCDD	1
1,2,3,7,8-PnCDD	1
2,3,7,8-TCDF	1/3
1,2,3,7,8-PnCDF	1/3
2,3,4,7,8-PnCDF	1/3

Example: An emission level of  $3 \text{ ng/m}^3$  of 1,2,3,7,8-PnCDF is converted to TCDD-equivalents by multiplying by 1/3, i e  $3 \times 1/3 \text{ ng/m}^3 = 1 \text{ ng/m}^3$ .

The emissions from SAKABs plant in Norrortorp, March to April 1984, converted to TCDD-equivalents, are shown in the table below.

Table 2

Period (week)	TCDD-equivalents $\text{ng/m}^3$ at 10 % $\text{CO}_2$
Day 73 - 80	1.4
80 - 87	2.7
87 - 93	2.0
100 - 107	3.4
107 - 115	6.3
115 - 123	0.8
Mean $\bar{x}$	2.8

The maximum short time emission registered, 14th of December 1983, was  $41 \text{ ng/m}^3$  TCDD-equivalents.

## 4 DISPERSION

An air dispersion model based on 5-year statistics collected in Studsvik was set up. This calculation has been presented elsewhere (7).

The meteorological data now collected at the plant in Norrtorp strongly support the use of Studsvik's weather statistics.

4.1 Air concentrations

In Table 3 the maximum daily average, in relative concentrations at ground level, is shown. The relative concentrations have been computed for 36 different bearings and four different distances from the source of emission. Computations were made based on Studsvik's weather statistics between the years 1960 to 1964.

Table 3

Distance from emission source km	Relative concen- tration s/m <sup>3</sup>
0.5	$2.8 \times 10^{-6}$
1.0	$3.1 \times 10^{-6}$
2.0	$1.8 \times 10^{-6}$
5.0	$8.8 \times 10^{-7}$

The air concentration at ground level is calculated by multiplying the relative concentration with the rate of emission.

The release on 14th December 1983 of 41 ng/m<sup>3</sup> TCDD-equivalents and the flue gas flow rate of 8 m<sup>3</sup>/s (at 10 % CO<sub>2</sub>) would under the most unfavourable conditions give rise to an air concentration at ground level of

$$41 \times 8 \text{ ng/s (rate of emission)} \times 3 \times 10^{-6}$$

$$\text{s/m}^3 = 10^{-12} \text{ g/m}^3 \text{ (1 pg/m}^3\text{)}$$

For a health risk estimation, when chronic effects such as cancer are involved, it is more relevant to consider the average concentrations in ambient air over a longer period of time. In Table 4 the maximum annual averages in relative concentrations for the most unfavourable bearings are shown. (Same conditions as above.)

Table 4

Distance from emission source km	Relative concen- tration s/m <sup>3</sup>
0.5	$5.6 \times 10^{-8}$
1.0	$9.3 \times 10^{-8}$
2.0	$8.7 \times 10^{-8}$
5.0	$3.8 \times 10^{-9}$

The "normal" emission of  $3 \text{ ng/m}^3$  TCDD-equivalents at 10 % CO<sub>2</sub> results in a maximum air concentration at ground level of

$$3 \times 8 \times 9.3 \times 10^{-8} \text{ ng/m}^3 = 2 \times 10^{-15} \text{ g/m}^3$$

(2 fg/m<sup>3</sup>) as annual average.

#### 4.2 Ground deposition

Technical data for estimating the deposition velocity of chlorinated dioxins and dibenzofurans in flue gas emissions do not exist. If these compounds are emitted principally in the gas phase, and are not adsorbed to particles in the flue gas plume, they will spread over large areas, and the deposition in the vicinity becomes small.

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Here we have made the conservative assumption that the compounds are completely adsorbed to particles with a deposition velocity of  $1 \cdot 10^{-2}$  m/s (corresponding to a particle size of 10  $\mu\text{m}$  or less).

Dry deposition is calculated according to the formula

$$\text{Deposition} = \text{rate of emission} \times \text{relative concentration} \times \text{deposition velocity} \times \text{time}$$

The maximum annual dry deposition, with an emission of  $3 \text{ ng/m}^3$  TCDD-equivalents, can be estimated to  $3 \times 8 \times 9.3 \times 10^{-8} \times 1 \times 10^{-2} \times 3.15 \times 10^7 \text{ ng/m}^2 = 0.7 \text{ ng/m}^2$  (1.0 km from the emission source).

Wet deposition is assumed to be of the same magnitude within a radius of 1.0 km from the source of emission. This assumption must also be regarded as conservative.

The total ground deposition of TCDD-equivalents per annum therefore will be  $1.5 \text{ ng/m}^2$  maximum.

Transport from the ground surface, as well as degradation and metabolism in the soil, is difficult to estimate. Results from several studies nevertheless show that such processes can take place for these compounds (8, 9). Here the following very conservative assumptions are made:

- chlorinated dioxins and dibenzofurans are bound to particles so strongly to be leached away.
- particles in question are not transported away by the outflow of water.
- no degradation or metabolism occurs at the surface or in the soil.

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- some distribution take place in the upper soil-layer (1 mm - 1 cm) by migration and infiltration of particles.

Based on these assumptions the annual contribution to ground contamination per kg soil can be estimated. The TCDD-equivalents deposited on one square metre are spread in a volume of 1 - 10 dm<sup>3</sup>, if the density is 1 - 2 kg/dm<sup>3</sup> that is equivalent to 1 - 20 kg of soil. The contribution to ground contamination is then 0.075 - 1.5 ng/kg.

## 5 EVALUATION - CONCLUSIONS

By now it should be obvious from this presentation that most steps in a health risk evaluation of chlorinated dioxins and dibenzofurans are very uncertain. This evaluation is based on present knowledge and a number of very conservative assumptions. Obviously this evaluation could come to other conclusions as new facts become available. The conclusions are as follows:

In the event of the interaction of the most disadvantageous conditions, both emission and weather, an ambient air concentration of 1 pg/m<sup>3</sup> TCDD-equivalents could arise somewhere in the neighbourhood of the SAKAB-plant. The "normal" emissions of TCDD-equivalents can give rise to an annual average ambient air concentration of at the most 2 fg/m<sup>3</sup>. Both these immission values should be compared with the "standards" for short term and chronic exposure for 2,3,7,8-TCDD, 10 pg/m<sup>3</sup> and 50 - 100 fg/m<sup>3</sup>. Exposure by inhalation cannot with the current emission levels be anticipated to have any significant adverse influence on public health.

The contribution as ground contamination is estimated to 0.075 - 1.5 ng/kg and year maximum. Assuming that no degradation or out-flow takes place, the "standard" 1 ppb (µg/kg) will be reached after 700 to 13 000 years. Exposure by dermal or other direct contact with soil in the vicinity of the SAKAB-plant can with the current emission levels not be anticipated to have any significant adverse influence on public health.

Data do not yet exist for a long-term assessment of transport in the environment, bio-accumulation and secondary exposure, e g via food-stuffs.

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Therefore in the future it may be justified to study the exposure risks that can arise in that connection. However, these exposure risks are judged to be without significance in a short-term perspective (the next few years).

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