

### ***Results***

The results obtained from the detailed evaluation given in the previous chapters are summarised in Table 15a/b. The re-estimation yields a total annual air emission being about twice as high compared to the value obtained by summation of the estimates given in the national reports. Since the sources selected for the re-estimation are assumed to approximately represent 90% of the actual emission from all known sources, an European total of ca. 6,500 g I-TEQ/a is estimated here to be emitted into the atmosphere.

European Dioxin Inventory - Volume 1, Results

SNAP	ITEM	Process/ material	A	B	CH	D	DK	E	F	GR	I	IRL	L	N	NL	P	S	SF	UK	TOTAL	%	Remark
0202	Res. combustion: Boilers, stoves, fireplaces	wood	67.62	9.13	8.30	27.22	2.90	70.26	323.17	51.57	198.79	0.0	0.0	23.9	14.0	59.2	48.4	28.1	12.4	945.0	16.4	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/ lignite	1.20	1.14	0.81	11.30	0.3	3.69	3.99	0.20	0.50	5.0	0.06	0.3	0.11	0.04	0.6	0.3	10.5	40.0	0.7	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0.43	0.55	0.39	4.45	0.29	2.17	3.16	0.56	3.11	0.19	0.02	0.24	0.84	0.54	0.48	0.28	3.18	20.9	0.4	
30301	Sinter plants		27.20	98.28		254.51		62.00	183.85		128.00		46.0		41.4	4.0	9.6	19.2	136.0	1010.1	17.6	
030308	Secondary zinc production		0.08	1.00		13.52		0.75	0.99		0.35	0.0153		0.795	0	0	0.025	0	2.34	19.9	0.3	
030309	Secondary copper production		2.42	5.14	1.50	31.09	0.00	3.21	6.45	0.00	16.50	0	0	0	2.6	0	1.03	1.25	5.745	76.9	1.3	
030310	Secondary aluminium		0.99	0.07	0.24	11.98	0.34	2.16	5.15	0.20	7.90	0.0	0.0	0.0	3.4	0.0	0.5	0.6	5.5	39.0	0.7	
30311	Cement		0.74	1.13	0.68	4.88	0.26	3.59	3.08	1.89	0.01	0.23	0.00	0.18	0.50	1.10	0.30	0.17	1.71	20.5	0.4	
030312	lime																			0.0	0.0	no estimate due to lack of activity data
030326	Other: metal reclamation from cables				0.00		0.13								1.52					1.7	0.0	insufficient data for re-estimation
040207	Electric furnace steel plant		0.43	6.42	8.03	2.43	0.62	13.20	6.15	0.89	26.11	0.27	2.35	0.46	1.30	0.72	2.45	0.70	10.90	83.4	1.5	
040309	Other: Non ferrous metal foundries		0.12	0.76	0.04	0.63	0.03	0.22	0.29	0.06	0.55	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	3.0	0.1	
040309	Other: sintering of special materials and dressing facilities					115.00														115.0	2.0	sinter plant for recycling materials (Germany only)
060406	Preservation of wood		7.92	10.08	7.13	81.34	5.28	39.57	57.75	10.28	56.76	3.5	0.4	4.3	15.4	9.9	8.7	5.1	58.0	381.4	6.7	
0701	Road transport		0.36	2.56	3.31	9.14	1.16	11.27	18.41	4.46	29.86	1.2	0.4	1.3	2.2	3.0	0.5	0.5	21.5	111.1	1.9	
090201	Inc. of Dom. or municipal wastes	legal combustion	0.06	187.00	123.10	157.25	25.00	0.60	161.40	0.00	252.00	0.0	0.1	2.6	6.2	0.0	3.0	3.0	515.7	1437.1	25.1	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	3.46	4.32	4.57	30.86	3.21	16.42	24.69	3.89	21.60	1.4	0.2	2.5	9.5	3.3	4.0	3.1	37.0	174.0	3.0	
090202	Inc. of Industrial wastes	hazardous waste	0.017	20.9	7	1.3	0.23	nd	2	nd	Nd	nd	nd	0.06	1	0.2	0.007	0.88	3.6	37.2	0.6	very uncertain due to lack of activity data
090207	Inc. of hospital wastes		0.00	95.00	10.00	0.03	5.00	57.50	262.50	37.50	250.00	22.5	0.0000	0.1	1.0	35.0	0.00	0.00	39.4	815.5	14.2	
090901	Cremation:		0.10	0.19	0.42	2.10	0.16	1.39	2.17	0.40	2.22	0.1	0.0	0.1	0.2	0.4	0.5	0.2	6.1	16.8	0.3	
1201	Fires		7.89	10.04	7.10	81.00	5.26	39.40	57.51	10.24	56.52	3.5	0.4	4.3	15.3	9.8	8.7	5.1	57.8	379.9	6.6	estimation based on German study and per-capita considerations
			121.0	453.7	182.6	840.0	50.2	327.4	1122.7	122.0	1050.8	37.9	49.9	41.1	116.5	127.3	88.8	68.5	927.6	5728.1		
	% of total:		2.1	8.4	3.2	14.6	0.9	5.7	19.5	2.1	18.3	0.6	0.9	0.7	2.0	2.2	1.5	1.2	16.1			

Table 15a Summary of the PCDD/F air emission rates gained by re-evaluation using default emission factors and activity data in g I-TEQ/a

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SNAP	ITEM	Process/ material	A	B	CH	D	DK	E	F	GR	I	IRL	L	N	NL	P	S	SF	UK	TOTAL	% of TOTAL	Remark
090201	Inc. of Dom. or municipal wastes	legal combustion	0.06	187.00	123.10	157.25	25.00	0.60	161.40	0.00	252.00	0.0	0.1	2.6	6.2	0.0	3.0	3.0	515.7	1437.1	25.1	
30301	Sinter plants		27.20	98.28		254.51		62.00	183.85		128.00		46.0		41.4	4.0	9.6	19.2	136.0	1010.1	17.6	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	67.62	9.13	8.30	27.22	2.90	70.26	323.17	51.57	198.79	0.0	0.0	23.9	14.0	59.2	48.4	28.1	12.4	945.0	16.4	
090207	Inc. of hospital wastes		0.001	95	10	0.033	5	57.5	262.5	37.5	250	22.5	0.00003	0.09	1	35	0.002	0.004	39.42	815.5	14.2	
060406	Preservation of wood		7.92	10.08	7.13	81.34	5.28	39.57	57.75	10.28	56.76	3.5	0.4	4.3	15.4	9.9	8.7	5.1	58.0	381.4	6.6	
12	Fires		7.89	10.04	7.10	81.00	5.26	39.40	57.51	10.24	56.52	3.5	0.4	4.3	15.3	9.8	8.7	5.1	57.8	379.8	6.6	estimation based on German study and per -capita considerations
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	3.46	4.32	4.57	30.86	3.21	16.42	24.69	3.89	21.60	1.4	0.2	2.5	9.5	3.3	4.0	3.1	37.0	173.9	3.0	
040309	Other: sintering of special materials and drossing facilities					115.00														115.0	2.0	sinter plant for recycling materials (D) only
0701	Road transport		0.36	2.56	3.31	9.14	1.16	11.27	18.41	4.46	29.86	1.2	0.4	1.3	2.2	3.0	0.5	0.5	21.5	111.1	1.9	
040207	Electric furnace steel plant		0.43	6.42	8.03	2.43	0.62	13.20	6.15	0.89	26.11	0.27	2.35	0.46	1.30	0.72	2.45	0.70	10.90	83.4	1.5	
030309	Secondary copper production		2.42	5.14	1.50	31.09	0.00	3.21	6.45	0.00	16.50	0	0	0	2.6	0	1.03	1.25	5.745	76.9	1.3	
0202	Res. Combustion: Boilers, stoves, fireplaces	coal/lignite	1.20	1.14	0.81	11.30	0.00	3.69	0.09	0.10	0.00	0.4	0.1	0.3	0.1	0.0	0.6	0.3	10.5	40.0	0.7	
030310	Secondary aluminium production		0.99	0.07	0.24	11.98	0.34	2.16	5.15	0.20	7.90	0.0	0.0	0.0	3.4	0.0	0.5	0.6	5.5	39.0	0.7	
090202	Inc. of Industrial wastes	hazardous waste	0.017	20.9	7	1.3	0.23	nd	2	nd	nd	nd	nd	0.06	1	0.2	0.007	0.88	3.6	37.2	0.6	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0.43	0.55	0.39	4.45	0.29	2.17	3.16	0.56	3.11	0.19	0.02	0.24	0.84	0.54	0.48	0.28	3.18	20.9	0.4	
30311	Cement		0.74	1.13	0.68	4.88	0.26	3.59	3.08	1.89	0.01	0.23	0.00	0.18	0.50	1.10	0.30	0.17	1.71	20.4	0.4	
030308	Secondary zinc production		0.08	1.00		13.52		0.75	0.99		0.35	0.0153		0.795	0	0	0.025	0	2.34	19.9	0.3	
090901	Cremation: Inc. of Corpses		0.10	0.19	0.42	2.10	0.16	1.39	2.17	0.40	2.22	0.1	0.0	0.1	0.2	0.4	0.5	0.2	6.1	16.8	0.3	
040309	Other: Non ferrous metal foundries		0.12	0.76	0.04	0.63	0.03	0.22	0.29	0.06	0.55	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	3.0	0.1	
030326	Other: metal reclamation from cables				0.00		0.13								1.52					1.7	0.0	insufficient data to make re-estimation

Table 15b: Emission data in g I-TEQ/a from Table 15a rearranged in decreasing order of relative importance (% of total emission)

### *Emissions via waste water*

Emissions of PCDD/F via waste waters from industrial processes have been investigated to a much lower extent than air emissions. The data available from the surveyed basic documents are shown in Table 16. Information could be drawn only from the reports of B, D, NL, and S with the Belgian report being largely based on measurements conducted in the other three countries. A re-estimation for all countries could not be performed since basic data like the specific waste water generation rate are largely missing. However, even if the remaining countries would be regarded, too, the quantity of emissions via waste waters would appear to be negligible compared to the air emissions.

### *Emissions via residual materials*

Compared to the PCDD/F water emissions the data situation concerning emissions via process/production residues is slightly better. Most values are known from filter dust measurements conducted in the course of air emission investigations, mainly in D, NL and S (see Table 17). Unfortunately, specific waste production rates are scarce; hence the possibilities of emission estimation are limited. The annual emissions via residual materials reported in the dioxin inventories of these countries alone amount to about 3.500 g I-TEQ/a; the high degree of uncertainty reflected by a maximum value of nearly 10.000 g I-TEQ/a is no surprise. Since some industrialised countries using - as a general rule - less sophisticated technologies are not implied in this estimation, a total annual emission of 20 kilograms I-TEQ/a or even more seems to be reasonable for Western Europe. It should be emphasised, however, that most of these PCDD/F emissions are „stored“ in reservoirs like disposal sites and most likely do not enter the food chain directly.

## Results

Corinair SNAP	Item	Process	Country	Concentrations			Emission factors			Annual emissions					Remark
				typ.	range	dim.	typ.	range	dim.	Particular value	total typ.	min	max	dim.	
03 03 01	Sinter plants		B				0.3		µg/t	(1990) 4.05 (1995) 3.19	3.19			g I- TEQ/a	no measurements. in Belgian sintering plants
03 03 01	Sinter plants		NL							1.5	1.5	0.47	4.7	g I-TEQ/a	
03 03 13	Asphalt mixing installations		NL							< 0.1	0.1	0.03	0.3	g I-TEQ/a	
04 02 01	Coke oven		B				0.063		µg/t	(1990) 0.33 (1995) 0.23	0.23			g I- TEQ/a	EF taken from Dutch study
04 03 01	Aluminium electrolysis		S	2.4		pg NTEQ/l									leach water; annual emissions not assessable
04 04 13	Chlorine production		B				10		mg I-TEQ per plant and Year	0.03	0.03	0.01	0.1	g I- TEQ/a	
04 04 13	Chlorine production		S							0.18				g NTEQ/a	release to water and products
04 05 03-04 03 05	EDC and vinyl chloride production		D				1.8	0.1- 33	µg I- TEQ/ t	2.8		0.15	51	g I-TEQ/a	
04 05 05	1,2 dichloroethane +vinylchloride		B				0.5		[µg I- TEQ/ t VC]	0.222	0.22	0.07	0.69	g I- TEQ/a	
04 05 24/25	Halogenated hydrocarbons and pesticide production		B				80		mg I-TEQ per plant and Year	*)					*) Evaluation was impossible since no basic data are available
04 06 02	Paper pulp		B				10		µg/t	(1985) 1.18 (1990) 2.18 (1995): 0		0.37 0.68 -	3.7 6.8 -	g I- TEQ/a	ClO <sub>2</sub> bleaching since 1993
04 06 02	Paper pulp		S	6.3	2.8- 9.7	pg NTEQ/l	4.3	0.34- 9.7	pg NTEQ/l effluent	2.7				g NTEQ/a	
06 03 12	Textile finishing		D				19	0.05- 369	ng I-TEQ/kg	1.43		0.5	45.9	g I-TEQ/a	concerns PCDD/F release from new textiles during washing in households

Table 16: Waste water PCDD/F emission data contained in the surveyed basic documents (continued on next page)

Results

Corinair SNAP	Item	Process	Country	Concentrations			Emission factors			Annual emissions					Remark
				typical	range	dimension	typical	range	dimension	Particular value	total typ.	min.	max.	dimension	
09 02 01	Incineration of domestic or municipal wastes		B				0.09		µg I- TEQ/l	(1985) 0.03 (1990) 0.05 (1995) 0.06	0.06			g I-TEQ/a	emission into waste water
09 02 01	Incineration of domestic or municipal wastes		NL				1.87	0.79-3.43	pg I-TEQ/l effluent	0.0003				g I-TEQ/a	
09 02 02	Incineration of industrial wastes		B				0.15		µg I- TEQ/t	(1985) 0.0024 (1990) 0.01 (1995) 0.021	0.21			g I-TEQ/a	
09 02 02	Incineration of industrial wastes		NL							0.8	0.8			g I-TEQ/a	(1991)
09 10 02	Waste water treatment in residential and commercial sectors		B				(1985) 0.039 (1990) 0.039 (1995) 0.024		ng I-TEQ/ kg d.s.	(1985) 18.2 (1990) 17.1 (1995) 9.74	9.74	1	100	g I-TEQ/a	values were taken from a German report (see Vol. 1)
09 10 02	Waste water treatment in residential and commercial sectors		NL							<0.1				g I-TEQ/a	
09 10 02	Waste water treatment in residential and commercial sectors		S		0.04-0.52	pg NTEQ/l				0.06- 0.78 0.007- 0.53	0.3	0.07	1.3	g NTEQ/a	outgoing water particle content
12	Fires		B				0.1- 1		µg I- TEQ/ t water	(1985) 0.02 (1990) 0.02 (1995) 0.015	0.015			g I-TEQ/a	
<b>TOTAL</b>											<b>17</b>	<b>2.3</b>	<b>204</b>		

Table 16 (cont.): Waste water PCDD/F emission data contained in the surveyed basic documents

## Results

Corinair SNAP	Item	Process	Country	Type of res.	Annual emissions					Remark
					particular value	total typ.	min	max	dimension.	
03 03 03	Grey iron foundries		S	filter dust exhaust dust shake out Filter dust surface swiipe from working hall scrubber sludge	0.79 0.02 0.007	0.817			g NTEQ/a g NTEQ/a g NTEQ/a	scrubber sludge sand waste filter dust
03 03 06	Primary copper production	lead kaldo shop clinker plant waste water treatment plant	S	venturi sludge filter dust sludge	0.35	0.35			g NTEQ/a	waste water sludge;- venturi sludge/filter dust are internally recycled
03 03 07	Secondary lead production		D	filter dust	*)					*) Evaluation was impossible since no basic data are available
03 03 08	Secondary zinc production		D	residual matter	*)					*) Evaluation was impossible since no basic data are available
03 03 10	Secondary aluminium production	lime injection fabric filter	NL		17.4	17.4	5.4	54	g I-TEQ/a	
04 02 01	Coke oven (door leakage and extinction)		S		0.31	0.31			g NTEQ/a	
04 02 01	Coke oven (door leakage and extinction)	purification plant	NL		0.04	0.04	0.013	0.13	g I-TEQ/a	
04 02 03	Pig iron tapping		S	slag sludge	0.041	0.041			g NTEQ/a	
04 02 06	Basis oxygen	furnace steel plant	S	scrubber sludge	filter dust	1.53	0.3003	7.8068	g NTEQ/a g NTEQ/a	scrubber sludge filter dust
04 02 07	Electric furnace steel plant		D	dust	0.4- 24	3.1	0.4	24	g I- TEQ/a	
04 02 07	Electric furnace steel plant	electric arc furnace rolling mill	S	slag sludge	0.055- 0.6 19	19.2	0.055	0.6	g NTEQ/a g NTEQ/a	slag/sludge filter dust
04 03 01	Aluminium electrolysis		S	sludge	0.034	0.034			g NTEQ/a	range 0.001- 0.1 g NTEQ/a

Table 17 Residue PCDD/F emission data contained in the surveyed basic documents

## Results

SNAP	Item	Process	Country	Type of res.	Annual emissions					Remark
					particular value	total	min	max	dimension.	
04 04 13	Chlorine production		B		0.3	0.3	0.1	1	g I- TEQ/a	
04 04 13	Chlorine production		S	wastes	3.35	3.35			g NTEQ/a	storage or deposit
04 05 03 - 04 03 05	EDC and vinyl chloride production		D	catalyst sludge	61.8	61.8			g I- TEQ/a	
04 05 05	1,2 -dichloroethane + vinylchloride		B		1.2- 24	5.4	1.2	24	g I- TEQ/a	
04 05 24/25	Halogenated hydrocarbons and pesticide production		B		*)					*) Evaluation was impossible since no base data are available
04 06 02	Paper pulp		S	pulp sludge	*)					*) no estimation could be made
06 02 02	Dry cleaning		D	distillation residues	3.15	3.15	0.3	31.5	g I- TEQ/a	
09 02 01	MSW incineration	ESP/wet scrubber	B	ESP ash						based on measurements at 18 install.
09 02 01	MSW incineration		B	fly ash	(1985) 334 (1990) 434 (1995) 472	472			g I-TEQ/a g I-TEQ/a g I-TEQ/a	annual PCDD/PCDF emissions into landfills
09 02 01	MSW incineration		S	fly ash	0.6- 2.4	1.2	0.6	2.4		
09 02 01	MSW incineration		NL	ESP ash, slags	1038.4	1038.4			g I-TEQ/a	
09 02 02	Incineration of industrial wastes		B	sewage sludge	(1985) 0.142 (1990) 0.164 (1995) 0.298	0.298	0.15	30	g I-TEQ/a g I-TEQ/a g I-TEQ/a	
09 02 02	Incineration of industrial wastes		D	filter dust, slag						
09 09 01	Cremation				0.02	0.02	0.006	0.06	g I-TEQ/a	
09 10 02	Waste water treatment in residential and commercial sectors		S	sludge	0.27- 6.3	1.3	0.27	6.3	g NTEQ/a	
09 10 03	Sludge spreading		D	sewage sludge	35.4	35.4	11	111	g I- TEQ/a	
09 10 04	Land filling		D	municipal waste	1623	1623	507	5070	g I- TEQ/a	
09 10 05	Compost production from waste		D	compost	13.6	13.6	4.2	42	g I- TEQ/a	
12	Fires		D	residues	deposited soot	220	2.5	4300	g I- TEQ/a g I- TEQ/a	
<b>Total</b>						<b>3522</b>	<b>533</b>	<b>9705</b>		

Table 17 (cont.): Residue PCDD/F emission data contained in the surveyed basic documents

## Conclusions and recommendations

### *AIR emissions*

According to the data presented in the previous section incineration of municipal and hospital waste and iron ore sinter plants are the most relevant *industrial* PCDD/F air emission sources covering more than 50 % of the total estimated annual emission. However, the quality of the basic data used for the estimations concerning these three types of sources differs considerably:

- Dioxin emissions from **incineration of domestic or municipal wastes** has been investigated most intensively during the recent past but still appears to be the most significant dioxin source for the total emission of PCDD/F in Europe. According to the available data the Belgian, German, French, Italian and British plants are of particular importance. This situation is due to certain near-future changes: while all German plants will have to comply to a 0.1 ng I-TEQ/m<sup>3</sup> limit and most of the old British incinerators are to be closed. Almost nothing is known about the emissions from the huge number of small plants operated in France. Despite their contribution to the national and European balance might be low at least spot- check measurements should be performed to assess possible local impacts of these facilities. In addition it should be noticed that the emissions from the Spanish facilities are likely to be underestimated since these plants almost have no equipment for dioxin abatement and no measurement results have become known supporting the low emission factor being applied for emission estimation. Thus emission measurements are urgently required at plants operated in Italy and Spain since the corresponding emission values are purely based on estimations.

Generally, a decrease of the emissions can be expected due to the enactment of emission limits in a certain number of countries. Most of these countries implemented an ambitious emission limit of 0.1 ng I-TEQ/m<sup>3</sup>; compliance of all

Conclusions and recommendations

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European facilities to this limit would result in a decrease by more than 98% compared to the emission value calculated in this report. Even a 10-fold higher emission limit as it has been set in the UK as a guidance value would cause the emissions to fall by more than 85%. Abatement technologies to ensure flue gas concentrations below 0.1 ng I-TEQ/m<sup>3</sup> are available; those facilities utilising adsorbent injection should be used only in connection with additional measures to destroy the dioxins collected by the adsorbent to avoid residue problems.

- The **illegal incineration of domestic or municipal wastes** is difficult to assess since the basic data are highly uncertain; yet it appears to be of only moderate significance for the total emission of PCDD/F in Europe. Being a non-industrial area source emission control seems to be nearly impossible; therefore any success in lowering the emissions would depend on people's reasonable behaviour. To a certain extent illegal incineration of domestic or municipal wastes probably will remain a constant dioxin source in Europe, particularly in regions with a high proportion of solid fuels used for domestic heating. Additionally, almost nothing is known about the extent of open MSW combustion at small illegal disposal sites or just near the households. The problem might be most actual in rural areas and in countries without effective waste collection systems. An improvement of this probably poor situation might be possible by changing the behaviour of the people by education and awareness of environmental protection.
- Only recently it was found that processes in the metallurgical sector may be nearly as strong dioxin emission sources as waste incineration. Putting together the emission estimates from all source types of this industrial branch yields a contribution of more than 20 % to the European total emissions. Of this, **Iron ore sinter plants** alone may account for 15.5 %. The German sinter plant for residual materials contribute with additional 1.8 %. Hence, sinter plants belong to the most important dioxin sources in Europe.

Due to measurement results from sinter plants the dioxin emissions are rather well known in some European countries, e. g. Germany, Luxembourg, The Netherlands, United Kingdom. By contrast almost no information exists about the emissions from the facilities located in other countries, the main sinterproducers being located in Belgium, Spain, France and Italy. Measured flue gas concentrations mostly have been observed to be in a similar range ; however, emissions from a single German plant were found unexpectedly to be a 10- to 20-fold higher than the „normal“ emission thus accounting for an annual freight of about 350 g I-TEQ (supposed that the observed conditions had been active continuously until the date of measurement).

The annual European PCDD/F emissions from sinter plants with about 1,000 g I-TEQ/a have been calculated provided that the measurement results usually found are valid for all plants in Europe. It should be stressed that this assumption cannot be verified by consideration and comparison of process conditions since it had been shown that apparently similar processes may lead to very different emissions. Hence the estimate given here may be associated with considerable uncertainty; in view of the extreme impact that single plants operating at worse conditions could have it is recommended to perform measurements on all operating plants in Europe that have not been investigated up to now.

The emissions from iron ore sinter plants may be decreased by certain primary (choice of raw material quality, throughput) and secondary measures (better dedusting, e.g. by rotating ESP) to flue gas concentrations levels below 1 ng I-TEQ/m<sup>3</sup>. Lower concentrations are achievable only with complex and expensive technologies currently being tested in Austria and Germany.

- The estimation of PCDD/F-emissions for **hospital waste incineration** is highly uncertain since no complete and entirely reliable activity statistics could be found. Particularly, the fraction of contaminated waste to be incinerated is not known for all countries; no information about the number of small incineration

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facilities operated on-site at the hospitals could be gathered. In view of these data gaps the estimated emissions were based on per-capita calculations. Since small on-site facilities without flue gas cleaning devices are likely to have a severe local impact due to the very high flue gas concentrations and low stack heights appropriate measures seem necessary. As in Germany and The Netherlands a closure of these installations in all countries would result in a significant reduction of dioxin emissions. Hospital wastes in the above mentioned countries are mainly transferred to hazardous waste incinerators. Larger facilities being equipped with some abatement technique should be subjected to emission measurements and an improvement of the waste gas cleaning system. It should be noticed that clinical waste and installations for incineration of clinical waste are not entirely subjected to the regulations of the European Directives concerning hazardous waste (94/67/EWG; 91/698/EWG, 74/442/EWG).

Another 50% of the total dioxin emissions to air is caused by a couple of different sources each contributing with less than 10%. Besides the incineration of hazardous waste they comprise industrial facilities mainly of the metallurgical and primary sector and non-industrial sources (traffic, domestic burning, crematoria) as well as „diffuse“ emitters (fires, contaminated wood).

- Being the only industrial emission source type which an emission limit has been set for by an European Directive the **incineration of hazardous waste** is likely to loose importance for the PCDD/F emission problem in the next decade. Nevertheless, the actual emissions are difficult to assess since there are many different types of wastes and corresponding treatment technologies; therefore, a general emission factor is of limited use. Moreover, statistics on the origin and fate of hazardous waste appear to be incomplete and contradictory and should be improved. Further, a complete database on existing facilities should be generated on European level that may be fed with emission measurement data in order to assess whether the EC Directive is complied with.

- With respect to the metallurgical sector **electric furnace steel plants** have been shown to be an additional emission source in the iron and steel industry. Up to 10 ng I-TEQ/m<sup>3</sup> were measured at facilities equipped with scrap preheating particularly. Since the number of these installations operating in Europe is small (< 10) it could be possible to perform measurements at each of them followed by appropriate abatement measures.
- All processes for **secondary production and smelting/casting of non-ferrous metals** must be suspected to generate dioxins and furans. With up to several hundreds of installations in Europe using a broad variety of techniques the prediction of PCDD/F emissions from this sector is difficult. Particularly concerning this branch a detailed inventory of facilities comprising data on the production process, raw materials and flue gas treatment would be needed in order to select a representative number of plants where measurements should be performed. However, some plants are recommended to be investigated preferentially, e. g. Imperial-Smelter installations for secondary zinc production. With respect to emission abatement some primary measures like pre-cleaning of input materials and avoidance of chlorine containing additives might be of benefit.
- Of the industrial emission sources which have been evaluated to be possibly relevant the installations for **production of cement and lime** appear to be the least important facilities. They entered the list mainly due to large uncertainties coupled with some contradictory results reported in the national surveys. **Cement production** using conventional fossil fuels is not likely to be accompanied by PCDD/F emissions; however, use of industrial wastes as supplementary fuel is increasing in Europe giving rise to the suspicion of increasing dioxin emissions. Indeed, some data have become known showing that flue gas concentrations may be above the 0.1 ng I-TEQ/m<sup>3</sup> limit which will also become valid for these processes when the EC Directive on the Incineration of Hazardous Wastes will be enacted finally. While a considerable impact of PCDD/F emissions from cement production on the total European emission balance is quite unlikely, increased flue gas concentration might cause local

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immission and deposition problems the extent of which are difficult to predict. To close this gap a „worst-case-study“ at a cement kiln, particularly of the wet type, using a high fraction of (chlorine containing) waste fuel could be performed. **Installations for the production of lime** entered the relevance list mainly because only few data were available which causes a high uncertainty estimation. Since no statistical data on lime production were gathered the dioxin emission freight importance of this industry cannot be assessed.

- **Industrial wood combustion for heat and energy generation** appears to be of certain relevance; again the emission estimate is quite uncertain because data are lacking about annual wood consumption and about wood composition in particular. From experimental investigations it is known that operation conditions largely influence the PCDD/F emissions; hence, primary measures leading to better burn-out promise to succeed in an emission reduction.

Finally, non-industrial sources need special consideration. About 25% of the estimated total emission is caused by **residential combustion** (mainly wood combustion), **fires**, **road traffic** and PCDD/F volatilisation from **wood treated with PCP**.

- The emissions from **domestic wood combustion** strongly depend on the fuel composition. Use of wood being contaminated by pesticides (like PCP) or coated with plastics (in particular polyvinylchloride) leads to increased PCDD/F concentrations in the flue gases. Since no reliable statistics were available on the consumption of different types of wood the emission estimate presented in this report must be considered as highly uncertain.
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- Clearly, the emissions from **fires** and from the past and present **use of PCP** are very rough estimates, too, associated with a high uncertainty concerning the activity rates and the basic emission factors as well. Since no technical abatement measures can be applied, the emissions from these sources will remain at a nearly constant level unless regulatory means like, for instance, the ban of PCP, are considered.

- The PCDD/F emissions from **traffic** are likely to decrease as the use of leaded petrol diminishes. PCDD/F generation in heavy duty diesel engines is discussed equivocally since only few studies on this topic have been performed. In view of increasing goods transportation on the road throughout Western and Eastern Europe it is recommended to spend additional research effort regarding this problem.

### *Emissions via Waste water and residues*

As shown before much less information exists concerning the other pathways of PCDD/F into the environment and food chain. At first glance contamination of waste water seems generally to be too low to produce considerable emissions; however, it is by far uncertain whether if all relevant emission sources are known today. On the contrary, production residues and solid wastes which are to be deposited have been shown to contain large amounts of PCDD/F, in total equalising or even exceeding the annual air emission freights. Despite not being introduced into the food chain directly the dioxins and furans emitted with such materials may cause future problems. It is likely that a small fraction of the PCDD/F bound to disposed materials will be washed out causing a continuous input flow to the environment. It seems not possible to assess this level on basis of the data surveyed in this report alone; thus, further research activities should be focused on this topic.