

Sweden

Description of surveyed documents

As in the Netherlands the Swedish environmental protection agency started to assess dioxin emissions and to introduce abatement strategies quite early. In 1985 a working group was formed within the National Environmental Protection Board to formulate a program dealing with the dioxin problem and which was introduced to the public in 1988 <1>. A first study <2> reported the total emission of PCDD/F into the atmosphere to be between 98 and 218 g Nordic TEQ (NTEQ) in 1987 which mainly was generated by waste incineration processes (see table). Legislation from 1987 required that all new municipal waste incinerators emit less than 0.1 ng Eadon TEQ/Nm³. Older plants also had to lower their emissions towards this limit; hence, considerable decrease of emissions could be stated in 1989.

On the formal request to the Swedish National Environmental Authorities a table containing air emission data for the years 1987, 1992 and 1995 was submitted (see table). For this compilation essentially the same source categories had been considered, but emissions to water caused by paper and pulp industry were added. In contrast to the data shown in the table emissions from waste incineration were reported to be only 20 - 30 g NTEQ in 1987. The estimate for emissions caused by the entire metal industry had been reduced to 45 g NTEQ/a (which amounts up to 70 g NTEQ/a in the table).

Meanwhile, the various research activities initiated by the National Environmental Protection Board are put together under the title „Swedish Dioxin Survey“. One objective of this survey - which has not yet been finished - is to identify major sources of PCDD/F and to estimate their emissions into the environment. First results concerning this topic had been published in 1993<3>. On request the responsible institute submitted a draft version of Part 2 of the surveys final report<4>. It will be used for this European

Inventory because it comprises the most comprehensive data base concerning dioxin emissions in Sweden today.

In this survey emissions to air but also emissions associated with wastes, residues and waste water and - as far as possible - with distribution of contaminated products are considered (see table). Actually, a large part of the report put the main focus on sources and processes contaminating the environment through these pathways. In particular, some special research was made regarding the formation of PCDD/Fs during chlorination of drinking water. In addition, extensive investigations of the role of household activities (dishwashing, laundry) as a probable source of PCDD/F in waste water and sewage sludge are reported. Because these sources are not covered by the structure of the CORINAIR source list, the main results of these experiments are referred to in the respective chapter Volume 2 of this study

	1987	1989
Energy from Waste	50 - 100	10
Hospital waste	10	10
Hazardous waste	2 - 6	2 - 6
Iron and steel	15 - 40	15 - 40
Iron foundries	1 - 10	1 - 10
Non ferrous metals	5 - 20	5 - 20
Cement/lime	5 - 10	5 - 10
Pulp and paper	4 - 6	4 - 5
Power stations (Coal)	1	1
Cars	5 - 15	5 - 15
Total	98 - 218	58 - 127

S: Estimates of dioxin emissions to air in Sweden

Regarding the PCDD/F-sources investigated within the Swedish Dioxin Survey generally a brief description of processes, sampling procedures and analysis data including congener profiles are given. In most cases, samples taken from production residues and wastes, that is sludge, slags, filter ashes, had been analysed with respect to their content of coplanar PCBs (concentrations are given in PCB-TEQ according to<5>, see table). The results are discussed comparing with information from measurements done apart from the survey and/or in foreign countries.

SOURCE	1987	1992	1995, estimated
Waste incineration	20 - 30	2	2
Hospital ovens	10	0.5	0.5
Hazardous waste incineration	2 - 6	0	0
Traffic	5 - 15	5 - 12	5 - 10
Pulp & paper industry			
- to air	4 - 6	1 - 2	4 - 5
- to water	15 - 30	2	1 - 2
Metal industry	20 - 45	9	8.5
Cement and lime kilns	5 - 10	2	1
Power plants (coal fired)	1	1	1
SUM	82-153	24.5 - 33.5	23 - 30

**S: Discharges from known larger sources in gram TCDD equivalents
(Nordic model); data submitted by Swedish EPA on official request**

In addition, for a certain range of source types no information was gained within the Swedish Dioxin Survey program but estimations are made on the basis of previous measurement or literature data. Here the information on basis data (measurements, statistical activity data) is quite poor and only total emission estimates are given.

As in most inventories from other countries the potential PCDD/F emission sources in the Swedish Dioxin Survey are arranged according to industrial or economic sectors. For the approach chosen for the present study this leads to the problem that in some cases emission estimates are given rather for the entire sector than for individual source types. In the following CORINAIR related summary of the Swedish survey such aggregated data have been split into the CORINAIR source types as far as possible.

So far, the Swedish Dioxin Survey comprises no standardised scheme for indicating the confidential level of activity rates and emission factors used for emission estimation. However, in many cases emission ranges are reported which are based on best-case or worst case assumptions. Therefore comments on data quality have been added for the present study if necessary.

CORINAIR SNAP	ITEM	Emission estimates g I-TEQ/a		
		typ	min	max
	SUM	36.4	13.2	157.0
01	Combustion in Energy Production and Energy Transformation	0.6	0.2	1.9
02	Combustion in Commercial, Residential...	5.1	2.2	12.3
03	Combustion in Industry	14.3	8.0	29.3
04	Production Processes	3.6	0.4	15.1
05	Extraction and Distribution of Fossil Fuels	nd	nd	nd
06	Solvent and Other Product USE	nd	nd	nd
07	Road Transport	0.6	0.2	2.3
08	Other Mobile Sources and Machinery	0.8	0.1	7.2
09	Waste Treatment and Disposal	3.5	1.3	9.7
10	Agriculture, Forestry, Land use change	nd	nd	nd
11	Nature	nd	nd	nd
12	Fires	7.9	0.8	79.1

S: annual PCDD/F AIR emissions (nd: no data available)

Preliminary estimates of PCDD/PCDF emissions from various sources in Sweden during 1993 given in grams of Nordic TCDD equivalents (NTEQ). Please note that several sources have not yet been estimated and are not included (textile industry, dry cleaning etc.).

INDUSTRY	TO AIR	TO WATER	IN WASTES	IN PRODUCTS
Bleached kraft pulp	1	1.5 - 5		0.3 - 6.6
Recycled paper pulp				2.8
Chloralkali plants		0.28 - 0.6	0.25	
Mercury distillation	0.000005	0.003	0.004	
Sewage sludge		0.11	2.9	1.5
Steel mills	1.6 - 4		8.2	
Scrap steel mills	0.4 - 15		20	
1° non-ferrous smelters	0.13 - 0.27		0.38	
2° non-ferrous smelters	4.3		2.1	
Foundries	0.007 - 0.49		0.82 - 15	
Cement kilns - gases	0.07 - 1.3			
Cement kilns - dust	0.28			
Lime burning - 1° prod.	2 - 2.5			
Lime burning - industrial use	0.5 - 1.9			
Ceramic salt glazing	0.02			
INCINERATION				
Glassfiber waste	0.00006			
Municipal waste	3.0		0.6 - 2.4	
Hazardous waste	0.007			
Hospital waste	0.001			
Cremation	0.37 - 0.73			
Uncontrolled landfill fires	2.8 - 30			
Illegal metal reclamation	?		?	
HEATING/ENERGY				
Oil	0.1 - 2.5			
Coal	0.61			
Natural gas	0.04			
Woodburning stoves	2.1 - 9.8			
Other biofuels	1.4 - 7.7			
TRAFFIC				
Ferries (gas oil, heavy oil)	0.63			
Planes (aviation fuel)	0.02 - 0.86			
Vehicles - diesel	0.073 - 0.15			
gasoline - leaded	0.009 - 0.97			
gasoline - unleaded	0.14 - 0.27			
TOTALS	21.6 - 88	1.6 - 5.1	35 - 52	4.6 - 11

S: PCDD/F emission estimates according to the Swedish Dioxin Survey<4>

Sweden

01 01 - 03 01 05

Combustion for Heat and Energy Production

01 01 - 03 01 05

Combustion for Heat and Energy Production

General remark:

This source was not studied within the Swedish Dioxin Survey. Some information about fuel use is given. Coal is burned mainly in power plants; the majority of heating oil is used in households and central heating boilers; except about 5 % which is used for ships and ferries. Nothing is said regarding to the type of installations consuming natural gas.

On basis of the mentioned data only coal consumption is considered here; emissions caused by burning the other fuels is considered under „02 02 05 domestic combustion“ and 08 04 „maritime activities“, respectively.

Considered pathways or media:

Air

Plant data:

No information on numbers or technical facilities or about fossil fuelled industrial furnaces is given.

Measurements:

No data from Sweden

National activity rates:

Year	1990	1993
coal consumption [kt/a]	2,139	1,752

S: Combustion for Heat and Energy Production; activity rates

Estimation of uncertainty:

As no Swedish measurements exist, the index „1“ is proposed here regarding the emission factor.

Combustion for Heat and Energy Production

Activity rates	0
emission factors	1
total uncertainty	1

S: Combustion for Heat and Energy Production; activity rates

Emission factors:

An emission factor of 0.35 µg/t as reported in the Dutch inventory is used.

Estimation of annual emission:

Year	1990	1993
Annual emission [g I-TEQ]	0.75	0.61
Margin of uncertainty	0.23 - 2.3	0.19 - 1.9

S: Combustion for Heat and Energy Production; annual PCDD/F emissions

Sweden

02 02 05

Other equipments (stoves, fireplaces, cooking...)

02 02 05

Other equipments (stoves, fireplaces, cooking...)

General remark:

Considered here is the domestic burning of heating oil, natural gas and wood

Considered pathways or media:

Air

Plant data:

No information is given about facilities for burning oil or natural gas. Regarding wood burning stoves it is stated that most of them are not equipped with high temperature chambers. From 767,000 households being capable of using wood burning boilers and stoves as primary heating source about 516,000 are assumed to do so. Additionally, 386,000 households have facilities used as secondary heating sources.

Measurements:

Measurements performed at wood burning facilities with high temperature chambers have been reported by the Swedish EPA<6>; details are not given in the report summarised here.

National activity rates:

Consumption rates for the different types of fuels are as follows:

Year	1990	1993	
light oil	2,940	2,492	kt/a
heavy oil	2,280	2,587	kt/a
natural gas	660	850	Mm ³ /a
wood	3,000 - 6,900	2,100 - 4,900	kt/a

S: Other equipments (stoves, fireplaces, cooking...); activity rates

Emission factors:

Heating Oil:

Other equipments (stoves, fireplaces, cooking...)

Taken from the literature; emission factors of $0.017 \mu\text{g}/\text{m}^3$ <7> and $0.5 \mu\text{g I-TEQ}/\text{t}$ <8> are used

Natural Gas:

The emission factor $0.05 \text{ ng I-TEQ}/\text{m}^3$, as reported by Bröker <7> is adopted.

Wood:

The test results indicate an emission factor range of $35.7 - 53.6 \text{ pg I-TEQ}/\text{kWh}$ ($10-15 \text{ pg I-TEQ}/\text{MW}$). With an average energy content of wood of $1.24 \text{ MWh}/\text{m}^3$ and an upper limit of wood density (0.22 to $0.5 \text{ t}/\text{m}^3$, depending on the water content) an emission factor range of $0.13 - 0.3 \mu\text{g}/\text{t}$ is calculated for stoves working at elevated temperatures.

(Comment: emission factors could be calculated more directly using conversion factors of $2.4-5.4 \text{ MWh}/\text{ton}$ wood which reflect the different water content. This would result in emission factors ranging from $0.086 \mu\text{g}/\text{t}$ to $0.298 \mu\text{g}/\text{t}$).

Comparing with results from foreign studies <7>, <8>, <9>, <10> generally reporting higher emission factors and having in mind that most of the Swedish stoves operate at lower temperatures overall emission factors ranging from

1 to $2 \mu\text{g}/\text{t}$ are obtained.

Estimation of uncertainty:

Considering the activity rates to be exactly known, an uncertainty is introduced by the emission factor. This leads to the following indication:

Activity rates	0
emission factors	1
total uncertainty	1

S: Other equipments (stoves, fireplaces, cooking...); indices of uncertainty

However, since the Swedish survey reports ranges for activity rates and emission factors, these values are used here for further calculation.

Estimation of annual emission:

With the data mentioned above, following emissions are estimated:

Sweden

02 02 05

Other equipments (stoves, fireplaces, cooking...)

	1990	1993
heating oil	0.1-2.6	0.1-2.5
natural gas	0.03	0.04
wood	3-13.8	2.1-9.8

S: Other equipments (stoves, fireplaces, cooking...); annual PCDD/F emissions [g N-TEQ]

Comment:

No information is given on the possible burning of treated wood; the emissions are regarded therefore to be valid for burning of clean material only.

Other stationary equipments (combustion of special fuels)

03 01 06**Other stationary equipments (combustion of special fuels)***General remark:*

Data are available for „biofuels“, including wood, woodchips, peat and different types of industrial wastes.

Considered pathways or media:

Air

Plant data:

Facilities for burning the biofuels mentioned above are assumed to have smoke-stack gas cleaning systems, thus being comparable to those installations that have been investigated by S-EPA.

Measurements:

see 02 02 05

National activity rates:

	TWh/a	kt/a
1990	53	9,300 - 21,400
1993	64	11,000 - 25,800

S: Other stationary equipments (combustion of special fuels); activity rates

The total energy consumption given in TWh/a is converted to mass consumption assuming that the whole fuel consisted of wood.

Emission factors:

The emission factor of 0.13 - 0.3 µg I-TEQ/t as reported by S-EPA (see 02 02 05) is used for emission estimation

Sweden

03 01 06

Other stationary equipments (combustion of special fuels)

Estimation of uncertainty:

Considering the activity rates to be nearly exact, an uncertainty is introduced by the emission factor. However, similar to the previous category the reported ranges are used for the emission estimation instead of the index-based approach:

Activity rates	0
emission factors	1
total uncertainty	1

S: Other stationary equipments (combustion of special fuels); indices of uncertainty

Estimation of annual emission:

	1990	1993
g I-TEQ/a	1.2 - 6.4	1.4 - 7.7

S: Other stationary equipments (combustion of special fuels); annual PCDD/F emissions

Comment:

Emissions are likely to be underestimated considering the different type of fuels and the possibility that they might contain contaminated parts.

03 03 01**Sinter plants***Considered pathways or media:*

Air

Plant data:

In Sweden, one sinter plant equipped with a cyclone dust collector (location: Öxelösund) and 3 pelletising plants (location: Kiruna, Svappavaara, Malmberget) are in operation. The sinter plant is to be closed down in 1995.

Measurements:

Smoke stack gases from the sinter plant were measured in 1990 to contain 0.86 ng NTEQ/m³ (mean of two measurements; 0.46 and 1.3 ng NTEQ/m³). Measurements were also performed at the pelletising plants but no flew gas concentrations are reported. Coplanar PCBs have not been measured in flew gases

National activity rates:

The Swedish survey provides no data; however from given emission factors and emission estimates a recalculation could be made indicating an annual activity rate of 1,300 kt, most probably referred to consumption of iron ore. Similarly, for the pelletising installations a consumption of 3,300 kt of iron ore is calculated.

Emission factors:

The range of emission factors is said to be 1 - 2.8 µg/t (referring to sinter material?) for the sinter plants; for pelletising plants, emission factors of 0.024 and 0.01 µg Eadon TEQ/t iron ore are given.

Estimation of uncertainty:

Despite the exact values of the activity rates are not reported it is assumed here, that they have been known quite exactly when calculating the PCDD/F emissions. Since the

Sweden

03 03 01

Sinter plants

majority of the plants have been investigated an index of „0“ is also applied regarding the emission factors.

Activity rates	0
emission factors	0
total uncertainty	0

S: Sinter plants; indices of uncertainty

Estimation of annual emission:

		annual emission
sinter plant	1.3 - 3.7	g NTEQ/a
pelletising plants	0.04 - 0.11	g Eadon/TEQ/a

S: Sinter plants; annual PCDD/F emissions to air

The low emissions from the pelletising plants would be even less if expressed in NTEQ.

Comment:

The data base regarding this very important source type is quite poor; however, reported emissions are of the same order as reported from plants in other countries. Air emissions from the whole iron and steel industry were dominated by the sinter plant; this will change largely after the plant's closure.

Grey iron foundries**03 03 03****Grey iron foundries**

Considered pathways or media:

Air, residues

Plant data:

50 larger companies with more than 5 employees and an unknown number of smaller facilities were in operation in 1993. Three iron foundries using induction furnaces and one foundry using a cupola furnace (with recuperator for flew gas combustion) were investigated within the Swedish Dioxin Survey.

Measurements:

Smoke-stack gas samples and diverse samples of solid residues have been collected. The flew gas concentrations measured ranged from almost zero (0.00004 ng NTEQ/m³, cupola furnace) to 0.036 ng/m³ measured at one of he induction furnaces. Diffuse emissions connected with the operation of the cupola furnace have not been quantified.

Concentrations found in the solid samples are shown in the following table:

Furnace type	sample type	PCDD/F [pg NTEQ/g]
induction	Filter dust	23,000
induction	exhaust dust from ventilation ducts	11
induction	shake out filter dust	0.93
induction	surface swipe from working hall	970 pg/dm ³
cupola	scrubber sludge	440

S: Grey iron foundries; measurement results

Additionally, the PCB content in the scrubber sludge sample was determined to be 110 pg PCB-TEQ/g.

National activity rates:

Total production of castings amounts to about 310,000 tons per year; of this total, 84 % or 260,400 tons are produced in iron foundries and 4 % or 12,400 tons in

Grey iron foundries

steel foundries. Estimates of the annual amounts of solid residues' production are shown in the following table.

Type of residue	Annual production [tons]	comment
scrubber sludge	1,800	approx. 50 % produced by the investigated foundry equipped with cupola furnace
sand waste	150,000 - 200,000	
filter dust	600	
slag	31,000	not analysed

S: Grey iron foundries; activity rates

Emission factors:

Air:

From the minimal and maximal concentrations obtained emission factors ranging from 0.01 to 3.5 µg NTEQ/ton castings may be evaluated. However, the calculations of emissions are made with the following values:

Parameter	Emission factor [µg NTEQ/t]
Minimal	0.02
Maximal	1.9
geom. mean	0.41
arithmetic mean	0.86

S: Grey iron foundries; emission factors

Here the emissions found for the cupola furnace/recuperator were disregarded.

Residues:

The measured concentrations serve as emission factors directly.

Estimation of uncertainty:

The emission factors used cover a range of two orders of magnitude; the activity rates are considered to be exactly known.

Activity rates	0
emission factors	2
total uncertainty	2

S: Grey iron foundries; indices of uncertainty

Grey iron foundries*Estimation of annual emission:***Air:**

For calculation of the total emission the annual production of the cupola furnace foundry (about 60,000 tons/a) was subtracted from the national production of castings (310,000 tons/a) to give 250,000 tons. Obviously, this value includes the production of non-ferrous metal castings and is used erroneously by the authors of the Survey. Taking this wrong production rate the emission is estimated to be

0.007 - 0.409 g NTEQ/a.

Including steel castings, a production rate of 212,800 tons/a may be a better base for emission estimation. With the emission factors shown above (geom. mean) the atmospheric emissions from iron foundries in Sweden is therefore estimated to be

	g I-TEQ/a
annual emission	0.087
margin of uncertainty	0.009 - 0.87

S: Grey iron foundries; annual PCDD/F emissions to air

Estimates for PCDD/F and PCB emissions via residues are given as follows:

Type of residue	Annual emissions [g NTEQ/a; g PCB-TEQ/a]	comment
scrubber sludge	0.79 ; 0.2	placed in deposition sites, location not given
sand waste	0.02 ; ?	placed in deposition sites, location not given
filter dust	0.007 - 14 ; ?	placed in deposition sites, location not given
slag	? ; ?	not analysed

S: Grey iron foundries; annual PCDD/F emissions via residues

Sweden

03 03 04

Primary lead production

03 03 04

Primary lead production

General Remark:

See 03 03 06

Primary zinc production

03 03 05

Primary zinc production

General Remark:

See 03 03 06

Sweden

03 03 06

Primary copper production

03 03 06

Primary copper production

Considered pathways or media:

Air, residues

Plant data:

A primary smelter is described producing diverse non ferrous metals with copper being about 50% of the products. The plant uses ores and secondary materials (electronic scrap and plastic covered cables as well). It is a large and complex operation consisting of numerous activities (90 emission points).

Measurements:

Samples were taken from different steps in the complex processes applied. These comprise smoke stack gas samples from a converter plant (Copper process), slag fuming plant (zinc and lead recovery), clinker plant (separation of mixed lead and zinc oxides) and sulphuric acid and sulphur dioxide plant (central gas cleaning system). In addition, sludge samples from a venturi scrubber at the so-called lead kaldo shop, filter dust from the clinker plant and sludge from the waste water treatment plant were analysed.

Emission point	PCDD/F [ng NTEQ/m ³]
Converter plant	0.001
Slag fuming plant	0.01 - 0.04
Clinker plant	0.19 - 2.0
Sulphuric acid plant	0.00002
Sulphur dioxide plant	0.0007

S: Primary copper production; measurement results

Emission point	sample type	PCDD/F [pg NTEQ/g]	PCB [pg PCB-TEQ/g]
Lead kaldo shop	Venturi sludge	1,500	160
Clinker plant	filter dust	440	20
Waste water treatment plant	sludge	25	3.4

S: Primary copper production; measurement results

Primary copper production

National activity rates:

The plant considered here produces about 350 kt per year of primary products (copper, lead, zinc, precious metals).

Emission factors:

Emission factors are not mentioned explicitly in the report.

Estimation of annual emission:

Emissions are actually associated with smoke-stack gases (0.13 - 0.27 g NTEQ/a) and with the waste water sludge (0.35 g NTEQ/a and 0.05 g PCB-TEQ/a) which is dumped on an open deposition site on the industry grounds. Venturi sludge from the lead kaldo shop and filter dust from clinker plant are internally recycled and thus do not cause emissions.

Estimation of uncertainty

According to the authors an underestimation of total emission from the considered plant is assumed, because less than 50% of emission points are monitored and fugitive emissions of contaminated dusts have not been assessed.

Comment:

Because the production rates of the diverse metals are not given in detail, only an overall emission factor might be recalculated from the estimated emissions and the total output of the plant complex. However, this is not considered to be useful.

Sweden

03 03 07

Secondary lead production

03 03 07

Secondary lead production

General remark:

The secondary production of non ferrous metals in Sweden is surveyed as a whole in the Swedish report. Therefore, it is difficult to assign the given information to the special CORINAIR source categories in all cases. About 18 facilities in the secondary non ferrous metal industries are known in Sweden, 8 larger requiring national licensing and 10 smaller installations. Total production amounts to 370,000 tons per year. Air emissions for all installations together are estimated to be 4.3 g NTEQ/a for 1991 and 4.9 g NTEQ/a for 1993. Via waste streams 2.1 g NTEQ/a PCDD/Fs and 0.12 g PCB-TEQ are emitted annually.

Considered pathways or media:

Air, residues

Plant data:

One lead-producing plant is mentioned in the report, no technical or other plant related information is given

Measurements:

No specific measurements at lead producing plants are reported

National activity rates:

No data given in the Swedish survey; from metal statistics a production of 91,200 tons of lead is reported for 1992. On basis of the reported emission factor and the annual emission the activity of the investigated plant is recalculated to be 45,236 tons and thus accounts for more than 50% of the total.

Secondary lead production

Emission factors:

An air emission factor of 19 µg NTEQ/t is given for one plant that has been measured apart from the Swedish Dioxin Survey.

Estimation of uncertainty:

Without having any data on other plants and on additional measurement results, the emission factor has to be considered as being quite uncertain. At least an index of „1“ should be applied. With the activity rates taken from metal statistics (index „0“) following estimate results:

Activity rates	0
emission factors	1
total uncertainty	1

S: Secondary lead production; indices of uncertainty

Estimation of annual emission:

From the reported emission factor and the total production the total annual emission into the atmosphere is calculated to be

	g I-NEQ/a
annual emission	1.73
margin of uncertainty	0.54 - 54

S: Secondary lead production; annual PCDD/F emissions to air

Nothing can be said with respect to emissions via production residues and wastes.

Sweden

03 03 08

Secondary zinc production

03 03 08

Secondary zinc production

General remark:

The secondary production of non ferrous metals in Sweden is surveyed as a whole in the Swedish report. Therefore, it is difficult to assign the given information to the special CORINAIR source categories in all cases. About 18 facilities in the secondary non ferrous metal industries are known in Sweden, 8 larger requiring national licensing and 10 smaller installations. Total production amounts to 370,000 tons per year. Air emissions for all installations together are estimated to be 4.3 g NTEQ/a for 1991 and 4.9 g NTEQ/a for 1993. 2.1 g NTEQ/a PCDD/Fs and 0.12 g PCB-TEQ are emitted annually via waste streams.

Comment:

No data are given specifically related to zinc production

Secondary copper production**03 03 09****Secondary copper production***General remark:*

see 03 03 08

Considered pathways or media:

Air, residues

Plant data:

Of the above mentioned 18 plants two of the larger ones are described in more detail. They are located at Västerås and Finspång producing copper goods. Relatively clean scrap is used as input material. Another plant located at Mölndal produces aluminium and copper and is considered under 03 03 10.

Measurements:

Analyses have been made at samples from a briquetting furnace and a combined smelter and casting furnace operating at Västerås. From the smelter in Finspång smoke stack samples have been taken at the combined melting and casting furnace.

The PCDD/F concentration range in smoke-stack gases was found to be 0.03 - 0.027 ng NTEQ/m³; filter dust from the briquetting furnace contained 12 ng NTEQ/g (PCDD/F) and 1.3 ng PCB-TEQ/g (PCB).

National activity rates:

The two plants investigated produce 61 kt/a and 48 kt/a, respectively.. Total secondary copper production rates are not given in the report. However, by comparison to data available from metal statistics (101.6 kt secondary copper in 1992) follows, that at the two plants almost the entire national production of secondary copper takes place.

Secondary copper production

Emission factors:

Emission factors of 0.024 µg/t and 0.04 µg/t could be derived from the measurement results. Additionally, based on previous studies an emission factor of 2.7 µg/t for a copper and brass smelter is reported. Since the corresponding activity rate must nearly be negligible, this emission factor is disregarded for the following calculation.

Estimation of uncertainty:

No indices of uncertainty are applied here since the emissions from the entire production of secondary copper may be described by the range of emission factors found.

Estimation of annual emission:

For secondary copper production no specific figures are explicitly mentioned in the report. For the investigated installations it can be calculated, that the air emissions range between 0.026 g NTEQ/a and 0.29 g NTEQ/a. These emissions may be indicated as the national emissions for the source type considered here.

Filter dust is recycled in another smelter plant and hence does not cause emissions.

Secondary aluminium production**03 03 10****Secondary aluminium production***General remark:*

The secondary production of non ferrous metals in Sweden is surveyed as a whole in the Swedish report. Therefore, it is difficult to assign the given information to the special CORINAIR source categories in all cases. About 18 facilities in the secondary non ferrous metal industries are known in Sweden, 8 larger requiring national licensing and 10 smaller installations. Total production amounts to 370,000 tons per year. Air emissions for all installations together are estimated to be 4.3 g NTEQ/a for 1991 and 4.9 g NTEQ/a for 1993. 2.1 g NTEQ/a PCDD/Fs and 0.12 g PCB-TEQ are emitted annually via waste streams.

Considered pathways or media

Air:

Plant data:

Two aluminium smelters located in Mölndal and Älmhult are described in the survey. The first plant partly uses mixed raw materials and produces copper goods also. The Älmhult plant is a secondary aluminium smelter using rotating furnaces. The melted scrap is covered by a salt layer, which forms a salt slag together with scrap contaminants. This slag is deposited at the city landfill. Flue gases are cleaned by bag filters. The melted metal from the rotating furnaces is transferred to a combined refining and casting furnace. Nitrogen and chlorine are used for cleaning the metal prior to alloy addition. Exhaust gases are treated by an venturi scrubber.

Besides the two plants at least one facility for secondary aluminium production exist with a reported emission factor.

Measurements:

Measurements have been performed at the two described plants. Samples have been drawn from different emission points and partly under different operation conditions:

Secondary aluminium production

Smoke-stack gases of the Älmhult plant have been previously analysed apart from the Swedish dioxin survey.

Plant	Input material	Sample type	PCDD/F [ng NTEQ/m ³] or [pg NTEQ/g]	PCBs [pg PCB- TEQ/g]
Mölnadal	Aluminium and brass	Smoke-stack gases	0.055	NA
	Aluminium only	Smoke-stack gases	0.019	
	Brass only	Smoke-stack gases	0.053	NA
	Aluminium and brass	Filter dust	9,700	NA
Älmhult	Aluminium, rotating furnace	Salt slag	11	0.58
	Aluminium, rotating furnace	Filter dust	3,000	200
	Aluminium refining and casting furnace	Venturi scrubber sludge	4,800	370

S: Secondary aluminium production; measurement results*National activity rates:*

No nation-wide data are given; the production of the plants under investigation was 15,000 tons aluminium (Älmhult) and 6,000 tons copper/1500 tons aluminium (Mölnadal), respectively.

A total production of 22,100 tons secondary aluminium is reported from 1992 metal statistics.

*Emission factors:***Air:**

For the Mölnadal plant a factor of 17 µg NTEQ/t is reported; however, this emission factor is an integrated value reflecting copper and aluminium production. Previous results obtained for the Älmhult facility showed an emission factor of 100 µg NTEQ/t. Additionally, an emission factor of 7.3 µg NTEQ/t is reported for another plant not investigated in the survey. Thus, emission factors found for Swedish secondary aluminium plants range from 7.3 to 100 µg NTEQ/t.

Secondary aluminium production

No emission factors are evaluated for emissions associated with filter dust and slags.

Estimation of uncertainty:

Since the emissions corresponding to a large part of the annual production are evaluated directly (see below) no indices are applied here.

Estimation of annual emission:

Air:

Annual emissions are given explicitly for the two measured plants and amount to 0.13 g NTEQ/a and 1.5 g NTEQ/a for the Mölndal and Älmhult plant, respectively. No information is given how much of the Mölndal emissions are associated with aluminium production. However, this contribution may be estimated by comparing the relation between concentrations found in smoke-stack gases when producing only aluminium (0.019 ng NTEQ/m³) or only brass (0.055 ng NTEQ/m³) taking into account the respective annual production rates (1500 t/6,000 t). It follows that secondary aluminium production contributes with 11.2 mg NTEQ, while copper production is responsible for more than 90% of the emissions.

Emissions for the for the remaining 5,600 tons of produced aluminium is estimated using the emission factor range given above and ranges from 0.04 to 0.56 g NTEQ. Hence, total emission from the source category considered here may be

1.55 to 2.07 g NTEQ/a

Residues:

From the concentrations found in filter dust samples the authors of the Swedish survey estimate total emissions for the non ferrous smelters to be 2.1 g NTEQ/a and 0.12 g PCB-TEQ/a. This estimation includes copper production in the Mölndal plant; due to lack of sufficient data a re-evaluation of the emissions connected with aluminium production only seems not possible.

Sweden

03 03 11

Cement

03 03 11

Cement

Considered pathways or media:

Air

Plant data:

Three plants exist in Sweden

Measurements:

An extensive study on smoke-stack gas emissions was performed in 1989 by the Skövde cement plant. Concentration ranged between 0.003 and 0.1 ng NTEQ/m³ (14 samples, mean 0.035 ng NTEQ/m³). Additionally analyses within the Swedish Dioxin Survey compared quite well to these results indicating a concentration range of 0.005 to 0.1 and a mean of 0.039 ng NTEQ/m³.

A filter dust sample taken at the plant in Slite contained 510 pg NTEQ/g PCDD/F and 0.57 pg PCB-TEQ/g PCBs. Only the finest of three dust fractions was analysed in this case.

National activity rates:

Annual production rates given in the report are as follows:

Plant	1990	1993
Slite	1,650	1,650
Skövde	568	360
Degerham	130	230
Total	2,348	2,240

S: Cement; activity rates

In order to make an estimation of emissions associated with operation interrupts dust emissions caused by these conditions are listed:

Plant	1990	1993
Slite	550	450
Skövde	110	50
Degerham	30	40
Total	690	540

S: Cement; annual PCDD/F emissions of process related cement dust [t/a]

Emission factors:

Air:

From the Survey results mentioned above emission factors ranging from 0.03 to 0.56 μg NTEQ/t are derived by relating the annual emission of the Skövde plant (0.018 - 0.32 g NTEQ/a, way of calculation not explained) to its annual production rate.

Interrupt emissions:

The concentration in filter dust found serves as emission factor directly.

Estimation of uncertainty:

With the given range of emission factors an uncertainty index of „2“ is appropriate for this parameter, while production statistics are taken as being accurate.

Activity rates	0
emission factors	2
total uncertainty	2

S: Cement; indices of uncertainty

Estimation of annual emission:

Air:

On basis of the production rates and the emission factor range the annual PCDD/F emission into the atmosphere is estimated to be 0.07 - 1.3 g NTEQ/a with a typical value (geom. Mean) of 0.3 g NTEQ/a for 1991 as well as for 1993.

Additionally, emissions during production interrupts have to be considered. Assuming that the entire dust emitted during production interrupts consists of the fine fraction; then emissions of at most 0.350 g NTEQ and 0.00039 g PCB-TEQ (1991) and 0.275 g NTEQ and 0.00031 mg PCB-TEQ (1993) are estimated.

Sweden

03 03 11

Cement

Comment:

The authors add the remark, that filter dust usually is returned into the production process; hence, the product itself, cement, might be contaminated with PCDD/F and PCBs.

Lime (incl. iron/steel ind. and Paper pulp ind.)

03 03 12**Lime (incl. iron/steel ind. and Paper pulp ind.)***Considered pathways or media:*

Air

Plant data:

There are six major lime plants in Sweden that produce and sell burned lime. In addition, burned lime is produced at several industries for their own use, that is in steel plants (2), bleached kraft pulp mills (15) and sugar refineries (4). The latter use lime for CO₂ generation which is used in the sugar making process. Hence no exhaust gases are emitted from these plants.

Measurements:

Within the Survey, two smoke stack samples from one plant were analysed; concentrations were 0.0034 and 0.0075 ng NTEQ/m³. More data exist from previous measurements at all six lime plants with a concentration range of 0.01-0.03 ng NTEQ/m³. PCDD/F emissions from lime furnaces at bleached kraft pulp mills were also investigated, but no concentration data are given. No information exists about lime plants at steel manufactories.

Parameter	concentrations [ng I-TEQ/m³]
Minimal	0.0034
Maximal	0.03
geom. mean	0.01
arithmetic mean	0.017

S: Lime (incl. iron/steel ind. and Paper pulp ind.); measurement results*National activity rates:*

Plant specific production rates related to the six larger plants and to plants of the iron and steel industries are reported for 1991 and 1993:

Lime (incl. iron/steel ind. and Paper pulp ind.)

	1990	1993
Lime plants	421,862	361,961
Iron/steel	61,282	118,600
Total	483,164	480,561

S: Lime (incl. iron/steel ind. and Paper pulp ind.); activity rates

Emission factors:

Emission factors used for estimation of the annual emissions are shown below:

Parameter	Emission factor [µg I-TEQ/t]	
	1991	1993
Minimal	0.01	0.01
Maximal	94	11.2
geom. mean	0.97	0.33
arithmetic mean	47	5.6

S: Lime (incl. iron/steel ind. and Paper pulp ind.); emission factors

These factors were derived from total emissions (probably company information) and annual production rates. The survey gives no information with respect to the decrease of the maximum emission factor.

Estimation of uncertainty:

According to the data shown above, an uncertainty of at least 3 powers must be assigned to the emission factors; activity rates are exactly known.

Activity rates	0
emission factors	3
total uncertainty	3

S: Lime (incl. iron/steel ind. and Paper pulp ind.); indices of uncertainty

Estimation of annual emission:

Emission data of four of the six larger plants are given explicitly and are most probably based on company information. Emissions of the remaining two plants and for the plants in iron and steel industry is estimated using the emission factor ranges shown above. Emissions from plants in bleached kraft pulp mills are taken from literature [1]. Thus, the following figures are given:

Lime (incl. iron/steel ind. and Paper pulp ind.)

	1990	1993
Large lime plants	9.8-18	2.0-2.5
steel industry	0.0006-6.3	0.0005-1.35
pulp mills	<0.5	<0.5
Total	10.3 - 24.3	2.5 - 4.35

S: Lime (incl. iron/steel ind. and Paper pulp ind.); annual PCDD/F emissions

Since these data are largely based on individual plant data no use is made here of the average uncertainty approach for emission factors.

Sweden

03 03 20

Fine ceramic materials

03 03 20

Fine ceramic materials

General remark:

Considered here is a traditional manufactory for glazed ceramics

Considered pathways or media:

Air

Plant data:

Glazing of stoneware is done at 1,250 °C with a mixture of sodium chloride, charcoal and water. Five tons of stoneware are treated each time; the process is performed once every two months. No flew gas cleaning device is installed. This plant is the only one being investigated; no information is given of other installations producing ceramic product exist in Sweden.

Measurements:

Dust samples were taken from the stack wall (25 m up) and from exhaust cages over the oven. The concentrations were 17,000 pg NTEQ/g and 1,400 pg NTEQ/g, respectively.

National activity rates:

According to the plant described above 30 tons of stoneware were produced in 1990; in 1993 the production increased to 60 tons.

Emission factors:

No emission factor was derived.

Estimation of uncertainty:

Despite the data base is quite poor and introduces a high degree of uncertainty no indices are calculated since the activity rates are almost negligible.

Fine ceramic materials

Estimation of annual emission:

Although the measurement results indicate that flew gas concentration may be high a total emission of less than 0.01 g NTEQ/a (1991) is estimated due to the small scale production. For 1993 this figure is estimated to be less than 0.02 g NTEQ/a

Sweden

03 03 26

Other - metal reclamation from cables

03 03 26

Other - metal reclamation from cables

Considered pathways or media:

Residues

Plant data:

There is no information about illegal wire reclamation facilities in Sweden. Only one dump was found and investigated.

Measurements:

Two samples have been drawn from a dump site where plastic covered cables had been incinerated illegally. The ashes contained 5,500 and 6,400 pg NTEQ/g. The total PCDD/F content in the estimated 3 - 5 m³ ash would be about 0.02 - 0.04 g NTEQ.

National activity rates:

No data available

Emission factors:

No data available

Estimation of annual emission:

No data available

Comment:

The authors of the Swedish Dioxin Inventory conclude:

„Illegal wire and cable burning can be a significant local source and measures should be taken to find and stop such activities. Wastes created by this type should be removed and placed in proper deposition sites as they represent uncontrolled releases to the environment“.

Coke oven (door leakage and extinction)
04 02 01**Coke oven (door leakage and extinction)***Considered pathways or media:*

Residues

Plant data:

Both steel plants currently operating in Sweden have integrated coke plants. Effluents of the coke plants (from wet scrubber) are treated at biological waste water treatment plants, at one plant sand filtration follows.

Measurements:

Sludge samples have been taken from the waste water treatment facilities connected to the two coke ovens. PCDD/F concentrations are reported to be 0.33 and 12 pg NTEQ/g, respectively. Coplanar PCBs were analysed in one sample and found to be 1 pg PCB-TEQ/g.

National activity rates:

No data are reported

Emission factors:

No data are reported

Estimation of uncertainty:

Since the emissions are calculated directly from measurement results, the uncertainty can be considered as low:

Activity rates	-
emission factors	-
total uncertainty	0

S: Coke oven (door leakage and extinction); indices of uncertainty

Sweden

04 02 01

Coke oven (door leakage and extinction)

Estimation of annual emission:

Total PCDD/F emissions are 0.31 g NTEQ; the measured PCB concentration translates into an annual release of 0.02 g PCB-TEQ.

Comment:

Diffuse emissions into the air were not considered!

04 02 03**Pig iron tapping**

Considered pathways or media:

Air, residues

Plant data:

Blast furnaces exist in the two integrated iron and steel plants in Öxelösund and Luleå. Dust containing exhaust gases are cleaned in wet electrostatic precipitators forming sludge (slag is produced from the lime added to the furnace charge). Dust is also collected before to wet precipitation.

Another type of plant that produces spongy iron and iron powder located at Höganäs uses solid state reduction processes instead of melting.

Measurements:

Measurements have been carried out with respect to blast furnaces. While the dry dust has not been analysed for PCDD/F, sludge and slag have been measured in 1992/93; results are shown in the following table:

	Dioxins [pg NTEQ/g]	PCB [pg PCB-TEQ/g]	
Oxelösund	0.001	0.05	slag
	0.03	0.08	sludge
Luleå	0.18	0.01	slag
	0.09	0.07	sludge

S: Pig iron tapping; measurement results in residues

No measurement results are available from the plant in Höganäs.

National activity rates:

No information about total national production rate is given.

The Höganäs plant is estimated to produce 95,000 tons of spongy iron and iron powder and an amount of 21,000 t/a of wastes annually. No specific data for the analysed

Sweden

04 02 03

Pig iron tapping

wastes generated by blast furnaces are reported; dust collected before the wet precipitation in these plants amounts to 28,300 tons/a.

Emission factors:

No emission factors are evaluated

Estimation of uncertainty:

Due to the poor data base the uncertainty of the following estimates cannot be assessed!

Estimation of annual emission:

Blast furnaces:

PCDD/F and PCB emissions in residues are estimated to be 41.65 mg NTEQ/a and 16.5 PCB-TEQ/a, respectively.

Höganäs plant:

Air emissions are estimated to be less than 0.1 g NTEQ/a, emissions associated with wastes are not assessed.

Basic oxygen furnace steel plant
04 02 06**Basic oxygen furnace steel plant**

Considered pathways or media:

Air, Residues

Plant data:

The steel plants in Lulea and Öxelösund use BOFs; these facilities are encapsulated in a „dog-house“.

Measurements:

PCDD/F concentrations in smoke-stack gases at the Lulea plant (presumably at different emission points and not specifically at the BOF) were measured in 1988. Values are not reported (however, see below).

Scrubber sludge and secondary filter dust (from „dog house“) were analysed for PCDD/Fs and PCBs.

	Dioxins [pg NTEQ/g]	PCB [pg PCB-TEQ/g]	
Oxelösund	0.65	0.29	scrubber sludge
	150	5.3	filter dust
Luleå	1.7	0.39	scrubber sludge
	290	9.9	filter dust

S: Basic oxygen furnace steel plant; measurement results

National activity rates:

The entire steel production in Sweden is said to be 4,500,000 tons per year, including secondary steel production. 3,000,000 tons of steel are produced by the ore based plants mentioned above.

Amounts of the annual production of sludge and filter dust are not given. Additionally to these types of wastes about 430,000 tons of slag as well as 2,400 tons of oxide scale sludge are produced (both not analysed)

Sweden

04 02 06

Basic oxygen furnace steel plant

Emission factors:

In case of the Lulea steel plant, an overall emission factor for emissions to AIR has been evaluated to be 0.006 µg/t

Residues:

No data are given, but emission factors may be calculated from reported annual emissions and production rates:

	Emission factor [µg NTEQ/t]
scrubber sludge	0.023
filter dust	2.71

S: Basic oxygen furnace steel plant; emission factors (recalculated)

Estimation of uncertainty:

The data given in the Swedish survey do not allow for recalculation of the emission estimates shown below. Other, information is lacking which would suffice for an estimation of the uncertainties.

Estimation of annual emission:

Air:

Emissions from Lulea steel plant were estimated to be less than 0.01 g NTEQ/a;

Residues:

Only for wastes that have been analysed totally PCDD/F and PCB emissions are reported:

		Dioxins [mg NTEQ/a]	PCB [mg PCB-TEQ/a]
Oxelösund	scrubber sludge	0.3	0.15
	filter dust	300	10.6
Luleå	scrubber sludge	68	16
	filter dust	7,830	270

S: Basic oxygen furnace steel plant; annual PCDD/F emissions with production residues

Basic oxygen furnace steel plant

From the data shown above it follows that total emissions are 8.2 g NTEQ/a (PCDD/Fs) and 0.31 g PCB-TEQ/a (PCBs)

Comment:

Air and Water emissions not considered generally!

Sweden

04 02 07

Electric furnace steel plant

04 02 07

Electric furnace steel plant

Considered pathways or media:

Air, Residues

Plant data:

In Sweden 10 scrap based steel mills with electric arc furnaces are in operation

Measurements:

Slag and sludge (from rolling mill) samples were taken from one plant (Ovako steel, Hofors) and analysed for PCDD/F and PCBs.

		Dioxins [pg NTEQ/g]	PCB [pg PCB-TEQ/g]
Electric arc furnaces	slag	3.4	0.18
		0.4	0.0014
Rolling mills	sludge	2.7	NA

S: Electric furnace steel plant; measurement results in residues

Within the Swedish dioxin survey no smoke stack samples have been analysed. However, results from different Swedish scrap-based steel mills are available from previous studies <12>, <13> showing a typical concentration range of 0.1 to 1 ng NTEQ/m³.

Further, filter dust samples were reported to contain about 1000 pg NTEQ/g

National activity rates:

The plant investigated produced 330 kt of steel. Total steel production amounted to 1.8 Million tons in 1993. From all scrap based steel mills a total of 26,000 tons filter dust was produced in 1991. Of this total, 19,000 tons were dumped into landfills.

Electric furnace steel plant

Emission factors:

Concerning air emissions, factors have been derived <12>, <13>. Emission factors for sludge and slag are not given explicitly but may be recalculated from the estimated emission and production rate for the Hofors steel plant. The same applies for the emission factor concerning filter dust:

AIR	0.2 - 8.6
Sludge/slag	0.03 - 0.3
Filter dust	10.5

S: Electric furnace steel plant; emission factors [$\mu\text{g NTEQ/ton of produced steel}$]

Estimation of uncertainty:

Following indices are assigned here to characterise the uncertainty:

Activity rates	0
emission factors	1
total uncertainty	1

S: Electric furnace steel plant; indices of uncertainty

Estimation of annual emission:

From the data given above the following annual emissions are estimated:

	PCDD/F [g NTEQ/a]	PCB [mg PCB-TEQ/a]
AIR	0.4 - 15	-
Sludge/slag	0.055 - 0.60	0.27 - 33
Filter dust	19	-

S: Electric furnace steel plant; annual PCDD/F emissions

Comment:

Emissions are probably underestimated as no coplanar PCBs have been measured in flow gases or filter dust.

Sweden

04 03 01

Aluminium production (electrolysis)

04 03 01

Aluminium production (electrolysis)

Considered pathways or media:

Water, residues

Plant data:

Located in Sundsvall, one primary aluminium plant is in operation using the „Hall-Héroult“ process (electrolysis). It consists of two electrolytic cells, one using Söderberg carbon anodes and the other using pre-baked carbon anodes. Spent potline wastes are dumped on the premises, leach waters from the dumping site are collected in a sedimentation basin.

Measurements:

Samples of filter dust have been taken from the Söderberg cell over an entire week and mixed up to one homogenate; no PCDD/F could be detected. Additionally, a spent potline sludge sample (7.8 pg NTEQ/g) and the leach water (2.4 pg NTEQ/l) were analysed in 1990.

National activity rates:

The aluminium plant holds a franchise to produce 100 kt aluminium per year.

Emission factors:

Emission factors are not given explicitly in the text. For spent potline waste a factor of 0.34 µg/t was calculated on basis of the annual capacity and the estimated annual release.

Estimation of uncertainty:

Since only one analysis was made, the uncertainty of the emission factor used is estimated to be at least one decade:

Aluminium production (electrolysis)

Activity rates	0
emission factors	1
total uncertainty	1

S: Aluminium production (electrolysis); indices of uncertainty*Estimation of annual emission:*

Emissions associated with the wastes are estimated to be 34 mg NTEQ/a (range: 1-100 mg NTEQ/a).

Insufficient data are given with respect to leach water; emissions via filter dust and flew gases are considered to be negligible:

Comment:

With respect to this source some contradictory information is given which is likely to be re-evaluated for the final report of the Swedish Dioxin Survey.

Sweden

04 03 09

Other - foundries

04 03 09

Other - foundries

Considered pathways or media:

Residues

Plant data:

85 non-ferrous foundries with more than 5 employees are reported to have been in operation in 1990. From a total of additional 90 smaller companies an unknown number may also produce non ferrous metal castings. Of the existing foundries producing non ferrous metal castings, one aluminium foundry was investigated within the Swedish Dioxin Survey. This foundry uses flame and induction furnaces.

Measurements:

Only emissions connected to the flame furnace were measured in 1990. Samples were dust from bag filters and scrapings from exhaust duct. PCDD/F concentrations 480 pg NTEQ/g in filter dust and 290 pg NTEQ/g in scrapings were found; additionally, the PCB contents of the scrapings were determined to be 32 pg PCB-TEQ/g.

National activity rates:

From a total production of 310,000 tons about 24,800 tons (8%) are associated to light metal castings and 12,400 tons (4%) relate to other non ferrous metal castings. Thus total production of castings amounts to 39,200 tons

Emission factors:

No data reported.

Estimation of uncertainty:

No reliable estimation can be performed

Activity rates	0?
emission factors	?
total uncertainty	?

S: Other - foundries; indices of uncertainty

Estimation of annual emission:

Not possible due to insufficient data;

Comment:

The data base concerning this important sector of the metallurgical industry is very poor and should be improved by further investigations!

Sweden

04 04 13

Chlorine production

04 04 13

Chlorine production

General remark:

Considered are chloralkali plants and mercury distillation

Considered pathways or media:

Water, residues

Plant data:

Currently, 3 chloralkali plants and 3 installations for chlorate production are active; 1 additional chlorate plant is to be closed in 1995. Only one chloralkali plant is reported to have a mercury distillation facility.

Measurements:

Some first PCDD/F analyses of graphite sludge samples had indicated that large amounts of PCDD/F may be generated by the chloralkali process. Thus several measurement programs on past and present chloralkali industries have been imposed by the Swedish EPA during the past years. Samples were taken from deposition sites of graphite sludge, from sediments and soil nearby the plants as well as from leach and ground water.

Concentration in a sample of run off water from a sludge deposit was 124 pg NTEQ/l;

With respect to mercury distillation a typical flew gas concentration of 0.9 ng NTEQ/m³ is reported.

National activity rates:

Production of sodium hydroxide serves as activity rate; however, no data are given in the survey;

In the case of mercury distillation annually production of about 60 tons of residues is reported which are going to an industrial deposition site on the premises.

Chlorine production

Emission factors:

Residues:

In order to estimate PCDD/F emissions in the past (period for use of graphite electrodes), a specific consumption rate of 2.5 kg graphite per ton of sodium hydroxide produced was estimated. About 75% of the graphite used was estimated to become sludge. PCDD/F concentrations ranging from 29 to 170 ng NTEQ/g are used to assess possible emissions.

Emissions' estimates for the currently active plants (chloralkali and mercury distillation) are based on the current amounts of wastes produced and on the PCDD/F concentrations found in these wastes (see table)

Year of analysis	sample type	number of samples	PCDD/F conc. [ng NTEQ/g]	ref.
1988	graphite sludge	4	13 - 28	<14>, <15>
1988	chromate sludge	1	0.72	<14>,<15>
?	scrapings of used electrode	1	0.19	
	scrapings of unused electrode	1	0.0003	
1989	soil		0.096 - 11.4	<15>
1991	sediments from receiving bay of an old plant	5	0.18 - 1.7	S-EPA
	Graphite electrode samples	?	29 - 170	S-EPA
	fresh graphite electrode sludge (from Norwegian plant)	3	0.029 - 0.38	S-EPA
	sludge samples from current processes /titanium electrodes		up to 28	S-EPA
	rubber siding from modern electrolytic cell		17.6	S-EPA
	mercury distillation: still bottoms /distilled charcoal filters	2*	0.063 / 0.0015	S-EPA

S: Chlorine production; measurement results of PCDD/F analyses of sludge and soil samples

***Concentrations before distillation: 1,8 / 9,7 ng NTEQ/g**

Sweden

04 04 13

Chlorine production

Estimation of uncertainty:

The index approach cannot be applied here in view of the insufficient data given in the Swedish survey.

Estimation of annual emission:

Past emissions

a) Chlorine production

Total produced PCDD/F during graphite period [g NTEQ]	Storage or deposition [g NTEQ]	Release to water [g NTEQ]
315 - 1,843	78 - 460	229 - 1,338

S: Chlorine production; past emissions of PCDD/F

b) Chlorate production

Past emission is estimated to be 1.4 g NTEQ with the majority assumed to have been released to receiving waters. There are insufficient data to estimate the current situation.

Current emissions

a) Chlorine production

Total produced PCDD/F after graphite period [g NTEQ]	Storage or deposition [g NTEQ]	Release to water and products [g NTEQ]	current annually emission [g NTEQ]
3.53	3.35	0.18	0.25

S: Chlorine production; current annual PCDD/F emissions

For one plant it is estimated that as much as 0.3 - 0.6 g NTEQ may still be leaching from deposition sites

b) Mercury distillation

AIR [mg NTEQ/a]	WATER [mg NTEQ/a]	RESIDUES [mg NTEQ/a]
0.005	3.2	4

S: Chlorine production; annual PCDD/F emissions from mercury distillation

Comment:

The Swedish situation is described very briefly and in many details that could not be included in this summary. The authors of the Swedish Dioxin Survey conclude, that

Chlorine production

“Graphite electrodes are still used in the chloralkali process in many countries. These industries must thus be regarded as an important source of PCDD/Fs internationally, especially if sludge has been released into nearby receiving waters.”

Sweden

04 06 02

Chlorine production

More, PCDD/F concentrations found in samples taken from modern installations (without graphite electrodes) indicate that even today's chlorine production may be a considerable emission source.

Paper pulp (kraft process)**04 06 02****Paper pulp (kraft process)***General remark:*

Here emissions are considered from bleached kraft pulp production and from production of recycled pulp.

Considered pathways or media:

Air, water, residues, product

Plant data:

Of the 47 paper pulp mills in Sweden 15 produce bleached kraft pulp.

Measurements:

During two periods of the Swedish dioxin survey (1988 and 1990) 16 samples of different pulp from 10 plants have been analysed for their PCDD/F content. Some of these samples were also tested for coplanar PCB. While the concentration ranges are given in the Swedish survey, the following mean values have been calculated for the present study:

Parameter	pg NTEQ/g ds	pg NTEQ/l	pg NTEQ/g ds
	pulp	effluent	sludge
Minimal	0.07	2.8	2.4
Maximal	7.7	9.7	44
geom. mean	0.52	5.2	10.3
arithmetic mean	3.9	6.3	23.2

S: Paper pulp (kraft process); measurement results*National activity rates:*

The total amount of bleached kraft pulp in Sweden was 7,636,928 t in the year 1992.

Sweden

04 06 02

Paper pulp (kraft process)

Emission factors:

The measured concentrations are used as emission factors. In the case of pulp, the highest value was considered as being probably unrepresentative and was discarded.

Emission factor ranges given in the Swedish survey are presented in the following table:

Pathway	Mean emission factor*)	range	dimension
PRODUCT (Pulp)	0.513	0.03 - 1.7	pg NTEQ/g dw
WATER (Effluent)	4.3	0.34 - 9.7	pg NTEQ/l
RESIDUES (Sludge)	26.7	2.4 - 54	pg NTEQ/g dw

S: Paper pulp (kraft process); emission factors;

*) arithmetic mean presumably

Estimation of uncertainty:

In view of the lower and upper limits shown above the index „1“ can be applied appropriately to the emission factors.

Activity rates	0
emission factors	1
total uncertainty	1

S: Paper pulp (kraft process); indices of uncertainty

Estimation of annual emission:

Water/product:

In the case of emissions associated with the pulp itself and with the effluent water, emissions were calculated exactly for the measured pulp mills on basis of their annual production and the concentrations found. For the remaining national production the emissions were estimated using the respective mean emission factor. However, the specific production of effluent water per ton of produced pulp is not given in the Swedish report. Comparing the total emission and the emission factor this value was re-calculated here to be about 82,000 l/t.

	Emission range 1987 [g Eadon TEQ/a]	Emissions 1988/90 [g NTEQ/a]	
	range	mean	range
WATER	13 - 40	2.7	1.5 - 5.0
PRODUCT	31 - 84	2.4	0.3 - 6.6

S: Paper pulp (kraft process); annual PCDD/F emissions [g N-TEQ/a]

Paper pulp (kraft process)

Though the results given in Eadon TEQ would be lower if converted to NTEQ a decrease of emissions may be stated anyway.

Additionally, 0,08 g PCB-TEQ/a and 0.28 - 0.49 PCB-TEQ/a are estimated to be emitted with bleached pulp and recycled pulp, respectively..

Residues:

Because of insufficient data about the fate of sludge (incineration/disposal) no estimation could be made.

Air:

In 1989, the emissions from smoke-stack gases were estimated to be 1 g NTEQ (basic data not given); this is considered to be still valid.

Comment:

The results of measurements are briefly discussed with respect to congener distribution and parameters influencing PCDD/F concentrations. Air emissions are estimated on old data basis.

Conclusions:

1. Higher PCDD/F concentrations correlate with higher chlorine contents.
2. High concentrations in the pulp do not necessarily mean that high concentrations are present in the effluents and /or sludge.
3. Concentrations of PCDD/F are quite low in the outgoing effluents, but the annual emission of PCDD/F via effluents is of importance due to the large quantities of water released.

Sweden

04 06 03

Paper pulp (acid sulphite process)

04 06 03

Paper pulp (acid sulphite process)

General remark:

Emissions associated with production of sulphite paper pulp are integrated in calculation for bleached kraft pulp (see. 04 06 02).

Considered pathways or media:

Products

Measurements:

One pulp sample from a sulphite pulp was analysed; PCDD/F concentration was found to be 0.64 pg NTEQ/g dw.

06 02 02 Dry cleaning

Considered pathways or media:

Residues

Plant data:

no information about number or technical features is given

Measurements:

Still bottoms or distillation residue samples have been taken from 13 dry cleaners.

Following results were obtained (see following table):

	PCDD/F [pg NTEQ/g]	PCBs [pg PCB-TEQ/g]
mean	1,314	84.5
min	0.3	0.6
max.	130,000	10,000
range without min/max. values	32 - 8,800	4.6 - 200

S: Dry cleaning; measurement results

National activity rates:

no data given in report; the evaluation concerning this topic is not yet finished

Emission factors:

no data given

Estimation of annual emission:

not yet performed

Comment:

The extreme concentration found in one case could not be explained. In accordance to other studies it is stated, that the major sources of PCDD/F in distillation residues are

Sweden

06 03 12

Textile finishing

textiles, most probably due to pentachlorophenol treatment. However, dyes and textile processing chemicals could not be ruled out.

06 03 12

Textile finishing

General remark:

The Swedish Dioxin Survey's chapter concerning textile manufacturing has not yet been finished. A lot of information has been collected from waste water treatment plants attached to textile industry as well as from the industries themselves. As a major result the bleaching with sodium hypochloride was identified as a considerable source of pentachlorophenol and PCDD/F. After stopping this method in 1991 the PCDD/F concentrations in sewage sludge from the attached treatment plant dropped drastically (see 09 10 02). Data given in the survey have to be revised and no emission factors or emission estimates for Sweden are reported here.

Passenger cars, light and heavy duty vehicles

07 01 -07 03**Passenger cars, light and heavy duty vehicles***General remark:*

This source type has not been investigated on experimental scale within the Swedish Dioxin Survey program but emission estimations are added to the report

Considered pathways or media:

Air

Plant data:

Numbers of passenger cars using unleaded gasoline (with and without catalytic converter) are given:

Automobile type	numbers in traffic in 1990	numbers in traffic in 1993
Without catalytic converter	2,514,000 (72%)	2,117,000 (61%)
With catalytic converter	980,000 (28%)	1,354,000 (39 %)
Total	3,494,000	3,471,000

S: Passenger cars, light and heavy duty vehicles; Number of cars with and without catalytic converters

Measurements:

No measurement data that are specifically valid for Sweden are mentioned; however, results from a Swedish study <16> are cited besides other from Germany<17> ,<18> .

National activity rates:

Fuel consumption is used to estimate emissions from traffic. The unleaded gasoline consumption by cars with and without catalytic converters is based on the percentages given in the previous table assuming identical specific fuel consumption for both types.

Sweden

07 01 -07 03

Passenger cars, light and heavy duty vehicles

	1990	1993
diesel	2,802,000	3,048,000
leaded	2,666,667	894,240
unleaded, without cat	1,397,799	2,515,018
unleaded with cat	1,565,534	2,179,682

S: Passenger cars, light and heavy duty vehicles; activity rates [m³/a]

Emission factors:

The following emission factors were extracted by combining the lowest and maximum value for each source type from the different studies mentioned above:

	min	max.
diesel	0.024	0.05
leaded	0.01	1.08
unleaded. without cat	0.051	0.09
unleaded with cat	0.0035	0.02

S: Passenger cars, light and heavy duty vehicles; emission factors [μ g I-TEQ/m³ fuel]

Estimation of uncertainty:

Generally, the uncertainty of the emission factors can be described as covering one decade. However, in the following emission estimation the range is calculated using the minimal and maximum values.

Activity rates	0
emission factors	1
total uncertainty	1

S: Passenger cars, light and heavy duty vehicles; indices of uncertainty

Passenger cars, light and heavy duty vehicles

Estimation of annual emission:

Ranges for the annual emissions were calculated using the data shown above:

	1990	1993
diesel	0.067 - 0.14	0.073 - 0.15
leaded	0.026 - 2.9	0.009 - 0.97
unleaded, without cat	0.07 - 0.13	0.13 - 0.23
unleaded with cat	0.0055- 0.031	0.0076 - 0.044
TOTAL, typical	0,74	0,55
range	0.169-3,20	0,22-1,4

S: Passenger cars, light and heavy duty vehicles; annual PCDD/F emissions [g I-TEQ/a]

Comment:

Nothing is said about diesel trucks; these are treated similar to passenger cars as the emission factors are applied to the overall consumed volume of diesel fuel. However, contradictory results that can be found in the literature are not mentioned.

Sweden

08 04

Maritime activities

08 04

Maritime activities

General remark:

Here ships and ferries are considered. This source type has not been investigated on experimental scale within the Swedish Dioxin Survey program but emission estimations are added to the report

Considered pathways or media:

Air

Plant data:

No data about numbers or specific technical information on the sources is given

Measurements:

No measurements are reported;

National activity rates:

An amount of 5 % of the overall heating oil consumption is taken as an estimate for oil burned by ships and ferries. Converted to tons these estimates are:

Fuel type	1990	1993
light oil [kt/a]	181	128
medium heavy oil [kt/a]	136	135

S: Maritime activities; activity rates

Emission factors:

Emission factors are taken from the Dutch inventory <8>:

Fuel Type	EF	Dim
gas oil	1	µg/t
heavy fuel oil	4	µg/t

S: Maritime activities; emission factors [I-TEQ]

Maritime activities
Estimation of uncertainty:

Both emission factors and activity rates must be considered as being uncertain.

Therefore, both are given the index „1“.

Activity rates	1
emission factors	1
total uncertainty	2

S: Maritime activities; indices of uncertainty

Estimation of annual emission:

Setting light heating oil equal to gas oil and medium or heavy oil equal to heavy fuel oil the following emissions are estimated:

	1990	1993
Annual emissions	0.7	0.63
Margin of uncertainty	0.07 - 7	0.06 - 6.3

S: Maritime activities; annual PCDD/F emissions [g I-TEQ/a]

Sweden

08 05

Air traffic

08 05

Air traffic

General remark:

This source type has not been investigated on experimental scale within the Swedish Dioxin Survey program but emission estimations are added to the report.

Considered pathways or media:

Air

Measurements:

PCDD/F emissions from aviation are estimated on the basis of results obtained from foreign measurement programs concerning gas oil (ferries) and diesel fuel. No specific measurements are known.

National activity rates:

Fuel consumption by aeroplanes is used as activity rate:

Year	1990	1993
m ³ /a	1,105,000	1,020,000

S: Air traffic; activity rates

Emission factors:

From the emission factors reported for gas oil (1 µg/t, <8>) and diesel (0.024 - 0.050 µg ITEQ/m³, <17> the range of possible emission factors was defined to be 0.024 - 0.84 µg/m³ with the density of gas oil estimated to be 0.84 t/m³.

Estimation of uncertainty:

The uncertainty is implicitly given in the range covered by the emission factors used for the estimation.

Estimation of annual emission:

The following emissions are calculated from the data mentioned above:

Air traffic

	1990	1993
geom. mean	0.17	0.14
margin of uncertainty	0.03 - 0.93	0.024 - 0.86

S: Air traffic; annual PCDD/F emissions [g I-TEQ/a]

Sweden

09 02 01

Incineration of domestic or municipal wastes

09 02 01

Incineration of domestic or municipal wastes

General remark:

This source was not studied within the Swedish Dioxin Survey. Data are available from previous studies. Legislation from 1987 required that all new municipal waste incinerators emit less than 0.1 ng Eadon TEQ/Nm³. Older plants also have to lower their emissions towards this limit (no information about time scales)

Considered pathways or media:

Air, residues

Plant data:

No information; from TNO study <19> it follows that Sweden has 21 facilities burning about 47 % of the municipal waste annually produced.

Measurements:

No data about measurements are reported within the Swedish survey

National activity rates:

Data are given for 1990 when 1,700 kt of waste was burned; 624,000 tons of fly ash and slag were produced and placed in landfills.

Emission factors:

Air: Emission factors range from 0.5 to 5 µg Eadon-TEQ/ton waste for the different plants.

Residues: Concentrations in fly ash have been found to be 1,000 to 4,000 pg Eadon-TEQ/g.

Incineration of domestic or municipal wastes

Estimation of uncertainty:

As the basic data regarding the emission factors are not given in the survey, the uncertainty cannot be assessed here independently. The factors used cover a range of one decade; the activity rates are presumably well known

Activity rates	0
emission factors	1
total uncertainty	1

S: Incineration of domestic or municipal wastes; indices of uncertainty

Estimation of annual emission:

Estimates of the annual emission are given as follows:

	1990	1993
emissions to air	4.5	3.0
margin of uncertainty	(1.4 - 14)	(0.9 - 9)
emissions with fly ash (filter deposits)	0.6 - 2.4	?

**S: Incineration of domestic or municipal wastes; annual PCDD/F emissions
[g Eadon-TEQ/a]**

If all facilities would comply to the emission limit of 0.1 ng Eadon-TEQ/Nm³ the emission would amount less than 1 g Eadon-TEQ/a.

Comment:

For the time before 1990 MSW incineration was one of the major emission sources for PCDD/F emitting 50 - 100 g Eadon-TEQ/a. This compares well with estimations of 86 g I-TEQ/a made by TNO <19>; however, this estimation is based on an analysis of the state of flew gas cleaning for the year 1993. Thus there is a large discrepancy between the data reported in the Swedish survey and the TNO report. This might be in part due to the rough estimation procedure applied by TNO, but the impression remains, that the emissions from the Swedish MSW incinerators may be underestimated.

Sweden

09 02 02

Incineration of industrial wastes (except flaring)

09 02 02

Incineration of industrial wastes (except flaring)

General remark:

Considered here: Hazardous waste incineration (HWI) and incineration of glass fibre wastes

Considered pathways or media:

Air

Plant data:

There is only one incinerator for hazardous waste in Sweden (SAKAB). Besides the information that this plant is subjected to a control program no other data are given on this plant.

Glass fibre wastes containing phenols and formalin are incinerated in a gasoline-fuelled oxymelt plant. After water-cooling the smoke stack gases are cleaned by a fabric filter. Only this single plant exists in Sweden.

Measurements:

No measurement results are reported for the hazardous waste incinerator;

One flew gas analysis was performed at the glass fibre incinerator in 1991, PCDD/F concentration was 0.0046 ng NTEQ/m³

National activity rates:

Quantities burned in the HWI plant are reported as follows:

Year	1990	1993
[kt/a]	32.5	31.4

S: Incineration of industrial wastes (except flaring); activity rates

At the glass fibre incinerator 1,000 tons were incinerated in 1991; this figure changed to 2,300 tons in 1993

Incineration of industrial wastes (except flaring)

Emission factors:

The emission factor for the HWI plant is reported to have decreased from 0.9 µg Eadon-TEQ/t (1990) to 0.19 µg Eadon-TEQ/t in 1993.

No explanation for this trend is given.

No emission factor is derived explicitly for the glass fibre incinerator; from the estimated annual emission and production rate a factor of 4 ng NTEQ/ton was calculated in the present study

Estimation of uncertainty:

Since emissions of both plants operating in Sweden are accessible directly from measurements, the uncertainty is assumed to be low.

Activity rates	0
emission factors	0
total uncertainty	0

S: Incineration of industrial wastes (except flaring); indices of uncertainty

Estimation of annual emission:

	1990	1993
HWI plant [g Eadon-TEQ/a]	0.01	0.007
Glass fibre inc. [g NTEQ/a]	0.00004	0.00006

S: Incineration of industrial wastes (except flaring); annual PCDD/F emissions to air

Estimation of uncertainty

Comment: Data regarding slag and fly ash are to be added during revision of survey.

Sweden

09 09

Cremation

09 09

Cremation

Considered pathways or media:

Air

Plant data:

75 crematories are reported to be in operation; there is no information about technical details.

Measurements:

Measurement results are not given in detail; indicated concentrations lie between 10 and 20 ng Eadon-TEQ/m³.

National activity rates:

Year	1990	1993
Cremations	57,000	61,237

S: Cremation; activity rates

Emission factors:

Emission factors are derived assuming a specific flew gas volume of 600 m³ per cremation. With the concentrations given above, the emission factors can be calculated to be

6 - 12 µg Eadon-TEQ/Cremation

Estimation of uncertainty:

Since no Swedish measurements exist and the emission factors used in the Swedish report are taken from foreign data, an index of „1“ is applied here to describe the possible limits.

Activity rates	0
emission factors	1
total uncertainty	1

S: Cremation; indices of uncertainty

Estimation of annual emission:

	1990	1993
typical*)	0.48	0.52
Margin of uncertainty**)	0.34 - 0.68	0.37 - 0.73

S: Cremation; annual PCDD/F emissions [g Eadon-TEQ/a]

***) calculated as geom. mean of upper and lower limits; **) as given in the Swedish report**

Sweden

09 10 02

Waste water treatment in residential and commercial sectors

09 10 02

Waste water treatment in residential and commercial sectors

General remark:

Before 1989, sewage sludge from waste water treatment plants was usually spread to land as fertiliser, since 1989 large amounts are placed in landfill sites. Within the Swedish Dioxin Survey the entry of PCDD/F into sewage sludge was investigated. Here measurement and results directly concerning the treatment plants are considered.

Considered pathways or media:

Water, residues

Plant data:

Besides location of the investigated plants no specific plant data are reported.

Measurements:

Early measurements by Rappe 20> showed sewage sludge to contain 23 - 24 pg NTEQ/g.

In outgoing water 0.06 and 0.04 pg NTEQ/l, in incoming water 1.6 / 1.6 pg NTEQ/l were measured. Even higher sewage sludge values, 32 / 33 pg NTEQ/g dw, were found at the Ryaverket plant(1990).

Samples were taken within the Swedish Dioxin Survey at the major treatment plant of Stockholm at Henriksdal in Feb.1989. Sample conditions: two occasions (weekend, working day), 4 sampling sites (2 pump stations, incoming water, outgoing water); 1 sludge sample, 1 storm sewer water sample; 1 sample of FeCl₃ (flocculating agent).

Results:

Waste water treatment in residential and commercial sectors

Sample type	PCDD/F concentration [pg NTEQ/l or pg NTEQ/g]
pump station water	0.63 - 4.5
incoming water	1.8 - 3.2
outgoing water	0.04 - 0.52
sewage sludge	24 / 31 / 17
FeCl ₃ solution	40

**S: Waste water treatment in residential and commercial sectors ;
measurement results**

Sewage sludge samples from other treatment plants have been taken in 1990 (3 plants) and 1992 (4 plants):

Year	location	attached industry	PCDD/F [pg NTEQ/g dw]	PCBs [pg PCB-TEQ/g dw]
1990	Gässlösa *)	Textile industries	120	NA
	Skene	Textile industries	7.5 / 7.5	NA
	Kristianstad	households	1.4	NA
1992	Gässlösa*)	Textile industries	7.3	17
	Kinnarumma	Textile industries	10	7.8
	Simsholmen	Recycled paper plant	13	13
	Huskvarna	Recycled paper plant	8.8	6.6
	Sickla (Stockholm)		NA	12
	Bromma (Stockholm)		NA	12
	Loudden (Stockholm)		NA	14

**S: Waste water treatment in residential and commercial sectors ;
measurement results; PCDD/F and PCBs in samples of sewage sludge**

*) Concentration dropped after pentachlorophenol contamination from textile industry was eliminated

National activity rates:

Treatment plant Henriksdal:

107,000,000 m³ water/a, 20 - 30 % from storm sewers, 13,5000 t sludge (dw);

560,000 person units attached, particle content in outgoing water was measured to be

3.3 / 10.7 mg/l

Sweden

09 10 02

Waste water treatment in residential and commercial sectors

190,000 tons sewage sludge are produced annually; using ratio of water volume per ton sewage sludge according to Henriksdal plant the total waste water is calculated to be 1,506,000,000 m³. With particle content: 5,000 - 16,000 tons of particles released annually in outgoing water

Emission factors:

Concentrations serve as emission factors directly; best case or worst case estimation is made by using following values:

Media	emission factor	dimension
sludge, PCDD/F	1.4 - 33	pg NTEQ/g dw
sludge, PCB	6.6 - 17	pg PCB-TEQ/g dw
outgoing water, PCDD/F	0.04 - 0.52	pg NTEQ/l

S: Waste water treatment in residential and commercial sectors ; emission factors

Estimation of uncertainty:

The range of uncertainty is given as indicated by the variability of the applied emission factors.

Estimation of annual emission:

The Swedish EPA has estimated for 1988 that 4.4 g NTEQ were emitted via sewage sludge to agricultural land; for the same year, emission to water was said to be 0.11 g NTEQ/a <21>

From the data obtained within the Swedish Dioxin Survey following estimates are derived for 1990:

Medium	PCDD/F [g NTEQ/a]	PCBs [g PCB-TEQ/a]
sewage sludge	0.27 - 6.3	1.3 - 3.2
outgoing water	0.06 - 0.78 0.007 - 0.53*	0.03 - 0.27*

S: Waste water treatment in residential and commercial sectors ; annual PCDD/F emissions into sewage sludge and water

* calculated from particle content of outgoing water

Waste water treatment in residential and commercial sectors

Comment:

Data analysis and emission estimation have not yet been finished by the authors of the survey.

Sweden

12

Fires - landfill fires

12

Fires - landfill fires

Considered pathways or media:

Air

Plant data:

No data in the report; from OECD data it follows that in 1990 there were 282 landfill sites having a total capacity of 7,300 kt.

Measurements:

6 experiments simulating the uncontrolled combustion of landfill waste resulted in PCDD/F concentrations of 66 - 518 ng NTEQ/m³.

National activity rates:

About 200 - 250 fires occur annually in Swedish landfills. With an estimated amount of 25,000 t waste being combusted annually and a typical specific volume of 1,700 m³/t <22> the rate is 42,500,000 m³/a

Emission factors:

Emission factors are identical to the concentrations found, that is 66 - 518 ng NTEQ/m³

Estimation of uncertainty:

Both parameters have to be considered as being uncertain. Therefore the index „1“ is applied to each:

Activity rates	1
emission factors	1
total uncertainty	2

S: Fires - landfill fires; indices of uncertainty

Fires - landfill fires

Estimation of annual emission:

Emissions are given for two scenarios with

Fires - landfill fires

1. using the above emission factors
2. a worst case assumption as drawn by the S-EPA

	min	max.
scenario 1	2.8	22
scenario 2		30
overall range	2.8	30

S: Fires - landfill fires; annual PCDD/F emissions [g N-TEQ/a]

Using the geometric mean of the emission factor range (185 ng NTEQ/m³) and applying the uncertainty indices following results are be obtained:

	g N-TEQ/a
annual emission	7.9
margin of uncertainty	0.8 - 79

S: Fires - landfill fires; annual PCDD/F emissions to air

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